BENGAL ENGINEERING AND SCIENCE UNIVERSITY, SHIBPUR
B.E. Part III 6th Semester Final Examination, 2012

Subject : Dynamics of Machines and Vibration Code No. AM 601
Branch: Mechanical Engineering

Time: 3 hrs. **Full Marks: 70**

Answer any SIX Questions taking THREE from Each Half
Assume reasonable data wherever necessary
Two marks reserved for neatness in each half

1st Half

1. a) Explain the method of finding the countermasses in two planes to balance the dynamic unbalance of rotating masses. (3)

b) A rotor has the following properties:

Mass	Magnitude	Radius	Angle	Axial distance from 1st mass
1	9 kg	100 mm	0°	
2	7 kg	120 mm	60°	160 mm
3	8 kg	140 mm	135°	320 mm
4	6 kg	120 mm	270°	560 mm

If the shaft is balanced by two countermasses located at 100 mm radii and revolving in planes midway of planes 1 and 2, and midway of 3 and 4, determine the magnitude of the masses and their respective angular positions. (4)

c) The firing order of a six-cylinder vertical four-stroke in-line engine is 1-4-2-6-3-5. The piston stroke is 80 mm and the length of each connecting rod is 180 mm. The pitch distances between the cylinder centre lines are 80 mm, 80 mm, 120mm, 80 mm and 80 mm respectively. The reciprocating mass per cylinder is 1.2 kg and the engine speed is 2400 rpm. Determine the out of balance primary and secondary forces and couples on the engine taking a plane midway between the cylinder 3 and 4 as the reference plane. (4)

2. a) What do you mean by gyroscopic couple? Derive a relation for its magnitude. (3)

b) A flywheel having a mass of 20 kg and a radius of gyration of 300 mm is given a spin of 500 rotation of the flywheel. Find the rate of precession of the wheel. (4)

c) Each road wheel of a motor cycle is of 600 mm diameter and has a moment of inertia of 1.1kg.m^2. The motorcycle and the rider together weigh 220 kg and the combined centre of mass is 620 mm above the ground level when the motorcycle is upright. The moment of inertia of the rotating parts of the engine is 0.18 kg.m^2. The engine rotates at 4.5 times the speed of road wheels in the same sense. Find the angle of heel necessary when the motorcycle is taking a turn of 35 m radius at a speed of 72 km/h. (4)

3. a) Explain the method of direct and reverse cranks to determine the unbalance forces in radial engines. (3)

b) Find the magnitudes of the unbalanced primary and secondary forces in V engines. Deduce the expressions when the lines of stroke of the two cylinders are at 60° and 90° to each other. (4)

c) The cranks of a three-cylinders locomotive are set at 120°. The reciprocating masses are 450 kg 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 500 mm. The planes of 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. (4)

4. a) Discuss the effect of friction on the functioning of a Porter governor? Deduce its governing equation taking into account the friction at the sleeve. (3)

b) What is the controlling force of a governor? How are the controlling force curves drawn? How do they indicate the stability or instability of a governor? Indicate the shape of such a curve for an isochronous governor. (4)

c) Each arm of a porter governor is 300 mm long and is pivoted on the axis of rotation. Each ball has a mass of 6 kg. and the sleeve weight 18 kg. The radius of rotation of the ball is 200 mm when the

governor begins to left and 250 mm when the speed is maximum. Determine the maximum and the minimum speeds and the range of speed of the governor. (4)

5. a) What are turning-moment diagrams? Why are they drawn? (3)

b) Find a relation for the coefficient of fluctuation of speed in terms of maximum fluctuation of energy and the kinetic energy of the flywheel at mean speed. (4)

c) The cranks of a three-cylinder single-acting engine are set equally at 120°. The engine speed is 540 rpm. The turning-moment diagram for each cylinder is a triangle for the power stroke with a maximum torque of 100 N.m at 60° after dead-centre of the corresponding crank. On the return stroke, the torque is sensibly zero. Determine

(i) the power developed

(ii) the coefficient of fluctuation of speed if the flywheel has a mass of 7.5 kg with a radius of gyration of 65 mm.

(iii) the coefficient of fluctuation of energy

(iv) the maximum angular acceleration of the flywheel. (4)

2nd Half

6. a) Find the Natural frequency of a vibratory system having a mass suspended from the free end of a massless spring. What is the effect of the inertia of the spring mass? (5)

b) A vibrating system consists of a mass of 20 kg, a spring of stiffness 20 kN/m and a damper. The damping provided is only 30% of the critical value. Determine the natural frequency of the damped vibration and the ratio of two consecutive amplitudes. (6)

7. a) A steel bar 22 mm wide and 45 mm deep is freely supported at two points 800 mm apart and carries a load of 180 kg midway between them. Determine the natural frequency of the transverse vibration, neglecting the weight of the bar. Also find the frequency of vibration if an additional load of 180 kg is distributed uniformly along the length of the shaft. Take E = 250 GN/m^2. (5)

b) The following data relate to a machine supported on four springs:
Mass of machine = 120 Kg, stroke = 90 mm, mass of reciprocating parts = 2.5 kg and speed = 750 rpm.
Springs are symmetrically placed with respect to the centre of mass of the machine. Neglecting any damping, find the combined stiffness of the springs so that force transmitted to the foundation is 1/22 of the impressed force.
If under actual working conditions, the damping reduces the amplitude of the successive vibrations by 25% determine the forces transmitted to the foundation at a 750 rpm and at resonance. Also find the amplitude of the vibrations at resonance. (6)

8. a). The following data relate to a shaft held in long bearings:
Length of shaft = 1.2 m, Diameter of shaft = 14 mm, Mass of a rotor at midpoint = 16 kg
Ecentricity of centre of mass of rotor from centre of rotor = 0.4 mm
Modulus of elasticity of shaft material = 200 GN/m^2 , Permissible stress in shaft material = 70 x 10^6 N/m^2
Determine the critical speed of the shaft and the range of speed over which it is unsafe to run the shaft. Assume the shaft to be massless. (5)

b) A spring mass system is excited by a force F sinωt. On measuring, the amplitude of vibration is found to be 12 mm at resonance. However, at a frequency 0.8 times the resonant frequency, the amplitude reduces to 8 mm. Determine the damping ratio of the system. (6)

9. a) A vibrating system has the following constants: $m = 17.5\,\text{kg}$, $k = 70.0\,\text{N/cm}$, and $c = 0.70\,\text{N/cm/s}$. Determine (a) the damping factor, (b) the natural frequency of damped oscillation, (c) the logarithmic decrement, and (d) the ratio of any two consecutive amplitudes. (5)

b) In a spring mass vibrating system, the natural frequency of vibration is reduced to half the value when a second spring is added to the first spring in series. Determine the stiffness of the second spring in terms of that of the first spring. (6)

10. Using Rayleigh's principle, determine the natural frequencies and normal modes of the system shown in Figure. (11)