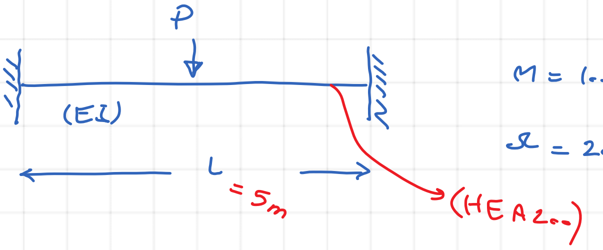
In the previous video, we analyzed the response of a system under harmonic loading, ignoring the effect of damping. In this video, we will delve deeper into the topic by solving a practical example that will allow us to explore the impact of various factors, including the loading frequency, on the system's response. By examining these factors, we will better understand how the system behaves under different conditions and how we can optimize its performance.

$$u(t) = \underbrace{u_0 \cos \omega t + \left(\frac{\dot{u}_0}{\omega} - \frac{P_0}{k} \cdot \frac{\beta}{1-\beta^2} \right) \sin \omega t}_{\text{transient vibration}} + \underbrace{\frac{P_0}{k} \cdot \frac{1}{1-\beta^2} \sin \Omega t}_{\text{steady vibration}}$$



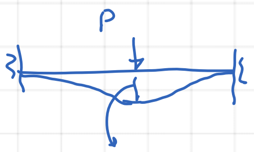
$M = 100$ kg

$\Omega = 20 \ \frac{rad}{sec}$

$E = 200$ GPa

$P(t) = P_0 \cdot \sin(20t)$

$M \cdot g = 100 \text{ kg} \times 9.81 \ \frac{m}{s^2} = 981 \ N$



$$\delta = \frac{PL^3}{192 EI} \rightarrow K = \frac{P}{\delta} = \frac{192 EI}{L^3}$$

$E := 200 \ GPa$ $\quad I := 36.92 \cdot 10^6 \cdot mm^4$ $\quad M := 100 \ kg$ $\quad l := 5 \ m$ $\quad \Omega := 20 \ \frac{rad}{s}$

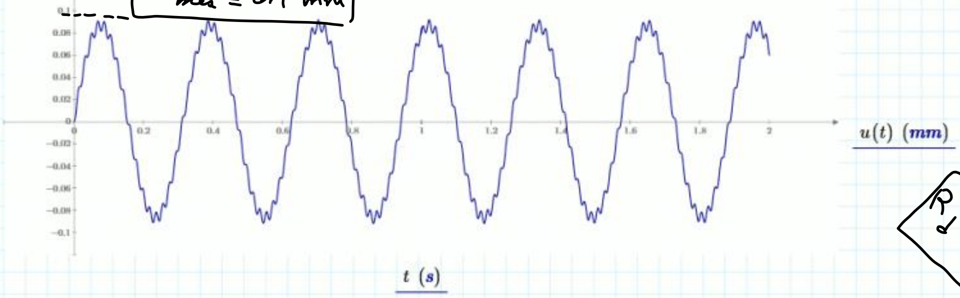
$k := \frac{192 \cdot E \cdot I}{l^3} = (1.134 \cdot 10^4) \ \frac{kN}{m}$ $\quad w := \sqrt{\frac{k}{M}} = 336.776 \ \frac{rad}{s}$ $\quad T := \frac{2 \cdot \pi}{w} = 0.019 \ s$ $\quad f := \frac{1}{T} = 53.6 \ Hz$

$\beta := \frac{\Omega}{w} = 0.059$ $\quad P_0 := M \cdot g$ $\quad u_0 := 0 \ mm$ $\quad u'_0 := 0 \ \frac{mm}{s}$

$$u(t) := \underbrace{u_0 \cdot \cos(w \cdot t) + \left(\frac{u'_0}{w} - \frac{P_0}{k} \cdot \frac{\beta}{1-\beta^2} \right) \cdot \sin(w \cdot t)}_{\text{Transient}} + \underbrace{\frac{P_0}{k} \cdot \frac{1}{1-\beta^2} \cdot \sin(\Omega \cdot t)}_{\text{stead\_state}}$$

$t := 0, 0.001 \ s .. 2 \ s$

$\boxed{u_{max} = 0.1 \ mm}$



$U_{max} \rightarrow$ Maximum displacement

$U_{st} \rightarrow P_0 / k$

$D = \frac{U_{max}}{U_{st}}$ (dynamic magnification factor)

$R_d = \underline{(U_{max})\ steady\_state} / U_{st}$

$R_d = \frac{P_0/k \cdot \frac{1}{1-\beta^2}}{P_0/k}$

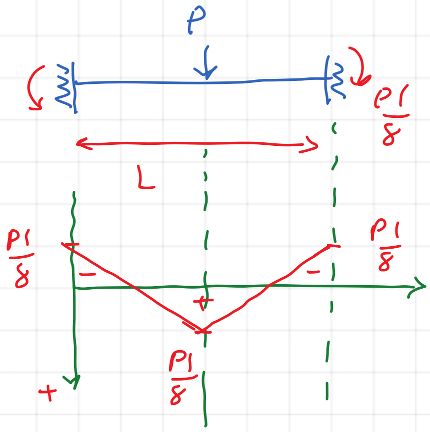
$\boxed{R_d = \frac{1}{1-\beta^2}}$

$\beta = 0.059$

$v_{max} = 0.1 \text{ mm}$

$$v_{st} = \frac{P_0}{k} = \frac{981 \text{ N}}{1.134 \times 10^{4} \text{ N/mm}} = 0.086 \text{ mm}$$

$$D = \frac{v_{max}}{v_{st}} = 1.16 \qquad R_d = \frac{1}{1-\beta^2} = 1.0035$$



$P = 981 \text{ N}$

$L = 5 \text{ m}$

$$M_{st} = \frac{Pl}{8} = 613 \text{ N m}$$

Maximum Bending moment for the entire harmonic load being applied

$$613 \times \underset{1.16}{\underset{\downarrow}{D}} = 711 \text{ N·m}$$