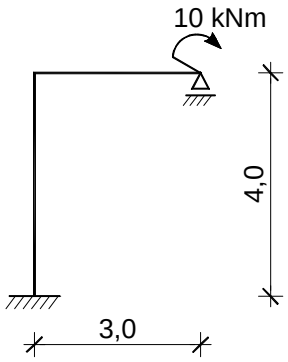
Wyznaczyć wykres momentów zginających w ramie metodą przemieszczeń.
EJ = const.

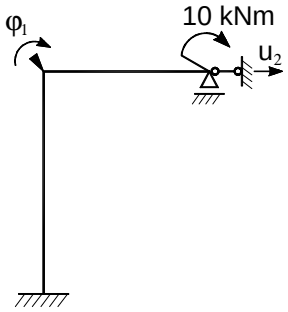


UWAGA!
Proszę zwrócić uwagę na stan „P”!

Rozwiązanie:

SGN=2

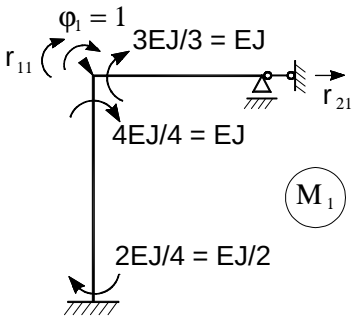
Układ podstawowy:



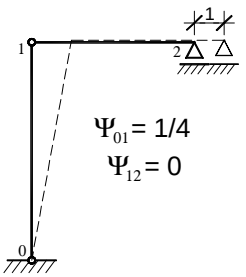
Układ równań kanonicznych:

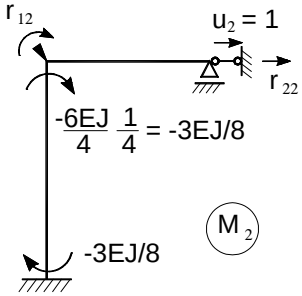
$$\begin{cases} r_{11}\varphi_1 + r_{12}u_1 + r_{1P} = 0 \\ r_{21}\varphi_1 + r_{22}u_1 + r_{2P} = 0 \end{cases}$$

Stan $\varphi_1 = 1$:

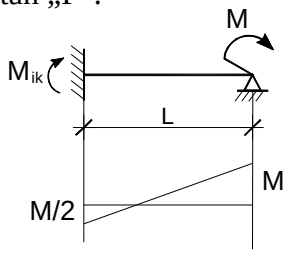


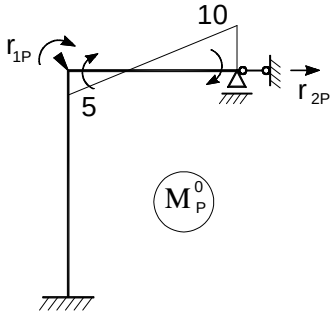
Stan $u_2 = 1$:





Stan „P”:





$r_{11} = 2EJ$

$r_{21} \cdot \bar{1} + \left(EJ + \frac{1}{2}EJ \right) \cdot \frac{\bar{1}}{4} = 0 \;\Rightarrow\; r_{22} = -\frac{3}{8}EJ$

$r_{12} = -\frac{3}{8}EJ$

$r_{22} \cdot \bar{1} - 2 \cdot \frac{3}{8}EJ \cdot \frac{\bar{1}}{4} = 0 \;\Rightarrow\; r_{22} = \frac{3}{16}EJ$

$r_{1P} = 5\,kNm$

$r_{2P} \cdot \bar{1} + (5+10) \cdot \bar{\psi}_{12} = 0 \;\Rightarrow\; r_{2P} = 0$

$$\begin{cases} 2EJ\cdot\varphi_1-\frac{3}{8}EJ\cdot u_2+5=0 \\ -\frac{3}{8}EJ\cdot\varphi_1+\frac{3}{16}EJ\cdot u_2=0 \end{cases} \Rightarrow \begin{cases} \varphi_1=-\frac{4}{EJ} \\ u_2=-\frac{8}{EJ} \end{cases}$$

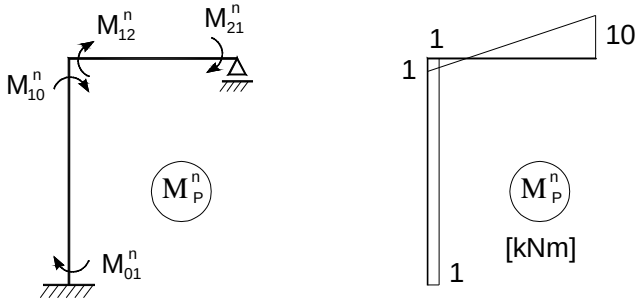
Ostateczny wykres momentów zginających:

$$M_{01}^n=\frac{1}{2}EJ\cdot\left(-\frac{4}{EJ}\right)-\frac{3}{8}EJ\cdot\left(-\frac{8}{EJ}\right)+0=1{,}0\ kNm$$

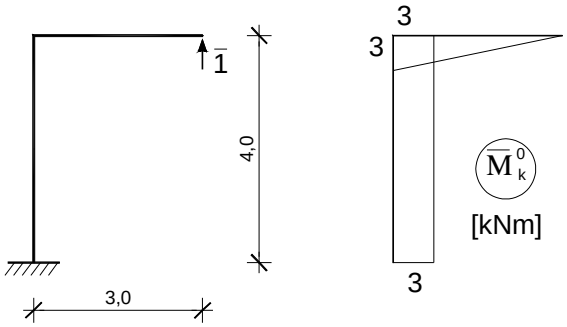
$$M_{10}^n=EJ\cdot\left(-\frac{4}{EJ}\right)-\frac{3}{8}EJ\cdot\left(-\frac{8}{EJ}\right)+0=-1{,}0\ kNm$$

$$M_{12}^n=EJ\cdot\left(-\frac{4}{EJ}\right)+0\cdot\left(-\frac{8}{EJ}\right)+5=1{,}0\ kNm$$

$$M_{21}^n=0\cdot\left(-\frac{4}{EJ}\right)+0\cdot\left(-\frac{8}{EJ}\right)+10=10{,}0\ kNm$$



Sprawdzenie kinematyczne:



$$\varphi=\sum\int_x\frac{\overline{M}_k^0M_P^n}{EJ}dx=\frac{1}{EJ}\cdot\left[\frac{1}{2}\cdot3\cdot3\cdot\left(\frac{2}{3}\cdot1-\frac{1}{3}\cdot10\right)\cdot1+4\cdot3\cdot1\right]=\frac{0}{EJ}$$