

# Mechanical Vibrations – Final Examination (Graduate School)

Upload deadline: 2025/06/17 24:00

1. A damped single degree of freedom mass-spring system consists of a  $m=5\text{kg}$  mass suspended by a linear spring which has a stiffness coefficient of  $k=500\text{N/m}$ . From the experimental measurements, it was observed that the amplitude of vibration diminishes from  $0.02\text{m}$  to  $0.012\text{m}$  in 6 cycles. Determine the damping coefficient  $c$ . (10%)
2. As shown in Fig. 1, a single degree of freedom mass-spring system consists of a  $m=5\text{kg}$  mass suspended by a linear spring which has a stiffness coefficient of  $k=5000\text{N/m}$ . The system is subjected to the friction force by the coefficient of dry friction  $\mu=0.1$ . The mass is given an initial displacement of  $0.03\text{m}$  and an initial velocity of  $0\text{m/s}$ . Determine the system (a) Differential equation of motion, (b) The number of cycles of oscillation of the mass before it comes to rest. (10%)

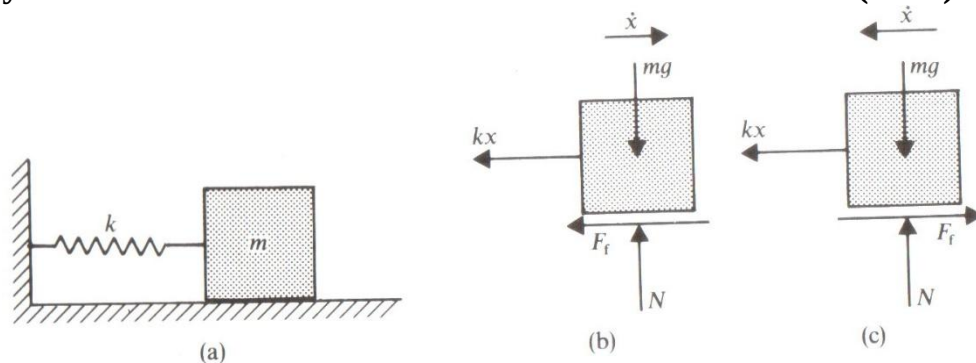


Fig. 1

3. A damped single degree of freedom mass-damper-spring system consists of a  $m=10\text{kg}$  mass suspended by a linear damper which has a damping coefficient of  $c=40\text{N}\cdot\text{s/m}$  and a linear spring which has a stiffness coefficient of  $k=4000\text{N/m}$ . The amplitude of the forcing function  $F=60\text{N}$ , and the frequency  $\omega_f=40\text{rad/s}$ . The mass is given an initial displacement of  $1\text{m}$  and an initial velocity of  $0\text{m/s}$ . Determine (a) The damping factor, (b) The magnification factor (amplitude ratio), (c) The displacement response, (d) The transmissibility and amplitude of the force transmitted to the support. (20%)
4. A single degree of freedom mass-spring system is such that an amplitude loss of 25% occurs in every five full cycles of oscillation. Obtain the damping factor of this vibration system. (10%)
5. A single degree of freedom system is subjected to a periodic forcing function  $f(t)$  as shown in Fig. 2. Determine the Fourier Series representation for  $f(t)$ . (10%)

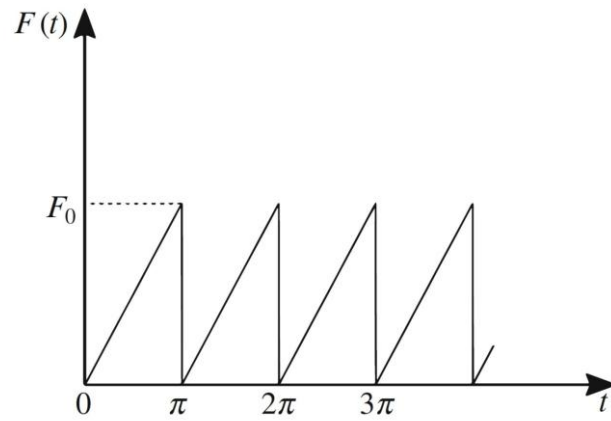


Fig. 2

6. For the system shown in Fig. 3, let  $m=0.5\text{kg}$ ,  $a=0.2\text{m}$ ,  $l=0.4\text{m}$ ,  $k=3000\text{N/m}$ . Determine the damping coefficient  $c$  if: (a) The system is underdamped with  $\xi=0.09$ , (b) The system is critically damped, (c) The system is overdamped with  $\xi=1.2$ . (10%)

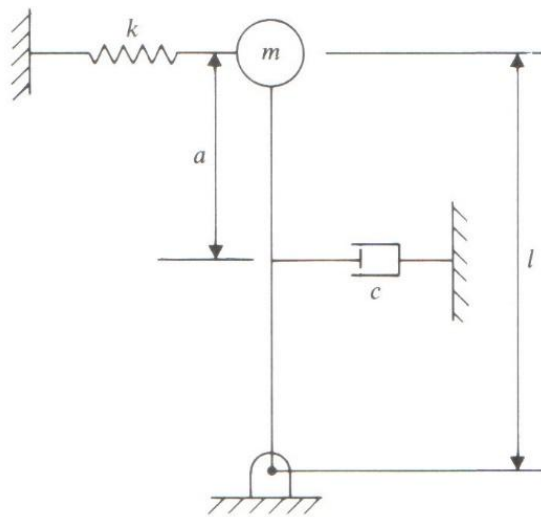


Fig. 3

7. For the two degree of freedom undamped free system shown in Fig. 4, let  $m_1=1\text{kg}$ ,  $m_2=2\text{kg}$ , and  $k_1=k_2=100\text{N/m}$ ,  $k_3=200\text{N/m}$  and let  $x_{10}=1.2$ ,  $x_{20}=0$ ,  $\dot{x}_{10}=0$  and  $\dot{x}_{20}=0$ . Determine the system modal natural frequency and the system response as a function of time. (10%)

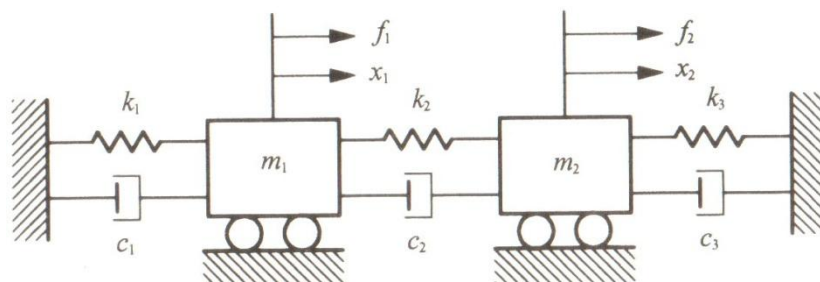


Fig. 4

8. (a) For the system shown in Fig. 5, derive the differential equation of motion for small oscillation. If  $m_1 = m_2 = 1$  kg,  $k_1 = k_2 = 1000$  N/m,  $C_1 = C_2 = 10$  N-s/m,  $a = b = 0.5$  m, and  $l = 1$  m, find the solution after 1 second provided that the initial angular displacement is zero and the initial angular velocity is 5 rad/s. Assume that the rod is massless. (10%)
- (b) If this vibration system is critically damped, please determine the relationship between the damping coefficients  $C_1$  and  $C_2$  in this problem. (5%)

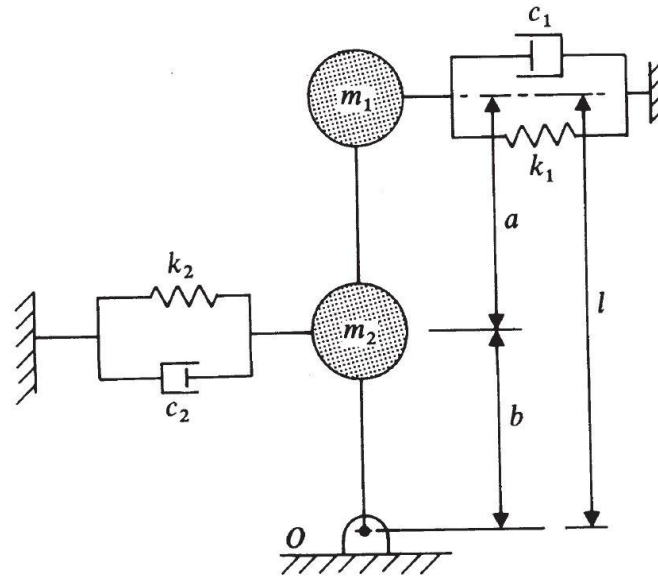


Fig. 5

9. (a) Derive the differential equation of motion of the simple vehicle model shown in Fig. 6. The vehicle is assumed to travel over the rough surface with a constant vehicle speed  $v$ . Obtain also the steady state response of the vehicle. (5%)
- (b) Let  $m = 10$  kg,  $k = 4000$  N/m,  $c = 150$  N-s/m,  $\lambda = 2$  m, and the amplitude  $Y_0 = 0.1$  m. Determine the maximum vertical displacement of the mass and the corresponding vehicle speed. Determine also the maximum dynamic force transmitted to the mass at the resonant speed. (10%)

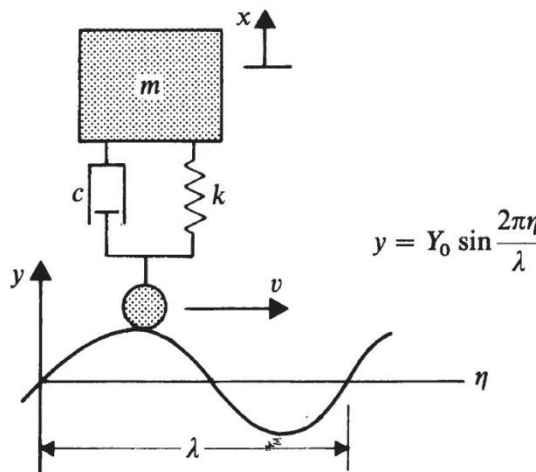


Fig. 6

10. (a) Obtain the Fourier series expansion of the periodic function  $F(t)$  shown in Fig. 7. (10%)
- (b) Determine the forced response of the single degree of freedom system shown in Fig. 8 to the periodic forcing function  $F(t)$  shown in Fig. 7. (5%)

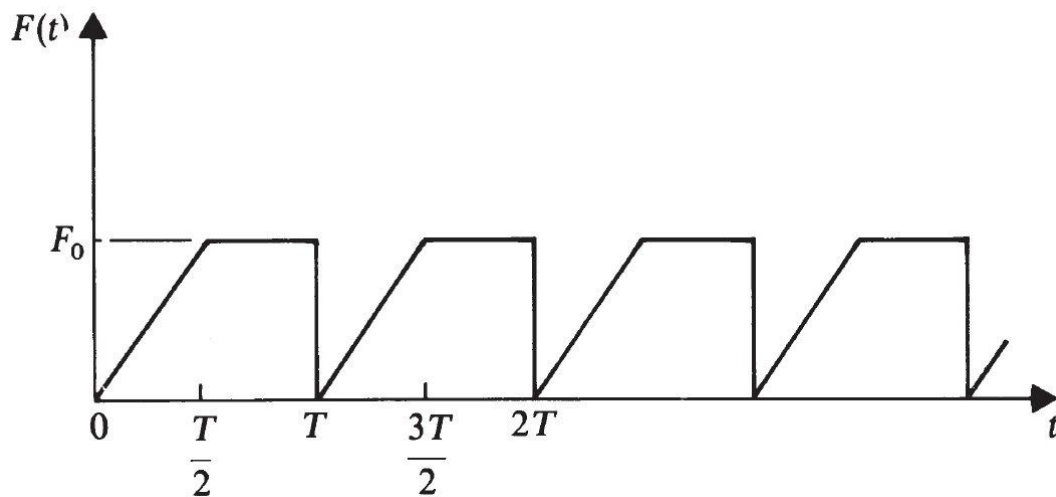


Fig. 7

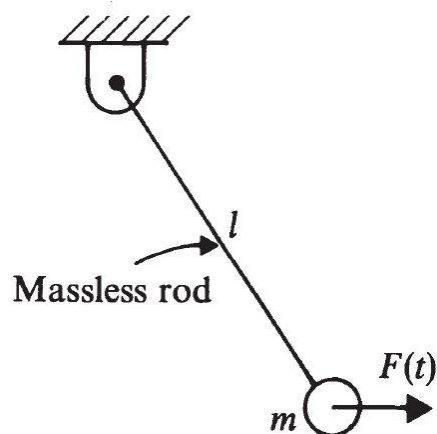


Fig. 8

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