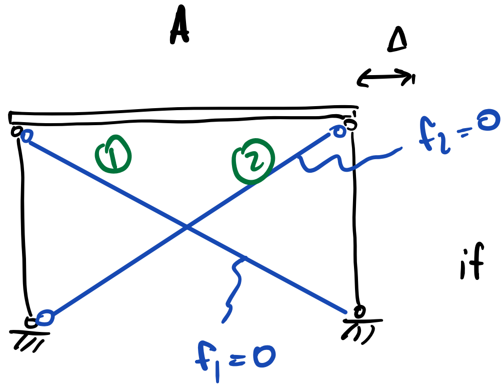
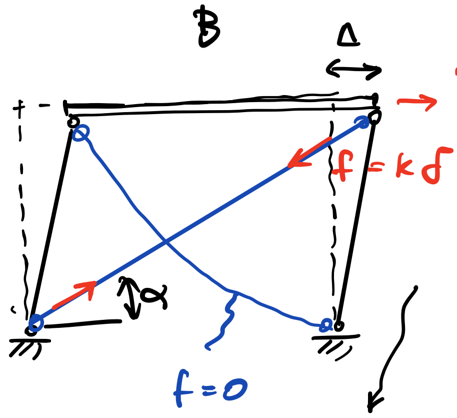
How does pre-stress work?



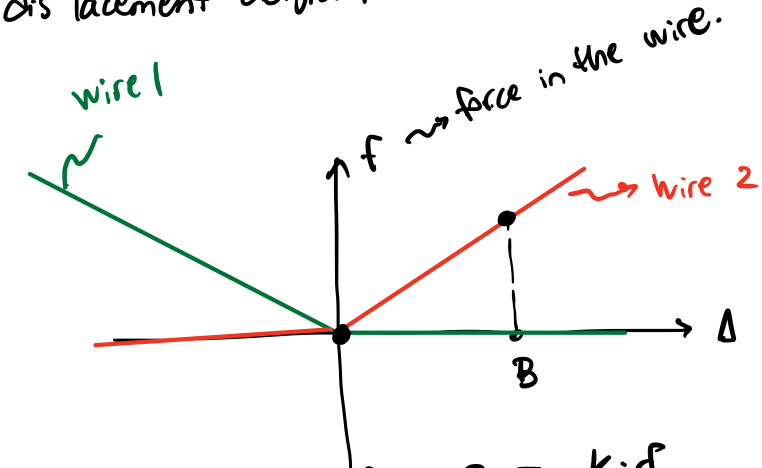
→ if not pre-tensioned



know that:

$\delta = \Delta \cdot \cos(\alpha)$

in a force-displacement diagram:

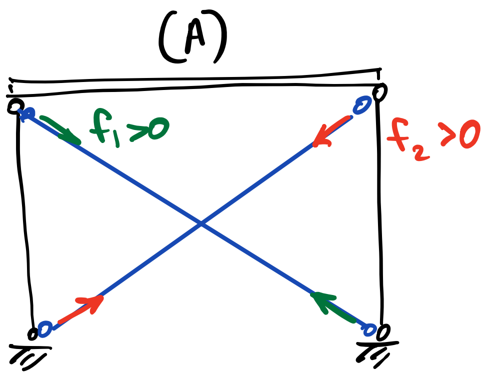


→ for $\Delta > 0$ → $f_2 > 0 = k \cdot \delta$ $\quad f_1 = 0$

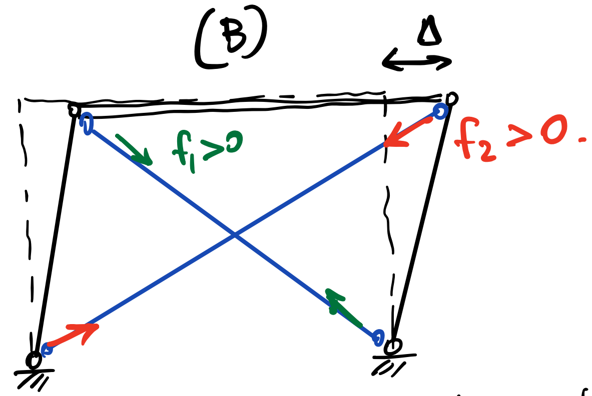
for $\Delta < 0$ → $f_1 > 0 = k \cdot \delta$ $\quad f_2 = 0$

then, only one of the wires contributes to the lateral resistance to motion.

If we have a pre-tensioned system

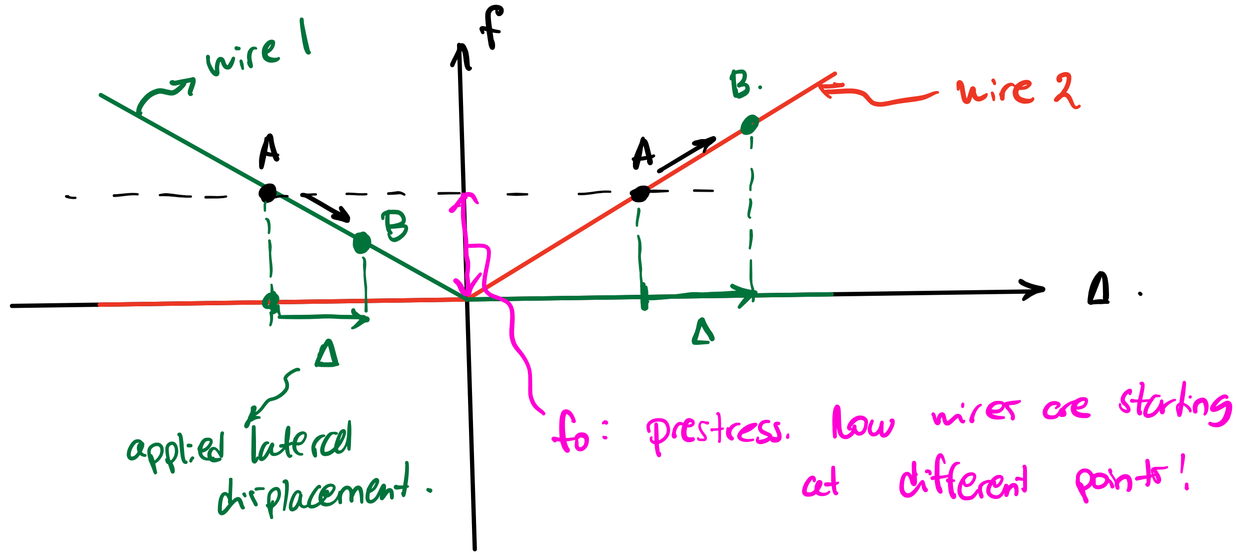


→



both wires are still in tension after deformation!

Let's see where they are in the f-Δ diagram:



the deformations on the wires follow the kinematics:

$$\delta_1 = -\Delta \cdot \cos(\alpha) \qquad \delta_2 = \Delta \cdot \cos(\alpha)$$

↖ shortens ↪ stretches.

and the change on the internal force on each wire follows the material constitutive behavior $(f = k \cdot \delta)$

wire 1

$$\Delta f_1 = \delta_1 \cdot k = -\Delta \cdot \cos(\alpha) \cdot k$$

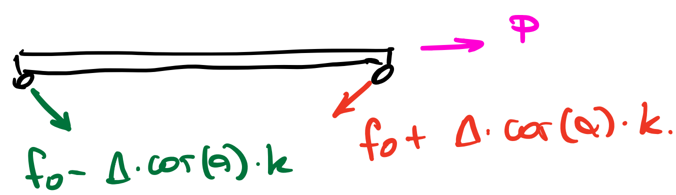
wire 2.

$$\Delta f_2 = \delta_2 \cdot k_2 = \Delta \cdot \cos(\alpha) \cdot k.$$

So, after deformation, the force on each wire is:

$$f_1 = f_0 - \Delta \cdot \cos(\alpha) \cdot k \qquad f_2 = f_0 + \Delta \cdot \cos(\alpha) \cdot k.$$

FBD:



$$\Sigma F_x = 0$$

$$-(f_0 - \Delta \cdot \cos(\alpha) \cdot k) \cdot \cos(\alpha) + (f_0 + \Delta \cdot \cos(\alpha) \cdot k) \cdot \cos(\alpha) = P$$

and $\Rightarrow \quad P = 2k \cdot \cos^2(\alpha)$