UNSW Sydney

School of Mechanical and Manufacturing Engineering

MMAN2300 Engineering Mechanics 2

Part A: Vibration Analysis

Tutorial 2

Q1. A 100kg mass is suspended by a spring of stiffness $30\times10^3\,\text{N/m}$ with a viscous damping constant of 1000Ns/m (1000kg/s). The mass is initially at rest. Calculate the steady state displacement amplitude and phase if the mass is excited by a harmonic force of 80N at 3Hz.

[$X = 4.07\text{mm},\ \phi = -1.29\text{rad}$]

Q2. A machine of mass 1.95 kg vibrates in a viscous medium. Determine the damping coefficient when harmonic exciting force of 24.46 N results in a resonant amplitude of 1.27 cm with a period of 0.20 s.

[55.8 kg/s]

Q3. A spring-mass system is excited by a force $F_o \sin\omega t$. At resonance, the amplitude is measured to be 0.58 cm. At 0.8 resonant frequency, the amplitude is measured to be 0.46 cm. Determine the damping ratio ζ of the system.

[0.185]

Q4. A weight attached to a spring of stiffness 525 N/m has a viscous damping device. When the weight is displaced and released, the observed period of natural vibration is 1.8 s, and the ratio of consecutive amplitudes is 4.2. Determine the steady-state amplitude and phase when a force $F(t) = 2\sin 3t$ acts on the system.

[$X = 7.97\text{mm},\ \phi = 0.898\text{rad}$]

Q5. In a resonance test under forced harmonic vibration, it was observed that the amplitude of motion at resonance was exactly twice the amplitude at an excitation frequency 20% greater than resonance. Determine the damping ratio ζ of the system.

[0.138]

Q6. A spring-mass system with m = 10 kg and k = 5000 N/m is subjected to a harmonic force of amplitude 250 N and frequency ω. If the maximum amplitude of the mass is observed to be 100 mm, find the value of ω.

[15.81 rad/s]

Q7. Consider a spring-mass-damper system with k = 4000 N/m, m = 10kg and c = 40 Ns/m. Find the steady-state and total responses of the system under the harmonic force $F(t)$ = 200sin10t N and the initial conditions x_o = 0.1 m and $\dot{x}_o$ = 0.

[$x(t) = 0.1109e^{-2t}\left(\sin 19.9t - 1.37\right) + 0.066\sin(10t - 0.13255)\,\text{m}$]

Q8. Consider a spring-mass-damper system with k = 4000 N/m, m = 10kg and c = 40 Ns/m. Find the total response of the system under the harmonic force $F(t)$ = 200sin10t N and the initial conditions x_o = 0 and $\dot{x}_o$ = 10 m/s.

[$x(t) = 0.47e^{-2t}(\sin 19.9t + 0.0186) + 0.066\sin(10t - 0.13255)\,\text{m}$]

Q9. A machine weighs 20 kg and supported on springs of total stiffness 10 kN/m has an unbalanced rotating element which generates a 8000 N disturbing force at 3000 rpm. Assuming a damping ratio of $\zeta = 0.2$, determine: (i) the amplitude of the motion due to the unbalance, and (ii) the transmitted force.

[4.07mm, 232.4N]

Q10. A vibrating mass of 300 kg, mounted on a massless support by a spring of stiffness 40 kN/m and a damper of unknown damping coefficient, is observed to vibrate with a 10 mm amplitude while the support has a maximum amplitude of only 2.5 mm (at resonance). Find the damping coefficient and the amplitude of the transmitted force from the base to the mass.

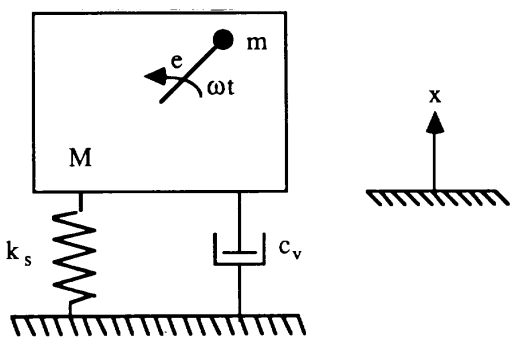
[894.4kg/s, 400.3N]

Q11. An electric motor is flexibly mounted on springs of total stiffness 87,600 N/m. The motor has an unbalanced mass of 28.5 g at a radius of 0.15 m. When the motor was not running, it was initially displaced and released. The natural frequency of oscillation was observed to be 15Hz. The amplitude ratio after twenty-one oscillations was 1.1. What vibration amplitude will the system have when the motor is running at 1800 rpm?

[0.58 mm]

Q12. A counter-rotating eccentric mass is used to produce forced oscillations of a spring-damper supported mass as shown in the figure below. By varying the speed of rotation, a resonant amplitude of 16 mm is recorded. When the speed of rotation is increased considerably beyond the resonant frequency, the amplitude approaches a constant value of 1.52 mm. Estimate the damping ratio of the system.

[0.0475]



Q13. An electric motor has a mass of 25 kg and is mounted on a beam cantilevered from a vertical wall. If the motor is displaced 16 mm in the *x*-direction as shown in the figure below, the vibration of the motor and beam is observed to dampen to 1 mm in 4 cycles. If the motor is unbalanced, estimate the value of the dimensionless amplitude MX/me for resonant forced vibration. What is the transmission ratio for $\omega/\omega_n = 5$?

[4.56, 0.062]