Code No: R31033 **R10** **Set No: 1**

III B.Tech. I Semester Supplementary Examinations, June/July - 2014

DYNAMICS OF MACHINERY

(Common to Mechanical Engineering and Automobile Engineering)

Time: 3 Hours **Max Marks: 75**

Answer any FIVE Questions

All Questions carry equal marks

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1. The turbine rotor of a ship has a mass of 20 tones and a radius of gyration of 0.75m. Its speed is 2000 rpm. The ship pitches 6^0 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 and,
   (iii).The direction in which the bow will tend to turn while rising, if the rotation of the rotor is clockwise when looking from ear. [15]

2. (a). Explain the difference between the coefficient of friction and angle of friction
   (b). A conical pivot bearing supports a vertical shaft of 200mm diameter. It is subjected to load of 30kN. The angle of cone is 120^0 and the coefficient of friction is 0.025. Find the power lost in friction when the speed is 140 rpm. Assuming (i). Uniform wear (ii).Uniform pressure. [5+10]

3. A friction clutch is required to transmit 34.5kW at 2000 rpm. It is to be single plate disk type with both sides of the plate effective; the pressure is being applied axially by means of springs and limited to 70 kPa on the plate. If the outer diameter of the friction limit is 1.5 times the internal diameter, find the required dimensions d_1 and d_2 of the clutch ring and the total force exerted by the springs. Assume uniform wear condition (coefficient of friction=0.3). [15]

4. The torque delivered by two stroke engine represented by T=1000+300 sin2Θ-500cosΘ N-m where Θ is the angle made by the crank from IDC. The engine speed is 250 rpm. The mass of flywheel is 400 kg and radius of gyration is 400 mm. determine
   (i) Total percentage of fluctuation of speed.
   (ii) The angular acceleration of flywheel when the crank has rotated through an angle of 60° from IDC.
   (iii) The maximum angular retardation of flywheel. [15]

5. A porter governor carries a central load of 30 kgf and each ball weighs 4.5 kgf. The upper links are 20 cm long and the lower links are 30 cm long. The points of suspensions of upper and lower links are 5 cm from axis of spindle. Calculate,
   (i). The speed of the governor in rpm if the radius of revolution of the governor balls is 12.5 cm and
   (ii) The effort of the governor for increase of speed of 1%. [15]

6. Two weights of 8kg and 14kg rotate in the same plane at radii of 1.5 and 2.25m respectively. The radii of these weights are 60° apart. Find the position of the third weight of the magnitude of 12kg in the same plane which can produce static balance of the system. [15]

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7. In a four cylinder petrol engine equally spaced, the cranks numbered from the front end are 1, 2, 3 and 4. The cranks 1 and 4 are in phase and 1800 ahead of cranks 2 and 3.The reciprocating mass of each cylinder is 1kg. The cranks are 50 mm radius and the connecting rod is 200mm long. What are the resultant unbalanced forces and couples, primary and secondary, when viewed from the front? Take the reference plane midway between cylinders 2 and 3. [15]

8. (a) What is meant by equivalent spring stiffness? How is it determined?
(b) The flywheel of an engine driving a dynamo has a mass of 180 kg and a radius of gyration of 30 mm. The shaft at the flywheel end has an effective length of 250 mm and is 50 mm diameter. The armature mass is 120 kg and its radius of gyration is 22.5 mm. The dynamo shaft is 43 mm diameter and 200 mm effective length. Calculate the position of the node and the frequency of torsional oscillation. G = 83 kN/mm^2. [5+10]

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1. (a). Explain the gyroscopic effect on four wheels.
(b). Locomotive moving at a speed of 100 km/hr. turns round a curve of 500m radius to the right. The pair of driving wheels is 2 m in diameter and along with the axle weigh 20 kN. The radius of gyration of wheels together with the axle may be taken as 0.6 m. Find the gyro effect on pair driving wheels. [5+10]

2. (a). Derive the expression for the force required to move the body up through the inclined plane.
(b). A conical pivot bearing supports a vertical shaft of 200mm diameter. It is subjected to a load of 30kN. The angle of the cone is 120^0 and the coefficient of friction is 0.025. Find the power lost in friction when the speed is 120 rpm, assuming uniform pressure and uniform wear conditions. [7+8]

3. An effective diameter of the cone clutch is 75mm, the semi-angle of the cone is 18°. Find the torque required to produce slipping of the clutch if an axial force applied is 200 N. This clutch is employed to connect an electric motor running uniformly at 100 r.p.m with a flywheel which is initially stationary. The flywheel has a mass of 13.5 kg and its radius of gyration to 150mm.Calculate the time required for the flywheel to attain full speed, and also the energy lost in the slipping of the clutch. Take coefficient of friction as 0.3 [15]

4. A certain machine requires a torque of (1500+200 sinΘ) N-m to drive it where Θ is the angle of rotation of shaft. The machine is directly connected to an engine which produces a torque (1500+250 sin Θ) N-m. The flywheel and other rotating parts have a mass 300 kg at radius of gyration 200mm. Mean speed is 200 r.p.m. Find,
(i). Kinetic energy of flywheel **(ii).** Percentage coefficient of fluctuation of speed
(iii). Crank angle at maximum turning moment. [15]

5. In a porter governor, each of the four arms is 400mm long. The upper arms pivoted on the axis of the sleeve, whereas the lower arms are attached to the sleeve at a distance of 45 mm from the axis of rotation. Each ball has a mass of 8kg and the load on the sleeve is 60 kg. What will be the equilibrium speeds for the two extreme radii of 250 mm and 300 mm of rotation of the governor balls? [15]

6. Four masses m_1, m_2, m_3 and m_4 having 100, 175, 200 and 25kg are fixed to cranks of 20cm radius and revolve in places 1, 2, 3 and 4. The angular position of the cranks in planes 2,3 and 4 with respect to the crank in plane 1 are75°,135° and 200° taken in the same sense. The distance of planes 2, 3 and 4 from plane 1 are 60 cm, 186 cm and 240 cm respectively. Determine the position and magnitude of the balance mass at a radius of 60cm in plane L and M located at the middle of the plane 1 and 2 and the middle of the planes 3 and 4 respectively. [15]

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7. The reciprocating masses of the three cylinder engine are 4.1, 6.2 and 7.4 tons respectively. The centre lines of the three cylinders are 5.2m, 3.2m and 1.2 m from the fourth cylinder. If the cranks for all the cylinders are equal, determine the reciprocating mass of the fourth cylinder and the angular position of the cranks such that the system is completely balanced for the primary force and couple .If the cranks are 0.8 m long, the connecting rods 3.8 m and the speed of engine 75 rpm, find the maximum unbalanced secondary force and the crank angle at which it occurs. [15]

8. (a) What is meant by equivalent spring stiffness? How is it determined?
(b) The flywheel of an engine driving a dynamo has a mass of 180 kg and a radius of gyration of 30 mm. The shaft at the flywheel end has an effective length of 250 mm and is 50 mm diameter. The armature mass is 120 kg and its radius of gyration is 22.5 mm. The dynamo shaft is 43 mm diameter and 200 mm effective length. Calculate the position of the node and the frequency of torsional oscillation. G = 83 kN/mm^2. [5+10]

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1. A rear engine automobile is travelling along a track of 100m mean radius. Each of the four road wheels have a moment of inertia 2 kg-m² and effective diameter of 60 cm. Engine rotating parts have a moment of inertia 1 kg-m². The engine axis is parallel to the rear axle and the crank shaft rotates in the same sense as the road wheels. The gear ratio engine to back axle is 3:1. The vehicle weighs 15000 N and has centre of gravity 50 cm above the road level. The width of the track of the vehicle is 1.5m. 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. [15]

2. (a). Derive the expression for the friction torque in conical pivot bearing considering uniform pressure.
(b). A conical pivot bearing supports a vertical shaft of 200mm diameter. It is subjected to a load of 30kN. The angle of the cone is 120^0 and the coefficient of friction is 0.025. Find the power lost in friction when the speed is 120 rpm, assuming uniform pressure and uniform wear conditions. [7+8]

3. (a). Derive the expression for the torque transmitting capacity of a single plate clutch by considering uniform wear
(b). A cone clutch with a cone semi –angle 14°is to transmit 12 kW at 750 rpm. The width of the face is $1/4^{th}$ of the mean diameter and the normal pressure between the contact faces is not to exceed 0.85 bar. Taking coefficient of friction between contact surfaces as 0.2, determine the mean dimensions of the clutch and the axial force. [5+10]

4. (a). Write a short notes on piston effort. [5+10]
(b). The turning moment diagram for a petrol engine is drawn to vertical scale of 1mm to 6N-m and a horizontal scale of 1mm to 1^0. The turning moment repeats itself after every half revolution of the engine. The areas above and below the mean torque line are 305, 710, 50, 350, 980 and 275 mm^2. The rotating parts amount to a mass of 40kg at a radius of gyration of 140mm. Calculate the coefficient of fluctuation of speed of engine is 1500 rpm.

5. In a porter governor, the links and arms are each 30 cm long. Each ball weighs 2.5 kg and the central load is 25 kg. For the lowest and highest of the sleeve the arms are inclined 30° and 40° respectively to the vertical. The friction at the governor and the mechanism connecting it to the value is equivalent to a force of 2.5 kg at the sleeve. Assuming the links and arms intersect on the axis, Find,
   (i) The travel of the sleeve (ii) The minimum ascending speed
   (iii) The maximum descending speed (iv) Range of speed of the governor. [15]

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6. A shaft carries four masses A, B, C and D of 12,20,30 and 16 kg respectively spaced 18cms apart .Measuring angle anti-clockwise from A,B is 240°, C is 135° and D is 270°.The radii are 15 cm , 12 cm, 6cm and 18 cm and the speed of the shaft is 120 rpm. Find the magnitude and direction relative to A of the resultant at a plane midway between A and B. [15]

7. A two cylinder uncoupled locomotive has inside cylinders 0.6 m apart. The radius of each crank is 300mm and are at right angles .The revolving mass per cylinder is 250 kg and the reciprocating mass per cylinder is 300 kg .The whole of the revolving and two – third of the reciprocating masses are to be balanced and the balanced masses are placed in the planes of rotation of the driving wheels, at a radius of 0.8 m. The driving wheels are 2 m in diameter and 1.5 m apart. If speed of the engine is 80 kmph; find hammer blow, maximum variation in tractive effort and maximum swaying couple. [15]

8. (a) Discuss the expression for a natural frequency of free transverse vibrations for a simply supported shaft carrying a uniformly distributed mass of m kg per unit length.
   (b) A mass hanging from a spring is observed to make one complete oscillation in 0.8 sec and the amplitude of the fifth oscillation is half that of first. If the top of the spring be compelled to make vertical oscillation of period 4 sec and amplitude 29 mm, find the amplitude of the motion of the mass. Damping is assumed proportional to the velocity. [5+10]

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1. A four wheel trolley car of total mass 2000 kg running on rails of 1 m guage, rounds a curve of 25 m radius at 40 km/hr. The track is banked at 10^o. The wheels have an external diameter of 0.6 m. and each pair of an axle has a mass of 200kg. The radius of gyration for each pair is 250 mm. the height C.G of the car above the wheel base 0.95 m. allowing for centrifugal force and gyroscopic couple action; determine the pressure in each rail. [15]

2. (a). Explain the difference between the coefficient of friction and angle of friction
(b). A Shaft has a number of collars integral with it. The external diameter of the collars is 400mm and the shaft diameter is 250mm. If the intensity of pressure is $0.35 N/mm^2$ (uniform) and the coefficient of friction is 0.05, estimate,
(i). Power absorbed when the shaft runs at 105 rpm carrying a load of 150kN
(ii). Number of collars required. [7+8]

3. (a). With the help of neat sketch, explain the working of a block or shoe brake
(b). In a single block brake, the drum diameter is 300mm, the angle of contact is 90^0, and the coefficient of friction between the lining and the drum is 0.30. If the operating force is 400N, applied at the end of a lever 400mm long, determine the torque transmitted by the brake. The distance of the fulcrum from the center of the brake drum is 200mm and assumes that the force of friction passes through the fulcrum. [7+8]

4. A high speed has connecting rod length 5 times the crank which is 6cm. It weighs 30 N has a center of gravity 10 cm from the big end bearing .When suspended in bearing it makes 50 complete oscillations in 52 seconds. The reciprocating parts weigh 15N.Determine the torque exerted on the crank shaft due to the inertia of the moving parts when the crank makes an angle of 135 degrees with the top dead center when the speed of rotation is 1200 r.p.m. [15]

5. In a porter governor, the links and arms are each 30 cm long. Each ball weighs 2.5 kg and the central load is 25 kg. For the lowest and highest of the sleeve the arms are inclined 30° and 40° respectively to the vertical. The friction at the governor and the mechanism connecting it to the value is equivalent to a force of 2.5 kg at the sleeve. Assuming the links and arms intersect on the axis, Find,
(i) The travel of the sleeve (ii) The minimum ascending speed
(iii) The maximum descending speed (iv) Range of speed of the governor. [15]

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6. A shaft 3 m span between the bearings carries two masses of 5 kg and 10 kg acting at the extremities of the arms 0.45m and 0.6m long respectively. the planes in which the masses rotate are 1.2 m and 2.4 m respectively from the left hand bearing and the angle between the arms is 60°.If the speed of rotation is 100r.p.m. Find the displacing force on the two bearings of the machine .If the masses are balanced by two additional rotation masses acting at a radius 0.3 and placed 0.3 from each bearing, estimate the magnitude of the two balanced masses and the angles at which they may be set with respect to the two arms. [15]

7. Two locomotives are built with similar sets of reciprocating parts. One is an inside cylinder engine with two cylinders with central lines at 0.5 m apart. The distance between the driving wheel centres is 1.5 m in both the cases. The inside cylinder locomotive runs at 0.75 times the speed of the outside cylinder locomotive and the hammer blow of the inside cylinder locomotive is 1.3 times hammer blow of outside cylinder locomotive. If the diameter of the driving wheel of the outside cylinder locomotive is 2m, calculate the diameter of the driving wheel of the inside cylinder locomotive compare also the variation of the swaying couples of the two engines assuming that the same fraction of the reciprocating masses are balanced in both the cases and that the cylinders are at the same distance from wheels in the outer cylinder locomotive. [15]

8. A cast iron flywheel used for a four stroke I.O engine is developing 180 kW at 240 r.p.m. The hoop stress developed in the flywheel is 5 MPa. The total fluctuation of speed is to be limited to 3% of the mean speed. If the work done during the power stroke is 1/3 times more than the average work done during the whole cycle. Find, (i) The mean diameter of the flywheel (ii) Mass of the flywheel and (iii) Cross-sectional dimensions of the rim when the width is twice the thickness. The density of cast iron may be taken as 7300 kg /m^3. [15]

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