

Examiners: Prof. Dr/ Sobhy Ghoneam + Dr/ Rafat Abou-elnasr  
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**Answer All The Following Questions:**

**Question No.(1):**

[25 Marks]

- (a)- Define the magnification factor and the transmissibility, and study the effect of damping factor on it for different values of frequency ratio.
- (b)- A Scotch yoke mechanism is used to impart motion to a body of equivalent mass-spring-damper system, as shown in Fig.(1). The mass of  $m = 22 \text{ kg}$ , a spring of stiffness  $K = 7,800 \text{ N/m}$  and a damper of coefficient  $C = 770 \text{ N.s/m}$ . In this mechanism a crank of radius  $r = 20 \text{ cm}$  rotates uniformly at speed  $n = 1200 \text{ r.p.m}$  about a fixed axis  $O$ . The other end of the crank,  $A$ , slides in a slotted elastic rod of equivalent stiffness  $K_1 = 10^5 \text{ N/m}$  which reciprocates in a vertical guide  $R$ .
- (1)- Derive the equation of motion of the body,
  - (2)- Determine the periodic time and the ratio of any two consecutive amplitudes,
  - (3)- Find the steady state response of the body and the force transmitted to the ground,
  - (4)- Evaluate the maximum amplitude during start up conditions of the system.

**Question No.(2):**

[25 Marks]

- (a)- Explain the basic principle of a vibration-measuring instrument. What are the differences between the accelerometer and seismometer?
- (b)- A marine propulsion is shown in Fig.(2). For the analysis of torsional vibration, the mass moments of inertia for the gearbox and propeller taken about the axis of rotation are  $J_1 = 1.75 \text{ J}$ ,  $J_2 = \text{J}$ , and  $J_P = \text{J}$  respectively, and the stiffnesses of the gearbox and propeller shafts are  $K_G = 5K$  and  $K_P = 4K$  respectively. If the gear ratio is ( $z_1/z_2 = 0.5$ ), damping can be neglected and the moment :  $M(t) = M_0 \sin \omega t$  acts on the first gear.
- (1)- Derive in matrix form the equations governing the torsional vibration of the system,
  - (2)- Determine the natural frequencies and corresponding mode shapes, and sketch these modes, then check the correctness of the results,
  - (3)- Find the proper value of  $J_P$  of the propeller such that the first gear  $J_1$  becomes at rest,
  - (4)- If the propeller is very large and modeled as built in, find the new natural frequency.

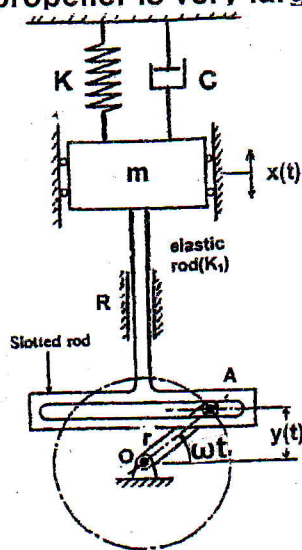


Fig.(1)

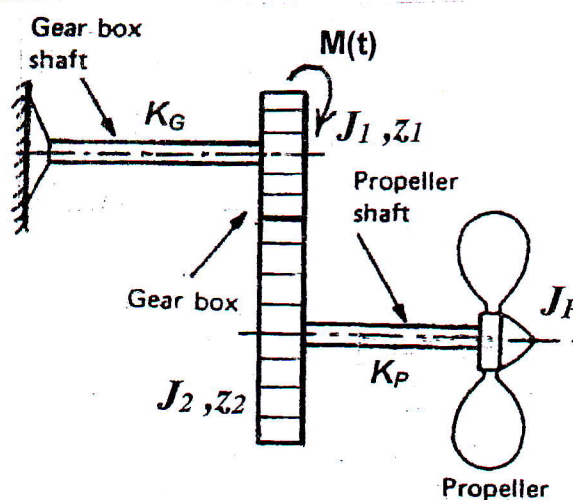


Fig.(2)

**Question No.(3):**

**[25 Marks]**

- (a)- Explain briefly the various methods available for vibration control.  
 (b)- The rotor of a small steam turbine weighs 27.5 kg and is mounted at the mid point of a steel shaft 30 mm diameter supporting in bearings over a span 80 cm. Owing to slight manufacturing inaccuracy, the rotor has an unbalance of 1.925 kg.cm. Assume the shaft to be simply supported and the shaft material has  $E = 2 \times 10^7 \text{ N/cm}^2$ .  
Determine: (1)- the critical speed of the shaft,  
 (2)- the amplitude of vibration of the rotor at a speed of 2400 rpm,  
 (3)- the vibratory force transmitted to each bearing at this speed,  
 (4)- the diameter of the steel shaft so that the amplitude of vibration of the rotor at this speed is reduced to 70% of the original value.

**Question No.(4):**

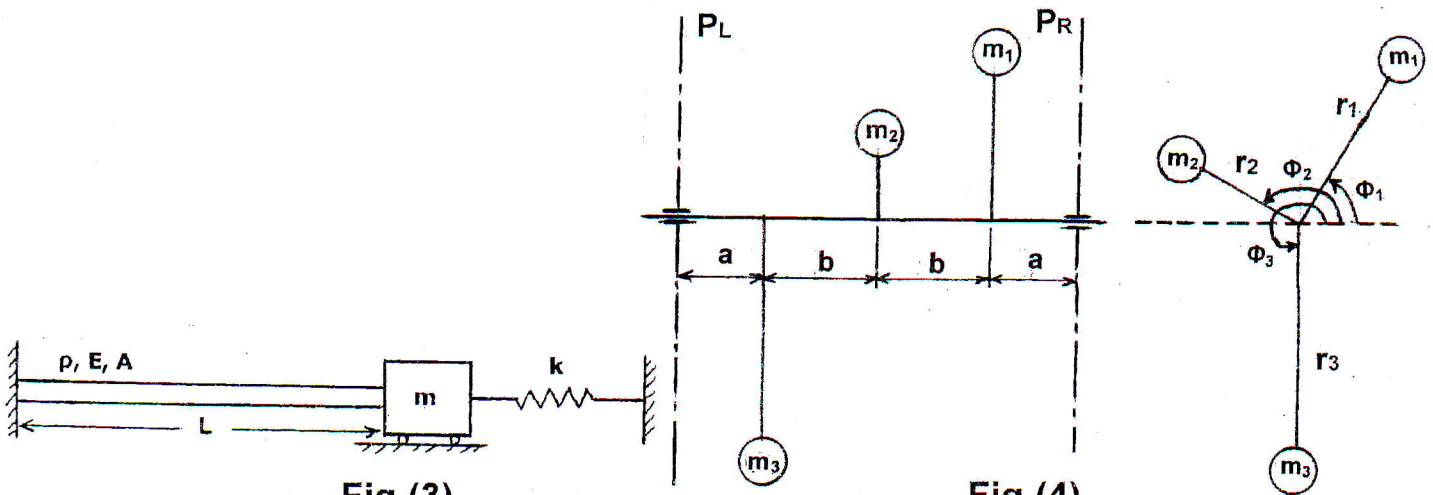
**[25 Marks]**

- (a)- Compare between the discrete and continuous systems.  
 (b)- A spring ( $k$ ) and a concentrated mass ( $m$ ) are connected to one end of a bar of uniform cross-section area  $A$ , length  $L$  and mass per unit volume  $\rho$ , the other end being fixed to the support as shown in Fig.(3).  
 (1)- If the system performs longitudinal vibrations, derive the frequency equation of the continuous system and plot the first four mode shapes of the system.  
 (2)- If  $\rho = 0$  and  $k = 0$ , the system is modeled as single D.O.F. system and excited by chance at resonance state so it is observed to vibrate with large amplitude. It is proposed to add a vibration dynamic absorber to reduce the vibration of the bar. Determine the mass and stiffness of the absorber needed in order to have the lower frequency of the resulting system equal to 75% of the operating speed.

**Question No.(5):**

**[20 Marks]**

- A rotating shaft with three unbalanced masses should be completely balanced by the two masses situated on the radius  $r_0$  in the two respective planes  $P_L$  and  $P_R$  as shown in Fig.(4).  
Find the magnitudes of these masses  $m_L$  and  $m_R$  and their angular locations  $\Phi_L$  and  $\Phi_R$ .  
Given:  $m_1 = 10 \text{ kg}$ ,  $m_2 = 20 \text{ kg}$ ,  $m_3 = 25 \text{ kg}$ ,  $a = 15 \text{ cm}$ ,  $b = 20 \text{ cm}$ ,  $r_0 = 25 \text{ cm}$ ,  
 $r_1 = 30 \text{ cm}$ ,  $r_2 = 20 \text{ cm}$ ,  $r_3 = 40 \text{ cm}$ ,  $\Phi_1 = 60^\circ$ ,  $\Phi_2 = 150^\circ$ , and  $\Phi_3 = 270^\circ$ .



**Fig.(3)**

**Fig.(4)**

*With our best wishes*

This exam measure the following ILOs													
Question No.	Q1-a	Q2-a	Q3-a	Q4-a	Q1-b	Q2-b	Q3-b	Q4-b	Q5	Q1-b	Q2-b	Q3-b	Q4-b
	a-1	a-19	a-19	a-1	b-13	b-17	b-13	b-17	b-13	c6	c1	c6	c1
Skills	Knowledge & Understand				Intellectual					Professional			