M.E. MECHANICAL ENGINEERING FIRST YEAR FIRST SEMESTER EXAM 2024

SUBJECT: THEORY OF MECHANICAL VIBRATION

Time: 3 Hours **Full Marks: (20 X 5) =100**

Any missing data may be assumed with suitable justification

The symbols/notations carry its usual meanings

(Answer Any Five Questions)

Q1. (a) The system shown in **Fig. Q1(a)** has a natural frequency of 5 Hz for the following data: m = 10 kg, J_0 = 5 kg-m^2, r_1 = 10 cm, r_2= 25 cm. When the system is disturbed by giving it an initial displacement, the amplitude of the free vibration is reduced by 80 percent in 10 cycles. Determine the values of k and c. **(10)**

(b) Find the Fourier series expansion of the periodic function shown in **Fig. Q1(b).** **(10)**

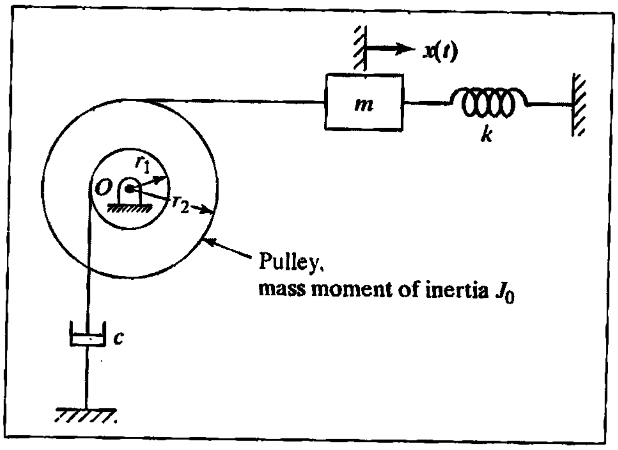

Fig. Q1(a)

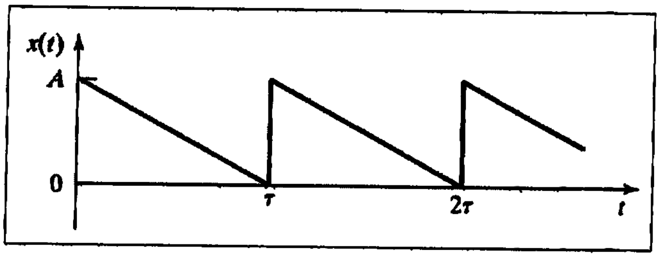

Fig. Q1(b)

Q2. (a) Fig. Q2(a) shows a mass block mounted on a spring and a Coulombic damper. The supporting base is excited by a harmonic movement. Derive the expression of equivalent viscous damping factor. **(10)**

(b) What is convolution integral? Using the integral, find the response history of the single-degree undamped ocillator for the forcing function, shown in **Fig. Q2(b).** **(10)**

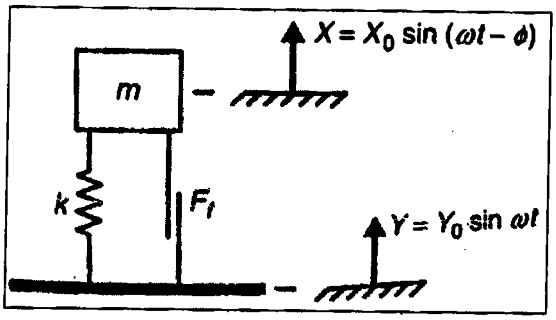

Fig. Q2(a)

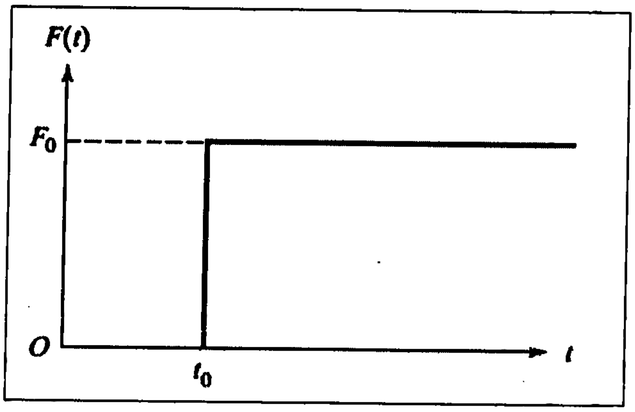

Fig. Q2(b)

Q3. (a) Write a short note on vibration absorber. **(8)**

[Turn over

(b) Use static equilibrium to determine the flexibility matrix of the system shown in **Fig. Q3(b).** **(12)**

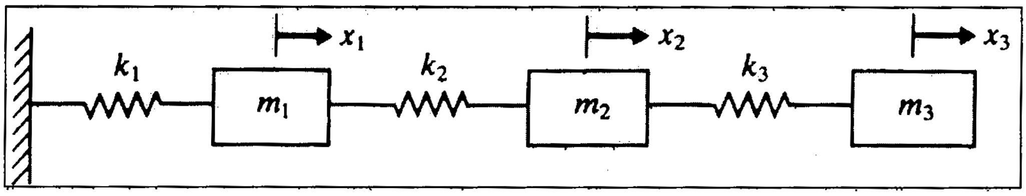

Fig. Q3(b)

Q4. **(a)** Write a short note on semi definite system. **(5)**

(b) Determine the pitch (angular motion) and bounce (up-and-down linear motion) frequencies and the location of oscillation centers (nodes) of an automobile with the following data (see **Fig. Q4(b)**): Mass (m) = 1000 kg, Mass moment of inertia (J_0) = 810 kg-m^2. Distance between front axle and C.G. (l_1) = 1 m, Distance between rear axle and C.G. (l_2) = 1.5 m, Front spring stiffness (k_f) = 18 kN/m, Rear spring stiffness (k_r) = 22 kN/m. **(15)**

Q5. Find the eigenvalues and eigenvectors for the system shown in the **Fig. Q5**. Verify the orthogonality principle of the eigenvectors. Using modal analysis, find the individual responses of the masses under the action of the forcing function, $F = F_0 \sin \omega t$. **(20)**

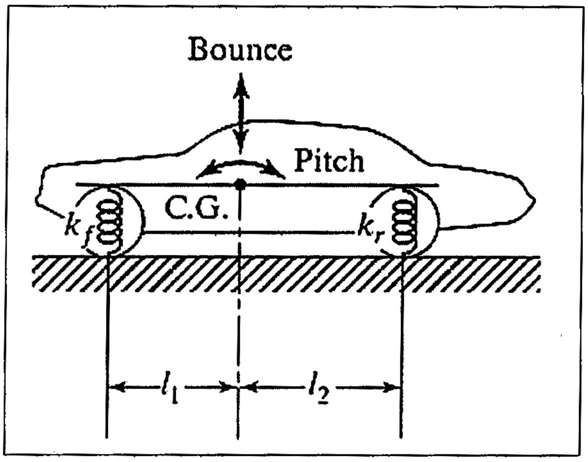

Fig. Q4(b)

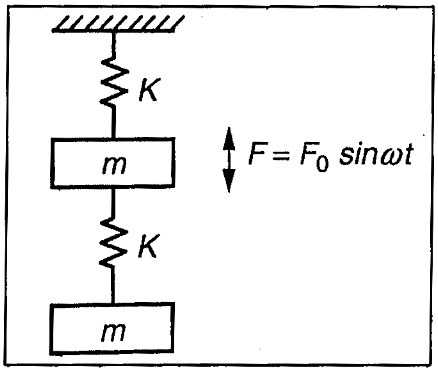

Fig. Q5

Q6. Solve the free vibration equation for the simply supported beam and discuss the solution of the beam frequency and the mode shape functions. **(20)**

Q7. Prove the following relations in connection with the free longitudinal vibration of a bar with uniform cross-section:

(i) $\dfrac{\partial^2 u}{\partial x^2}(x,t) = \dfrac{\rho}{E}\dfrac{\partial^2 u}{\partial t^2}(x,t)$

(ii) $\int_0^L U_i(x)U_j(x)\,dx = 0$ **(10 +10)**

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