Free Vibration

Mechanical Engineering

Two numbers describe any mount: natural frequency and damping ratio.

An undamped mass on a spring oscillates at one natural frequency, set only by stiffness and mass.

$$\omega n = \sqrt{(k \div m)} \cdot \text{zeta} = c \div 2\sqrt{(km)} \cdot \omega d = \omega n\sqrt{(1 - \text{zeta}^2)}$$

k = 4000 N/m, m = 10 kg → **ωn = 20 rad/s**

About 3.2 Hz.

zeta = 0.05 → **ωd is 99.9% of ωn**

Barely shifted.

zeta = 1 → **Critically damped**

Fastest, no overshoot.

THE COMMON MISTAKE

× Adding mass to cure a resonance

✓ Check which way ωn moves

Natural frequency falls as mass rises. If the forcing sits above resonance, extra mass drags ωn towards it and makes the vibration worse.

Assumes small amplitude and linear stiffness. Real rubber mounts stiffen as they deflect.