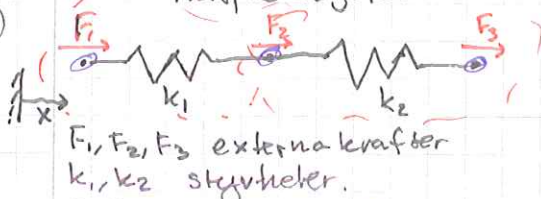
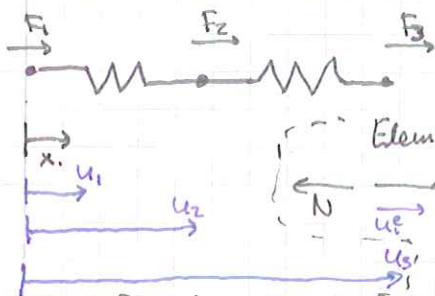


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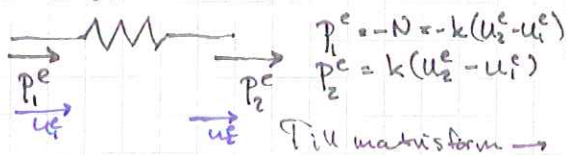
Tvåfjädersystem.



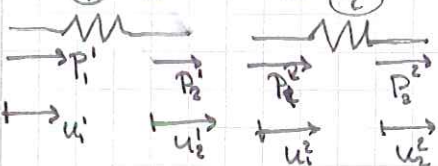
- Definiera noder
- Definiera element



Vi ritar om kräfterna



$$\begin{pmatrix} K & -K \\ -K & K \end{pmatrix} \begin{pmatrix} u_1^e \\ u_2^e \end{pmatrix} = \begin{pmatrix} P_1^e \\ P_2^e \end{pmatrix} \quad K^e a = f^e$$



Element 1.

Element 2.

$$\begin{pmatrix} k_1 & -k_1 \\ -k_1 & k_1 \end{pmatrix} \begin{pmatrix} u_1^1 \\ u_2^1 \end{pmatrix} = \begin{pmatrix} P_1^1 \\ P_2^1 \end{pmatrix}$$

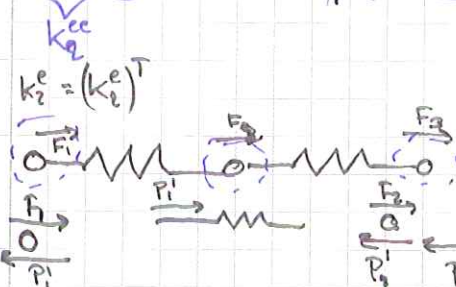
$$\begin{pmatrix} k_2 & -k_2 \\ -k_2 & k_2 \end{pmatrix} \begin{pmatrix} u_2^2 \\ u_3^2 \end{pmatrix} = \begin{pmatrix} P_2^2 \\ P_3^2 \end{pmatrix}$$

Kinematisk kompatibilitet:

$$\begin{pmatrix} u_1 \\ u_2 \\ u_3 \end{pmatrix} = \begin{pmatrix} u_1 \\ u_2 \\ u_2 \end{pmatrix} \quad \begin{pmatrix} k_1 & -k_1 \\ -k_1 & k_1 \end{pmatrix} \begin{pmatrix} u_1 \\ u_2 \end{pmatrix} = \begin{pmatrix} P_1^1 \\ P_2^1 \end{pmatrix}$$

Expandera (inför alla frihetsgrader)

$$\begin{pmatrix} k_1 & -k_1 & 0 \\ -k_1 & k_1 & 0 \\ 0 & 0 & 0 \end{pmatrix} \begin{pmatrix} u_1 \\ u_2 \\ u_3 \end{pmatrix} = \begin{pmatrix} P_1^1 \\ P_2^1 \\ 0 \end{pmatrix}$$



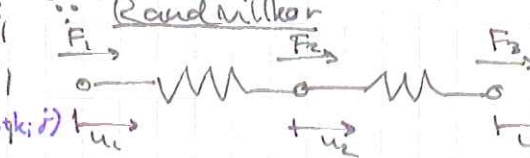
$$\begin{pmatrix} F_1 \\ F_2 \\ F_3 \end{pmatrix} = \begin{pmatrix} P_1^1 \\ P_2^1 \\ 0 \end{pmatrix} + \begin{pmatrix} 0 \\ P_2^2 \\ P_3^2 \end{pmatrix}$$

$$K_i^e a = f_i^e; K_2^e a = f_2^e \Rightarrow \{f = f_1 + f_2\}$$

$$K_i^e a + K_2^e a = f \Rightarrow (K_i^e + K_2^e) a \Rightarrow K a = f$$

$$K = \begin{pmatrix} k_1 & -k_1 & 0 \\ -k_1 & k_1+k_2 & -k_2 \\ 0 & -k_2 & k_2 \end{pmatrix}$$

Determinanten för styghetsmatrisen blir 0, ty vi har ej fäst kroppen.



$$\begin{pmatrix} k_1 & -k_1 & 0 \\ -k_1 & k_1+k_2 & -k_2 \\ 0 & -k_2 & k_2 \end{pmatrix} \begin{pmatrix} u_1 \\ u_2 \\ u_3 \end{pmatrix} = \begin{pmatrix} F_1 \\ F_2 \\ F_3 \end{pmatrix}$$

Kan aldrig föreskriva kraft och förskjutning i samma punkt $\Rightarrow F_1, u_2, u_3 = ?$ (okända).

$$\det(K) = k_1 k_2 > 0$$

$$I = a^T K a = k_1 (u_1 - u_2)^2 + k_2 (u_2 - u_3)^2 > 0$$

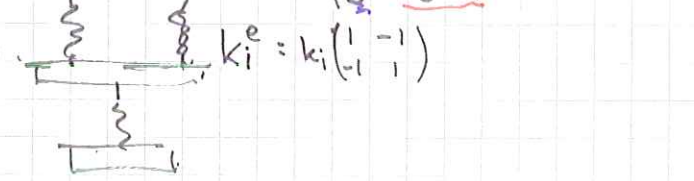
Viken hitte ett $a \neq 0$ som ger $I = 0$. Stelkroppsrörelser måste förhindras!

Positivt definit! Positivt definit! Positivt definit!

1. Etablera elementstyvmatriserna
2. Kompatibilitet
3. Uppfyll punkt.
4. Assemblera
5. Randvillkor

Utdelat papper med fjädersystem.

$$K = \begin{pmatrix} 1 & 1 & 2 \\ 2 & 1 & 2 \\ 3 & 2 & 3 \\ 4 & 1 & 3 \\ 5 & 3 & 4 \end{pmatrix}$$



$$K_i^e = k_i \begin{pmatrix} 1 & -1 \\ -1 & 1 \end{pmatrix}$$