BIRLA INSTITUTE OF TECHNOLOGY & SCIENCE
FIRST SEMESTER 2023-24, COMPREHENSIVE EXAMINATION
DE G611 DYNAMICS & VIBRATIONS (Regular)

Date: 12-12-2023 **Maximum Marks: 35** **Time: 3 Hours**

Part-A (Closed Book)(17 Marks)

Q1. A 75 kg reciprocating machine is placed on a massless structure having stiffness 96 kN/m. A frequency sweep is run to determine machine's rotating unbalance and equivalent damping of structure. As the speed increases, the following is noted,

(a) The steady state amplitude of the machine is same at 36 rad/s and 56 rad/s

(b) As the speed increases. the steady state amplitude approaches to 12 mm

(i) Determine the damping co-efficient of the structure.

(ii) Determine unbalance present in the system.

(iii) Determine the maximum steady state amplitude of the reciprocating system and corresponding speed of machine. **[5]**

Q2. A double pendulum is shown in Fig. Q2. Use Lagrange's equations to derive the differential equation of motion of the system. Also find the natural frequencies and corresponding mode shapes of the system if $m_1 = m_2 = m$ and $L_1 = L_2 = L$. **[5]**

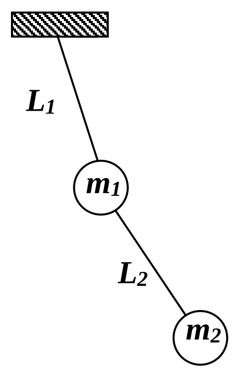


Fig. Q2

Q3. State the orthogonality condition for modes in a continuous system. Prove the orthogonality condition for a fixed-free beam. **[3]**

Q4. A uniform beam (E, I, ρ) of length 'L' is pinned at one end and a linear spring (stiffness, k) is attached as shown in Figure Q4. Derive the frequency equation for transverse vibration of a beam. **[4]**

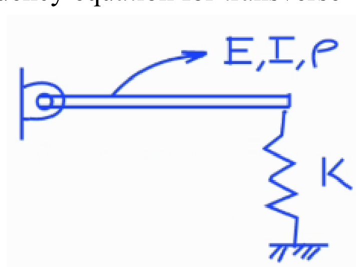


Fig. Q4

Part-B (Open Book)(18 Marks)

Q1. The wing of an aircraft is modeled by considering lumped mass system with three degrees of freedom as shown in the figure Q1(a) and Fig. Q1(b).

Assume $(EI)_1 = (EI)_2 = (EI)_3 = EI$ = constant, $l_1 = l_2 = L/2$, $l_3 = L$, $m_1 = m_2 = M$, $m_3 = M/2$ Determine the following:

(a) Flexibility matrix of the system

(b) First natural frequency and corresponding mode shape using matrix iteration method. Minimum three iterations should perform. **[6]**

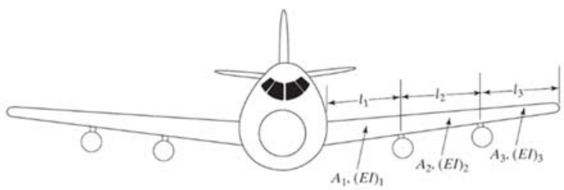


Fig. Q1 (a)

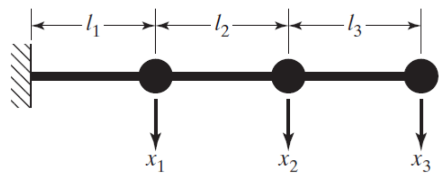
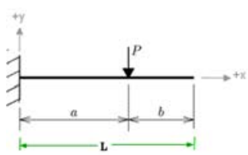


Fig. Q1 (b)

Hints: The deflection of a cantilever beam is given by:



$$w(x) = \begin{cases} \frac{Px^2}{6EI}(-x + 3a) & 0 \le x \le a \\ \frac{Pa^2}{6EI}(-a + 3x) & a \le x \le L \end{cases}$$

Q2. Use the Rayleigh-Ritz method to approximate the two lowest natural frequency of a uniform cross section cantilever beam as shown in Fig. Q2. The beam suspended on a discrete linear spring 'K' and a lumped mass 'M' is attached at the end of the beam. Linear spring Stiffness K is $\frac{3EI}{10l^3}$ and Lumped mass 'M' is $\frac{1}{10}th$ of total mass of the beam. **[8]**

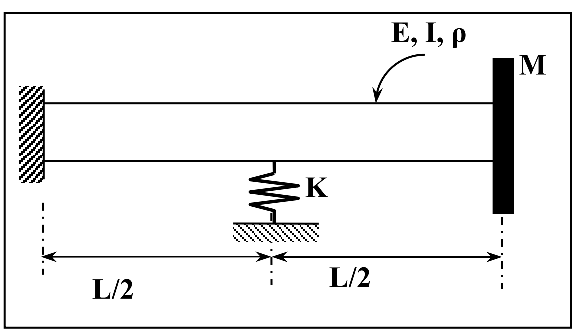


Fig: Q2

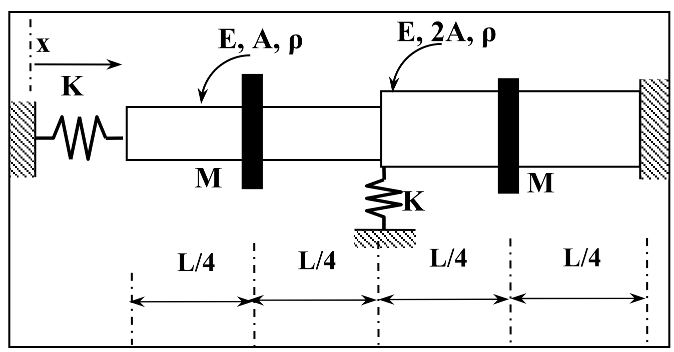


Fig. Q3

Q3. Using four element finite element model find the following for the Longitudinal motion of the continuous system as shown in Fig.Q3. Each lumped mass 'M' is 5% of total mass of the continuous member and each spring Stiffness K is equivalent to, $K = \left(\frac{EA}{10L}\right)$

(i) write the mass matrices and stiffness matrices for individual element

(ii) Find assemble mass matrix and stiffness matrix of the system. **[2+2= 4]**