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B. E. (Fifth Semester) Examination, April-May 2021

(New Scheme)

(Mechanical Engg. Branch)

DYNAMICS of MACHINES

Time Allowed : Three hours

Maximum Marks : 80

Minimum Pass Marks : 28

Note : *Part (a) is compulsory and any* ***two*** *parts from (b), (c) and (d) from each question. Suitable data if required.*

Unit-I

1. (a) Define sensitivity of Governor. 2

(b) Each arm of porter governor is 300 mm long and is pivoted on the axis of rotation. Each ball has a mass of 6 kg and of the sleeve weights 18 kg. The radius of rotation of the ball is 200 mm when the governor begins to lift and 250 mm when the speed is maximum. Determine the maximum and minimum speeds and the range of the governor. 7

(c) The arms of a Hartnell governor are of equal length, when the sleeve is in mid position, the masses rotate in a circle of diameter 150 mm (the arms are vertical in mid position). Neglecting friction, the equilibrium speed for this position is 360 rpm. Maximum variation of speed, taking friction into account is to be ±6% of the mid position speed for a maximum sleeve movement of 30 mm. The sleeve mass is 5 kg and the friction at the sleeve is 35 N. Assuming that the power of the governor is sufficient to overcome the friction by 1% change in speed on each side of the mid position, find 7

(i) The mass of rotating ball

(ii) Spring stiffness

(iii) Initial compression of spring.

(d) Derive an expression for effort and power of a porter governor. 7

Unit-II

2. (a) What is static and dynamic balancing? 2

(b) The axes of a three cylinder air compressor are at 120° to one another and their connecting rods are coupled to a single crank. The length of each connecting rod is 240 mm and the stroke is 160 mm. The reciprocating parts have a mass of 2·4 kg per cylinder. Determine the primary and secondary forces if the engine runs at 2000 rpm. 7

(c) The cylinder axes of V-engine are at right angle to each other. The weight of each piston is 2 kg and of each connecting rod is 2·8 kg. The weight of the rotating parts like crank webs 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 countermass. 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? 7

(d) Four masses A, B, C and D are completely balanced. Masses C and D make angles of 90° and 195° respectively with B in the counter clockwise direction. The planes containing B and C are 250 mm apart. Masses A, B, C and D can be assumed to be concentrated at radii of 150, 200, 100 and 180 mm respectively. The masses B, C and D are 25 kg, 40 kg and 35 kg respectively.

Determine : 7

(i) The mass A and its angular position with that of B.

(ii) The position of all planes relative to plane of mass A.

Unit-III

3. (a) State Gyroscopic effect with an example. 2

(b) Derive an expression for stability of a four wheeled automobile while turning considering the effect of centrifugal and gyroscopic couple. 7

(c) The rotor of the turbine of a ship has a mass of 2500 kg and rotates at a speed of 3200 rpm counter-clockwise when viewed from stern. The rotor has radius of gyration of 0·4 m. Determine the gyroscopic couple and its effect when :

(i) The ship steers to the left in the curve of 80 m radius at a speed of 15 knots (1 knot = 1860 m/hr).

(ii) The ship pitches 5 degree above and 5 degree below the normal position and the bow is descending with its maximum velocity. The pitching motion is simple harmonic with a periodic time of 40 seconds.

(iii) The ship rolls and at the instant, its angular velocity is 0·4 rad per second clockwise when viewed from stern.

Also find the maximum angular acceleration during pitching. 7

(d) An aeroplane flying at 240 km/hr turns towards left and completes a quarter circle of 60 m radius. The mass of the rotary engine and the propeller of the plane amounts to 450 kg with the radius of gyration of 320 mm. The engine speed is 2000 rpm clockwise when viewed from the rear. Determine the gyroscopic couple on the aircraft and state its effect.

In what way the effect changed when :

(i) The aeroplane turns towards right

(ii) The engine rotates clockwise when viewed from the front (nose end) and the aeroplane turns (a) left (b) right. 7

Unit-IV

4. (a) Define free, free damped and forced damped vibration. 2

(b) A machine mounted on springs and fitted with a dashpot has a mass of 60 kg. There are three springs, each of stiffness 12 N/mm. the amplitude of vibrations reduces from 45 to 8 mm in two complete oscillations. Assuming that the damping factor varies as the velocity, determine :

(i) Damping coefficient.

(ii) Ratio of frequencies of damped and undamped vibrations.

(iii) Periodic time of damped vibrations. 7

(c) What is vibration isolation and transmissibility? Derive an expression for transmissibility for forced vibration system. 7

(d) A machine supported symmetrically on four springs has a mass of 80 kg. the mass of the reciprocrating parts is 2·2 kg which move through a vertical stroke of 100 mm with simple harmonic motion, neglecting damping determine the combined stiffness of the springs so that the force transmitted to foundation is $1/20^{th}$ of the impressed force. The machine crank-shaft rotates at 800 rpm.

If under actual working conditions the damping reduces the amplitudes of successive vibrations by 30%, find :

(i) The force transmitted to the foundation at 800 rpm.

(ii) The force transmitted to foundation at resonance, and

(iii) The amplitude of vibrations at resonance. 7

Unit-V

5. (a) Differentiate between function of flywheel and governor. 2

(b) The crank and the connecting rod of a vertical single cylinder gas engine running at 1800 rpm are 60 and 240 mm respectively. The diameter of the piston is 80 mm and the mass of the reciprocating parts is 1·2 kg. At a point during the power stroke when the piston has moved 20 mm from the top dead centre position, the pressure on the piston is 800 kN/m^2. Determine :

(i) The net force on piston.

(ii) The thrust on connecting rod.

(iii) The thrust on sides of cylinder walls.

(iv) The engine speed at which the above values are zero. 7

(c) A punching machine carries out 6 holes/min. Each hole of 40 mm diameter in 35 mm thick plate requires 8 N.m of energy/mm^2 of the sheared area. The punch has a stroke of 95 mm. Find the power of the motor required if the mean speed of the flywheel is 20 m/s. If total fluctuation of speed is not to exceed 3% of the mean speed, determine the mass of flywheel. 7

(d) A machine is coupled to a two stroke engine which produces a torque $T = 800 + 180\sin 3\theta$ N.m, where θ is the crank angle. The mean engine speed is 400 rpm. The flywheel and the other rotating parts attached to the engine have a mass of 350 kg at a radius of gyration of 220 mm.

Calculate : 7

(i) The power of the engine

(ii) The total fluctuation of speed of the flywheel when

(A) The resisting torque is constant

(B) The resisting torque is $T = 800 + 80\sin\theta$.