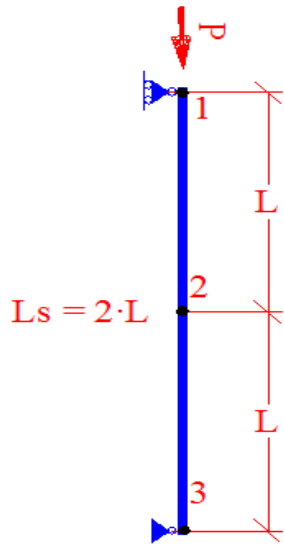


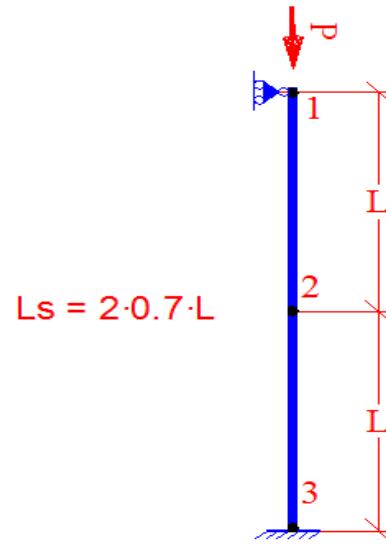
[ > Opgave 4.22. Løsningsforslag

Søjle 2, løsningsforslag med 2 elementer.

April 2010, LC



Søjle 1



Søjle 2

$$K = E \cdot I \cdot \begin{pmatrix} \frac{12}{L^3} & -\frac{6}{L^2} & -\frac{12}{L^3} & -\frac{6}{L^2} & 0 & 0 \\ -\frac{6}{L^2} & \frac{4}{L} & \frac{6}{L^2} & \frac{2}{L} & 0 & 0 \\ -\frac{12}{L^3} & \frac{6}{L^2} & \frac{24}{L^3} & 0 & -\frac{12}{L^3} & -\frac{6}{L^2} \\ -\frac{6}{L^2} & \frac{2}{L} & 0 & \frac{8}{L} & \frac{6}{L^2} & \frac{2}{L} \\ 0 & 0 & -\frac{12}{L^3} & \frac{6}{L^2} & \frac{12}{L^3} & \frac{6}{L^2} \\ 0 & 0 & -\frac{6}{L^2} & \frac{2}{L} & \frac{6}{L^2} & \frac{4}{L} \end{pmatrix}$$

$$u_1 = 0 \quad u_3 = 0 \quad r_3 = 0$$

L svarer til figuren

$$K_{\text{mod}} = E \cdot I \cdot \begin{pmatrix} \frac{4}{L} & \frac{6}{L^2} & \frac{2}{L} \\ \frac{6}{L^2} & \frac{24}{L^3} & 0 \\ \frac{2}{L} & 0 & \frac{8}{L} \end{pmatrix}$$

$$K_{\sigma} = P \cdot \begin{pmatrix} \frac{6}{5 \cdot L} & -\frac{1}{10} & -\frac{6}{5 \cdot L} & -\frac{1}{10} & 0 & 0 \\ -\frac{1}{10} & \frac{2 \cdot L}{15} & \frac{1}{10} & -\frac{1}{30} \cdot L & 0 & 0 \\ -\frac{6}{5 \cdot L} & \frac{1}{10} & \frac{12}{5 \cdot L} & 0 & -\frac{6}{5 \cdot L} & -\frac{1}{10} \\ -\frac{1}{10} & -\frac{1}{10} \cdot L & 0 & \frac{4 \cdot L}{15} & \frac{1}{10} & -\frac{1}{10} \cdot L \end{pmatrix}$$

$$K_{\sigma, \text{mod}} = P \cdot \begin{pmatrix} \frac{2 \cdot L}{15} & \frac{1}{10} & -\frac{1}{30} \\ \frac{1}{10} & \frac{12}{5 \cdot L} & 0 \\ -\frac{1}{30} & 0 & \frac{4 \cdot L}{15} \end{pmatrix}$$

$$\mathbf{k}_G = N \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & \frac{6}{5} \frac{1}{l} & \frac{1}{10} & 0 & -\frac{6}{5} \frac{1}{l} & \frac{1}{10} \\ 0 & \frac{1}{10} & \frac{2}{15} l & 0 & -\frac{1}{10} & -\frac{1}{30} l \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & -\frac{6}{5} \frac{1}{l} & -\frac{1}{10} & 0 & \frac{6}{5} \frac{1}{l} & -\frac{1}{10} \\ 0 & \frac{1}{10} & -\frac{1}{30} l & 0 & -\frac{1}{10} & \frac{2}{15} l \end{bmatrix}$$

restart

$$> Kmod := E \cdot I_y \cdot \begin{bmatrix} \frac{4}{L} & \frac{6}{L^2} & \frac{2}{L} \\ \frac{6}{L^2} & \frac{24}{L^3} & 0 \\ \frac{2}{L} & 0 & \frac{8}{L} \end{bmatrix}$$

$$Kmod := \begin{bmatrix} 2.039100000 \cdot 10^9 & 1.529325 \cdot 10^6 & 1.019550000 \cdot 10^9 \\ 1.529325 \cdot 10^6 & 3058.650000000000 & 0. \\ 1.019550000 \cdot 10^9 & 0. & 4.078200000 \cdot 10^9 \end{bmatrix} \quad (1)$$

$$> Ksmod := P \cdot \begin{bmatrix} \frac{2 \cdot L}{15} & \frac{1}{10} & -\frac{1}{30} \cdot L \\ \frac{1}{10} & \frac{12}{5 \cdot L} & 0 \\ -\frac{1 \cdot L}{30} & 0 & \frac{4 \cdot L}{15} \end{bmatrix}$$

$$Ksmod := \begin{bmatrix} \frac{800000}{3} & 100 & -\frac{200000}{3} \\ 100 & \frac{6}{5} & 0 \\ -\frac{200000}{3} & 0 & \frac{1600000}{3} \end{bmatrix} \quad (2)$$

$$> Arb := Kmod - \lambda \cdot Ksmod$$

$$Arb := \left[ \left[ -\frac{800000}{3} \lambda + 2.039100000 \cdot 10^9, -100 \lambda + 1.529325 \cdot 10^6, \frac{200000}{3} \lambda + 1.019550000 \cdot 10^9 \right], \right] \quad (3)$$

$$\left[ -100 \lambda + 1.529325 \cdot 10^6, -\frac{6}{5} \lambda + 3058.650000000000, 0. \right],$$

$$\left[ \frac{200000}{3} \lambda + 1.019550000 \cdot 10^9, 0., -\frac{1600000}{3} \lambda + 4.078200000 \cdot 10^9 \right]$$

> Cra := LinearAlgebra[Determinant](Arb)

$$Cra := -160000000000 \lambda^3 + 2.990680000000000 \cdot 10^{15} \lambda^2 - 1.33053721920000 \cdot 10^{19} \lambda + 1.27176489547065 \cdot 10^{22} \quad (4)$$

> Cra = 0

$$-160000000000 \lambda^3 + 2.990680000000000 \cdot 10^{15} \lambda^2 - 1.33053721920000 \cdot 10^{19} \lambda + 1.27176489547065 \cdot 10^{22} = 0 \quad (5)$$

> E := 210000

$$E := 210000 \quad (6)$$

> Iy := 4.855 · 10<sup>6</sup>

$$Iy := 4.855000000 \cdot 10^6 \quad (7)$$

> P := 1000

$$P := 1000 \quad (8)$$

> L := 2000

$$L := 2000 \quad (9)$$

> Cra = 0

$$-160000000000 \lambda^3 + 2.990680000000000 \cdot 10^{15} \lambda^2 - 1.33053721920000 \cdot 10^{19} \lambda + 1.27176489547065 \cdot 10^{22} = 0 \quad (10)$$

> solve( { (10) }, [λ] )

$$[[\lambda = 1319.603605], [\lambda = 4785.606764], [\lambda = 12586.53963]] \quad (11)$$

> Pcr := 1319.6 · 1000

$$Pcr := 1.3196000 \cdot 10^6 \quad (12)$$

$$Pcr = \frac{\pi^2 \cdot Iy \cdot E}{Ls^2}$$

$$1.3196000 \cdot 10^6 = \frac{1.006255517 \cdot 10^{13}}{Ls^2} \quad (13)$$

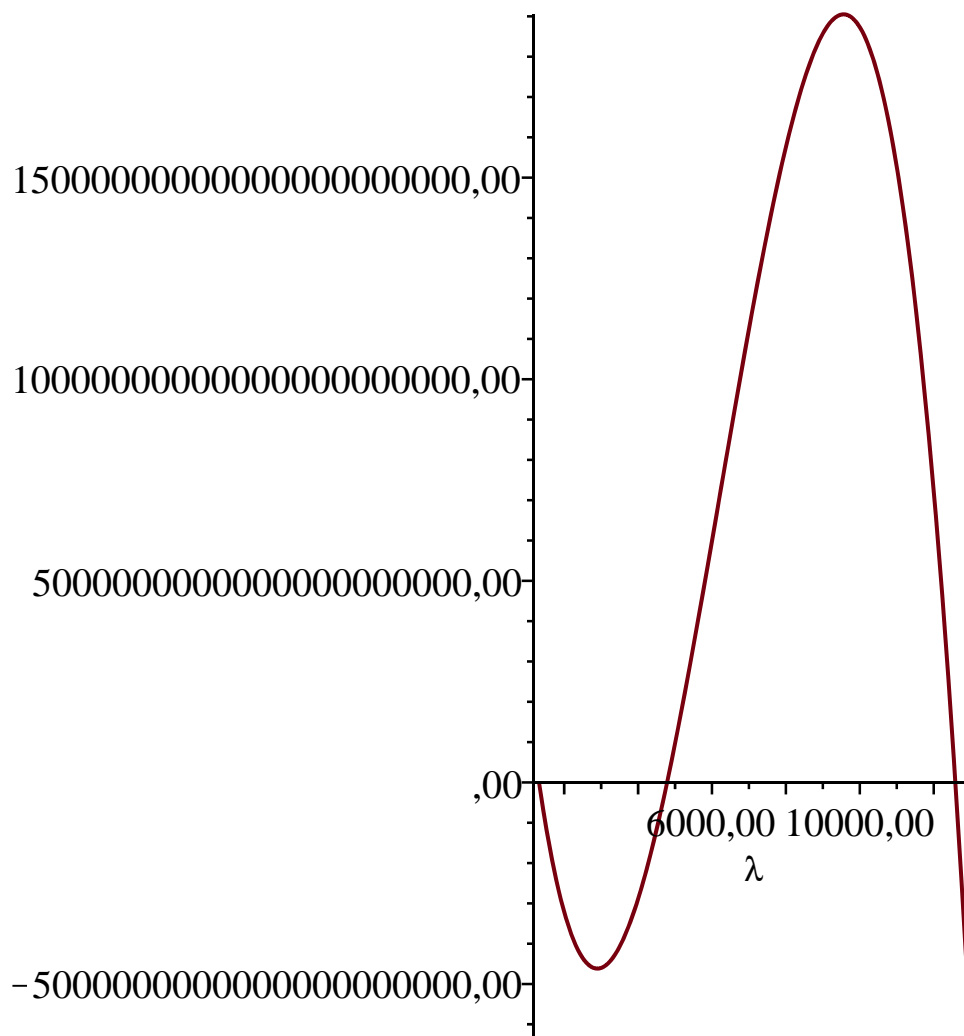
> solve( { Pcr = π<sup>2</sup> \* Iy \* E / Ls<sup>2</sup> }, [Ls] )

$$[[Ls = 2761.423293], [Ls = -2761.423293]] \quad (14)$$

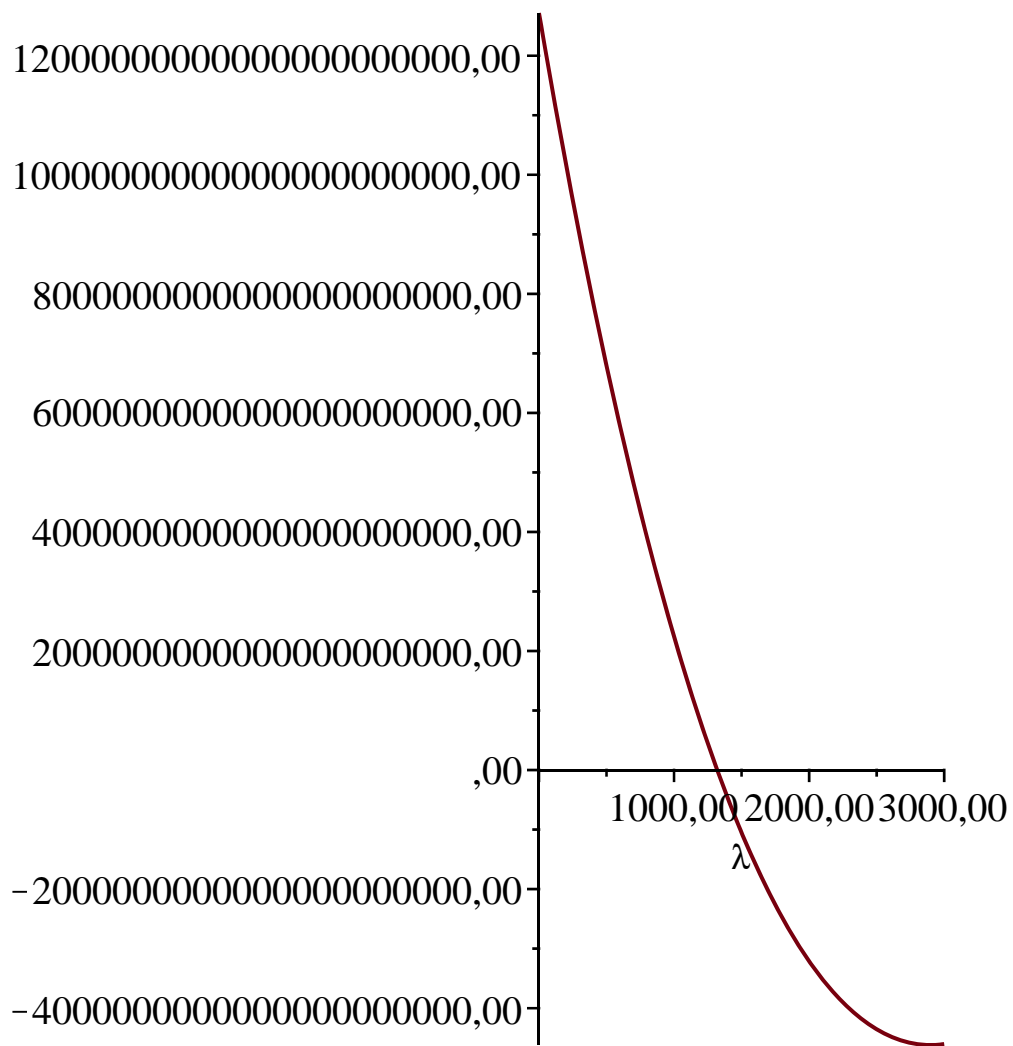
$$f(\lambda) := \frac{2}{75} \frac{-3 L^6 P^3 \lambda^3 + 220 E Iy L^4 P^2 \lambda^2 - 3840 E^2 Iy^2 L^2 P \lambda + 14400 E^3 Iy^3}{L^5}$$

$$f := \lambda \rightarrow .03 \frac{-3.00 L^6 P^3 \lambda^3 + 220.00 E Iy L^4 P^2 \lambda^2 - 3840.00 E^2 Iy^2 L^2 P \lambda + 14400.00 E^3 Iy^3}{L^5} \quad (15)$$

> plot(f(λ), λ = 1319 .. 13000)



```
> plot(f(λ), λ=0..3000)
```



```
> plot(f(λ), λ = 1319.603605 ..1319.60361)
```

