SIDDHARTH INSTITUTE OF ENGINEERING & TECHNOLOGY:: PUTTUR (AUTONOMOUS)
Siddharth Nagar, Narayanavanam Road – 517583

QUESTION BANK (DESCRIPTIVE)

Subject with Code: Theory of Machines (20ME0310) **Course & Branch**: AGE

Year & Sem: II-B.Tech & II-Sem **Regulation:** R20

UNIT –I

PRECESSION & TURNING MOMENT DIAGRAM

1	**a.**	An fighter plane makes a 180 degree turn of 75 m radius towards right, when flying at 280 km/hr. The engine and the propeller of the plane has a mass of 600 kg and a radius of gyration of 0.3 m. The engine rotates at 2800 rpm anticlockwise when viewed from the rear. Find the magnitude of gyroscopic couple and its effect on the aircraft.	[L3][CO1]	**[10M]**
	b.	Define reactive gyroscopic couple.	[L1][CO1]	**[2M]**
2	**a.**	Explain the effect of Gyroscopic couple on a Naval ship during pitching.	[L2][CO1]	**[04M]**
	b.	The turbine rotor of a ship has a mass of 8 tonnes and a radius of gyration 0.6 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.	[L3][CO1]	**[08M]**
3	**a.**	Explain the effect of gyroscopic couple on a Aeroplane.	[L2][CO1]	**[04M]**
	b.	An aircraft makes a half circle of 50 m radius towards left, when flying at 200 km/hr. The 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 rpm clockwise when viewed from the rear. Find the gyroscopic couple and its effect on the aircraft.	[L3][CO1]	**[08M]**
4	**a.**	A ship propelled by a turbine rotor which has a mass of 5 tonnes 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 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. 2. 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. Determine also the maximum angular acceleration during pitching. Explain how the direction of motion due to gyroscopic effect is determined in each case.	[L3][CO1]	**[8M]**
	b.	Define the Gyroscopic torque	[L1][CO1]	**[4M]**
5		The turbine rotor of a ship has a mass of 3500 kg. It has a radius of gyration of 0.45 m and a speed of 3000 r.p.m. clockwise when looking from stern. Determine the gyroscopic couple and its effect upon the ship: 1. When the ship is steering to the left on a curve of 100 m radius at a speed of 36 km/h. 2. When the ship is pitching in a simple harmonic motion, the bow falling with its maximum velocity. The period of pitching is 40 seconds and the total angular displacement between the two extreme positions of pitching is 12 degrees.	[L2][CO1]	**[12M]**
6	**a.**	A four-wheeled trolley car of mass 2500 kg runs on rails, which are 1.5 m apart and travels around a curve of 30 m radius at 24 km / hr. The rails are at	[L3][CO1]	**[8M]**

		the same level. Each wheel of the trolley is 0.75 m in diameter and each of the two axles is driven by a motor running in a direction opposite to that of the wheels at a speed of five times the speed of rotation of the wheels. The moment of inertia of each axle with gear and wheels is 18 kg-m2. Each motor with shaft and gear pinion has a moment of inertia of 12 kg-m2. The centre of gravity of the car is 0.9 m above the rail level. Determine the vertical force exerted by each wheel on the rails taking into consideration the centrifugal and gyroscopic effects. State the centrifugal and gyroscopic effects on the trolley.		
	b.	Define Co efficient of fluctuation of energy also deduce the formula to calculate it.	[L1][CO1]	[4M]
7		The turning moment diagram for a petrol engine is drawn to the following scales : Turning moment, 1 mm = 5 N-m ; crank angle, 1 mm = 1°. The turning moment diagram repeats itself at every half revolution of the engine and the areas above and below the mean turning moment line taken in order are 295, 685, 40, 340, 960, 270 mm2. The rotating parts are equivalent to a mass of 36 kg at a radius of gyration of 150 mm. Determine the coefficient of fluctuation of speed when the engine runs at 1800 r.p.m.	[L3][CO1]	**[12M]**
8		The turning moment diagram for a multi cylinder engine has been drawn to a scale 1 mm = 600 N-m vertically and 1 mm = 3° horizontally. The intercepted areas between the output torque curve and the mean resistance line, taken in order from one end, are as follows: + 52, – 124, + 92, – 140, + 85, – 72 and + 107 mm2, when the engine is running at a speed of 600 r.p.m. If the total fluctuation of speed is not to exceed ± 1.5% of the mean, find the necessary mass of the flywheel of radius 0.5 m.	[L3][CO1]	**[12M]**
9		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.	[L3][CO1]	**[12M]**
10	**a.**	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 m2; Compression stroke = 1.7 × 10–3 m2; Expansion stroke = 6.8 × 10–3 m2; Exhaust stroke = 0.65 × 10–3 m2. Each m2 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.	[L3][CO1]	**[8M]**
	b.	Draw a turning moment for single cylinder double acting steam engine.	[L3][CO1]	**[4M]**

UNIT –II
CLUTCHES, BRAKES AND DYNAMOMETERS

1		Explain the working of a single-plate clutch with neat sketch	[L1][CO2]	**[12M]**
2		A single plate clutch, effective on both sides, is required to transmit 25 kW at 3000 r.p.m. Determine the outer and inner radii of a frictional surface if the coefficient of friction is 0.255, the ratio of radii is 1.25 and the maximum pressure is not to exceed 0.1 N/mm^2. Also determine the axial thrust to be provided by springs. Assume the theory of uniform wear.	[L3][CO2]	**[12M]**
3	**a.**	A multi-disc clutch has three discs on the driving shaft and two on the driven shaft. The outside diameter of the contact surfaces is 240 mm and inside diameter 120 mm. Assuming uniform wear and coefficient of friction as 0.3, find the maximum axial intensity of pressure between the discs for transmitting 25 kW at 1575 r.p.m.	[L3][CO2]	**[8M]**
	b.	Distinguish between a brake and a dynamometer.	[L4][CO2]	**[4M]**

4		An engine developing 45 kW at 1000 r.p.m. is fitted with a cone clutch built inside the flywheel. The cone has a face angle of 12.5° and a maximum mean diameter of 500 mm. The coefficient of friction is 0.2. The normal pressure on the clutch face is not to exceed 0.1 N/mm^2. Determine 1.the axial spring force necessary to engage to clutch, and 2.the face width required.	[L3][CO2]	**[12M]**
5	**a.**	A conical friction clutch is used to transmit 90 kW at 1500 r.p.m. The semi cone angle is 20º and the coefficient of friction is 0.2. If the mean diameter of the bearing surface is 375 mm and the intensity of normal pressure is not to exceed 0.25 N/mm2, find the dimensions of the conical bearing surface and the axial load required.	[L3][CO2]	**[8M]**
	b.	List various types of brakes.	[L1][CO2]	**[4M]**
6		A centrifugal clutch is to transmit 15 kW at 900 r.p.m. The shoes are four in number. The speed at which the engagement begins is 3/4th of the running speed. The inside radius of the pulley rim is 150 mm and the center of gravity of the shoe lies at 120 mm from the center of the spider. The shoes are lined with Ferrodo for which the coefficient of friction may be taken as 0.25. Determine 1. Mass of the shoes, and 2**.** Size of the shoes, if angle subtended by the shoes at the center of the spider is 60º and the pressure exerted on the shoes is 0.1 N/mm^2.	[L3][CO2]	**[12M]**
7	**a.**	A band brake acts on the 3/4th of circumference of a drum of 450 mm diameter which is keyed to the shaft. The band brake provides a braking torque of 225 N-m. One end of the band is attached to a fulcrum pin of the lever and the other end to a pin 100 mm from the fulcrum. If the operating force is applied at 500 mm from the fulcrum and the coefficient of friction is 0.25, find the operating force when the drum rotates in the (a) anticlockwise direction, and (b) clockwise direction.	[L3][CO2]	**[10M]**
	b.	Distinguish between absorption and transmission dynamometers.	[L4][CO2]	**[02M]**
8	**a.**	A band and block brake, having 14 blocks each of which subtends an angle of 15° at the centre, is applied to a drum of 1 m effective diameter. The drum and flywheel mounted on the same shaft has a mass of 2000 kg and a combined radius of gyration of 500 mm. The two ends of the band are attached to pins on opposite sides of the brake lever at distances of 30 mm and 120 mm from the fulcrum. If a force of 200 N is applied at a distance of 750 mm from the fulcrum, find: 1.maximum braking torque, 2.angular retardation of the drum, and 3.time taken by the system to come to rest from the rated speed of 360 r.p.m. The coefficient of friction between blocks & drum may be taken as 0.25.	[L3][CO2]	**[8M]**
	b.	Define centrifugal clutch	[L1][CO2]	**[4M]**
9	**a.**	Describe the construction and operation of a rope brake absorption dynamometer with neat sketch.	[L1][CO2]	**[8M]**
	b.	Write the principle of Dynamometer and types of Dynamometers	[L1][CO2]	**[4M]**
10	**a.**	Describe with sketches one form of torsion dynamometer and explain in detail the calculations involved in finding the power transmitted.	[L1][CO2]	**[6M]**
	b.	A torsion dynamometer is fitted to a propeller shaft of a marine engine. It is found that the shaft twists 2° in a length of 20 metres at 120 r.p.m. If the shaft is hollow with 400 mm external diameter and 300 mm internal diameter, find the power of the engine. Take modulus of rigidity for the shaft material as 80 GPa.	[L3][CO2]	**[6M]**

UNIT –III
GOVERNORS

1	**a.**	How the governors are classified?	[L1][CO3]	**[6M]**
	b.	Explain with neat sketch the working principle of centrifugal governor	[L3][CO3]	**[6M]**
2	**a.**	Calculate the vertical height of a Watt governor when it rotates at 60 r.p.m. Also find the change in vertical height when its speed increases to 61 r.p.m.	[L1][CO3]	**[10M]**
	b.	What is meant by Sensitiveness of governors?	[L1][CO3]	**[02M]**

3	**a.**	Derive the expression for Porter governor	[L3][CO3]	**[06M]**
	b.	Derive the expression for Proell governor	[L3][CO3]	**[06M]**
4	**a.**	A Porter governor has equal arms each 250 mm long and pivoted on the axis of rotation. Each ball has a mass of 5 kg and the mass of the central load on the sleeve is 25 kg. The radius of rotation of the ball is 150 mm when the governor begins to lift and 200 mm when the governor is at maximum speed. Find the minimum and maximum speeds and range of speed of the governor.	[L3][CO3]	**[8M]**
	b.	Distinguish between a Governor and a flywheel.	[L4][CO3]	**[4M]**
5	**a.**	The arms of a Porter governor are each 250 mm long and pivoted on the governor axis. The mass of each ball is 5 kg and the mass of the central sleeve is 30 kg. The radius of rotation of the balls is 150 mm when the sleeve begins to rise and reaches a value of 200 mm for maximum speed. Determine the speed range of the governor. If the friction at the sleeve is equivalent of 20 N of load at the sleeve, determine how the speed range is modified.	[L3][CO3]	**[10M]**
	b.	**b.** What is meant by isochronous condition in Governors?	[L1][CO3]	**[2M]**
6		In an engine governor of the Porter type, the upper and lower arms are 200 mm and 250 mm respectively and pivoted on the axis of rotation. The mass of the central load is 15 kg, the mass of each ball is 2 kg and friction of the sleeve together with the resistance of the operating gear is equal to a load of 25 N at the sleeve. If the limiting inclinations of the upper arms to the vertical are 30° and 40°, find, taking friction into account, range of speed of the governor.	[L3][CO3]	**[12M]**
7		A Porter governor has all four arms 250 mm long. The upper arms are attached on the axis of rotation and the lower arms are attached to the sleeve at a distance of 30 mm from the axis. The mass of each ball is 5 kg and the sleeve has a mass of 50 kg. The extreme radii of rotation are 150 mm and 200 mm. Determine the range of speed of the governor.	[L3][CO3]	**[12M]**
8		A Proell governor has equal arms of length 300 mm. The upper and lower ends of the arms are pivoted on the axis of the governor. The extension arms of the lower links are each 80 mm long and parallel to the axis when the radii of rotation of the balls are 150 mm and 200 mm. The mass of each ball is 10 kg and the mass of the central load is 100 kg. Determine the range of speed of the governor.	[L3][CO3]	**[12M]**
9	**a.**	A governor of the Proell type has each arm 250 mm long. The pivots of the upper and lower arms are 25 mm from the axis. The central load acting on the sleeve has a mass of 25 kg and the each rotating ball has a mass of 3.2 kg. When the governor sleeve is in mid-position, the extension link of the lower arm is vertical and the radius of the path of rotation of the masses is 175 mm. The vertical height of the governor is 200 mm. If the governor speed is 160 r.p.m. when in mid-position, find : 1. length of the extension link; and 2. tension in the upper arm.	[L3][CO3]	**[10M]**
	b.	Define effort and power of governor.	[L1][CO3]	**[2M]**
10		A Hartnell governor having a central sleeve spring and two right-angled bell crank levers moves between 290 r.p.m. and 310 r.p.m. 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 mass of each ball is 2.5 kg. The ball arms are parallel to the governor axis at the lowest equilibrium speed. Determine : 1. loads on the spring at the lowest and the highest equilibrium speeds, and 2. stiffness of the spring.	[L3][CO3]	**[12M]**

UNIT –IV

BALANCING OF ROTATING AND RECIPROCATING MASSES

1	**a.**	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 angles between successive masses are 45°, 75° and 135°. Find the position and magnitude of the balance mass required, if its	[L3][CO4]	**[10M]**

<table>
<tr><td></td><td></td><td>radius of rotation is 0.2 m.</td><td></td><td></td></tr>
<tr><td></td><td>b.</td><td>Define Swaying couple?</td><td>[L1][CO4]</td><td>[2M]</td></tr>
<tr><td>2</td><td></td><td>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 and angular positions.</td><td>[L3][CO4]</td><td>[12M]</td></tr>
<tr><td>3</td><td>a.</td><td>A shaft carries three masses A, B, and C of magnitude 150 kg, 200 kg, and 275 kg respectively and revolving at radii 70 mm, 60 mm and 80 mm in planes measured from A at 400 mm, and 800 mm. The angles between the cranks measured anticlockwise are A to B 125°, and B to C 250° The balancing masses are to be placed in planes X. The distance between the planes A and X is 500 mm. If the balancing masses revolve at a radius of 100 mm, find their magnitudes and angular positions.</td><td>[L3][CO4]</td><td>[12M]</td></tr>
<tr><td></td><td>b.</td><td>Define i) attractive force ii) hammer blow.</td><td>[L1][CO4]</td><td>[2M]</td></tr>
<tr><td>4</td><td></td><td>Four masses A, B, C and D as shown below are to be completely balanced
<table>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Mass (kg)
Radius (mm)</td><td>—
180</td><td>30
240</td><td>50
120</td><td>40
150</td></tr>
</table>
The planes containing masses B and C are 300 mm apart. The angle between planes containing B and C is 90°. B and C make angles of 210° and 120° respectively with D in the samesense. Find
1. The magnitude and the angular position of mass A ; and
2. The position of planes A and D.</td><td>[L3][CO4]</td><td>[12M]</td></tr>
<tr><td>5</td><td>a.</td><td>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 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</td><td>[L3][CO4]</td><td>[10M]</td></tr>
<tr><td></td><td>b.</td><td>What is primary unbalanced force and secondary unbalanced force ?</td><td>[L1][CO4]</td><td>[2M]</td></tr>
<tr><td>6</td><td></td><td>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 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.</td><td>[L3][CO4]</td><td>[12M]</td></tr>
<tr><td>7</td><td>a.</td><td>Differentiate ‘static balancing’ and ‘dynamic balancing’. State the necessary conditions to achieve them.</td><td>[L4][CO4]</td><td>[10M]</td></tr>
<tr><td></td><td>b.</td><td>What is balancing of rotating masses?</td><td>[L1][CO4]</td><td>[2M]</td></tr>
<tr><td>8</td><td></td><td>A single cylinder reciprocating engine has speed 240 r.p.m., stroke 300 mm, mass of reciprocating parts 50 kg, mass of revolving parts at 150 mm radius 37 kg. If two third of the reciprocating parts and all the revolving parts are to be balanced, find : 1. The balance mass required at a radius of 400 mm, and 2. The residual unbalanced force when the crank has rotated 60° from top dead centre.</td><td>[L3][CO4]</td><td>[12M]</td></tr>
<tr><td>9</td><td>a.</td><td>Derive the following expression of effects of partial balancing in two cylinder locomotive engine (i) Variation of attractive force (ii) Swaying couple (iii) Hammer blow</td><td>[L3][CO4]</td><td>[10M]</td></tr>
<tr><td></td><td>b.</td><td>Why rotating masses are to be dynamically balanced?</td><td>[L1][CO4]</td><td>[2M]</td></tr>
</table>

10		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/hr. ; 2. the variation in tractive effort ; and 3. the maximum swaying couple.	[L3][CO4]	**[12M]**

UNIT –V
MECHANICAL VIBRATIONS

1		Derive an expression for the natural frequency of the free longitudinal vibration by (i)Equilibrium method (ii) Energy method (iii) Rayleigh's method	[L3][CO5]	**[12M]**
2	**a.**	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/m2 Determine the frequency of longitudinal and transverse vibrations of the shaft.	[L3][CO5]	**[10M]**
	b.	Define Whirling speed (or) critical speed.	[L1][CO5]	**[2M]**
3		A shaft of length 0.75 m, supported freely at the ends, is carrying a body of mass 90 kg at 0.25 m from one end. Find the natural frequency of transverse vibration. Assume E = 200 GN/m2 and shaft diameter = 50 mm.	[L3][CO5]	**[12M]**
4	**a.**	Derive the natural frequency of Free Transverse Vibrations by (i) Rayleighs method (ii) Dunkerleys method.	[L3][CO5]	**[10M]**
	b.	Define logarithmic decrement.	[L1][CO5]	**[2M]**
5		A shaft 50 mm diameter and 3 metres long is simply supported at the ends and carries three loads of 1000 N, 1500 N and 750 N at 1 m, 2 m and 2.5 m from the left support. The Young's modulus for shaft material is 200 GN/m2 Find the frequency of transverse vibration.	[L3][CO5]	**[12M]**
6	**a.**	A vibrating system consists of a mass of 200 kg, a spring of stiffness 80 N/mm and a damper with damping coefficient of 800 N/m/s. Determine the frequency of vibration of the system.	[L3][CO5]	**[10M]**
	b.	Define Damping factor.	[L1][CO5]	**[2M]**
7		The measurements on a mechanical vibrating system show that it has a mass of 8 kg and that the springs can be combined to give an equivalent spring of stiffness 5.4 N/mm. If the vibrating system have a dashpot attached which exerts a force of 40 N when the mass has a velocity of 1 m/s, find : 1. critical damping coefficient, 2. damping factor, 3. Logarithmic decrement, and 4. ratio of two consecutive amplitudes.	[L3][CO5]	**[12M]**
8		Calculate the whirling speed of a shaft 20 mm diameterand 0.6 m long carrying a mass of 1 kg at its mid-point. The density of the shaft material is 40 Mg/m3, and Young's modulus is 200 GN/m2. Assume the shaft to be freely supported.	[L3][CO5]	**[12M]**
9	**a.**	Derive the Natural Frequency of Free Torsional Vibrations	[L3][CO5]	**[10M]**
	b.	Define resonance.	[L1][CO5]	**[2M]**
10		A shaft of 100 mm diameter and 1 metre long has one of its end fixed and the other end carries a disc of mass 500 kg at a radius of gyration of 450 mm. The modulus of rigidity for the shaft material is 80 GN/m2.Determine the frequency of torsional vibrations.	[L3][CO5]	**[12M]**

PREPARED BY: Mr. V. KARTHIKEYAN Assoc.Professor/ME