Reg. No. : ☐☐☐☐☐☐☐☐☐☐☐☐

## P 1329

B.E./B.Tech. DEGREE EXAMINATION, NOVEMBER/DECEMBER 2007.

Fourth Semester

Mechanical Engineering

ME 236 — DYNAMICS OF MACHINES

(Common to Mechatronics Engineering)

Time : Three hours                                   Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. What are the conditions for static equilibrium?

2. What is crank effort?

3. How do you ensure dynamic balancing of rotating masses?

4. List down the planes of consideration for uncoupled and coupled locomotives.

5. Determine the natural frequency of the mass of 10 kg suspended at the bottom of two springs (of stiffness : 5 N/mm and 8 N/mm) in series.

6. Why is critical speed encountered?

7. What is magnification factor? What are the factors on which it depend?

8. A machine of 343.35 N is supported on three springs, each of stiffness 's'. When it operates at 480 rpm, only 10% of the shaking force may be transmitted to the supporting structure. Find the value of 's' in N/mm.

9. What is meant by isochronous governor? Why is isochronism impractical?

10. What is the effect of gyroscopic couple on rolling of ship? Why?

PART B — (5 × 16 = 80 marks)

11. (a) (i) The slider of a slider crank mechanism is subjected to a force of 3000 N. The crank is at 60° position. The length of the crank and connecting rod are 100 mm and 300 mm respectively. Determine the driving torque on the crank. (8)

(ii) The following data refer to a horizontal reciprocating engine :

    Mass of reciprocating parts        = 120 kg

    Crank length                       = 90 mm

    Engine speed                       = 600 rpm

    Connecting rod : Mass              = 90 kg

    Length between centres             = 450 mm

    CG distance from big end centre    = 180 mm

Determine the net force on the piston and turning moment on crank shaft. (4 + 4)

Or

(b) (i) Deduce the expression for the follower command in a undamped cam mechanism. (6)

(ii) The turning moment diagram of an engine rotating at 200 rpm is expressed as $T(kN.m) = 15 + 8\sin 2\theta - 2\cos 2\theta$ where $\theta$ is the crank angle). The external resistance is found to be constant. A fly wheel weighing 20 kN is fitted on the engine shaft so that the total fluctuation of speed does not exceed 1%. Evaluate the least value of moment of inertia of the flywheel and the radius of gyration. (8 + 2)

12. (a) (i) How will you balance several masses in different planes? Explain with suitable sketches and tables. (8)

(ii) The four masses (namely, 200 kg, 300 kg, 240 kg and 260 kg) are at radii of 200 mm, 150 mm, 250 mm and 300 mm in the same plane. If the first mass is assumed to be in the positive direction of $x$-axis, the second mass is at 45° anticlockwise (ACW) from the first mass, the third mass is at 75° ACW from the second mass and the fourth is at 135° ACW from the third mass. Find the position and magnitude of the balancing mass required if the radius of rotation is limited to 200 mm. (8)

Or

(b)  (i)  What is swaying couple? Deduce its maximum value.                    (2 + 6)

    (ii) A vertical single cylinder opposed piston type engine has reciprocating parts of mass 2,000 kg for the lower piston and 2750 kg. for the upper piston. The lower piston has a stroke of 600 mm and the engine is in primary balance. If the ratio of the length of the connecting rod to crank is 4 for the lower and 8 for the upper piston, what is the maximum secondary unbalanced force for crank shaft speed of 135 rpm?

13. (a) (i) Deduce the expression for the free longitudinal vibration in terms of the spring stiffness, its inertial effect and suspended mass.      (6)

    (ii) A rotor of 10 kg mass is fixed mid-way on a 20 mm diameter horizontal shaft supported at the ends by two bearings. The bearing span is 800 mm. The eccentricity of disc is 0.1 mm. If the system rotates at 50 rps, determine the amplitude of the steady state vibration and the dynamic force and total force transmitted to the bearing. Take E = 200 GPa.                    (6 + 2 + 2)

Or

(b) (i) Determine the torsional frequency of a disc mass 96 kg, which is on the vertical rod of dia 40 mm. The rod is 1.8 m in length and the disc is fixed at 1 m from the top end. Both ends of the rods are fixed. The radius of gyration of disc is 0.4 m. Take G = 85 GPa.      (6)

    (ii) A reciprocating IC engine is coupled to a centrifugal pump through a pair of gears. The shaft from the flywheel of the engine to the gear wheel has a 48 mm diameter and is 800 mm long. the shaft from the pinion to the pump has a 32 mm diameter and is 280 mm long. Pump speed is four times the engine speed. Moment of inertia of flywheel, gear wheel, pinion and pump impeller are 1000 kg.m$^2$, 14 kg.m$^2$, 5 kg.m$^2$ and 18 kg.m$^2$ respectively. Find the natural frequency of the torsional oscillation of the system. Take G = 80 GN/m$^2$.

14. (a) A machine weighs 18 kg and is supported on springs and dashpots. The total stiffness of the springs is 12,000 N/m and damping is 0.2 N/mm/s. The system is initially at rest and a velocity of 120 mm/s is imparted to the mass. Determine

    (i)  the displacement and velocity of mass as a function of time.

    (ii) the displacement and velocity after 0.4 s.

Or

P 1329

(b) A single cylinder engine has an out of balance force of 500 N at an engine speed of 300 rpm. The total mass of the engine is 150 kg. and it is carried on a set of springs of total stiffness 300 N/cm.

(i) Find the amplitude of the 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.

15. (a) In an 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 the ball arms vertical and sleeve arms horizontal. The 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 isochronism at 300 rpm. (10 + 2 + 2 +2)

Or

(b) A four wheeled motor car weighing 2000 kg has height of C.G. of 600 mm above ground level. The engine parts and transmission are equivalent to a flywheel of 80 kg with radius of gyration of 150 mm and their axis coincide with longitudinal axis of the vehicle. The car negotiates a curve (turning right) of 60 m radius at 72 kmph with overall gear ratio 4 :1, The radius of road wheel is 300 mm and its moment of inertia is 3 kg.m². Assuming wheel track as 1.5 m, weight distribution as 50 : 50, determine reaction at each wheel.

———— ————————— ————