

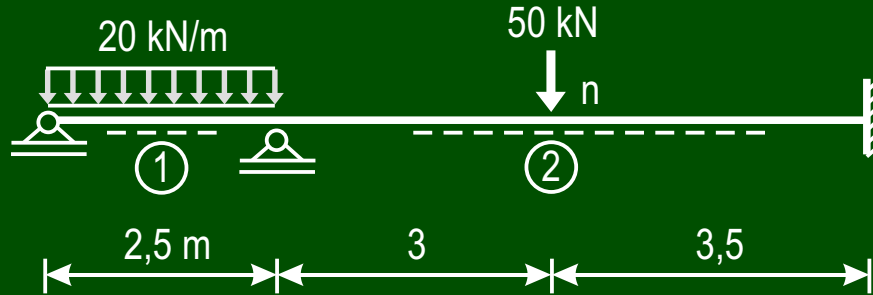
Diethard Thieme

Übungen

zur

Baustatik

BS 11



Kennwerte

$$J_2 = 600\,000 \text{ cm}^4 \quad ; \quad J_1 = 0,7 J_2$$

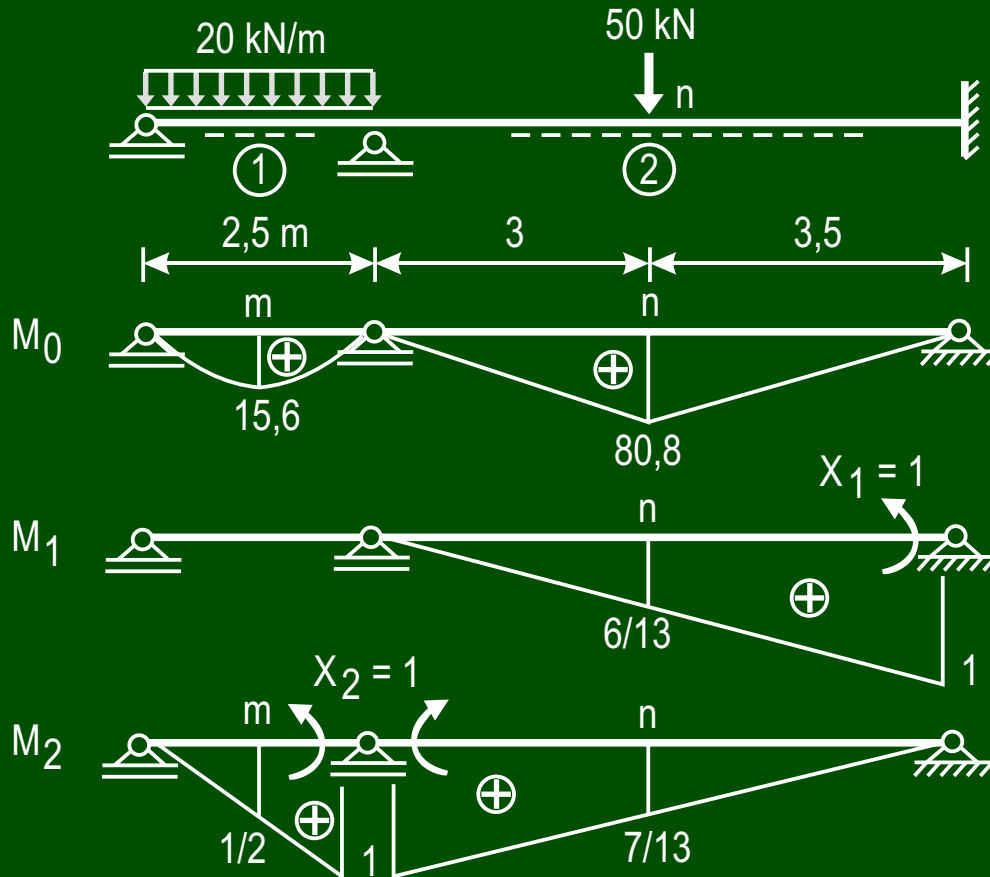
$$E_1 = E_2 = 3 \cdot 10^7 \text{ kN/m}^2$$

$$\text{Gewählt: } J_0 = J_1 \quad ; \quad E_0 = E_1$$

Reduzierte Stablängen

$$L'_1 = L_1 \frac{E_0 J_0}{E_1 J_1} = 2,5 \frac{1}{1} \frac{1}{1} = 2,5 \text{ m}$$

$$L'_2 = 4,55 \text{ m}$$



$$L'_1 = 2,5 \quad ; \quad L'_2 = 4,55$$

$$a = E_0 J_0 1^* \delta$$

Belastungszahlen

$$a_{10} = 4,55 \frac{1}{6} 1 \cdot 80,8 \left(1 + \frac{3}{6,5}\right) = 89,6$$

$$a_{20} = 2,50 \frac{1}{3} 1 \cdot 15,6 + \\ + 4,55 \frac{1}{6} 1 \cdot 80,8 \left(1 + \frac{3,5}{6,5}\right) = 107,2$$

Vorzahlen

$$a_{11} = 4,55 \frac{1}{3} 1^2 = 1,517$$

$$a_{22} = 2,50 \frac{1}{3} 1^2 + 4,55 \frac{1}{3} 1^2 = 2,35$$

$$a_{12} = 4,55 \frac{1}{6} 1^2 = 0,758$$

Gleichungssystem

$$a_{11} X_1 + a_{12} X_2 = -a_{10}$$

$$a_{21} X_1 + a_{22} X_2 = -a_{20}$$

$$1,571 X_1 + 0,758 X_2 = -89,6$$

$$0,758 X_1 + 2,350 X_2 = -107,2$$

$$X_1 = -43,2 \quad ; \quad X_2 = -31,7$$

Superposition

$$M_m = M_{m0} + X_1 M_{m1} + X_2 M_{m2}$$

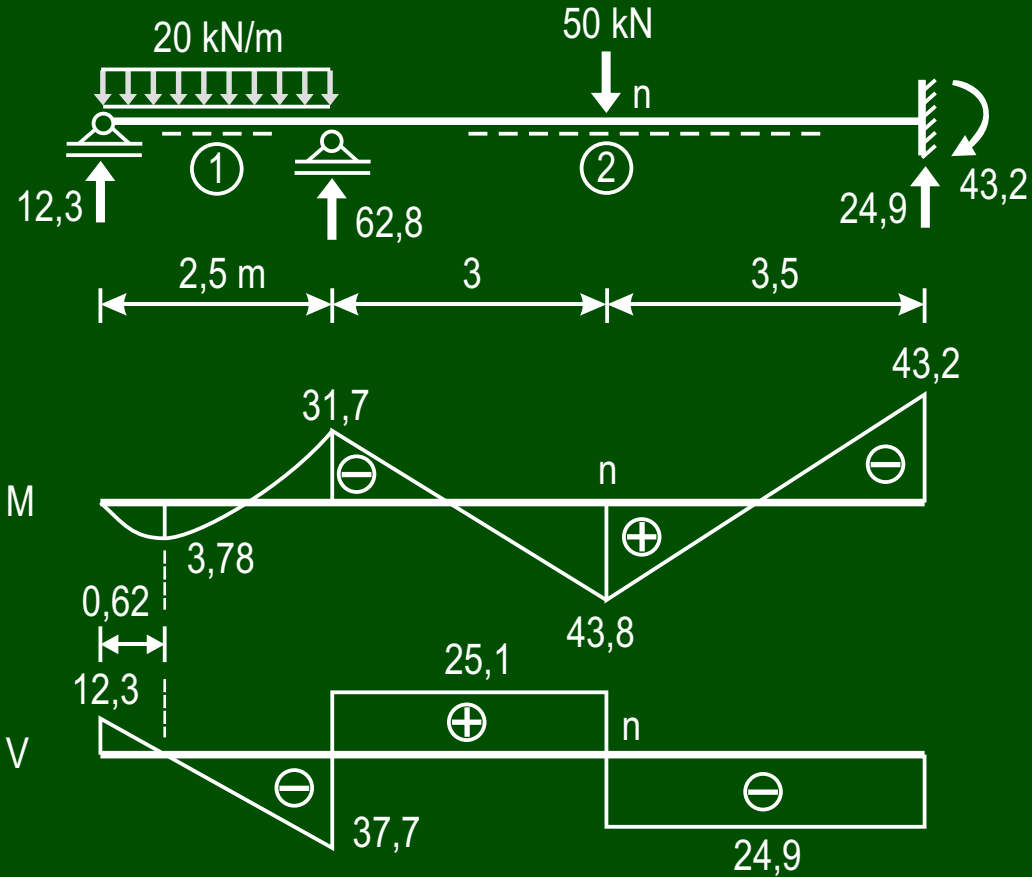
$$M_m = 15,6 + (-43,2) 0 + (-31,7) \frac{1}{2}$$

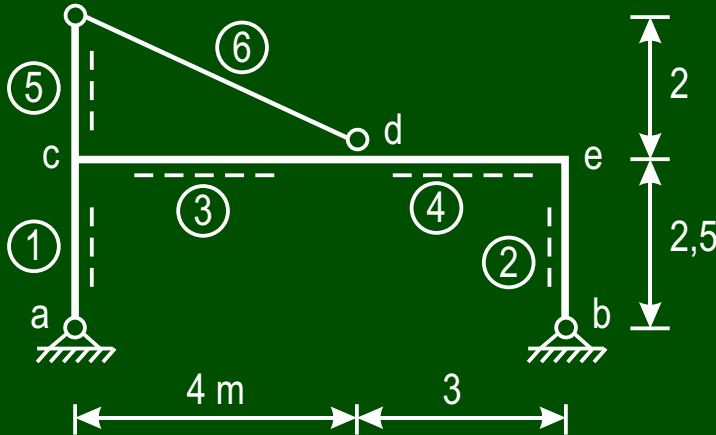
$$M_m = -0,25 \text{ kNm}$$

$$M_n = M_{n0} + X_1 M_{n1} + X_2 M_{n2}$$

$$M_n = 80,8 + (-43,2) \frac{6}{13} + (-31,7) \frac{7}{13}$$

$$M_n = 43,8 \text{ kNm}$$





Reduzierte Stablängen

$$L'_1 = L'_2 = 2,5 \text{ m} ; L'_5 = 2 \text{ m}$$

$$L'_3 = 3,33 \text{ m} ; L'_4 = 2,5 \text{ m}$$

$$L''_6 = L_6 \frac{E_0 J_0}{E_6 A_6} = 4,46 \frac{1}{10} \frac{0,004}{0,0008} = 2,23 \text{ m}$$

Kennwerte

$$J_1 = J_2 = J_5 = 400\,000 \text{ cm}^4$$

$$J_3 = J_4 = 1,2 J_2$$

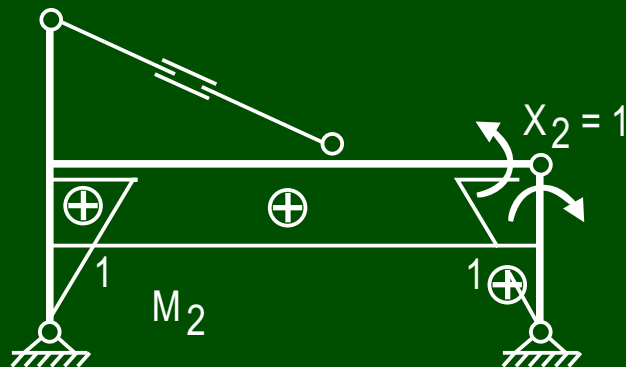
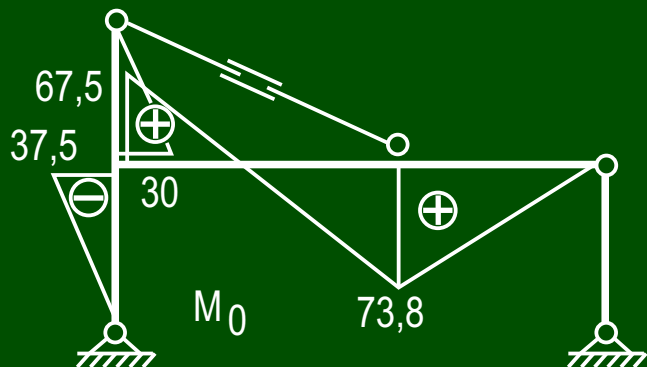
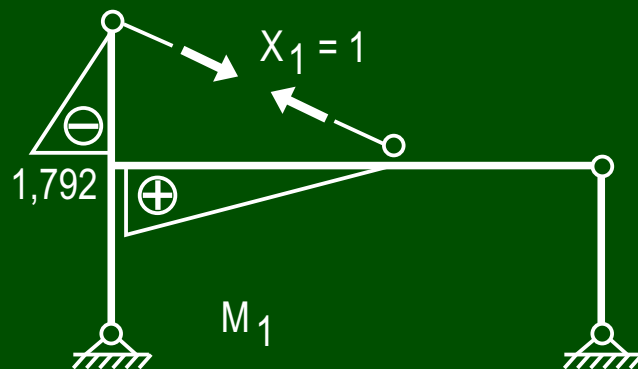
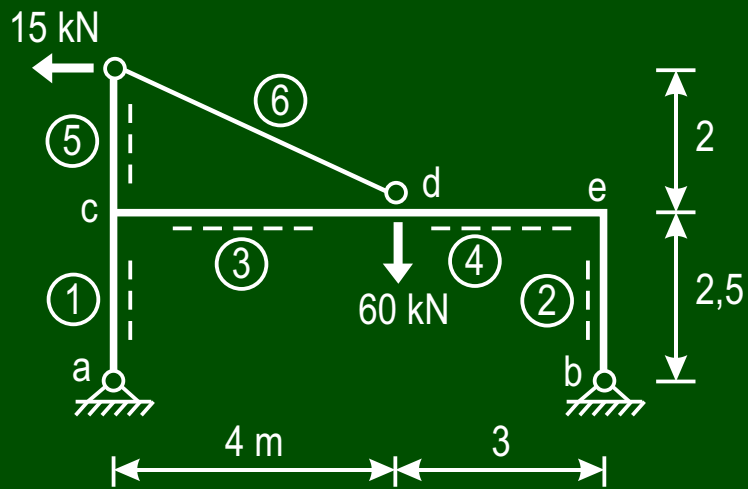
$$E_1 = E_2 = E_3 = 2,1 \cdot 10^7 \text{ kN/m}^2$$

$$E_4 = E_8 = 2,1 \cdot 10^7 \text{ kN/m}^2$$

$$A_6 = 8 \text{ cm}^2$$

$$E_6 = 2,1 \cdot 10^8 \text{ kN/m}^2$$

$$\text{Gewählt: } J_0 = J_1 ; E_0 = E_1$$



$$a = E_0 J_0 1^* \delta$$

Belastungszahlen

$$a_{10} = 2 \frac{1}{3} 30 (-1,792) + \\ + 3,33 \frac{1}{6} 1,792 (-2 \cdot 67,5 + 73,8)$$

$$a_{10} = -96,7$$

$$a_{20} = 71,6$$

Vorzahlen

$$a_{11} = 2 \frac{1}{3} (-1,792)^2 + 3,33 \frac{1}{3} 1,792^2 + \\ + 2,23 \cdot 1^2 = 7,94$$

aus N in Stab 6

$$a_{22} = 7,50$$

$$a_{12} = 2,98$$

Gleichungssystem

$$a_{11} X_1 + a_{12} X_2 = -a_{10}$$

$$a_{21} X_1 + a_{22} X_2 = -a_{20}$$

$$X_1 = 18,5 \quad ; \quad X_2 = -16,9$$

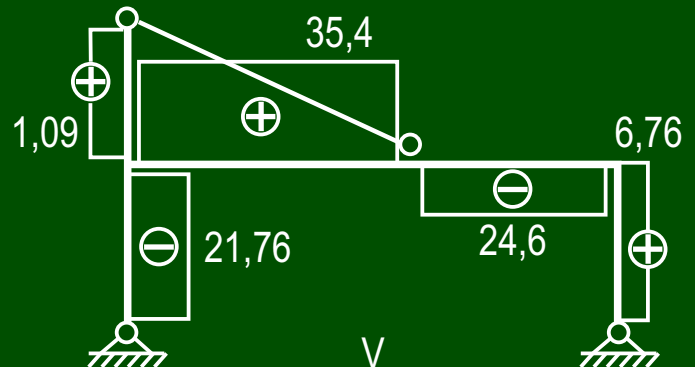
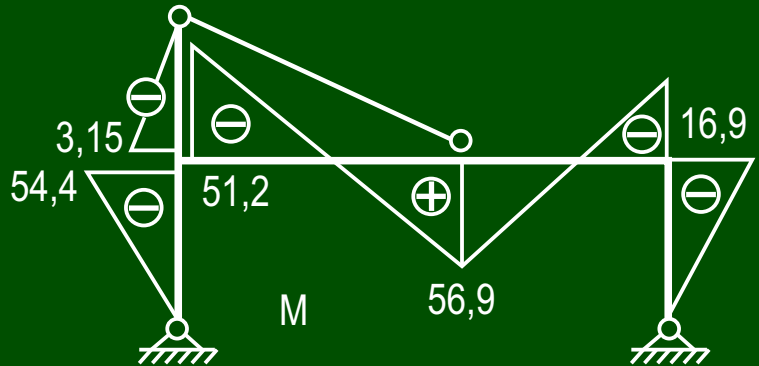
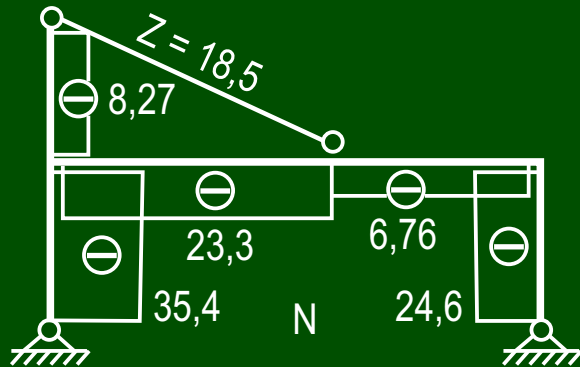
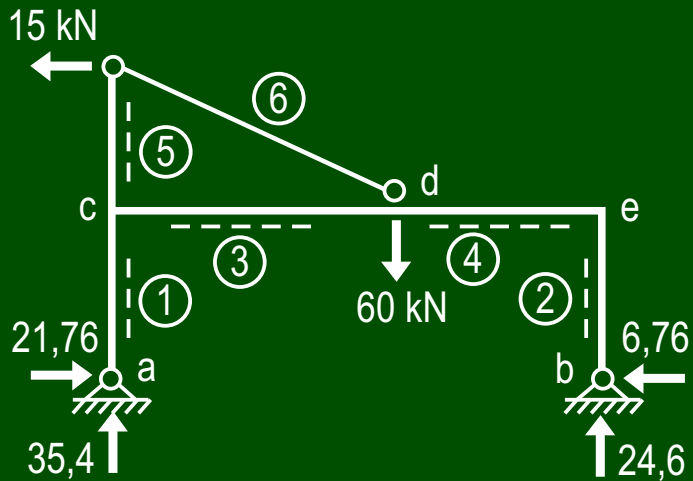
Superposition

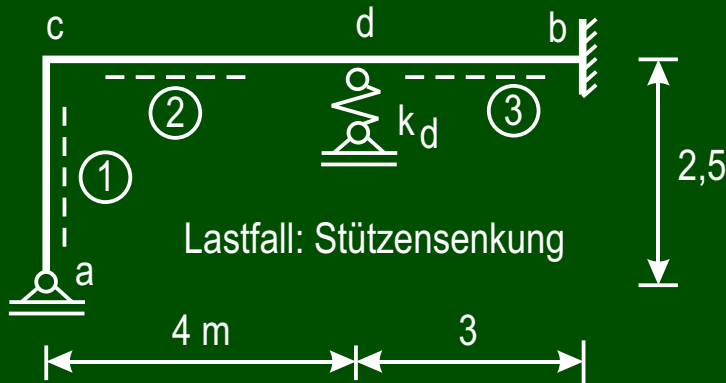
$$M_{c,oben} = 30 + 18,5 (-1,792) = -3,15$$

$$M_{c,unten} = -37,5 - 16,9 \cdot 1 = -54,4$$

$$M_{c,rechts} = -67,5 + 18,5 \cdot 1,792 - \\ - 16,9 \cdot 1 = -51,2$$

$$M_d = 73,9 - 16,9 \cdot 1 = 56,9$$





Lastfall: Stützensenkung

Kennwerte

$$J_1 = 100\,000 \text{ cm}^4$$

$$J_2 = J_3 = 2 J_1$$

$$E_1 = E_2 = E_3 = 2,1 \cdot 10^7 \text{ kN/m}^2$$

$$k_d = 0,1 \text{ mm/kN}$$

$$\text{Stützensenkung } \delta_a = 3 \text{ mm nach unten}$$

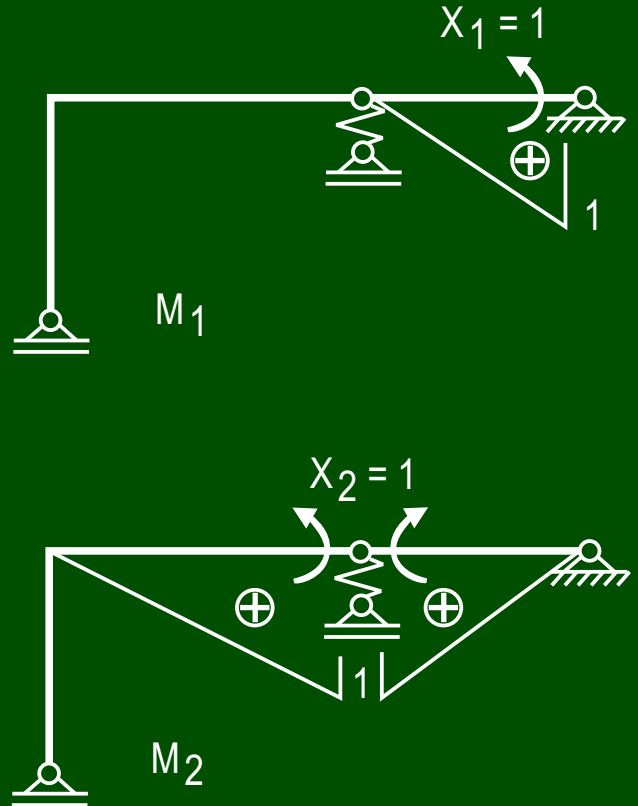
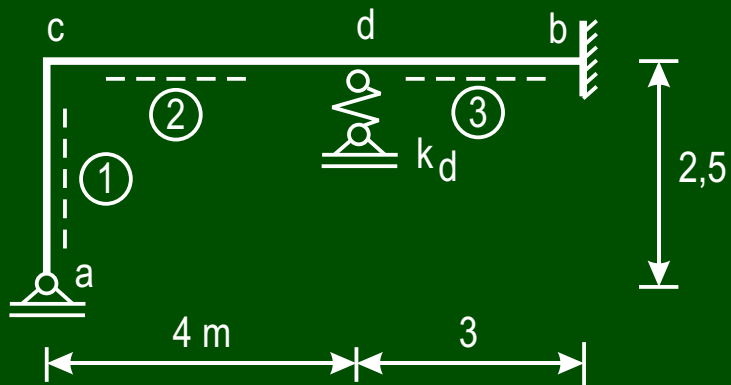
$$\text{Gewählt: } J_0 = J_2 ; E_0 = E_1$$

$$E_0 J_0 \delta_a = 126$$

$$E_0 J_0 k_d = 4,2$$

Reduzierte Stablängen

$$L'_1 = 5 \text{ m} ; L'_2 = 4 \text{ m} ; L'_3 = 3 \text{ m}$$



$$L'_1 = 5 ; L'_2 = 4 ; L'_3 = 3$$

$$E_0 J_0 \delta_a = 126$$

$$E_0 J_0 k_d = 4,2$$

$$a = E_0 J_0 1^* \delta$$

Belastungszahlen

$$a_{10} = 0$$

$$a_{20} = \frac{1}{4} 126 = 31,5$$

aus
Stützensenkung

Vorzahlen

$$a_{11} = 3 \frac{1}{3} 1^2 = 1$$

$$a_{22} = 4 \frac{1}{3} 1^2 + 3 \frac{1}{3} 1^2 + \frac{7}{12} \frac{7}{12} 4,2 = 3,76$$

aus k_b aus k_b

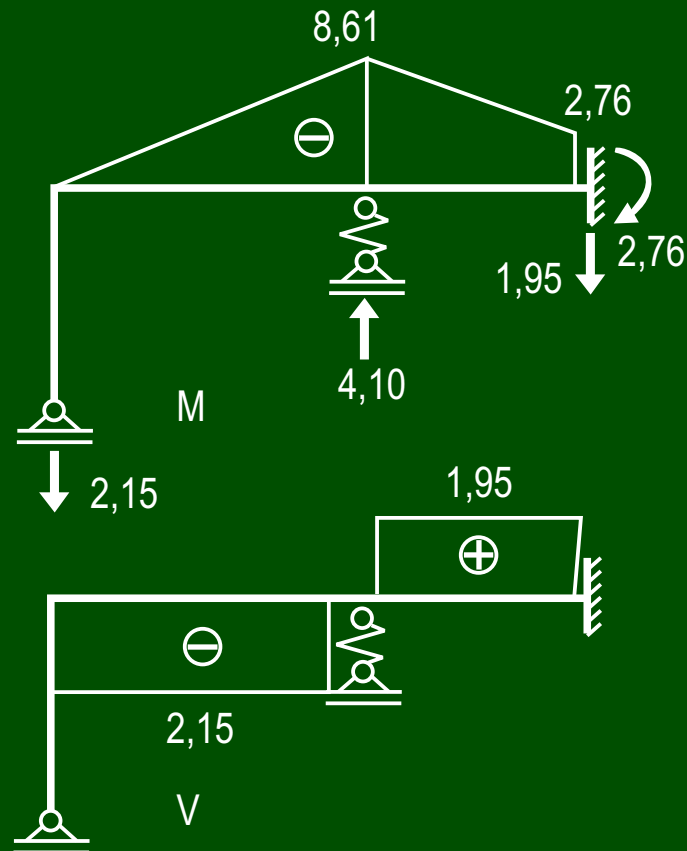
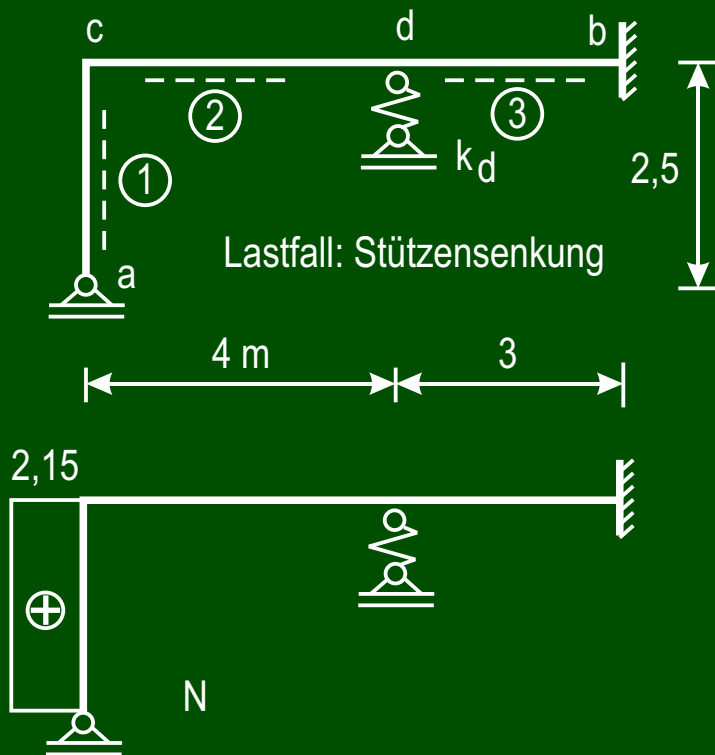
$$a_{12} = 3 \frac{1}{6} 1^2 - \frac{1}{3} \frac{7}{12} 4,2 = -0,32$$

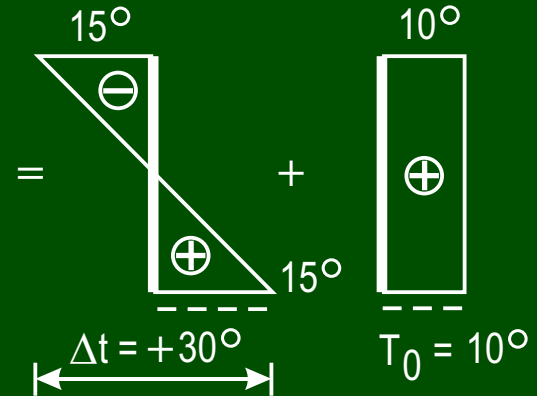
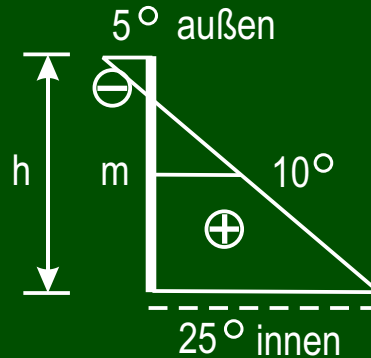
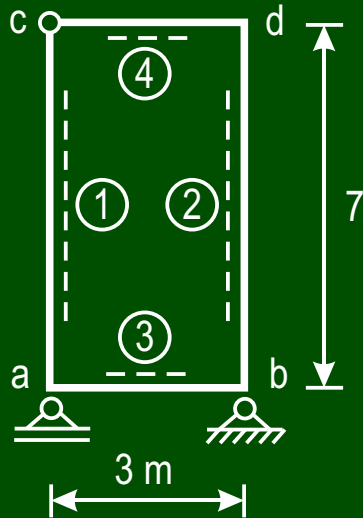
Gleichungssystem

$$a_{11} X_1 + a_{12} X_2 = -a_{10}$$

$$a_{21} X_1 + a_{22} X_2 = -a_{20}$$

$$X_1 = -2,76 ; X_2 = -8,61$$





Temperaturänderung in den Stäben 1 . . . 4

Abkühlung außen um -5°C

Erwärmung innen um $+25^{\circ}\text{C}$

$\alpha_t = 1,2 \cdot 10^{-5} \text{ Grad}^{-1}$

Gewählt: $J_0 = J_1$; $E_0 = E_1$

$E_0 J_0 \alpha_t = 3,23 \text{ kN} \cdot \text{m}^2 \cdot \text{Grad}^{-1}$

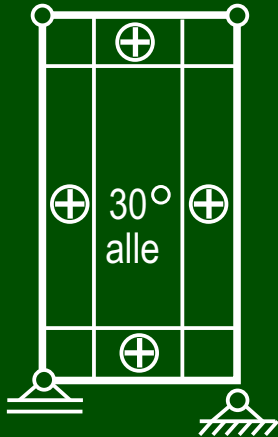
Kennwerte

$J_1 = J_2 = 1\,280\,000 \text{ cm}^4$; $J_3 = J_4 = \frac{1}{8} J_1$

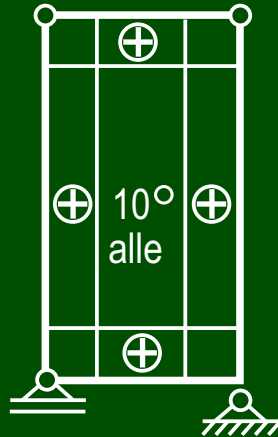
$E_1 \dots E_4 = 2,1 \cdot 10^7 \text{ kN/m}^2$

Höhe der Stäbe 1, 2 : $h = 80 \text{ cm}$

Höhe der Stäbe 3, 4 : $h = 40 \text{ cm}$



$\Delta t = +30^\circ$
Belastung



$T_0 = +10^\circ$
Belastung

$$E_0 J_0 \alpha_t = 3,23 \text{ kN} \cdot \text{m}^2 \cdot \text{Grad}^{-1}$$

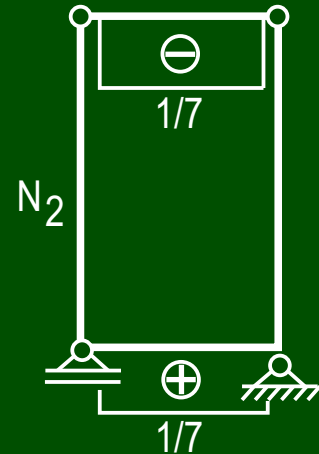
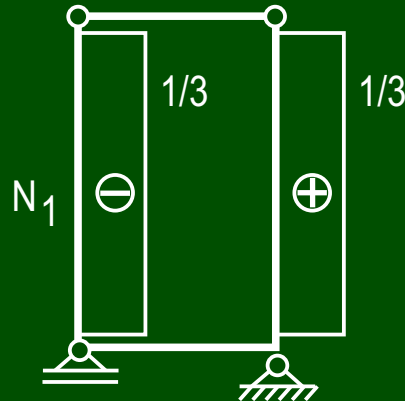
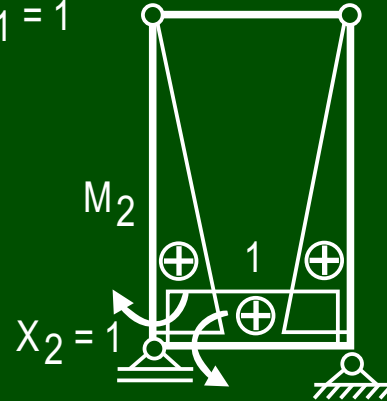
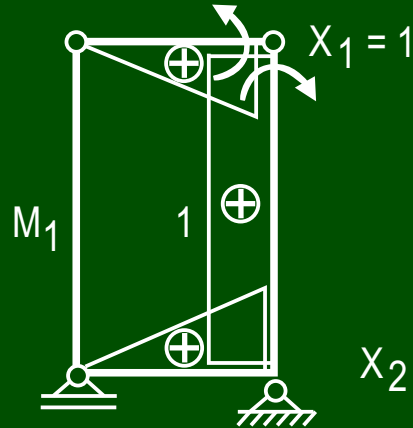
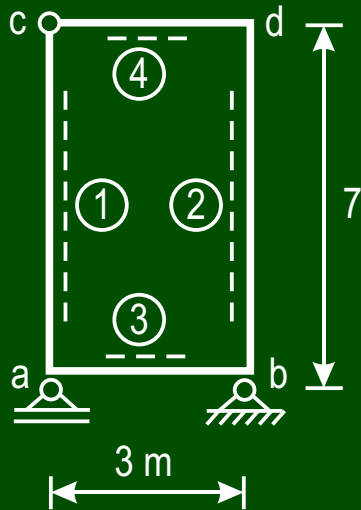
Reduzierte Stablängen

$$L'_1 = L'_2 = 7 \text{ m}$$

$$L'_3 = L'_4 = 3 \frac{1}{1} \frac{8}{1} = 24 \text{ m}$$

$$L_1^{(4)} = L_2^{(4)} = 7 \cdot 3,23 = 22,6 \text{ kN} \cdot \text{m}^3 \cdot \text{Grad}^{-1}$$

$$L_3^{(4)} = L_4^{(4)} = 3 \cdot 3,23 = 9,69 \text{ kN} \cdot \text{m}^3 \cdot \text{Grad}^{-1}$$



$$L'_1 = L'_2 = 7 \quad ; \quad L'_3 = L'_4 = 24 \quad ; \quad L^{(4)}_1 = L^{(4)}_2 = 22,6 \quad ; \quad L^{(4)}_3 = L^{(4)}_4 = 9,69$$

$$a = E_0 J_0 1^* \delta$$

Belastungszahlen

$$a_{10} = 22,6 \left[1 \frac{30}{0,8} + \left(-\frac{1}{3} \right) 10 + \frac{1}{3} 10 \right] + 9,69 \left(\frac{1}{2} 1 \frac{30}{0,4} + \frac{1}{2} 1 \frac{30}{0,4} \right) = 1574,3$$

$$a_{20} = 22,6 \left(\frac{1}{2} 1 \frac{30}{0,8} + \frac{1}{2} 1 \frac{30}{0,8} \right) + 9,69 \left[1 \frac{30}{0,4} + \left(-\frac{1}{7} \right) 10 \right] = 1560,4$$

Vorzahlen

$$a_{11} = 7 \cdot 1^2 + 24 \frac{1}{3} 1^2 + 24 \frac{1}{3} 1^2 = 23$$

$$a_{22} = 7 \frac{1}{3} 1^2 + 7 \frac{1}{3} 1^2 + 24 \cdot 1^2 = 28,7$$

$$a_{12} = 7 \frac{1}{2} 1^2 + 24 \frac{1}{2} 1^2 = 15,5$$

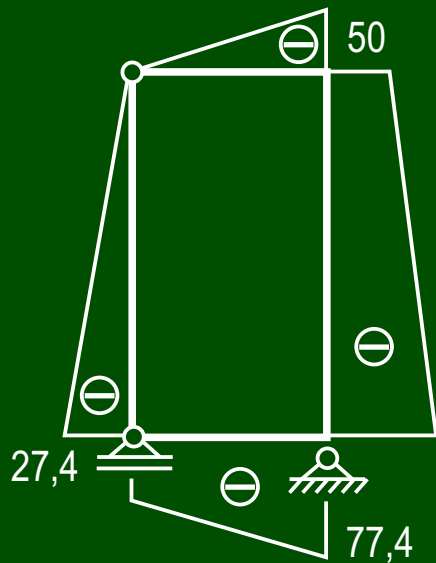
Gleichungssystem

$$a_{11} X_1 + a_{12} X_2 = -a_{10}$$

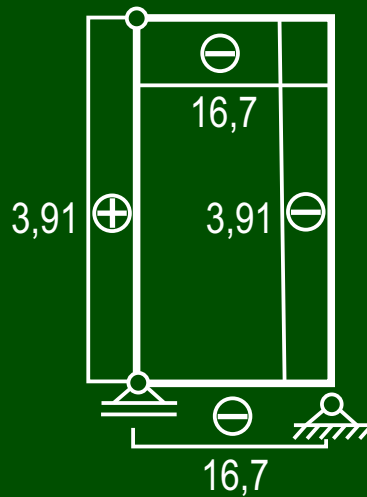
$$a_{21} X_1 + a_{22} X_2 = -a_{20}$$

$$X_1 = -50,0$$

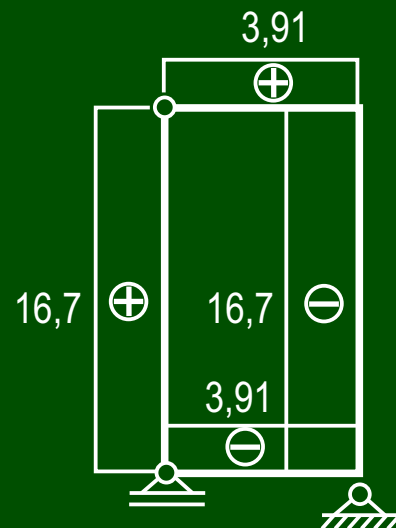
$$X_2 = -27,4$$



M



V



N