INDIAN INSTITUTE OF TECHNOLOGY KHARAGPUR

Department of Mechanical Engineering

Autumn Semester (Mid Term) Examination. 2018 - 2019

Number of Students: 70 | Date of Examination:- 19.9.18

Subject No. **ME 60403** | Name: **Vibration Analysis**

Time: **Two Hours** | Full Marks: 50

Specialization : ME-3 and DDME-3

Answer first three questions and any one of Q4. Figure numbers correspond to the question numbers.

1(a). Explain why the damping factor of a seismic accelerometer should be adjusted to around 0.7. Draw only rough sketches of the diagrams.

1(b). A force $F\sin\omega t$ is applied to the mass of simple spring-mass oscillator. If $\omega = (1+\varepsilon)\omega_n$, determine the motion of the mass. Assume zero initial conditions and $\varepsilon << 1$.

2(a). The following data are given for a system with viscous damping : m = 4 kg, k = 5 kN/m, and the amplitude decreases to 0.25 of the initial value after five consecutive cycles. Find the damping coefficient of the damper in this single DOF system.

2(b). The point of suspension of a simple pendulum is given a harmonic motion $x = X_0 \sin\omega t$ along a horizontal line. Obtain the equation of motion for small amplitude of oscillation using the coordinates shown. Determine the solution θ/X_0 and show that when $\omega = \sqrt{2}\omega_n$ the node (point of no motion) is found at the midpoint of l.

3(a). Find the response of a single degree spring-mass oscillator under Coulomb damping. Explain how the amplitude decays in this case. The Coulomb friction force F_c is given by $F_c = F_d\ \mathrm{sgn}(\dot{x})$. Assume motion in a horizontal surface. When does the motion stop?

3(b). A rigid rod of negligible mass and length $2l$ is pivoted at the middle point and is constrained to move in the vertical plane by springs and masses as shown. Find the natural frequencies and mode shapes of the system.

4(a). An electric overhead travelling crane, consisting of a girder, trolley, and wire rope, is shown in the figure. The girder has a flexural rigidity (EI) of 2×10^9 N-m^2 and a span (L) of 10 m. The rope is made of steel and has a length of 6 m. The weights of the trolley and the load lifted are 4000 Kg. and 1000 Kg, respectively. Find the area of cross-section of the rope such that the lowest (fundamental) natural frequency is greater than 20 Hz.

4(b). In the cam-follower system shown, the rotation of the cam imparts a vertical motion to the follower. The pushrod, which acts as a spring, has been compressed by a amount x_o before assembly. Determine the equation of motion of the follower, including the gravitational force; and the force exerted on the follower by the cam.

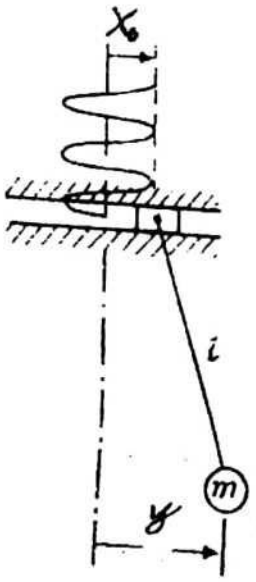

Fig 2(b)

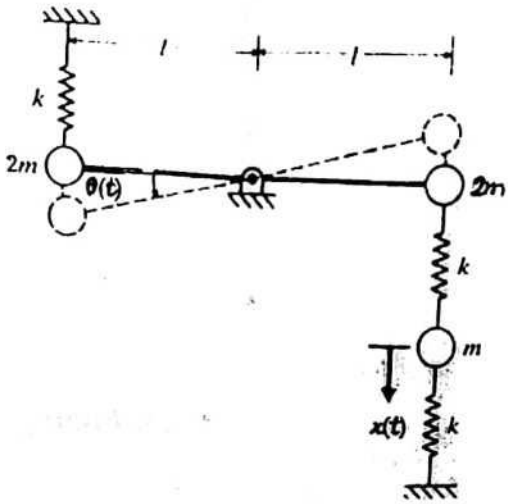

Fig. 3(b)

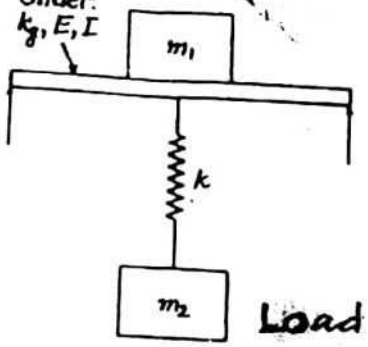

Fig. 4(a)

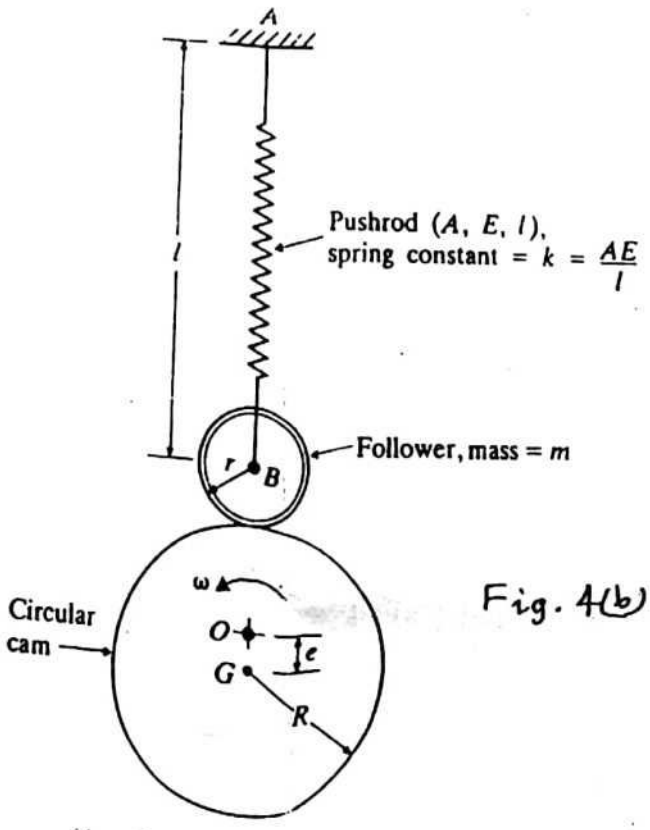

Fig. 4(b)