Indian Institute of Engineering Science and Technology, Shibpur
B.E. (AE) Part-III 6th Semester Midterm Examination, May 2014
MECHANICAL VIBRATIONS (AE-602)

Time: 3 hours | Full Marks: 70

Answer any FIVE questions.
Assume reasonable data, if not supplied with the problems.

1. a) In the system shown in Fig. Q1a, mass m_2, is resting on mass m_1, which is supported by a spring of stiffness k. The mass m_1 is 1 kg, the mass m_2 is 0.5 kg, and the stiffness k is 1 kN/m. If the spring is pushed down 15 mm below the system's static equilibrium position and released, determine if the mass m_2 will ever lose contact during the subsequent motion.
b) A uniform bar of length L and weight W is suspended symmetrically by two strings as shown in Fig. Q1b. Set up the differential equation of motion for small angular oscillations of the bar about the vertical axis $O-O$, and determine its period. [8+6]

2. a) Determine the effective mass at the point n for the system shown in Fig. Q2a and its natural frequency.
b) The system shown in Fig. Q2b has two rigid uniform beams of length l and mass per unit length m, hinged at the middle and resting on rollers at the test stand. The hinge is restrained from rotation by a torsional spring K and supports a mass M held up by another spring k to a position where the bars are horizontal. Determine the equation of motion using virtual work method. [7+7]

3. a) A sensitive instrument with mass 113 kg is to be installed at a location where the acceleration is 15.24 cm/s^2 at a frequency of 20 Hz. It is proposed to mount the instrument on a rubber pad with $k = 2802\ N/cm$ and $\varsigma = 0.10$. What acceleration is transmitted to the instrument?
b) The rotor of a turbine 13.6 kg in mass is supported at the midspan of a shaft with short bearings 0.4064 m apart. The rotor is known to have an unbalance of 0.2879kg-cm. Determine the forces exerted on the bearings at aspeed of 6000 rpm if the diameter of the steel shaft is 2.54 cm. Compare this result with that of the same rotor mounted on a steel shaft of diameter 1.905 cm. Young's modulus of steel is 2.1×10^6 kgf/cm^2. [6+8]

4. a) Derive the expression for logarithmic decrement in term of damping ratio for viscously damped free vibration.
b) Determine the limiting frequency ω for an accelerometer with 2.5% error having damping factor $\varsigma = 0.7$ and natural frequency 100 Hz. [6+8]

5. Choose the coordinated x for the displacement of c and θ clockwise for the rotation of the uniform bar shown in Fig. Q5 and determine the natural frequencies and mode shapes. [14]

6. Derive the differential equation of motion for longitudinal vibration of a rod of uniform cross-sectional area A, Young's modulus E and material density ρ and determine the frequencies and mode shapes of a rod with one end fixed and other end free. [14]

7. Using Rayleigh's method, estimate the fundamental frequency of the lumped mass system shown in Fig. Q7. The beam is simply supported at both ends. [14]

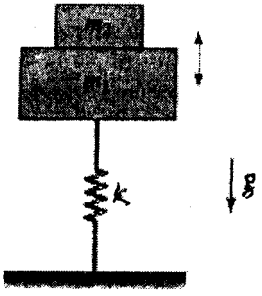

Fig. Q1a

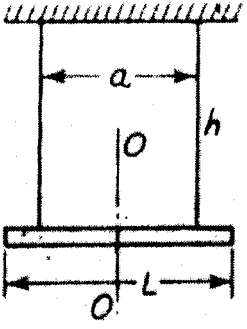

Fig. Q1b

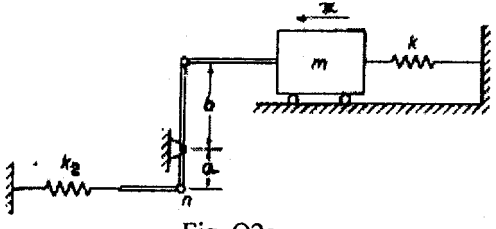

Fig. Q2a

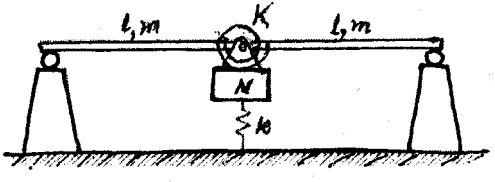

Fig. Q2b

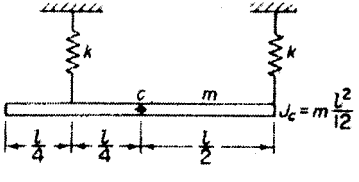

Fig. Q5

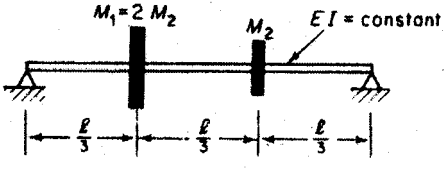

Fig. Q7