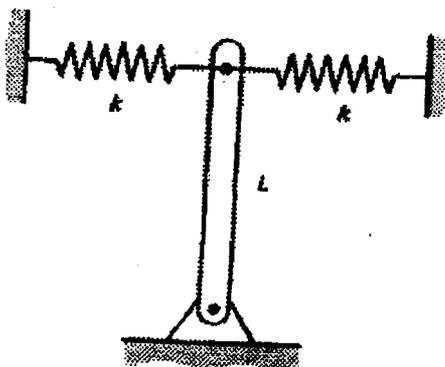


PART B — (5 × 16 = 80 marks)

11. (a) (i) Part of a structure is modelled by a thin rigid rod of mass m pivoted at the lower end, and held in the vertical position by two springs, each of stiffness k , as shown.

Find the frequency of small amplitude oscillation of the rod about the pivot. (6)



- (ii) A motor generator set of total mass 365 kg is mounted on damped vibration isolators. It runs at 1450 rev/min, and the unit is disturbed at stand still, it is found that the resulting damped oscillation have a frequency of 23 Hz and a decay factor of 15. Find (1) the coefficient of viscous damping (2) the magnitude of the exciting force at the normal running speed, and (3) the amplitude of the forced vibration if damping were not present. (10)

Or

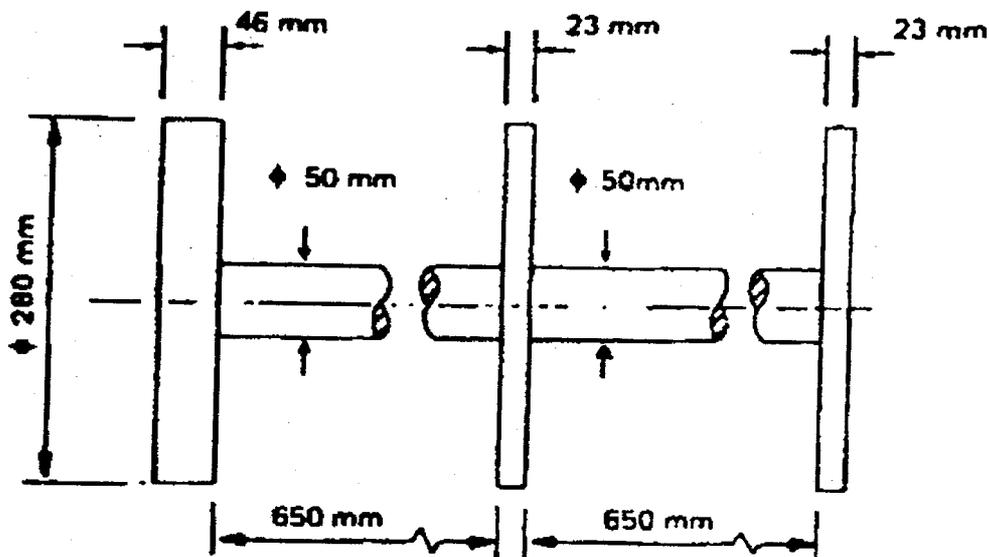
- (b) A turbine disc of mass 20 kg has its mass centre on the axis of a central hole 40 mm in diameter. The disc is suspended from a horizontal knife edge passed through the central hole, and makes small free oscillations in the plane of the disc while immersed in a fluid which exerts a resistance proportional to the angular velocity of the disc. The period of the oscillations is found to be 1.6 s and the amplitude is observed to decrease sixfold in each complete oscillation. Write down the equation of motion and derive its solution, and hence calculate the mass moment of inertia of the disc about the axis of the central hole and the effective viscous damping coefficient. (16)

2. (a) A turbine rotor with mass moment of inertia 12 kg m^2 is connected to a generator by a straight shaft of length 1 m and torsional stiffness 600 kN m/rad . The generator armature has a mass moment of inertia of 5 kg m^2 . Calculate the natural frequency of free torsional oscillation of the system and give the mode shape. Ignore damping.

Or

- (b) A vehicle has a mass of 2000 kg and a 3 m wheelbase. The mass moment of inertia about the centre of mass is 500 kg m^2 , and the centre of mass is located 1 m from the front axle. Considering the vehicle as a two degree of freedom system, find the natural frequencies and the corresponding modes of vibration; if the front and rear springs have stiffnesses of 50 kN/m and 80 kN/m respectively. The expansion joints of a concrete road are 5 m apart. These joints cause a series of impulses at equal intervals to vehicles traveling at a constant speed. Determine the speeds at which pitching motion and up and down motion are most likely to arise for the above vehicle.

13. (a) The figure shows a steel shaft which can rotate in frictionless bearings, and which has three discs rigidly attached to it in the positions shown. Each of the three discs is solid, uniform, and of diameter 280 mm . The modulus of rigidity of the shaft material is 83 GN/m^2 , and the density of the discs is 7000 kg/m^3 . Find the frequencies of free torsional vibrations of the system.

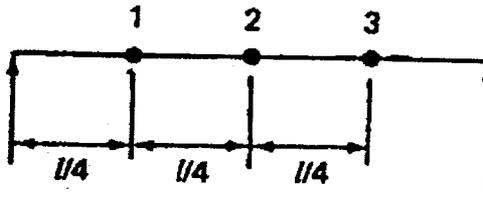


Or

- (b) A simply supported beam of negligible mass and of length l has three bodies each of mass m attached as shown. The influence coefficients are, using standard notation.

$$\alpha_{11} = 3 l^3 / 256 EI \quad \alpha_{21} = 3.67 l^3 / 256 EI \quad \alpha_{31} = 2.33 l^3 / 256 EI$$

$$\alpha_{22} = 5.33 l^3 / 256 EI .$$



Write down the flexibility matrix, and determine by iteration the frequency of the first mode of vibration, correct to 2 significant figures, if $EI = 10 \text{ Nm}^2$, $m = 2 \text{ kg}$, and $l = 1 \text{ m}$. Comment on the physical meaning of the eigenvector you have obtained, and use the orthogonality principle to obtain the frequencies of the higher modes.

14. (a) Part of the cooling system in a generating station consists of a steel pipe 80 mm in outer diameter, 5 mm thick, and 4 m long. The pipe may be assumed to be built in at each end so that the static deflection y at a distance x from one end of the pipe of length l is given by $y = (mg / 24 EI) x^2(l - x)^2$ where m is the mass per unit length. Calculate the lowest natural frequency of transverse vibration of the pipe when full of liquid having a density of 930 kg/m^3 . Take the density of steel as 7750 kg/m^3 and E as 200 GN/m^2 .

Or

- (b) A uniform horizontal steel beam is built in to a rigid structure at one end and pinned at the other end; the pinned end cannot move vertically but is otherwise unconstrained. The beam is 8 m long, the relevant flexural second moment of area of a cross-section is $4.3 \times 10^6 \text{ mm}^4$, and the beam's own mass together with the mass attached to the beam is equivalent to a uniformly distributed mass of 600 kg/m . Using a combination of sinusoidal functions for the deflected shape of the beam, estimate the lowest natural frequency of flexural vibrations in the vertical plane.
15. (a) A spring mass system with mass $m = 0.5 \text{ kg}$ and stiffness $k = 10,000 \text{ N/m}$, with negligible damping, is used as vibration pickup. When mounted on a structure vibrating with amplitude of 4 mm, the total displacement of the mass of the pickup is observed to be 12 mm. Find the frequency of the vibrating structure.

Or

- (b) Write short notes for the following:
- Difference between transducer and pickup
 - Types of Vibration exciters.