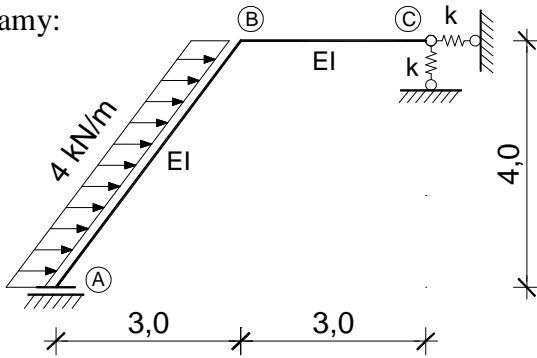


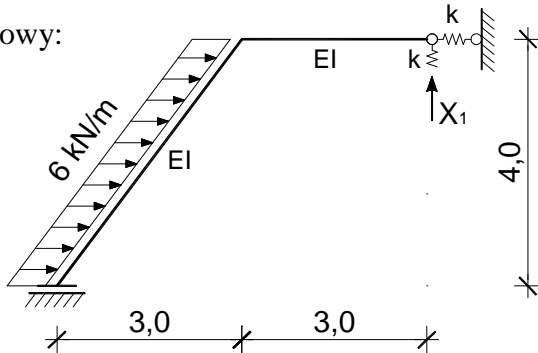
**Wyznaczyć max moment zginający w ramie (metodą sił). Wykonać sprawdzenie kinematyczne:**

Schemat ramy:



$EI = \text{const}$   
 $SSN = 1$   
 $k = EI/16$

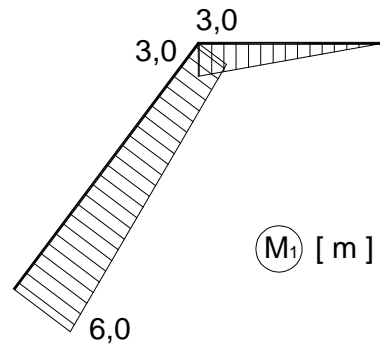
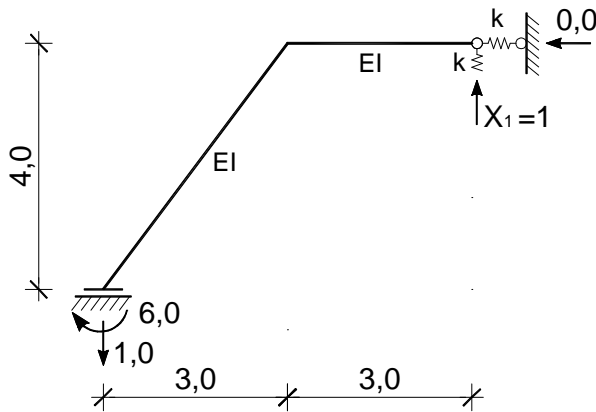
Układ podstawowy:



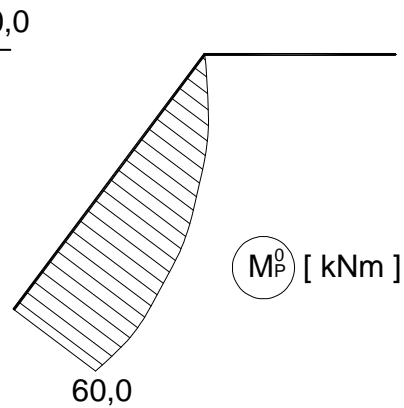
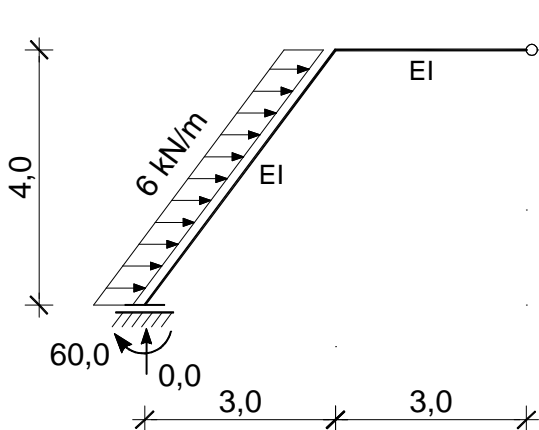
Układ równań kanonicznych:

$$\delta_{11} \cdot X_1 + \delta_{1P} = 0$$

Stan  $X_1=1$ :



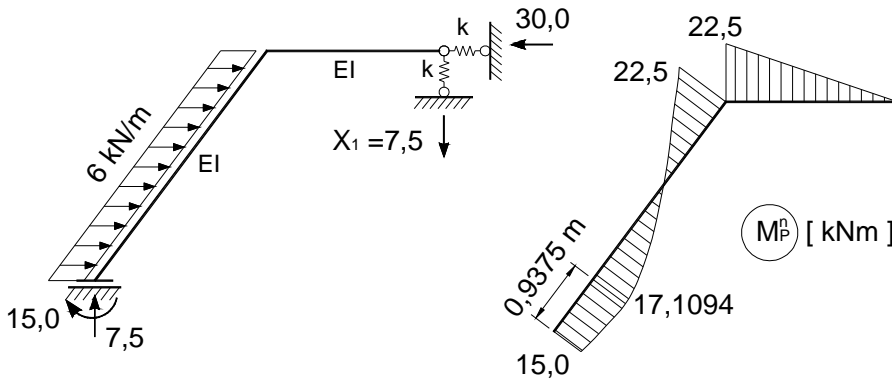
Stan „P”:



$$\delta_{11} = \sum \int_x \frac{M_1^2}{EJ} dx + \sum \frac{R_1^2}{k} = \frac{1}{EJ} \cdot \left[ \frac{1}{2} \cdot 3 \cdot 3 \cdot \frac{2}{3} \cdot 3 + \frac{1}{2} \cdot 3 \cdot 5 \cdot \left( \frac{2}{3} \cdot 3 + \frac{1}{3} \cdot 6 \right) + \frac{1}{2} \cdot 6 \cdot 5 \cdot \left( \frac{2}{3} \cdot 6 + \frac{1}{3} \cdot 3 \right) + 2 \cdot 3 \cdot 6 \right] + 0 + 1 \cdot 1 \cdot \frac{16}{EJ} = \frac{130}{EJ}$$

$$\delta_{1P} = \sum \int_x \frac{M_1 \cdot M_P^0}{EJ} dx + \sum \frac{R_1 \cdot R_P^0}{k} = \frac{1}{EJ} \cdot \left[ \frac{1}{2} \cdot 5 \cdot 60 \cdot \left( \frac{2}{3} \cdot 6 + \frac{1}{3} \cdot 3 \right) + \frac{2}{3} \cdot \frac{6 \cdot 5 \cdot 4}{8} \cdot 5 \cdot \frac{1}{2} (6+3) \right] + 0 + 0 = \frac{975}{EJ}$$

$$X_1 = -\frac{\delta_{1P}}{\delta_{11}} = -\frac{975}{EJ} \cdot \frac{EJ}{130} = -7,5 \text{ kN}$$



Wyznaczenie ekstremum  $M(x)$ :

$$T(x) = 7,5 \cdot \cos \alpha - 6 \cdot \sin \alpha \cdot x_e$$

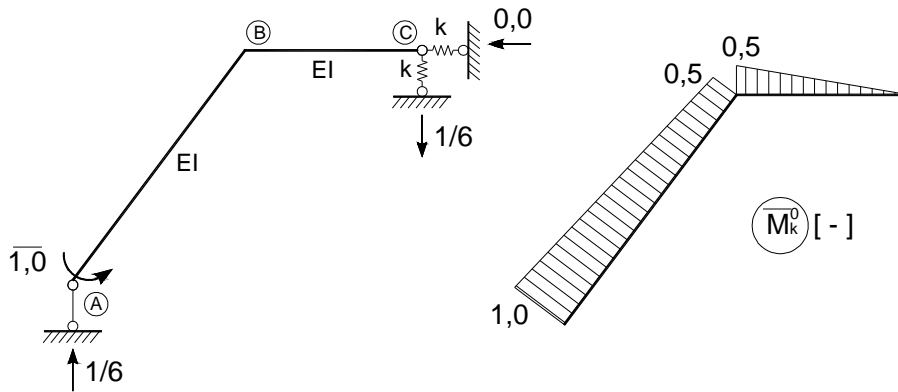
$$7,5 \cdot \cos \alpha - x_e \cdot 6 \cdot \sin \alpha = 0$$

$$x_e = 0,9375 \text{ m}$$

$$M_e = 15 + 7,5 \cdot \cos \alpha \cdot x_e - 6 \cdot \sin \alpha \cdot \frac{x_e^2}{2}$$

$$M_e = 17,1094 \text{ kNm}$$

Sprawdzenie kinematyczne:



$$\begin{aligned} \varphi_A &= \sum \int_x \frac{M_P^n \cdot \bar{M}_k^0}{EJ} dx + \sum \frac{R_P^n \cdot \bar{R}_k^0}{k} = \\ &= \frac{1}{EJ} \cdot \left[ \frac{1}{2} \cdot 3 \cdot 22,5 \cdot \frac{2}{3} \cdot \frac{1}{2} + \frac{1}{2} \cdot 5 \cdot 22,5 \cdot \left( \frac{2}{3} \cdot \frac{1}{2} + \frac{1}{3} \cdot 1 \right) - \frac{1}{2} \cdot 5 \cdot 15 \cdot \left( \frac{2}{3} \cdot 1 + \frac{1}{3} \cdot \frac{1}{2} \right) - \frac{2}{3} \cdot \frac{6 \cdot 5 \cdot 4}{8} \cdot 5 \cdot \frac{1}{2} \left( 1 + \frac{1}{2} \right) \right] + 7,5 \cdot \frac{1}{6} \cdot \frac{16}{EJ} + 0 = \frac{0}{EJ} \end{aligned}$$