21-R-VIB-SS-53

A m=2000kg car is driving on a road with bumps of wavelength λ=2m. The car's suspension system effectively have a spring constant of k=15kN/m and damping coefficient of 20kNs/m. At what speed will the car feel he most vibrations?

Solution

The car feels the greatest vibrations when it experiences resonance. We want $\omega_{\text{driving}} = \omega_{\text{system}}$. ω_{system} is the frequency of damped oscillations.

$$\begin{aligned}\omega_{\text{natural}} &= \sqrt{\frac{k}{m}} \\ &= 7.071 \quad [\text{ rad/s }]\end{aligned}$$

$$\begin{aligned}\zeta &= \frac{c}{2m\omega_{\text{natural}}} \\ &= 0.530\end{aligned}$$

$$\begin{aligned}\omega_{\text{damped}} &= \omega_{\text{natural}}\sqrt{1-\zeta^2} \\ &= 5.99 \quad [\text{ rad/s }]\end{aligned}$$

We can use the period of the oscillation to find the speed of the car.

$$\begin{aligned}\tau &= \frac{2\pi}{\omega_{\text{damped}}} \\ &= 1.048\end{aligned}$$

$$\begin{aligned}v &= \frac{\lambda}{\tau} \\ &= 1.91 \quad [\text{ m/s }]\end{aligned}$$