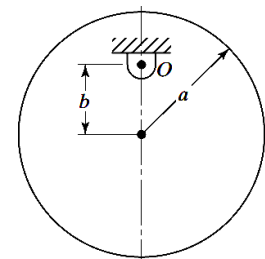


(3 Hours)

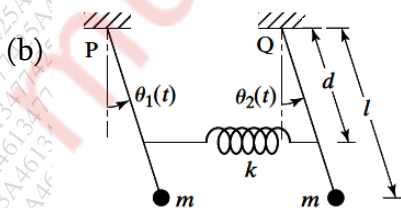
- N.B.:** 1. Question No.1 is compulsory  
 2. Attempt any three from the remaining five questions  
 3. Assume suitable data wherever required, with proper justification

1. Attempt any four of the following. All sub-questions carry equal marks. 20
- A spring-mass system having 2 Hz natural frequency is disturbed by applying an initial displacement of (+2) cm and an initial velocity of (-5) cm/s. Calculate the displacement, velocity and acceleration amplitudes. Also, find the corresponding phase differences.
  - In a very long elastic beam, two point loads viz. 10 N and 50 N, act at two different locations  $i$  and  $j$  separated by some distance apart, between the supports. Given that the deflection at either location due to unit load at the same location is 2 mm, and that the deflection at some location due to unit load at other location is 1 mm; calculate the net deflection in both the locations, using Rayleigh's principle. Assume that the deflections are very small compared to the length of the beam.
  - For a spring-mass-damper system,  $m = 50$  kg,  $k = 5000$  N/m. Find the value of the damped natural frequency when the viscous damping coefficient equals half of the critical damping coefficient.
  - Calculate the transmissibility at 60 Hz for a 10 tonnes chiller unit supported by eight springs with 8 cm static deflection. Also find the % isolation.
  - A spring-mass system with  $m = 0.5$  kg and  $k = 10,000$  N/m, with negligible damping, is used as a vibration pick-up. When mounted on a structure vibrating with an amplitude of 4 mm, the total (absolute) displacement of the mass of the pick-up is observed to be 12 mm. Find the frequency of the vibrating structure.
  - Write a short note on the phase-plane technique of non-linear vibrations.

2. (a) A uniform circular disc is pivoted at point  $O$ , as shown in the figure. Find the natural frequency of the system. Also find the maximum frequency of the system by varying the value of  $b$ .



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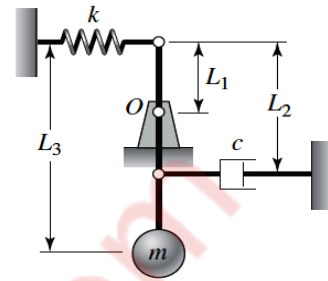


For the given 2 d.o.f. system, derive the equations of motion using Lagrange's method. Also find the natural frequencies of the system.

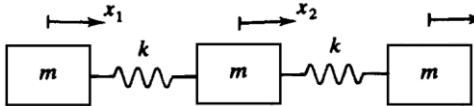
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3. (a) Develop a sequence of three mathematical models of a motorcycle with a rider, in the order of increasing complexity, for investigating vibration in the vertical direction. Supplement your models with proper labeling, and a short description of the same. 10

- (b) For the given system, the pendulum oscillates about the pivot at  $O$ . Distances are given as—  $L_1 = 0.1$  m,  $L_2 = 0.2$  m, and  $L_3 = 0.3$  m. Also,  $m = 1$  kg,  $k = 1000$  N/m, and  $c = 20$  Ns/m. Estimate the value of the damped natural frequency in Hz, for small angular oscillations.



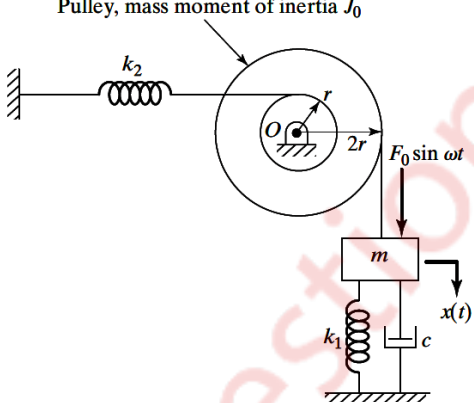
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4. (a)  For the given spring-mass system, determine the natural frequencies of vibration using Holzer's method. Given: mass  $m = 1$  kg, and stiffness  $k = 1$  N/m.

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- (b) An air compressor of mass 50 kg is mounted on an elastic support and operates at a speed of 1000 rpm. It has an unbalanced mass of 2 kg at a radial distance (eccentricity) of 0.1 m from the axis of rotation. If the damping factor of the elastic support is 0.1, determine the following: (a) the spring constant of the elastic support which transmits no more than 25% of the unbalanced force to the foundation, and (b) the magnitude of the force transmitted to the foundation.

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5. (a)  Find the steady state response of the system shown in figure, for the following data:

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$k_1 = 1000$  N/m,  $k_2 = 500$  N/m  
 $c = 500$  N-s/m,  $m = 10$  kg  
 $r = 5$  cm,  $J_0 = 1$  kg-m<sup>2</sup>  
 $F_0 = 50$  N,  $\omega = 20$  rad/s.

- (b) Write a short note on—Condition and vibration monitoring techniques. 5  
 (c) State and explain the significance of Duffing's equation, and briefly describe the associated parameters. 5

6. (a) Derive the equation to find peak frequency ratio for the case of frequency-squared excitations. 5  
 (b) Determine the necessary stiffness and the damping constant of an accelerometer if the maximum error is to be limited to 3 percent for measurements in the frequency range of 0 to 100 Hz. Assume that the suspended mass is 0.05 kg. 10  
 (c) Write a short note on—Limit cycle, in non-linear vibration theory. 5