National Institute of Technology Silchar
Waves and oscillation

Q. 1: The Q value of an underdamped harmonic oscillator of frequency 480 Hz is 80000. Calculate the time in which its amplitude reduces to $1/e$ of its initial value. How many oscillations does it make in this time?

Q. 2: A 0.5 kg mass is attached to a spring of spring constant 150 N/m. A driving force $F(t) = 12\cos(\omega\, t)$ N is applied to the mass, and the damping coefficient γ is 6 Ns/m. What is the amplitude of the steady-state motion if ω is equal to half of the natural frequency ω_0 of the system? Find the phase difference between the forced oscillation and the driving force.

Q. 3: Amplitude of a damped harmonic oscillator decreases by 5% during each oscillatory cycle. Find the percentage of mechanical energy of the oscillator that is lost in each cycle.

Q. 4: Consider a damped harmonic oscillator of the form $\ddot{x} + 2\dot{x} + 10\,x = 0$. If $x(0) = 4$ and $\dot{x}(0) = -4$, find the solution.

Q. 5: The equation of motion of a damped harmonic oscillator is of the form $\ddot{x}+2\dot{x}+10\,x = 0$. Suggest and explain the nature of damping. Find the frequency of oscillation and the Q value of the oscillator.

Q. 6: Consider a spring mass system with mass $m = 2$, spring constant $k = 3$, and damping constant $c = 1$. Is this system underdamped, overdamped or critically damped?

Q. 7: The Q value of a spring loaded with 0.3 kg is 60. It vibrates with a frequency of 2 Hz. Calculate the force constant and mechanical resistance.

Q. 8: The Q-value of an under-damped harmonic oscillator of frequency 480 Hz is 80000. Calculate the time in which its amplitude reduces to 1/e of its initial value. How many oscillations does it make in this time?

Q. 9: Show that the ratio of two successive maxima in the displacement of a damped harmonic oscillator is constant.

Q. 10: The energy of a piano string of frequency 256 Hz reduces to half of its initial value in 2 s. What is the Q-value of the string?

Q. 11: In the equation $\ddot{x} + b\,\dot{x} + x = 0$, find the value of b so that it will represent a critically damped system.

Q. 12: After a big earthquake, seismologists determined the vibrating Earth has a time period of 54 min and a Q value of about 400. Find the percentage of the energy lost to damping forces during each cycle.

Q. 13: A weakly damped oscillator is driven by a force $F = F_0 \cos\omega\, t$, where F_0 is the amplitude. It is observed that the amplitude of the steady state oscillations is 0.1 mm at very low values of ω and attains a maximum value of 10 cm when $\omega = 100\,\mathrm{rad\,s^{-1}}$. Calculate the Q value of the system.

Q. 14: Consider a spring mass system with mass $m = 2$, spring constant $k = 3$, and damping coefficient $\gamma = 1$.
a) Set up the equation of motion and find the general solution of the system.
b) Is the system under-damped, over-damped or critically damped? c) If the system is not critically damped, find a value of c that makes the system critically damped.

Q. 15: A critically damped oscillator is represented by $\ddot{x} + 4\,\dot{x} + 4\,x = 0$, where the coefficients are in SI units. It is initially at $x = 0$ with velocity $6\,\mathrm{m\,s^{-1}}$. What is the maximum displacement of the oscillator from the origin?
Q. 16: The frequency of an underdamped harmonic oscillator is adjusted to be equal to the half frequency experienced by the oscillator without damping. Calculate the logarithmic decrement of the system.

Q. 17: A simple pendulum has a period of 1 sec and an amplitude of 10. After 10 complete oscillations, its amplitude is reduced to 5. what is the relaxation time of the pendulum and quality factor?

Q. 18: A damped vibrating system starting from rest reaches the first amplitude of 300 mm which reduces to 30 mm in that direction after 100 vibrations each of period 1.5 sec. Find the damping coefficient.