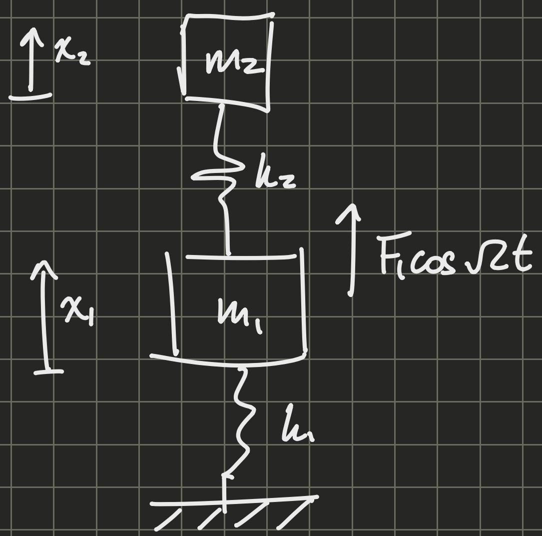
Lezione 13 – TMD

TMD ⇒ Tuned-Mass Damper

TMD Analysis → 2 dof approach

Dynamic Shock Absorber undamped



Absorber $\omega_2 = \sqrt{\dfrac{k_2}{m_2}}$

system we're trying to protect $\omega_1 = \sqrt{\dfrac{k_1}{m_1}}$

$\mu = \dfrac{m_2}{m_1}$

The system will vibrate more if $\omega_1 \approx \Omega$

Equation of motion:

pg. 4

$$\frac{X_1}{F_1} = \frac{-m_2\Omega^2 + k_2}{(-m_1\Omega^2 + k_1 + k_2)(-m_2\Omega^2 + k_2) - k_2^2}$$

Adding the dynamic absorber, we change were our system resonates (changing km 10 → 8) but this only work if our vibration is very fixed and it adds another resonance frequency.

With $\Omega = \omega_1 = \omega_2$:

$$\left.\begin{aligned} \frac{X_1}{F_1} &= 0 \\ \frac{X_2}{F_1} &= -\frac{1}{k_2} \end{aligned}\right\}$$ The absorber is moving a lot and the mass, not because the global equilibrium is null.

This is only a theoretical case, which won't work in real life, because F_1 needs to be precise and in real systems there is damping

Dimensionless | Design Parameters:

$$a_1 = \frac{\Omega}{\omega_1}$$

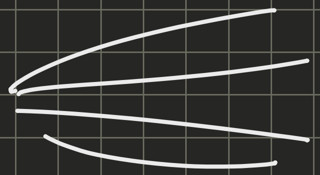
$$a_2 = \frac{\Omega}{\omega_2} = \frac{\Omega}{\omega_1} \frac{\omega_1}{\omega_2} = \frac{a_1}{f}$$

$$f = \frac{\omega_2}{\omega_1} \qquad \mu = \frac{m_2}{m_1} \qquad \frac{k_2}{k_1} = \frac{\omega_2^2 m_2}{\omega_1^2 m_1} = f^2 \mu$$

↳ mass ratio

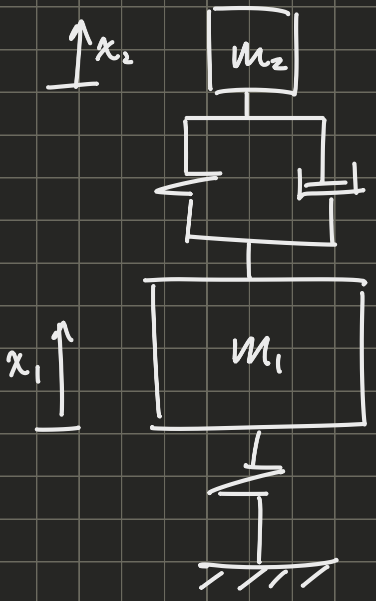
$$\delta_{ST} = \frac{F_1}{k_1}$$

→ Deflection of main system in static case

8:55  diagram

With f and μ we are able to tune how far the resonance frequencies are

Real System → TMD



We add m_2 to balance the force F on m_1.

We increase the damping without adding a damper to the group

This is similar to how skyscrapers use masses to dampen the system.

pg. 15 By adding a dampers we decrease the resonance, but in some areas it's worse.
Adding the damper we increase the range of frequencies at which we are able to reduce the vibration (not just 10)

Another design parameter:

$$h = \frac{r_2}{r_{crit}}$$

Our design is now based on how much energy we can dissipate:

pg. 18, 19

pg. 20 → we can see how h changes with h

We try to find the optimal h. We don't want to increase h too much since it will mean the masses start to move as one

Changing f at different h, we have two fixed point, but everything is moved up or down a bit.

We have

μ, f, h

Our target is to dampen the system as much as possible with the lightest TMD possible

- we need to contain the movement of the TMD
- stiffness of the system.

Electrical Cable Damper

↳ 4 dof system since the TMD needs to block a large range of frequencies since wind exite different modes of the cables.

Arcler around viaduct for EXPO 2015