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

III B.Tech. I Semester Regular Examinations, November/December - 2012

DYNAMICS OF MACHINERY

(Common to Mechanical Engineering & Auto Mobile Engineering)

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

Answer any FIVE Questions

All Questions carry equal marks

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1. (a) What do you mean by spin, precession and gyroscopic planes? Explain
   (b) A racing car weighs 20kN. It has a wheel base of 2 m, track width 1 m and height of C.G. 300 mm above the ground level and lies midway between the front and rear axle. The engine flywheel rotates at 3000 r.p.m. Clockwise when viewed from the front. The moment of inertia of the flywheel is 4 kg-m^2 and moment of inertia of each wheel is 3 kg-m^2. Find the reactions between the wheels and the ground when the car takes a curve of 15 m radius towards right at 30km/h, taking into consideration the gyroscopic and the centrifugal effects. Each wheel radius is 400mm.

2. (a) Which of the two assumptions-uniform intensity of pressure or uniform rate of wear, would you make use of in designing bearing and why?
   (b) A shaft carrying a load of 12 tonnes and running at 120 rpm has a number of collars integral with it. Shaft diameter is 240 mm and the external diameter of the collars 360 mm Intensity of uniform pressure is 400 kN/m^2 and the friction and the number of collars required.

3. (a)Though cone clutches provide high frictional torque, yet they have become obsolete. Why?
   (b) A multiplate clutch has three pairs of contact surfaces. The outer and inner radii of the contact surfaces are 100 mm and 50 mm respectively. The maximum axial spring force is limited to 1 kN. If the coefficients of friction is 0.35 and assuming uniform wear, find the power transmitted by the clutch at 1500 r.p.m.

4. (a) Explain the turning moment diagram of a four stroke cycle internal combustion engine.
   (b) A single cylinder, single action four stroke cycle gas engine develops 20 kW at 250 r.p.m. The work done by the gases during the expansion stroke is 3 times the work done on the gases during the compression stroke. The work done on the suction and exhaust strokes may be neglected. If the flywheel has a mass of 1.5 tonnes and has a radius of gyration of 0.6m, find the cyclic fluctuation of energy and the coefficient of fluctuation of speed.

5. (a) What are centrifugal governors? How do they differ from inertia governors?
   (b) 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 extension 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?

6. (a)Explain clearly the terms static balancing and dynamic balancing state the necessary conditions to achieve them.
(b) Four masses (m_1, m_2, m_3, and m_4) 300kg, 450 kg, 360 kg and 390 kg are attached to a shaft. These masses are revolving at radii 135 mm, 105 mm, 150 mm and 180 mm respectively in planes measured from A at 135 mm, 210 mm and 360 mm respectively. The angle measured anti-clockwise are m_1 to m_2 45° , m_2 to m_3 75° , m_3 to m_4 135° and the distance between the planes L and M in which the balance masses are to be placed is 250 mm. The distance between planes A and L is 60 mm and M and D is 50 mm. If the balancing masses revolve at a radius of 36 mm, find their magnitudes and angular positions.

7. The cranks of a three-cylinder locomotive are set at 120°. The reciprocating masses are 450kg for the cylinder and 390 kg for each outside cylinder. The pitch of the cylinders is 1.2 m and the stroke of each piston 500mm. The planes of the rotation of the balance masses are 960 mm from the inside cylinder. If 40% of the reciprocating masses are to be balanced, determine the magnitude and the position of the balancing masses required at a radial distance of 500 mm and the hammer-blow per wheel when the axle rotates at 350 rpm.

8. (a)What are the causes and effects of vibrations?
(b) A vibrating system consists of a mass of 50 kg, a spring of stiffness 30 kN/m and a damper. The damping provided is only 20% of the critical value. Determine: (i). the damping factor (ii) the critical damping coefficient (iii). The natural frequency of damped vibrations (iv)The logarithmic decrement (v).The ratio of two consecutive amplitudes.

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Code No: R31033 **R10** **Set No: 2**

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1. (a) Write a short note on gyroscope.
   (b)An aeroplane runs at 600km/h the rotor of the engine weighs 4000 N with radius of gyration of 1 metre. The speed of rotor is 3000 r.p.m. in anticlockwise direction when seen from rear side of the aeroplane. If the plane takes a loop upwards in a curve of 100 metres radius, find (i) Gyroscopic couple developed and (ii) Effect of reaction gyroscopic couple developed on the body of aeroplane.

2. (a) What is meant by the expression friction circle? Deduce an expression for the radius of friction circle in terms of radius of the journal and angle of friction.
   (b) A conical pivot bearing supports a vertical shaft of 200 mm diameter. It is subjected to a load of 30kN. The angle of the cone is 120° and the coefficient of friction is 0.25. Find the power lost in friction when the speed is 140 r.p.m., assuming (i) Uniform pressure and (ii) Uniform wear.

3. (a) Which of the two assumptions-uniform intensity of pressure or uniform rate of wear, would you consider in designing friction clutch and why?
   (b)An engine developing 45kW 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 (i) the axial spring force necessary to engage to clutch, and (ii) the face width required.

4. (a) Explain the terms 'fluctuation of energy' and 'fluctuation of speed' as applied to flywheels.
   (b)A vertical double action steam engine develops 75 kW at 250 r.p.m. The maximum fluctuation of energy is 30 percent of the work done per stroke. The maximum and minimum speeds are not to vary more than 1 per cent on either side of the mean speed. Find the mass of the flywheel required, if the radius of gyration is 0.6 m.

5. (a) Define and explain the following terms relating to governors: i) Sensitiveness and ii) Isochronism.
   (b) The arms of a porter governor are 300 mm long. The upper arms are pivoted on the axis of rotation and the lower arms are attached to the sleeve at a distance of 35 mm from the axis of rotation. The load on the sleeve is 54 kg and the mass of each ball is 7 kg. Determine the equilibrium speed when the radius of the balls is 225 mm. What will be the range of speed for this position, if the frictional resistance to the motion of the sleeve are equivalent to a force of 30 N.

6. (a) Discuss how a single revolving mass is balanced by two masses revolving in different planes.
(b) Four masses A, B, C, and D revolve at equal radii and are equally spaced along a shaft. The mass of 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 the masses A, C and D and the angular position of A so that the system may be completely balanced.

7. Find the magnitudes of the unbalanced primary and secondary force in V-engines. Deduce the expressions when the lines of stroke of the two cylinders are at 60° and 90° to each other.

8. (a)Deduce an expression for the natural frequency of free transverse vibrations for a simply supported shaft carrying uniformly distributed mass of m kg per unit length.
(b) Explain the terms under damping, critical damping, and over damping

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Code No: R31033 **R10** **Set No: 3**

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1. a) Explain the application of gyroscopic principles to aircrafts.
   b) The mass of the motor cycle along with the rider is 180 kg. The height of the centre of gravity of total mass is 60 cm above the ground when it moves straight. Each wheel has diameter equal to 70 cm and polar mass moment of inertia of each wheel is 2 kg-m^2. The engine rotates at a speed 5 times the road wheel and engine rotating parts have polar mass moment of inertia equal to 0.2 kg-m^2. Determine the angle of heel required, if motor cycle negotiates a curve of radius 100m at a speed of 108 km/hr.

2. a) Deduce an expression for the efficiency of an inclined plane when a body moves up a plane.
   b) Do you recommend the uniform pressure theory or uniform wear theory for the friction torque of a bearing? Explain.

3. a) What is the difference between brake and dynamometer ?
   b) A leather faced conical clutch has a cone angle of 30°. If the intensity of pressure between the contact surfaces is limited to 0.35 N/mm^2 and the breadth of the conical surface is not to exceed one-third of the mean radius, find the dimensions of the contact surface to transmit 22.5 kW at 2000 r.p.m. Assume uniform rate of wear and take coefficient of friction as 0.15.

4. a) What is meant by piston effort and crank effort?
   b) The turning moment diagram for a four stroke gas engine may be assumed for simplicity to be represented by four triangles, the areas of which from the line of zero pressure are as follows: Expansion stoke = 3550 mm^2; exhaust stroke = 500 mm^2; suction stroke = 350 mm^2; and compression stroke = 1400 mm^2. Each mm^2 represent 3 N-m. Assuming the resting moment to be uniform, find the mass of the rim of a flywheel required to keep the mean speed 200 r.p.m within $\pm$ 2%. The mean radius of the rim may be taken as 0.75 m. Also determine the crank positions for the maximum and minimum speeds.

5. a) Define and explain the following terms relating to governors i) Stability and ii) Hunting.
   b) In a porter governor, the mass of the central load is 18 kg and the mass of each ball is 2 kg. The top arms are 250 mm while the bottom arms are each 300 mm long. The friction of the sleeve is 14 N. If the top arms make 45° with the axis of rotation in the equilibrium position, find the range of speed of the governor in that position.

6. a) How the different masses rotating in different planes are balanced?
   b) A shaft carries four masses A, B, C and D of magnitudes 18 kg. 15kg, 27 kg, and 22.5 kg respectively and revolving at radii 20 mm, 25 mm, 30 mm and 15 mm respectively. The masses are rotating in the same plane. The angular position of masses B, C and D are 60°, 135° and 270° from mass A. Find the magnitude and position of the balancing mass at a radius of 50 mm.

7. The cylinder axes of a V-engine are at right angle to each other. The weight of each piston is 2 kg and of each connecting rod 2.8 kg. The weight of the rotating parts like crank web and the crank pin is 1.8 kg. The connecting rod is 400 mm long and its centre of mass is 100 mm from the crank pin centre. The stroke of the piston is 160 mm. Show that the engine can be balanced for the revolving and the primary force by a revolving counter mass. Also, find the magnitude and the position if its centre of mass from the crankshaft centre is 100 mm. What is the value of the resultant secondary force if the speed is 840 rpm?

8. A vertical steel shaft 15 mm diameter is held in long bearings 1 metre 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 0.30 mm. 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.

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Code No: R31033 **R10** **Set No: 4**

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1. a) Describe the gyroscopic effect on sea going vessels.
   b) An air-craft consists of a propeller and engine. The mass moment of inertia of propeller and engine is 100kg-m^2. The engine rotates at 2500 r.p.m in the clockwise direction if viewed from the front of the air-craft. The air-craft completes half circle of radius of 1000 m, while flying at 500 km/hr. Determines the gyroscopic couple on the air-craft and state its effect.

2. a) What is meant by the expression 'friction circle'? Deduce an expression for the radius of friction circle in terms of the radius of the journal and the angle of friction.
   b) An effort of 1500 N is required to just move a certain body up an inclined plane of angle 12°, force acting parallel to the plane. If the angle of inclination is increased to 15°, then the effort required is 1720 N. Find the weight of the body and the coefficient of friction.

3. 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 (i) Maximum braking torque (ii) Angular retardation of the drum and (iii) Time taken by the system to come to rest from the rated speed of 360 r.p.m. The coefficient of friction between blocks and drum may be taken as 0.25.

4. a) Define the terms coefficient of fluctuation of energy and coefficient of fluctuation of speed.
   b) The equation of the turning moment diagram for the three crank engine is give by:
   $$T\ (\text{N-m}) = 25\,000 - 7500 \sin 3\theta$$
   Where θ radians is the crank angle from inner dead centre. The moment of inertia of the flywheel is 400 kg-m^2 and the mean engine speed is 300 r.p.m. Calculate the power and the total percentage fluctuation of speed of the flywheel, if (i) the resisting torque constant, and (ii) the resisting torque is (2500 + 3600 sin θ) N-m.

5. a) What is stability of a governor? Sketch the controlling force versus radius for a stable, unstable and isochronous governor.
   b) A porter governor has two balls each of mass 3 kg and a central load of mass 15 kg. The arms are all 200 mm long, pivoted on the axis. If the maximum and minimum radii of rotation of the balls are 160 mm and 120 mm respectively find the range of speed.

6. a) Why is balancing necessary for rotors of high speed engines?
b) A rotating shaft carries four masses A, B, C and D which are radially attached to it. The mass centre are 30 mm, 38 mm, 40 mm and 45 mm respectively from the axis of rotation the masses A, C and D are 7.5 kg 5 kg and 4 kg respectively. The axial distances between the planes of rotation of A and B is 400 mm and between B and C is 500 mm. The masses A and C are at right angles to each other. Find for a complete balance (i) The angle between the masses B and D from mass A, (ii) The axial distance between the planes of rotation of C and D (iii) The magnitude of mass B.

7. The following data refer to a two cylinder uncoupled locomotive;

Rotating mass per cylinder	= 280 kg
Reciprocating mass per cylinder	= 300 kg
Distance between wheels	= 1400 mm
Distance between cylinder centres	= 600 mm
Diameter of treads of driving wheels	= 1800 mm
Crank radius	= 300 mm
Radius of centre of balance mass	= 620 mm
Locomotive speed	= 900 r.p.m
Dead load on each wheel	= 3.5 tonne

Determine:

(i) The balancing mass required in the planes of driving wheels, if whole of the revolving and two- third of the reciprocating mass are to be balanced.
(ii) The swaying couple
(iii) The variation in the tractive force
(iv) The maximum and minimum pressure on the rails.
(v) The maximum speed of locomotive without lifting the wheels from the rails.

8. a) What is meant by vibrations? How are they caused?
b) A coil of spring stiffness 4 N/mm supports vertically a mass of 20 kg at the free end. The motion is resisted by the oil dashpot. It is found that the amplitude at the beginning of the fourth cycle is 0.8 times the amplitude of the previous vibration. Determine the damping force per unit velocity. Also find the ratio of the frequency of damped and undamped vibrations.

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