BENGAL ENGINEERING AND SCIENCE UNIVERSITY, SHIBPUR
B.E. Part III 6th Semester Examination 2013

Subject: Dynamics of Machines and Vibration **Code No. AM 601**

Branch: Mechanical Engineering

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

Assume reasonable data wherever necessary

FIRST HALF
QUESTION NO. 1 COMPULSORY AND ANY TWO FROM THE REST

1.

For a uniform cantilever beam of length L, assume a first mode shape $X_a(x) = 1 - \cos\frac{\pi x}{2L}$.

a) Verify which of the four boundary conditions are satisfied by this assumed mode. (3)

b) Obtain approximately the value of the first natural frequency by using Rayleigh's method. (6)

OR

1.

Determine the natural frequency of small oscillation for the system shown in Figure 1, assuming the strings to be inextensible. The masses and friction of the pulleys are negligible. (9)

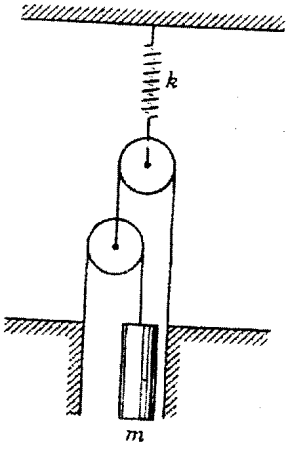

Figure 1

2.

a) Explain the meaning of sensitiveness, hunting and stability of the governor? (2)

b) Define effort and power of the governor. (2)

c) What is the controlling force of the governor? How does the controlling force curve help in establishing the stability or instability of the governor?

(2)

d) A Proell governor has all four arms of length 300 mm. The upper arms are pivoted on the axis of rotation and the lower arms are attached to a sleeve at a distance of 40 mm from the axis. The mass of each ball is 5kg and are attached to the extension of the lower arms, which are 100 mm long. The mass of the sleeve is 50kg. The minimum and maximum radii of governor are 160mm and 210mm. Assuming that the extensions of lower arms are parallel to the governor axis at the minimum radius, find the corresponding equilibrium speeds.

(7)

3.

a) What is the main function of a flywheel?

(2)

b) Write the relation between coefficient of fluctuation of speed, maximum fluctuation of energy and kinetic energy of flywheel.

(3)

c) The turning moment exerted by two stoke engine at crankshaft is given by:

$$T = 10 + \sin 2\theta - 3cos2\theta kNm$$

where, θ= inclination of crank to inner dead centre.

The mass of the flywheel is 600 kg and its radius of gyration 0.8m. The engine speed is 360 rpm. Assuming external resistance as constant, determine (i) power developed, (ii) fluctuation of speed, and (iii) maximum angular retardation of flywheel.

(8)

4.

a) A rear engine automobile is traveling along a track of 100 m mean radius. Each of the four road-wheels has a moment of inertia of 2kg.m^2 and an effective diameter of 60 cm. The rotating parts of the engine have a moment of inertia of 1kg.m^2. The engine axis is parallel to the rear axel and the crank shaft rotates in the same sense as the road wheels. The gear ratio, engine to back axel, is 3 : 1. The vehicle weight 14.71kNand has its 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 the vehicle around the curve for all four wheels to maintain contact with the road surface if this is not cambered.

(6)

b) A shaft is supported in bearing 180 cm apart and projects 45cm beyond bearing at each end. The shaft carries three pulleys one at each end and one at the middle of its length. The end pulleys weight 471N and 196.2N and their centres of gravity are 1.5 cm and 1.25 cm respectively from the shaft axis. The central pulleys weights 549.4N and its centre of gravity is 1.5 cm from the shaft axis. If the pulleys are arranged so as to give static balance, determine (i) relative angular positions of the pulleys and (ii) dynamic force produced on the bearings when the shaft rotates at 300r.p.m.

(7)

5.

a) The six cylinders of a single acting, two stroke cycle diesel engine are pitched 1m apart and the cranks are spaced at 60° intervals. The crank length is 300mm and the ratio

of connecting rod to crank is 4.5. The reciprocating mass per line is 1350 Kg and the rotating mass is 1000 Kg. The speed is 200 rev/min.
Show with regard to primary and secondary balance, that the firing order 1 – 5 – 3 – 6 – 2 – 4 gives unbalance in primary moment only, and the order 1 – 4 – 5 – 2 – 3 – 6 gives secondary moment balance only. Compare the maximum values of these moments, evaluating with respect to the central plane of the engine.

(6)

b) Investigate the out-of-balance force of an eight cylinder V-engine consisting of two banks of cylinders, each having four cylinders in line and both working upon one four-throw crank shaft. The centre lines of the two banks are included at angle $\phi/2$ on each side of the vertical plate. The relative positions of the four cranks are 0°, 180°, 180° and 0° and two connecting rods work on each crank. Find the maximum value of the horizontal and vertical force acting on the engine, in terms of angle ϕ, the angular velocity ω of the crank shaft, the crank radius r, the connecting rod length l, and the reciprocating mass M per cylinder. State the nature and amount of the total force, (i) when $\phi=90^0$ and (ii) when $\phi=60°$

(7)

SECOND HALF
ANSWER QUESTION NO. 6 AND ANY TWO FROM THE REST

6.

For an N degrees-of-freedom system, show that the normal modes are orthogonal with respect to both mass and stiffness matrices. What is physical significance of these orthogonality relations? (8+3)

7.

Figure 2 shows a system consisting of two discs connected in series to a fixed wall through two shafts. The moments of inertia of discs are J and $2J$, the torsional stiffness of the shafts being K as indicated. The outer disc (J) is given a rotation ψ while holding the other disc fixed. Then the system is released from rest. Determine
(i) the natural frequencies and the normal modes
(ii) the subsequent motion of the discs with the prescribed initial disturbance. (6+6)

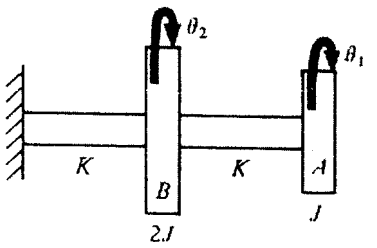

Figure 2

8.

A section of a pipeline carrying a fluid from a compressor is found to resonate when the compressor speed is 1500 rpm. A trial absorber of mass 0.1 kg, tuned to 1500 cycles per

minute, resulted in two natural frequencies, namely, 1400 cycles/min and 1607 cycles/min. Determine the absorber mass and stiffness, tuned to the same frequency as the trial absorber, if the natural frequencies have to lie outside the range 1350 – 1650 cycles/min. Derive any formula that you may use.

(6+6)

9.

a) Derive the equation of motion for the axial vibration of a uniform, elastic bar. Explain all the symbols that you use.

(4)

(b) One end of an elastic, uniform bar is fixed while the other end is resting against a spring of stiffness *K*. Determine the frequency equation for axial vibration of this bar.

(8)