SRM VALLIAMMAI ENGINEERING COLLEGE

SRM Nagar, Kattankulathur – 603 203

(An Autonomous Institution)

DEPARTMENT OF MECHANICAL ENGINEERING

QUESTION BANK

V SEMESTER

1909504–DYNAMICS OF MACHINES

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SUBJECT CODE / NAME : 1909504 – DYNAMICS OF MACHINES

SEM / YEAR : V SEM / III YEAR

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 (2 Marks)			
S.No	**Questions**	**Level**	**Competence**
1.	Define static force analysis.	BT-1	Remember
2.	Define dynamic force analysis.	BT-1	Remember
3.	List the sufficient conditions of static equilibrium of a body.	BT-2	Understand
4.	Mention some examples of applied forces.	BT-2	Understand
5.	Differentiate between active force and reactive force.	BT-2	Understand
6.	Define constraint forces.	BT-1	Remember
7.	Point out the methods used for static force analysis of mechanisms.	BT-2	Understand
8.	State the principle of superposition.	BT-1	Remember
9.	Compare inertia force and inertia torque.	BT-2	Understand
10.	State D'Alembert's principle.	BT-1	Remember
11.	Write the expression for acceleration of the piston at the inner dead centre position.	BT-1	Remember
12.	Write the expression for piston effort for a vertical engine by considering the weight of the engine and frictional resistance.	BT-1	Remember
13.	Determine the thrust on the sides of the cylinder walls having the piston effort as 400 N and angle made by the connecting rod as 30˚.	BT-5	Evaluate

14.	Define crank effort.	BT-1	Remember
15.	A force of 4000 N is applied on a piston along the line of stroke of a horizontal steam engine. When the crank is at 60˚ to IDC, Calculate the torque on the crank shaft, when the length of the connecting rod is 0.8 m and the length of the stroke is 0.4 m.	BT-5	Evaluate
16.	Define obliquity ratio.	BT-1	Remember
17.	Sketch the turning moment diagram for a single cylinder double acting steam engine.	BT-1	Remember
18.	Sketch the turning moment diagram for a single cylinder four stroke IC engine.	BT-1	Remember
19.	List the significance of turning moment diagram.	BT-2	Understand
20.	Multi cylinder engines have less fluctuation in turning moment diagram. Justify	BT-2	Understand
21.	Mention the significance of flywheels used in engines.	BT-2	Understand
22.	Write the expression for maximum fluctuation of energy stored in a flywheel.	BT-1	Remember
23.	Define coefficient of steadiness.	BT-1	Remember
24.	List the reasons for windup in the camshaft.	BT-2	Understand
25.	Point out the objectives of analyzing the dynamics of any cam system.	BT-2	Understand

PART-B (13 Marks)

S.No	Questions	Marks	Level	Competence
1.	Derive the expression for the velocity and acceleration of the piston and connecting rod in a reciprocating engine.	13	BT-4	Analyze
2.	The length of crank and connecting rod of a horizontal reciprocating engine are 100 mm and 500 mm respectively. The crank is rotating at 400 rpm when the crank has turned 30˚ from the inner dead centre, find analytically (i) acceleration of the piston (ii) velocity of the piston (iii) angular velocity of the connecting rod (iv) angular acceleration of the connecting rod.	13	BT-5	Evaluate
3.	The length of the crank and connecting rod of a vertical reciprocating engine are 300 mm and 1.5 m respectively. The	13	BT-5	Evaluate

	crank is rotating at 200 rpm clockwise. Determine analytically (i) acceleration of the piston (ii) velocity of the piston (iii) angular acceleration of the connecting rod when the crank has turned through 40˚ from the top dead centre and the piston is moving downwards.			
4.	The crank and connecting rod of a reciprocating engine are 150 mm and 600 mm respectively. The crank makes an angle of 60˚ with the inner dead centre and revolves at a uniform speed of 300 rpm. By using Klien's construction determine (i) velocity and acceleration of the piston (ii) velocity and acceleration of the mid point of the connecting rod (iii) Angular velocity and angular acceleration of the connecting rod.	13	BT-5	Evaluate
5.	Derive the expression for the forces acting in the reciprocating parts of an engine neglecting the weight of the connecting rod.	13	BT-4	Analyze
6.	During a trial on a steam engine, it is found that the acceleration of the piston is 36 m/s^2 when the crank has moved 30˚ from the inner dead centre position. The net effective steam pressure on the piston is 0.5 MPa and the frictional resistance is equivalent is equivalent to a 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 to the crank length is 4.5. Determine (i) Reaction on the guide bars (2) Thrust on the crank shaft bearings (3) Turning moment on the crankshaft.	13	BT-5	Evaluate
7.	A horizontal steam engine running at 120 rpm has a bore of 250 mm and a stroke of 400 mm. The connecting rod is 0.6 m and mass of the reciprocating parts is 60 kg. When the crank has turned through an angle of 45˚ from the inner dead centre, the steam pressure on the cover end side is 550 kN/mm2 and that on the crank end side is 70 kN/mm2. Considering the diameter of the piston rod equal to 50 mm. Determine (i) Turning moment on the crank shaft (ii) Thrust on the bearings	13	BT-5	Evaluate

	(iii) Acceleration of the flywheel, if the power of the engine is 20 kW, mass of the flywheel is 60 kg and radius of the gyration is 0.6 m.			
8.	A petrol engine 90 mm in diameter and 120 mm stroke has a connecting rod of 240 mm length. The piston has a mass of 1 kg and the speed is 1800 rpm. On the expansion stroke with the crank at 30° from top dead centre, the gas pressure is 0.5 N/mm^2. Determine (i) The resultant load on the gudgeon pin (ii) The thrust on the cylinder walls (iii) The speed above which other things remains the same, the gudgeon pin load would be reversed in direction. Also calculate the crank effort at the given position of the crank.	13	BT-5	Evaluate
9.	A vertical single cylinder diesel engine running at 300 rpm has a cylinder diameter 250 mm and stoke 400 mm. The mass of the reciprocating parts is 200 kg. The length of the connecting rod is 0.8 m. The ratio of the compression ratio is 14 and the pressure remains constant during the injection of the oil for 1/10 th of the stroke. If the index of the law of expansion and compression is 1.35, Estimate the torque on the crankshaft when it makes an angle of 60° with the top dead centre during the expansion stroke. The suction pressure may be taken as 0.1 N/mm^2.	13	BT-3	Apply
10.	(i) Derive the expression for the energy stored in a flywheel.	8	BT-4	Analyze
	(ii) A vertical double-acting steam engine develops 75 kW at 250 r.p.m. The maximum fluctuation of energy is 30% of the work done per cycle. The maximum and minimum speeds are not to vary more than 1% on either side of the mean speed. Find the mass of the flywheel required if the radius of gyration is 0.6metres.	5	BT-5	Evaluate
11.	The areas above and below the mean torque line for an IC engine are -25,+200, -100, +150, -300, +150 and -75 mm^2 taken in order. The scale for the turning moment diagram is 1mm vertical scale = 10 Nm and 1 mm of the horizontal scale	13	BT-3	Apply

	= 1.5˚. The mass of the rotating parts are 45 kg with a radius of gyration of 150 mm. If the engine speed is 1500 rpm. Find the coefficient of the fluctuation of speed.			
12.	The turning moment diagram for a petrol engine is drawn to a scale of 1mm to 6 N-m and the horizontal scale of 1mm to 1°.The turning moment repeat itself after every half revolution of the engine. The area above and below the mean torque line are 305, 710, 50, 350, 980and 275 mm^2. The mass of rotating parts is 40kg at a radius of gyration of 140 mm. calculate the coefficient of fluctuation of speed if the mean speed is 1500 rpm.	13	BT-3	Apply
13.	(i) In an engine, the speed varies from 98 rpm to 102 rpm. It has a flywheel of mass 5000 kg and the radius of gyration is 900 mm. Determine (i) The mean speed of the flywheel (ii) Coefficient of fluctuation of speed (iii) Maximum fluctuation of energy.	7	BT-5	Evaluate
	(ii) Determine the coefficient of fluctuation of speed and the limiting speeds of a flywheel of mass 4000 kg having a radius of gyration of 1.4 m. The mean speed of the engine is 200 rpm and the fluctuation of energy is 90 kNm.	6	BT-5	Evaluate
14.	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 : Suction stroke = 0.45×10^{-3} m^2; Compression stroke = 1.7×10^{-3} m^2; Expansion stroke = 6.8×10^{-3} m^2; Exhaust stroke = 0.65×10^{-3} m^2. Each m^2 of area represents 3 MN-m of energy. Assuming the resisting torque to be uniform, find the mass of the rim of a flywheel required to keep the speed between 202 and 198 r.p.m. The mean radius of the rim is 1.2 m.	13	BT-3	Apply
15.	A shaft fitted with a flywheel rotates at 250 r.p.m. and drives a machine. The torque of machine varies in a cyclic manner over a period of 3 revolutions. The torque rises from 750 N-m to 3000 Nm uniformly during 1/2 revolution and remains	13	BT-5	Evaluate

	constant for the following revolution. It then falls uniformly to 750 N-m during the next 1/2 revolution and remains constant for one revolution, the cycle being repeated thereafter. Determine the power required to drive the machine and percentage fluctuation in speed, if the driving torque applied to the shaft is constant and the mass of the flywheel is 500 kg with radius of gyration of 600mm			
16.	A punching press is driven by a constant torque electric motor. The press is provided with a flywheel that rotates at maximum speed of 225 rpm. The radius of gyration of the flywheel is 0.5 m. The press punches 720 holes per hour, each punching operation takes 2 seconds and requires 15 kNm of energy. Determine the power of the motor and the minimum mass of the flywheel if speed of the same is not to fall below 200 rpm.	13	BT-4	Analyze
17.	A constant torque 4 kW motor drives a riveting machine. A flywheel of mass 130 kg and radius of gyration 0.5 m is fitted to the riveting machine. Each riveting operation takes 1 second and requires 9000 Nm of energy. If the speed of the flywheel is 420 rpm before riveting. Estimate (i) The fall in speed of the flywheel after riveting (ii) The number of rivets fitted per hour.	13	BT-5	Evaluate
18.	A single cylinder single acting 4 stroke cycle gas engine develops 22 kW at 300 r.p.m. The flywheel mass is 100 kg. Hoop stress developed is 5MPa. Density of material of rim of flywheel is 8000 kg/m^3. The speed variation on either side is 1% of mean speed. Determine ratio of work done during expansion and compression strokes. Work done in suction and exhaust stroke is negligible.	13	BT-5	Evaluate

PART-C (15 Marks)				
S.No	**Questions**	**Marks**	**Level**	**Competence**
1	A vertical double acting steam engine has cylinder diameter of 240 mm, length of the stroke is 360 mm and length of the connecting rod is 0.6 m. The crank rotates at 300 rpm and the	15	BT-5	Evaluate

	mass of the reciprocating parts is 160 kg. The steam is admitted at a pressure of 8 bar gauge and cut off takes place at 1/3 rd of the stroke. The expansion of steam is hyperbolic. The exhaust of steam takes place at a pressure of -0.75 bar gauge. The frictional resistance is equal to a force of 500 N. Determine the turning moment on the crank shaft, when the piston is 75˚ from the top dead centre. Neglect the effect of clearance and assume the atmospheric pressure as 1.03 bar.			
2	A single cylinder, single acting, four stroke gas engine develops 20 kW at 300 r.p.m. 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 being negligible. If the total fluctuation of speed is not to exceed ± 2 per cent 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.	15	BT-5	Evaluate
3	During forward stroke of the piston of the double acting steam engine, the turning moment has the maximum value of 2000 N-m when the crank makes an angle of 80° with the inner dead centre. During the backward stroke, the maximum turning moment is 1500 N-m when the crank makes an angle of 80° with the outer dead centre. The turning moment diagram for the engine may be assumed for simplicity to be represented by two triangles. If the crank makes 100 r.p.m. and the radius of gyration of the flywheel is 1.75 m, find the coefficient of fluctuation of energy and the mass of the flywheel to keep the speed within ± 0.75% of the mean speed. Also determine the crank angle at which the speed has its minimum and maximum values.	15	BT-5	Evaluate
4	The turning moment curve for an engine is represented by the equation, $T = (20\,000 + 9500 \sin 2\Theta - 5700 \cos 2\Theta)$ N-m, where Θ is the angle moved by the crank from inner dead	15	BT-5	Evaluate

	centre. If the resisting torque is constant, find:1. Power developed by the engine ; 2. Moment of inertia of flywheel in kg-m^2, if the total fluctuation of speed is not exceed 1% of mean speed which is 180 r.p.m; and 3. Angular acceleration of the flywheel when the crank has turned through 45° from inner dead centre.			
5	A certain machine requires a torque of (5000 + 500 sin Ө) N-m to drive it, where Ө is the angle of rotation of shaft measured from certain datum. The machine is directly coupled to an engine which produces a torque of (5000 + 600 sin 2 Ө) N-m. The flywheel and the other rotating parts attached to the engine has a mass of 500 kg at a radius of gyration of 0.4 m. If the mean speed is 150 r.p.m., find : 1. the fluctuation of energy, 2. the total percentage fluctuation of speed, and 3. the maximum and minimum angular acceleration of the flywheel and the corresponding shaft position.	15	BT-5	Evaluate

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 (2 Marks)			
S.No	**Questions**	**Level**	**Competence**
1.	Define Balancing.	BT-1	Remember
2.	List the types of balancing.	BT-1	Remember
3.	Point out the necessity of balancing.	BT-2	Understand
4.	Define centrifugal force.	BT-1	Remember
5.	Write the expression for the centrifugal disturbing force.	BT-1	Remember
6.	Define static balancing.	BT-1	Remember
7.	Define dynamic balancing.	BT-1	Remember
8.	State the conditions for static balancing.	BT-2	Understand
9.	State the conditions for dynamic balancing.	BT-2	Understand
10.	Differentiate between static balancing and dynamic balancing.	BT-2	Understand
11.	Mention the conditions for complete balancing.	BT-2	Understand
12.	State the effect of centrifugal force on the rotating system.	BT-2	Understand
13.	List the important cases used for balancing of the rotating mass.	BT-1	Remember
14.	Point out the methods used for balancing several masses rotating in a same plane.	BT-2	Understand
15.	Define the term reference plane.	BT-1	Remember
16.	Indicate the significance of the reference plane in balancing.	BT-2	Understand
17.	Define shaking force.	BT-1	Remember
18.	Mention the purpose of balancing the reciprocating mass.	BT-2	Understand
19.	Write the expression for primary unbalanced force and secondary unbalanced force.	BT-1	Remember
20.	Differentiate between inside cylinder locomotive and outside cylinder locomotive.	BT-2	Understand
21.	Differentiate between single locomotive and coupled locomotive.	BT-2	Understand
22.	Mention the effect of partial balancing of reciprocating parts of the two-cylinder locomotives.	BT-2	Understand

23.	Define hammer blow.	BT-1	Remember
24.	Define tractive force.	BT-1	Remember
25.	Write the expression for swaying couple.	BT-1	Remember

PART-B (13 Marks)				
S.No	**Questions**	**Marks**	**Level**	**Competence**
1.	Four masses M1, M2, M3, and M4 are 200 kg, 300 kg, 240 kg and 260 kg respectively. The corresponding radii of rotation are 0.2 m, 0.15 m, 0.25 m and 0.3 m respectively and the angle between successive masses 45°, 75°, and135°.Find the position and magnitude of balance mass required if its radius of rotation is 0.2 m.	13	BT-5	Evaluate
2.	A rigid rotor has all its unbalance in one plane and can be considered to consist of three masses m_1 = 5 kg, m_2 = 3 kg at an angle 165° counter clockwise from m1 and m_3 = 8 kg at angle 85° clockwise from m_1. The radii r_1= 20 cm, r_2=8 cm, r_3=14 cm. Determine the balancing mass required at a radius of 10 cm. Specify the location of this mass with respect to m_1.	13	BT-5	Evaluate
3.	A rotating shaft carries four unbalanced masses 18 kg, 14 kg, 16 kg and 12 kg at radii 5 cm, 6 cm, 7 cm and 6 cm respectively. The 2nd, 3rd and 4th masses revolve in planes 8 cm, 16 cm and 28 cm respectively measured from the plane of the first mass and are angularly located at 60°, 135° and 270° respectively measured clockwise from the first mass looking from this mass end of the shaft. The shaft is dynamically balanced by two masses, both located at 5 cm radii and revolving in planes mid-way between those of 1s and 2nd masses and mid-way between those of 3rd and 4th masses. Determine graphically or otherwise, the magnitudes of the masses and their respective angular positions	13	BT-5	Evaluate
4.	A shaft caries four rotating masses A, B, C and D which are completely balanced. The masses B, C and D are 50 kg, 80	13	BT-5	Evaluate

	kg and 70 kg respectively. The masses C and D make angles of 90° and 195° respectively with mass B in the same sense. The masses A, B, C and D are concentrated at radius 75 mm, 100 mm, 50 mm and 90 mm respectively. The plane of rotation of masses B and C are 250 mm apart. Determine (i) the magnitude of mass A and its angular position (ii) the position of planes A and D.			
5.	A, B, C and D are four masses carried by a rotating shaft at radii 100 mm,150 mm, 150 mm and 200 mm respectively. The planes in which the masses revolve are spaced 500 mm apart and the masses of B, C and D are 9 kg, 5 kg and 4 kg respectively. Find the required mass A and relative angular setting of the four masses so that the shaft be in complete balance.	13	BT-5	Evaluate
6.	Four masses A, B, C and D revolves at equal radii and are equally spaced along a shaft. The mass B is 7 kg and the radii of C and D make angles of 90° and 240° respectively with the radius of B. Find the magnitude of masses A, C and D and angular position of A so that the system may be completely balanced.	13	BT-5	Evaluate
7.	A shaft has three 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 centres from the axis of rotation are 12 mm, 18 mm and 12 mm and their angular positions are 120° apart. The density of metal is 7000 kg/m3. Find the amount of out-of-balance force and couple at 600 r.p.m. If the shaft is balanced by additional two masses at a radius 75 mm and at a distance of 100 mm from the central plane of the middle eccentric, find the amount of the masses and their angular positions.	13	BT-5	Evaluate
8.	A, B, C and D are four masses carried by a rotating shaft at radii 100, 125, 200 and 150 mm respectively. The planes in which the masses revolve are spaced 600 mm apart and the	13	BT-5	Evaluate

	mass of B, C and D are 10 kg, 5 kg, and 4 kg respectively. Find the required mass A and the relative angular settings of the four masses so that the shaft shall be in complete balance.			
9.	(i) A single cylinder horizontal engine runs at 120 rpm. The length of the stroke is 400 mm. The mass of the revolving parts assumed concentrated at the crank pin is 100 kg and mass of the reciprocating parts is 150 kg. Determine the magnitude of the balancing mass required to be placed opposite to the crank at a radius of 150 mm which is equivalent to all the revolving and 2/3rd of the reciprocating masses. If the crank turns 30° from the inner dead centre, find the magnitude of the unbalanced force due to the balancing mass.	13	BT-5	Evaluate
	(ii) Prove that the resultant unbalanced force is minimum when half of the reciprocating masses are balanced by rotating masses i.e, when c = 1/2.	13	BT-4	Analyze
10.	An inside cylinder locomotive has its cylinder centre lines 0.7 m apart and has a stroke of 0.6 m. The rotating masses per cylinder are equivalent to 150 kg at the crank pin and the reciprocating masses per cylinder to 180 kg. The wheel centre lines are 1.5 m apart. The cranks are at right angles. The whole of the rotating and 2/3 of the reciprocating masses are to be balanced by masses placed at a radius of 0.6 m. Find the magnitude and direction of the balancing masses. Find the fluctuation in rail pressure under one wheel, variation of tractive effort and the magnitude of swaying couple at a crank speed of 300 r.p.m.	13	BT-5	Evaluate
11.	The three cranks of a three cylinder locomotive are all on the same axle and are set at 120°. The pitch of the cylinders is 1 metre and the stroke of each piston is 0.6 m. The reciprocating masses are 300 kg for inside cylinder and 260 kg for each outside cylinder and the planes of rotation of the balance masses are 0.8 m from the inside crank. If 40% of the reciprocating parts are to be balanced, find the magnitude and	13	BT-5	Evaluate

	the position of the balancing masses required at a radius of 0.6 m and the hammer blow per wheel when the axle makes 6 r.p.s.			
12.	The following data refer to two cylinder locomotive with cranks at 90° : Reciprocating mass per cylinder = 300 kg ; Crank radius = 0.3 m ; Driving wheel diameter = 1.8 m ; Distance between cylinder centre lines = 0.65 m ; Distance between the driving wheel central planes = 1.55 m. Determine : 1. the fraction of the reciprocating masses to be balanced, if the hammer blow is not to exceed 46 kN at 96.5 km.p.h. ; 2. the variation in tractive effort ; and 3. the maximum swaying couple.	13	BT-5	Evaluate
13.	The following data apply to an outside cylinder uncoupled locomotive : Mass of rotating parts per cylinder = 360 kg ; Mass of reciprocating parts per cylinder = 300 kg ; Angle between cranks = 90° ; Crank radius = 0.3 m ; Cylinder centres =1.75 m ; Radius of balance masses = 0.75 m ; Wheel centres = 1.45 m. If whole of the rotating and two-thirds of reciprocating parts are to be balanced in planes of the driving wheels, find : 1. Magnitude and angular positions of balance masses, 2. Speed in kilometres per hour at which the wheel will lift off the rails when the load on each driving wheel is 30 kN and the diameter of tread of driving wheels is 1.8 m, and 3. Swaying couple at speed arrived at in (2) above.	13	BT-5	Evaluate
14.	The following particulars relate to a two-cylinder locomotive with two coupled wheels on each side : Stroke = 650 mm,Mass of reciprocating parts per cylinder = 240 kg, Mass of revolving parts per cylinder = 200 kg, Mass of each coupling rod = 250 kg, Radius of centre of coupling rod pin = 250 mm, Distances between cylinders = 0.6 m, Distance between wheels = 1.5 m, Distance between coupling rods = 1.8 m, The main cranks are at right angles and the coupling rod pins are at 180° to their respective main cranks. The balance	13	BT-5	Evaluate

	masses are to be placed in the wheels at a mean radius of 675 mm in order to balance whole of the revolving and 3/4th of the reciprocating masses. The balance mass for the reciprocating masses is to be divided equally between the driving wheels and the coupled wheels. Find : 1. The magnitudes and angular positions of the masses required for the driving and trailing wheels, and 2. The hammer blow at 120 km/h, if the wheels are 1.8 metre diameter.			
15.	Derive the expression for primary and secondary unbalanced forces of reciprocating masses.	13	BT-4	Analyze
16.	Write short notes on partial balancing of unbalanced primary forces in a reciprocating engine.	13	BT-4	Analyze
17.	Enumerate on the effect of partial balancing of reciprocating parts of two cylinder locomotives.	13	BT-4	Analyze
18.	Explain the various methods of balancing the rotating masses.	13	BT-4	Analyze

PART-C (15 Marks)				
S.No	**Questions**	**Marks**	**Level**	**Competence**
1	The cranks 2 to 9 of a nine cylinder engine running at 1000 rpm makes 240˚, 120 ˚, 160 ˚, 280 ˚, 40 ˚, 80 ˚, 320 ˚ and 200 ˚ respectively with crank 1, when measured in a counter clockwise direction. The rotating masses for each cylinder are estimated to be 20 kg at 0.5 m radius. The distance between centre lines of the cranks is 0.4 m. it is proposed to balance this engine by two masses, one in the damper at a distance of 0.6 m from the cylinder one and the other located in the flywheel at a distance of 0.6 m from cylinder nine. Determine the kg-m magnitudes and locations of the balancing masses.	13	BT-4	Analyze
2	A shaft carries four masses in parallel planes A, B, C and D in this order along its length. The masses at B and C are 18 kg and 12.5 kg respectively, and each has an eccentricity of 60 mm. The masses at A and D have an eccentricity of 80 mm. The angle between the masses at B and C is 100° and that	13	BT-4	Analyze

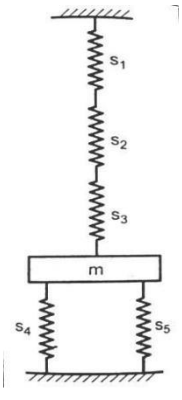
	between the masses at B and A is 190°, both being measured in the same direction. The axial distance between the planes A and B is 100 mm and that between B and C is 200 mm. If the shaft is in complete dynamic balance, determine : 1. The magnitude of the masses at A and D ; 2. the distance between planes A and D ; and 3. the angular position of the mass at D.			
3	A shaft carries four masses A, B, C and D of magnitude 200 kg, 300 kg, 400 kg and 200 kg respectively and revolving at radii 80 mm, 70 mm, 60 mm and 80 mm in planes measured from A at 300 mm, 400 mm and 700 mm. The angles between the cranks measured anticlockwise are A to B 45°, B to C 70° and C to D 120°. The balancing masses are to be placed in planes X and Y. The distance between the planes A and X is 100 mm, between X and Y is 400 mm and between Y and D is 200 mm. If the balancing masses revolve at a radius of 100 mm, find their magnitudes.	13	BT-5	Evaluate
4	A shaft is supported in bearings 1.8 m apart and projects 0.45 m beyond bearings at each end. The shaft carries three pulleys one at each end and one at the middle of its length. The mass of end pulleys is 48 kg and 20 kg and their centre of gravity are 15 mm and 12.5 mm respectively from the shaft axis. The centre pulley has a mass of 56 kg and its centre of gravity is 15 mm from the shaft axis. If the pulleys are arranged so as to give static balance, determine (i).relative angular positions of the pulleys.	13	BT-5	Evaluate
5	A four crank engine has the two outer cranks set at 120° to each other, and their reciprocating masses are each 400 kg. The distance between the planes of rotation of adjacent cranks are 450 mm, 750 mm and 600 mm. If the engine is to be in complete primary balance, find the reciprocating mass and the relative angular position for each of the inner cranks. If the length of each crank is 300 mm, the length of each connecting rod is 1.2 m and the speed of rotation is 240r.p.m., what is the	13	BT-5	Evaluate

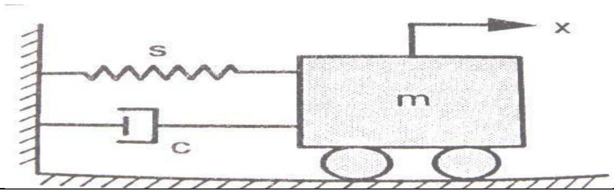
	maximum secondary.			

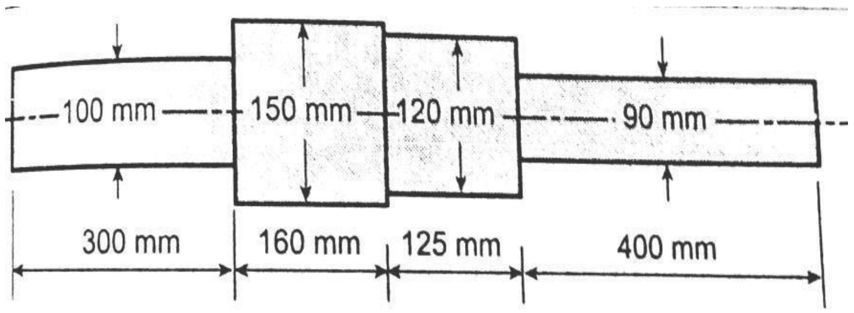
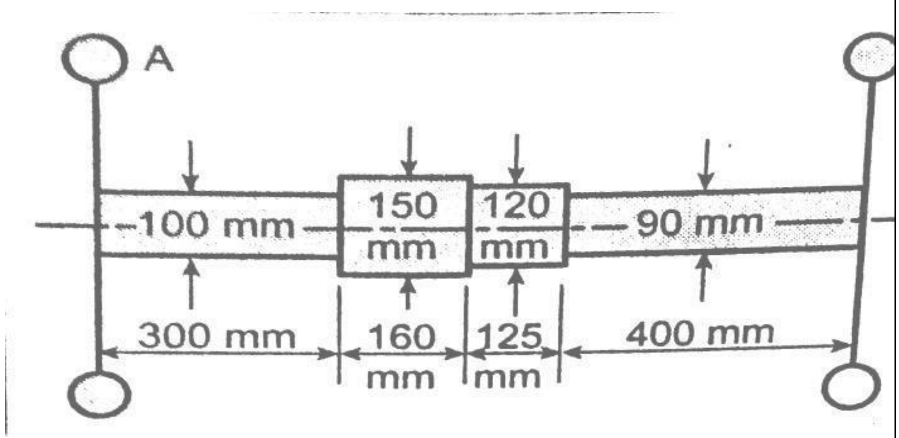
UNIT III – FREEVIBRATION			
Basic features of vibratory systems – Degrees of freedom – single degree of freedom – Free vibration – Equations of motion – Natural frequency – Types of Damping – Damped vibration– Torsional vibration of shaft– Critical speeds of shafts – Torsional vibration – Two and three rotor torsional systems.			
PART – A (2 Marks)			
S.No	**Questions**	**Level**	**Competence**
1.	Define vibratory motion.	BT-1	Remember
2.	Mention the types of vibratory motion.	BT-2	Understand
3.	Define time period.	BT-1	Remember
4.	Define damped vibration.	BT-1	Remember
5.	Differentiate between forced vibration and free vibration.	BT-2	Understand
6.	List the types of free vibration.	BT-2	Understand
7.	Point out the methods used for determining the natural frequency of longitudinal vibration.	BT-2	Understand
8.	Differentiate between longitudinal vibration and transverse vibration.	BT-2	Understand
9.	Define torsional vibration.	BT-1	Remember
10.	Write the expression for natural frequency of a transverse vibration.	BT-1	Remember
11.	Define whirling speed.	BT-1	Remember
12.	Define viscous damping.	BT-1	Remember
13.	Mention the effects of whirling speed of the shaft.	BT-2	Understand
14.	List some applications of damping.	BT-2	Understand
15.	A shaft fixed at one end has a stiffness of ‘*s*’ N/m and fitted with a mass ‘m’ at its free end. Its longitudinal natural frequency comes down by 10 %, if a mass of 1 kg is added to ‘m’. Find the value of initial mass.	BT-2	Understand
16.	Mention the types of damping based on the source of damping.	BT-2	Understand
17.	List the types of damping based on the nature of damping.	BT-2	Understand
18.	Define logarithmic decrement.	BT-1	Remember

19.	Sketch the displacement – time curves for over damped system.	BT-1	Remember
20.	Sketch the displacement – time curves for critically damped system.	BT-1	Remember
21.	Sketch the displacement – time curves for under damped system.	BT-1	Remember
22.	Mention the methods for determining the natural frequency of the free transverse vibration for a shaft subjected to a number of point loads.	BT-2	Understand
23.	Write the expression for natural frequency of a torsional vibration.	BT-1	Remember
24.	Differentiate node and anti node.	BT-2	Understand
25.	List some applications of critical damping.	BT-3	Apply

PART-B (13 Marks)

S.No	Questions	Marks	Level	Competence
1.	An unknown mass m is attached to one end of a spring of stiffness k having natural frequency of 6 Hz. When 1 kg mass is attached with m the natural frequency of the system is lowered by 20%. Determine the value of unknown mass m and stiffness k.	13	BT-5	Evaluate
2.	Deduce the expression for the free longitudinal vibration in terms of spring stiffness, its inertia effect and suspended mass.	13	BT-5	Evaluate
3.	Derive an expression for the natural frequency of the free longitudinal vibration by (i) Equilibrium method (ii) Energy method (iii) Rayleigh's method.	13	BT-5	Evaluate
4.	For the system shown in the diagram $s_1 = s_2 = 500$ N/m; $s_3 = 1500$ N/m; $s_4 = 3000$ N/m; $s_5 = 2000$ N/m. Find the mass 'm' such that the system has a natural frequency of 6.75 Hz. 	13	BT-3	Apply

5.	Find the equation of motion for the spring mass-dashpot system shown in diagram for the cases when (i) $\zeta = 2$ (ii) $\zeta = 1$ and (iii) $\zeta = 0.3$. The mass 'm' is displaced by a distance of 30 mm and released. 	13	BT-3	Apply
6.	Explain with sketches for different cases of damped vibrations.	13	BT-5	Evaluate
7.	A mass of 1 kg is attached to a spring having stiffness of 3920 N/m. The mass slides on a horizontal surface, the coefficient of friction between the mass and surface being 0.1. Determine the frequency of vibrations of the system and the amplitude after one cycle if the initial amplitude is 0.25 cm. Determine the final rest position.	13	BT-5	Evaluate
8.	A shaft of diameter 10 mm carries at its centre a mass of 12 kg. It is supported by two short bearings, the centre distance of which is 400 mm. Find the whirling speed: (a) Neglecting the mass of the shaft and (b) considering the mass of the shaft. The density of shaft material is 7500 kg/m^3. Take E = 200 GN/m^2.	13	BT-5	Evaluate
9.	A vertical steel shaft of 14 mm diameter is mounted in long bearings which are1.2 m apart and carries 160 N of disc at its middle. The eccentricity of the centre of gravity of the disc from the centre of the rotor is 0.4 mm. Taking Young's modulus as 200 GN/m^2 and permissible stress as 70×10^6 N/m^2, calculate the critical speed of the shaft and range of speed over which it is unsafe to run the shaft. Assume the shaft to be massless.	13	BT-5	Evaluate
10.	A rotor of mass 10 kg is mounted mid-way on a 20 mm diameter horizontal shaft supported at the ends by two bearings. The bearing span is 800 mm. Because of certain manufacturing defect, the centre of gravity of the disc is 0.1 mm away from the geometric centre of the rotor. If the system rotates at 50 r.p.s., determine the amplitude of steady state vibrations and the dynamic load transmitted to the bearings Take E = 200 GN/m^2.	13	BT-5	Evaluate

11.	Reduce the stepped shaft shown in figure to torsionally equivalent shaft of 100 mm diameter. 	13	BT-5	Evaluate
12.	A stepped shaft is 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-m^2. If the modulus of rigidity of the shaft material is 0.83 x 10^{11} N/m^2, find the natural frequency of torsional oscillations, neglecting the inertia effect of the shaft.	13	BT-5	Evaluate
13.	The shaft shown in fig. carries two masses. The mass A is 350 kg with radius of gyration 0.8 m and the mass B is 550 kg with radius of gyration 0.95 m. Determine the location of the node and the natural frequency of free torsional vibration of the system. It is desired to have the node at the midsection of the shaft of 120 mm diameter. By changing the diameter of the section having a 90 mm diameter, what will be the new diameter. Take C=84 GN/m^2 	13	BT-5	Evaluate

14.	Three rotors A, B and C having moment of inertia of 2000, 6000 and 3500 kg- m^2 respectively are carried on a uniform shaft of 0.35m diameter. The length of the shaft between the rotors A and B is 6 m and between B and C is 32 m. Find the natural frequency of the torsional vibrations. The modulus of rigidity for the shaft material is 80 GN/m^2.	13	BT-5	Evaluate
15.	An electric motor rotating at 1500 r.p.m drives a centrifugal pump at 500 r.p.m through a single stage reduction gearing. The moments of inertia of the electric motor and the pump impeller are 400 kg-m^2 and 1400 kg- m^2respectively. The motor shaft is 45 mm in diameter and 180 mm long. The pump shaft is 90 mm in diameter and 450 mm long. Determine the frequency of torsional oscillations of the system, neglecting the inertia of the gears. The modulus of rigidity for the shaft material is 84 GN/m^2.	13	BT-5	Evaluate
16.	Between a solid mass of 10 kg and the floor are kept two slabs of isolators, natural rubber and felt in series. The natural rubber slab has a stiffness of 3000 N/m and an equivalent viscous damping coefficient of 100 N-sec/m. The felt has a stiffness of 12000 N/m and equivalent viscous damping coefficient of 330 N-sec/m. Determine the undamped and the damped natural frequencies of the system in vertical direction, neglecting the mass of the isolators.	13	BT-5	Evaluate
17.	In a single degree damped vibrating system, the suspended mass of 3.75 kg makes 12 oscillations in 7 seconds when disturbed from its equilibrium position. The amplitude decreases to 0.33 of the initial vale after 4 oscillations. Determine (i) Stiffness of the spring (ii) Logartmic decrement (iii) Damping factor (iv) damping coefficient	13	BT-5	Evaluate
18.	A body of 50 kg mass is supported by an elastic structure of stiffnes 10 kN/m. The motion of the body is controlled by a dashpot such that the amplitude of vibration decreases to one-tenth of its original value after two complete vibrations. Determine (i) damping ratio (ii) damping force at 1 m/s (iii) natural frequency of vibration.	13	BT-5	Evaluate

PART-C (15 Marks)				
S.No	**Questions**	**Marks**	**Level**	**Competence**
1	A vertical steel shaft 15 mm diameter is held in long bearings1 m apart and carries at its middle a disc of mass 15 kg. The eccentricity of the centre of gravity of the disc from the centre of the rotor is 0.30mm. The modulus of elasticity for the shaft material is 200 GN/m^2 and the permissible stress is 70 MN/m^2. Determine: (i) The critical speed of the shaft and (ii) The range of speed over which it is unsafe to run the shaft. Neglect the mass of the shaft.	15	BT-6	Create
2	Determine: (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.	15	BT-5	Evaluate
3	A steel shaft of diameter 10 cm is carrying three masses 2.5 kg, 3.75 kg and 7 kg respectively. The distances between the rotors are 0.70 m. Determine the natural frequencies of torsional vibrations. The radii of gyration of three rotors are 0.20, 0.30, 0.40m respectively. Take G= 9 x 10^8 N/m^2.	15	BT-3	Apply
4	(i) A cantilever shaft 50 mm diameter and 300 mm long has a disc of mass 100 kg at its free end. The young's modulus for the shaft material is 200 GN/m^2. Determine the frequency of longitudinal and transverse vibrations of the shaft.	8	BT-4	Analyze
	(ii) Explain with sketches different cases of damped vibrations.	7		
5	A machine mounted on springs and filled with a dashpot has a mass of 100 kg. There are four springs, each of stiffness 25 kN/m. The amplitude of vibrations reduces from 40 mm to 10 mm in three complete oscillations.Assuming that the damping forces varies as the velocity. Determine (i) the resistance of	15	BT-5	Evaluate

	dashpot at unit velocity. (ii) the ratio of frequencies of damped and undamped vibrations (iii) the periodic time of damped vibrations.			

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 (2 Marks)			
S.No	**Questions**	**Level**	**Competence**
1.	Define forced vibration with sketch.	BT-2	Understand
2.	Generalize the sources of excitation in forced vibration.	BT-6	Create
3.	Define damping ratio or damping factor.	BT-1	Remember
4.	Define logarithmic decrement.	BT-1	Remember
5.	Give equation for damping factor ζ and damped frequency f_d.	BT-2	Understand
6.	Define harmonic forcing.	BT-2	Understand
7.	A vibrating spring having a mass of 1 kg is suspended by a spring of stiffness 1000 N/m and its put to harmonic excitation of 10 N. Determine the resonant frequency and the amplitude of vibration at resonance.	BT-4	Analyze
8.	Write the expression for magnification factor.	BT-2	Understand
9.	Define transmissibility.	BT-1	Remember
10.	Define transmissibility ratio or isolation factor.	BT-1	Remember
11.	Illustrate vibration isolation.	BT-3	Apply
12.	Write the governing differential equation for forced vibration.	BT-4	Analyze
13.	Mention the instruments used for measurement of vibration levels in a body.	BT-3	Remember
14.	Show that for effective isolation of vibration, frequency ratio $r > \sqrt{2}$.	BT-6	Create
15.	Identify the type of motion that is exhibited by a vibrating system when it is critically damped.	BT-1	Remember
16.	Recognize the methods of isolation in the vibration.	BT-3	Apply
17.	Write the equation of motion for the forced damped vibration.	BT-5	Evaluate
18.	Indicate the various types of damping.	BT-4	Analyze
19.	Define steady state vibration.	BT-5	Evaluate
20.	Define transient Vibration.	BT-1	Remember
21.	Illustrate amplitude of vibration.	BT-3	Apply
22.	Define magnification factor.	BT-1	Remember
23.	Define whirling speed of rotating shaft.	BT-2	Understand
24.	Illustrate damped force vibration system.	BT-3	Apply

25.	Mention different types of forced vibration.	BT-1	Remember

PART-B (13 Marks)				
S.No	**Questions**	**Marks**	**Level**	**Competence**
1.	A vibrating system having mass 1 kg is suspended by a spring of stiffness 1000 N/m and it is put to harmonic excitation of 10 N. Assuming viscous damping, determine (i) the resonant frequency (ii) the phase angle at resonance (iii) the amplitude at resonance (iv) the frequency corresponding to the peak amplitude and(v) damped frequency. Take C = 40 N-sec/m.	13	BT-3	Apply
2.	A mass of 50kg is supported by an elastic structure of total stiffness 20 kN/m. A simple harmonic disturbing force in Newton, expressed as 75 cos12t acts on the mass. If t is expressed in seconds and the damping force is 0.25, find amplitude of the vibration and phase angle caused by the damping.	13	BT-3	Apply
3.	A mass of 10 kg is suspended from one end of a helical spring; the other end being fixed. The stiffness of the spring is 10 N/mm. The viscous damping causes the amplitude to decrease to one-tenth of the initial value in four complete oscillations. If a periodic force of 150 cos50t N is applied at the mass in the vertical direction. Find the amplitude of the forced vibrations? What is its value of resonance?	13	BT-3	Apply
4.	A harmonic exiting force of 25 N is acting on a machine part which is having a mass of 2 kg and is vibrating in a viscous medium. The exciting force causes resonant amplitude of 12.5 mm with a period of 0.2 sec. Determine the damping coefficient.	13	BT-5	Evaluate
5.	A body having a mass of 15 kg is suspended from a spring which deflects 12 mm under the weight of the mass. Determine the frequency of the free vibrations. What is the viscous damping force needed to make the motion a periodic at a	13	BT-5	Evaluate

	speed of 1mm/s? If, when damped to this extent, a disturbing force having a maximum value of 100 N and vibrating at 6 Hz is made to act on the body, determine the amplitude of the ultimate motion.			
6.	A single cylinder vertical petrol engine of total mass of 200 kg 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 mass of the reciprocating parts is 9 kg and stroke of the piston is 160 mm with S.H.M. If dashpot of damping coefficient of 1 N/mm/s is used to dampen the vibrations, calculate at steady state (i) The amplitude of forced vibrations at 500 r.p.m. engine speed. (ii) The speed of the driving shaft at which resonance will occur.	13	BT-3	Apply
7.	A vertical single stage air compressor having a mass of 500 kg is mounted on spring having stiffness of 1.96 x 10^5 N/m and dashpots with damping factor of 0.2 m. The rotating parts are completely balanced and the equivalent reciprocating parts weigh 20 kg. The stroke is 0.2 m. Determine the dynamic amplitude of vertical motion and the phase difference between the motion and the excitation force if the compressor is operated at 200 r.p.m.	13	BT-5	Evaluate
8.	A vehicle has a mass of 490 kg and the total spring constant of its suspension system is 58800 N/m. The profile of the road may be approximated to a sine wave of amplitude 40 mm and wavelength 4 metres. Determine the critical speed of the vehicle, the amplitude of the steady state motion of the mass when the vehicle is driven at critical speed and the damping factor is 0.5 the amplitude of steady state motion of the mass when the vehicle is driven at 57 km/hr and the damping factor is 0.5 .	13	BT-5	Evaluate
9.	A vibratory body of mass 150 kg supported on springs of total stiffness 1050 kN/m has a rotating unbalance force of 525 N at a speed of 6000rpm. If the damping factor is 0.3, determine (i)	13	BT-3	Apply

	the amplitude caused by the unbalance and its phase angle (ii) the transmissibility and (iii) the actual force transmitted and its phase angle.			
10.	A single cylinder engine has an out of balance force of 500 N at an engine speed of 300 r.p.m. The total mass of engine is 150 kg and it is carried on a set of springs of total stiffness 300 N/cm. (i) Find the amplitude of steady motion of the mass and the maximum oscillating force transmitted to the foundation. (ii) If a viscous damping is interposed between the mass and the foundation, the damping force being 1000 N at 1 m/s of velocity, find the amplitude of the forced damped oscillation of the mass and its angle of lag with disturbing force.	13	BT-3	Apply
11.	An industrial machine weighting 445 kg is supported on a spring with a statical deflection of 0.5 cm. If the machine has rotating imbalance of 25 kg- cm, determine the force transmitted at 1200 r.p.m. and the dynamic amplitude at that speed.	13	BT-5	Evaluate
12.	The mass of an electric motor is 120 kg and it runs at 1500 r.p.m. The armature mass is 35 kg and its centre of gravity lies 0.5 mm from the axis of rotation. The motor is mounted on five springs of negligible damping so that the force transmitted is one-eleventh of the impressed force. Assume that the mass of the motor is equally distributed among the five springs. Determine (i) the stiffness of each spring (ii) the dynamic force transmitted to the base at the operating speed (iii) the natural frequency of system.	13	BT-5	Evaluate
13.	A centrifugal fan of mass 5kg has a rotating unbalance of 0.25kg.m when dampers having damping factor of 0.2 are used specify, the springs for mounting such that only 10% of unbalance force is transmitted to the floor. The fan is running at constant speed of 1000rpm.	13	BT-3	Apply
14.	A compressor supported symmetrically on four springs has a			

	mass of 100 kg. The mass of the reciprocating parts is 2 kg which moves through a vertical stroke of 80 mm with SHM. Neglecting damping, determine the combined stiffness of the springs so that the force transmitted to the foundation is 1/25th of the impressed force. The machine crankshaft rotates at 1000 r.p.m. When the compressor is actually supported on the springs, it is found that the damping reduces the amplitude of successive free vibrations by 25%. Find the force transmitted to the foundation at 1000r.p.m and the force transmitted to the foundation at resonance and the amplitude of the vibrations at resonance.	13	BT-5	Evaluate
15.	A trailer has 1000 kg mass when fully loaded and 250 kg when empty. The spring of the suspension is 350 kN/m. The damping factor is 0.5 when the trailer is fully loaded. The speed is 100 km/hr. The varies sinusoidally with a wave length of 5 m. Determine the amplitude ratio of the trailer when fully loaded and empty.	13	BT-5	Evaluate
16.	The vibrations of the platform of railway station are periodic at the frequency range of 12-50 Hz. A vibration measuring instrument is to be installed on some foundation independent of the platform. The small foundation is supported by four identical springs resting on the platform. The total mass of the instrument and foundation is 50 kg. What is the maximum value of spring stiffness, if the amplitude of transmitted vibration is to be less than 10% of the platform vibration over the given frequency range. Take damping factor 0.20. System is treated as single degree of freedom.	13	BT-3	Apply
17.	A vibratory body of mass 150 kg supported on springs of total stiffness 1050 kN/m has a rotating unbalance force of 525 N at a speed of 6000 rpm. If the damping factor is 0.3, determine (i) the amplitude caused by the unbalance and its phase angle (ii) the transmissibility and (iii) the actual force transmitted and its phase angle.	13	BT-3	Apply

18.	A machine of mass one tonne is acted upon by an external force of 2450 N at a frequency of 1500 rpm. To reduce the effects of vibration, isolator of rubber having a static deflection of 2 mm under the machine load and an estimated damping Ɛ = 0.2 are used. Determine (i) the force transmitted to the foundation (ii) the amplitude of vibration of machine (iii) the phase lag.	13	BT-5	Evaluate

PART-C (15 Marks)				
S.No	**Questions**	**Marks**	**Level**	**Competence**
1.	A trailer has 1000 kg mass when fully loaded and 250 kg when empty. The spring of the suspension is 350 kN/m. The damping factor is 0.5 when the trailer is fully loaded. The speed is 100 km/hr. The road varies sinusoidally with a wave length of 5m. Determine the amplitude ratio of the trailer when fully loaded and empty.	15	BT-5	Evaluate
2.	A vibrating system having a mass of 1.5 kg is suspended by a spring of stiffness 1200 N/m and it is put to harmonic excitation of 12 N. Assuming viscous damping, Determine, (i) Resonant Frequency (ii) Phase angle at resonance (iii) Amplitude at resonance (iv) Damped frequency; Take c = 48 Ns/m.	15	BT-6	Create
3.	A 75 kg machine is mounted on springs of stiffness K= 11.76 X 10^5 N/m with an assumed damping factor of 0.2. A 2 kg piston within the machine has a reciprocating motion with a stroke of 0.08 m and a speed of 3000 rpm. Assuming the motion of the piston to be harmonic, determine the amplitude of vibration of the machine and the vibratory force transmitted to the foundation.	15	BT-4	Analyze
4.	The support of a spring mass system is vibrating with amplitude of 6 mm and a frequency of 1200 cycles/min. If a mass is 95 kg and the spring has a stiffness of 1950 N/m, determine the amplitude of vibration of the mass. If a	15	BT-3	Apply

	damping factor of 0.2 is include, what would be the amplitude?			
5.	A vehicle of mass 490 kg and total spring constant of its suspension system is 60 x 10^3 N/m. The profile of the road may be approximated to a line curve of amplitude 4.0 cm and wavelength of 4.0 meters. Determine: (i) the critical speed of the vehicle (ii) the amplitude of the steady state motion of the mass when the vehicle is driven at critical speed and the damping factor is 0.5 ; and (iii) the amplitude of the steady state motion of the mass when the vehicle is driven at 57 km/hr and the damping factor is 0.5.	15	BT-6	Create

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 (2 Marks)

S.No	Questions	Level	Competence
1.	Point out the function of governor.	BT-1	Remember
2.	Classify governors.	BT-3	Apply
3.	Differentiate between governor and fly wheel.	BT-3	Apply
4.	Define sensitiveness of a governor.	BT-2	Understand
5.	Classify spring controlled governors.	BT-4	Analyze
6.	Define coefficient of sensitiveness.	BT-2	Understand
7.	Define hunting of governor.	BT-2	Understand
8.	Mention the isochronous condition in a governor.	BT-2	Understand
9.	Recognize the application of gyroscopic principle.	BT-3	Apply
10.	Define gyroscopic torque.	BT-1	Remember
11.	Identify the effects of gyroscopic couple on rolling of ship.	BT-5	Evaluate
12.	Define gyroscopic couple.	BT-1	Remember
13.	Write the expression for gyroscopic couple.	BT-1	Remember
14.	Define reactive gyroscopic couple.	BT-5	Evaluate
15.	Generalize the differences between stable governors and isochronous governors.	BT-1	Remember
16.	A flywheel of mass 10 kg and radius of gyration 200 mm is spinning about its axis, which is horizontal and is suspended at a point 150 mm from the plane of rotation of the flywheel. Determine the angular velocity of precession of the flywheel. The spin speed of the flywheel is 900 rpm.	BT-4	Analyze
17.	Mention the gyroscopic effect on a sea going vessels.	BT-1	Remember
18.	Mention the gyroscopic effect on a flying machine.	BT-1	Remember
19.	State the expression for height in the case of Watt Governor.	BT-1	Remember
20.	Differentiate reaction torque and active torque.	BT-4	Analyze
21.	Define equilibrium speed of governors.	BT-1	Remember
22.	Define sensitiveness of a governor.	BT-1	Remember
23.	Illustrate coefficient of insensitiveness of a governor.	BT-3	Apply

24.	Depict the effect of gyroscopic couple in ships during pitching.	BT-2	Understand
25.	List some of the terms related to motion of ships using gyroscopic principle.	BT-1	Remember

PART-B (13 Marks)				
S.No	**Questions**	**Marks**	**Level**	**Competence**
1	(i)The length of the upper arm of a Watt governor is 400 mm and its inclination to the vertical is 30°. Find the percentage increase in speed, if the ball rise by 20mm.	5	BT-3	Apply
	(ii)In the Watt governor, length of each arm is 350 mm, and they are pivoted on the axis of rotation. Determine the governor height and the radii of rotation of the balls, when (a) the governor speed is 62 r.p.m. and (b) the governor speed is 75r.p.m.	8		
2.	The length of the upper and lower arms of a porter governor are 200 mm and 250 mm respectively. Both the arms are pivoted on the axis of rotation. The central load is 150 N, the weight of the each ball is 20 N and the friction of the sleeve together with the resistance of the operating gear is equivalent to a force of 30N at the sleeve. If the limiting inclinations of the upper arms to the vertical are 30° and 40°, taking friction in to account, find the range of speed of the governor.	13	BT-3	Apply
3.	A loaded governor of the Porter type has equal arms and links each 250 mm long. The mass of each ball is 2 kg and the central mass is 12 kg. When the ball radius is 150 mm, the valve is fully open and when the radius is 185 mm, the valve is closed. Find the maximum speed and the range of speed. If the maximum speed is to be increased 20% by an addition of mass to the central load, find what additional mass is required.	13	BT-3	Apply
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	13	BT-5	Evaluate

	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 150mm.			
5.	A Proell governor has arms of 300 mm length. The upper arms are hinged on the axis of rotation, whereas the lower arms are pivoted at a distance of 35 mm from the axis of rotation. The extensions of lower arms to which the balls are attached are 100 mm long. The mass of each ball is 8 kg and the mass on the sleeve is 60 kg. At the minimum radius of rotation of 200 mm, the extensions are parallel to the governor axis. Determine the equilibrium speed of the governor for the given configuration. What will be the equilibrium speed for the maximum radius of 250 mm?	13	BT-5	Evaluate
6.	Calculate the minimum speed of a porter governor, which has equal arms each of 200 mm and are pivoted on the axis of rotation. The mass of each ball is 4 kg and the central mass on the sleeve is 20 kg. The radius of rotation of the ball is 100mm when the governor begins to lift and 130mm the governor is at maximum speed.	13	BT-3	Apply
7.	A spring loaded governor of Wilson-Hartnell type is shown in fig. Two balls each of mass 6 kg are connected by two spring. A speed of the governor is 600 r.p.m. in its mean position. The radius of the governor ball is 150 mm. The tension in each of the spring A is 1300 N. Find the tension in the spring B for this position. Find the necessary stiffness of the spring B if the speed is 630 r.p.m. when the sleeve moves up 20 mm from mean position and if stiffness of each spring A is 10 kN/m.	13	BT-3	Apply
8.	A ship propelled by a turbine rotor which has a mass of 5 tonne and a speed of 2100 r.p.m. The rotor has a radius of gyration of 0.5 m and rotates in a clockwise direction when	13	BT-3	Apply

	viewed from the stern. Find the gyroscopic effects in the following conditions: 1. The ship sails at a speed of 30 km/h and steers to the left in a curve having 60 m radius. The ship pitches 6 degree above and 6 degree below the horizontal position. The bow is descending with its maximum velocity. The motion due to pitching is simple harmonic and the periodic time is 20 seconds.3. The ship rolls and at a certain instant it has an angular velocity of 0.03 rad/s clockwise when viewed from stern. Determine also the maximum angular acceleration during pitching. Explain how the direction of motion due to gyroscopic effect is determined in each case.			
9.	The turbine rotor of a ship has a mass of 8 tonnes and a radius of gyration0.6 m. It rotates at 1800 r.p.m. clockwise, when looking from the stern. Determine the gyroscopic couple, if the ship travels at 100 km/hr and steer to the left in a curve of 75 m radius.	13	BT-3	Apply
10.	An aero plane makes a complete half circle of 50 metres radius, towards left, when flying at 200 km per hr. The rotary engine and the propeller of the plane has a mass of 400 kg and a radius of gyration of 0.3 m. The engine rotates at 2400 r.p.m. clockwise when viewed from the rear. Find the gyroscopic couple on the aircraft and state its effect on it.	13	BT-3	Apply
11.	(i) Explain the effect of Gyroscopic couple on a Naval ship during the pitching.	7	BT-4	Analyze
	(ii) Explain the effect of Gyroscopic couple on a Aero plane.	6		
12.	The rotor of a turbine installed in a boat with its axis along the longitudinal axis of the boat makes 1500 r.p.m. clockwise when viewed from the stern. The rotor has a mass of 750 kg and a radius of rotation of 300 mm. If at an instant, the boat pitches in the longitudinal vertical plane so that bow rises from the horizontal plane with an angular	13	BT-5	Evaluate

	velocity of 1 rad/s, determine the torque acting in the boat and the direction in which it tends to turn the boat at the instant.			
13.	The turbine rotor of a ship has a mass of 20 tonnes and a radius of gyration 0.75. Its speed is 2000 r.p.m. The ship pitches 6° above and below the horizontal position. One complete oscillation takes 18 seconds and the motion is simple harmonic. Determine (i) the maximum couple tending to shear the holding down bolts of the turbine (ii) The maximum angular acceleration of the ship during pitching (iii) The direction in which the bow will tend to turn while rising, if the rotation of the rotor is clockwise when looking from rear.	13	BT-5	Evaluate
14.	The turbine rotor of a ship has a mass of 2000 kg and rotates at a speed of 3000 r.p.m. clockwise when looking from a stern. The radius of gyration of the rotor is 0.5 m. Determine the gyroscopic couple and its effects upon the ship when the ship is steering to the right in a curve of 100 m radius at a speed of 16.1 knots (1 knot = 1855 m/hr). Calculate also the torque and its effects when the ship is pitching in simple harmonic motion, the bow falling with its maximum velocity. The period of pitching is 50 seconds and the total angular displacement between the two extreme positions of pitching is 12°. Find the maximum acceleration during pitching motion.	13	BT-5	Evaluate
15.	In a spring controlled governor mass of each governor ball is 6.80 kg and moves radially under the action of a controlling force F= a+br, where 'r' is the ball path radius. If the speed range is 42.5 to 44.0 radian per sec. and the corresponding values of r are 12.38 cm and 13.01 cm, obtain the values of 'a' and 'b'. Find the equilibrium speed in rad/sec for r = 12.7 cm.	13	BT-3	Apply
16.	The arms of a Porter governor are 25 cm long and pivoted	13	BT-5	Evaluate

	on the governor axis, Mass of each ball is 5 kg and mass of central sleeve is 30 kg. The radius of rotation of balls is 15 cm when the sleeve begins to rise and reaches a value of 20 cm for maximum speed. Determine the speed range of governor.			
17.	The propeller of aero weighs 500 N and has radius of gyration of 0.8 m. The propeller shaft rotates at 2000 rpm., clockwise, as viewed from tail end. The plane turns left, making a U turn,i.e., through 180^0, of 120 m radius, at a speed of 360 kmph, determine the gyroscopic couple and its effect on the aircraft. Also find the extra pressure on bearings if the distance between two bearings of the propeller is 0.75 m.	13	BT-5	Evaluate
18.	A disc with radius of gyration 60 mm and a mass of 4.0 kg is mounted centrally on a horizontal axle of 80 mm length between the bearings. It spins about the axle at 800 r.p.m. anticlockwise when viewed from the right hand side bearing. The axle processes about a vertical axis at 50 r.p.m. in the anticlockwise direction when viewed from above. Determine the resultant reaction at each bearing due to the mass and the gyroscopic effect.	13	BT-3	Apply

PART-C (15 Marks)				
S.No	**Questions**	**Marks**	**Level**	**Competence**
1.	(i) Explain the function of a proell governor with the help of a neat sketch. Derive the relationship among the various forces acting on the link.	8	BT-3	Apply
	(ii) What are centrifugal governors? How do they differ from inertia governors?	7	BT-3	Apply
2.	In a Hartnell governor the lengths of ball and sleeve arms of a bell crank lever are 120 mm and 100 mm respectively. the fulcrum of the bell crank lever is located at 140 mm from the governor axis each governor ball is 4 kg.the governor runs at 5 rps with ball arms vertical and sleeve arms horizontal the	15	BT-5	Evaluate

	sleeve movement is found to be 10 mm (upwards) for an increase of speed of 4%.find (i) maximum speed if the total sleeve movement is limited to 20 mm (ii) the spring stiffness (iii) sensitiveness of governor (iv) required spring stiffness for isochronous at 300 rpm.			
3.	A ship is propelled by a turbine rotor which has a mass of 5 tonnes and a speed of 2100 rpm. The rotor has a radius of gyration of 0.5 m and rotates in a clockwise direction when viewed from the stern. Find the gyroscopic effect in the following conditions: (i) the ship sails at a speed of 30 km/hr and steers to the left in curve having 60 m radius; (ii) the ship pitches 6° above and 6° below the horizontal position. The bow is descending with its maximum velocity. the motion due to pitching is simple harmonic and a periodic time is 20 seconds.(iii) the ship rolls and at a certain instant it has an angular velocity of 0.03 rad/sec clockwise when viewed from stern.	15	BT-4	Analyze
4.	The mass of the turbine rotor of a ship is 20 tonnes and has a radius of gyration of 0.60 m. Its speed is 2000 r.p.m. The ship pitches 6° above and 6° below the horizontal position. A complete oscillation takes 30 seconds and the motion is simple harmonic. Determine the following: 1. Maximum gyroscopic couple, 2. Maximum angular acceleration of the ship during pitching, and 3. The direction in which the bow will tend to turn when rising, if the rotation of the rotor is clockwise when looking from the left.	15	BT-6	Create
5.	A Rear Engine automobiles is travelling along a track of 100 m mean radius. Each of 4 road wheels have I= moment of inertia = 2 kg m^2 and effective dia = 60 cm. The rotating parts of engine have I = moment of inertia = 1 kg m^2. The engine axis is parallel to rear axle and crank shaft rotates in the same sense as the road wheels. The gear ratio between engine to back axle is 3 : 1. The vehicle weighs 1500 kg and has C.G. 50 cm	15	BT-6	Create

	above road level. The width of track of vehicle is 1.5 m. Determine the limiting speed of vehicle around the curve for all four wheels to maintain contact with the road surface if this is not cambered.			