

Aufgabe 1



$$B_H = 0$$

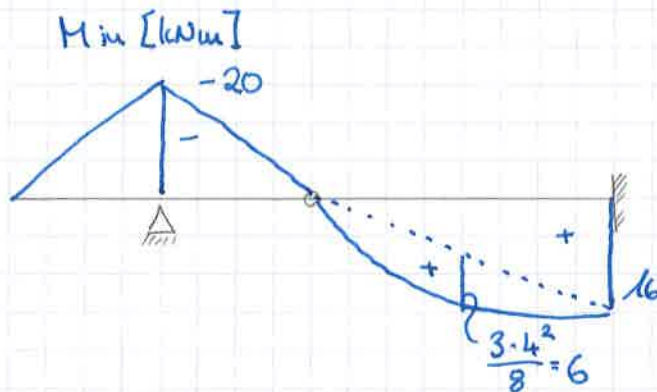
$$A_H = 0$$

$$B_v = \frac{1}{2} (10 \cdot 4) = 20 \text{ kN}$$

$$A_v = -20 + 10 + 3 \cdot 4 = 2.0 \text{ kN}$$

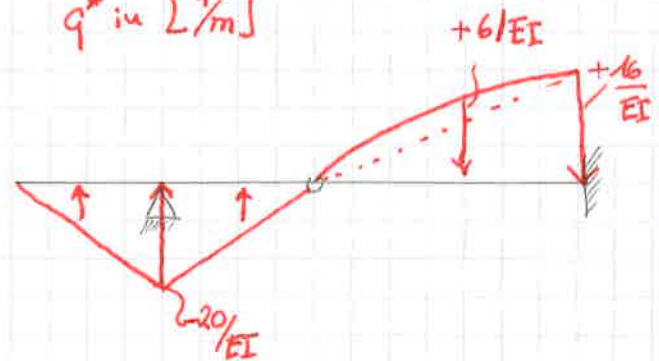
$$M_A = 20 \cdot 6 - 10 \cdot 8 - 3 \cdot 4 \cdot 2 = 16 \text{ kN}$$

Momentenverlauf



Einfeldlast q^*

$$q^* \text{ in } [1/m]$$



Biegelinien

$$w_{1-2}(x) = -\frac{20}{EI} \cdot \frac{2^2}{6} \left(\frac{x}{2} - \left(\frac{x}{2} \right)^3 \right)$$

$$w_{\max} = \frac{20}{EI} \cdot \frac{2^2}{9\sqrt{3}} = 5.13 \cdot 10^{-4} \text{ m}$$

$$\text{Stelle } x: \frac{1}{\sqrt{3}} \cdot 2 = 1.15 \text{ m}$$

$$w_{2-3}(x) = -\frac{20}{EI} \cdot \frac{2^2}{6} \left(\frac{2-x}{2} - \left(\frac{2-x}{2} \right)^3 \right)$$

$$w_{\max} = 5.13 \cdot 10^{-4} \text{ m}$$

$$\text{Stelle } x: 0.4226 \cdot 2 = 0.85 \text{ m}$$

$$w_{3-4}(x) = \frac{16}{EI} \cdot \frac{4^2}{6} \left(\frac{x}{4} - \left(\frac{x}{4} \right)^3 \right) + \frac{6}{EI} \cdot \frac{4^2}{3} \cdot \left(\frac{x}{4} - 2 \left(\frac{x}{4} \right)^3 + \left(\frac{x}{4} \right)^4 \right)$$

$$w_{\max}^{\text{Parabel}} = \frac{6}{EI} \cdot \frac{5 \cdot 4^2}{48} = 1 \cdot 10^{-3} \text{ m}$$

$$w_{\max}^{\text{Gerade}} = \frac{16}{EI} \cdot \frac{4^2}{9\sqrt{3}} = 1.64 \cdot 10^{-3} \text{ m}$$

Einzelverformungen

②

ΔM in [kNm]

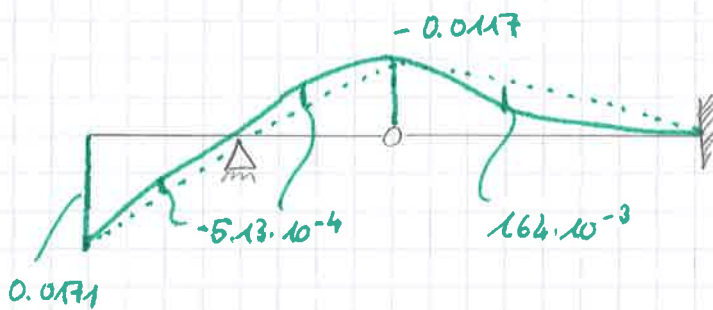


$$w_1 = \left(\frac{1}{3} \cdot 2 \cdot (-2) \cdot 2 + \frac{1}{3} \cdot 4 \cdot 16 \cdot 4 + \frac{1}{3} \cdot 4 \cdot 6 \cdot 4 \right) \frac{1}{EI} = 0.0171 \text{ m}$$



$$w_3 = \left(\frac{1}{3} \cdot 4 \cdot 16 \cdot (-4) + \frac{1}{3} \cdot 4 \cdot 6 \cdot (-4) \right) \frac{1}{EI} = -0.017 \text{ m}$$

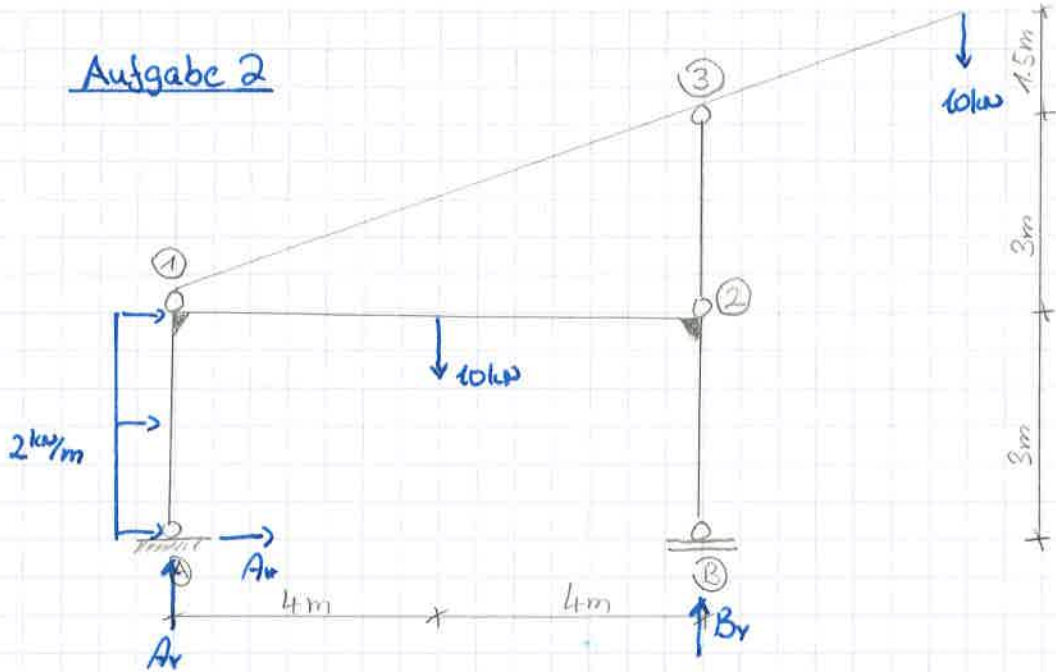
Biegelinie



$w(x)$ in [m]

Aufgabe 2

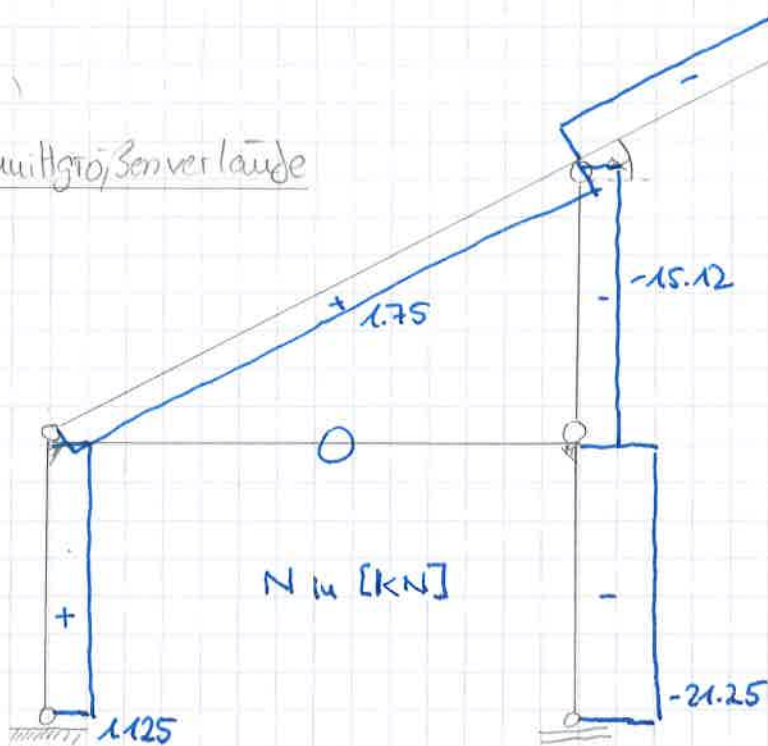
③



a) System ist statisch bestimmt

$$\begin{aligned}
 b) \quad A_V &= \frac{1}{8} (-2 \cdot 3 \cdot 1.5 + 10 \cdot 4 - 10 \cdot 4) = -1.125 \text{ kN} \\
 A_H &= -2 \cdot 3 = -6.0 \text{ kN} \\
 B_V &= +1.125 + 10 + 10 = 21.25 \text{ kN}
 \end{aligned}$$

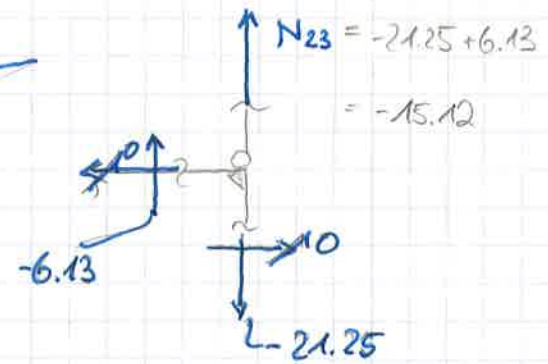
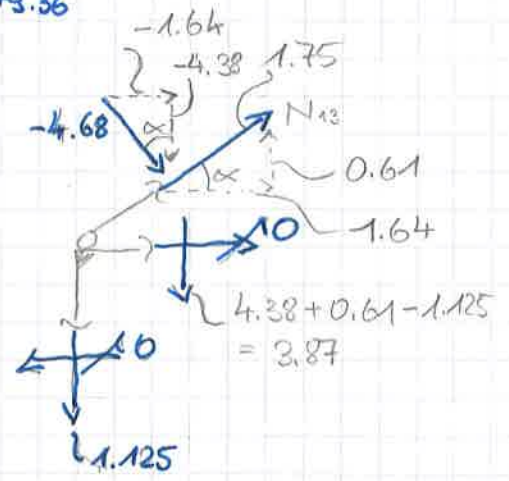
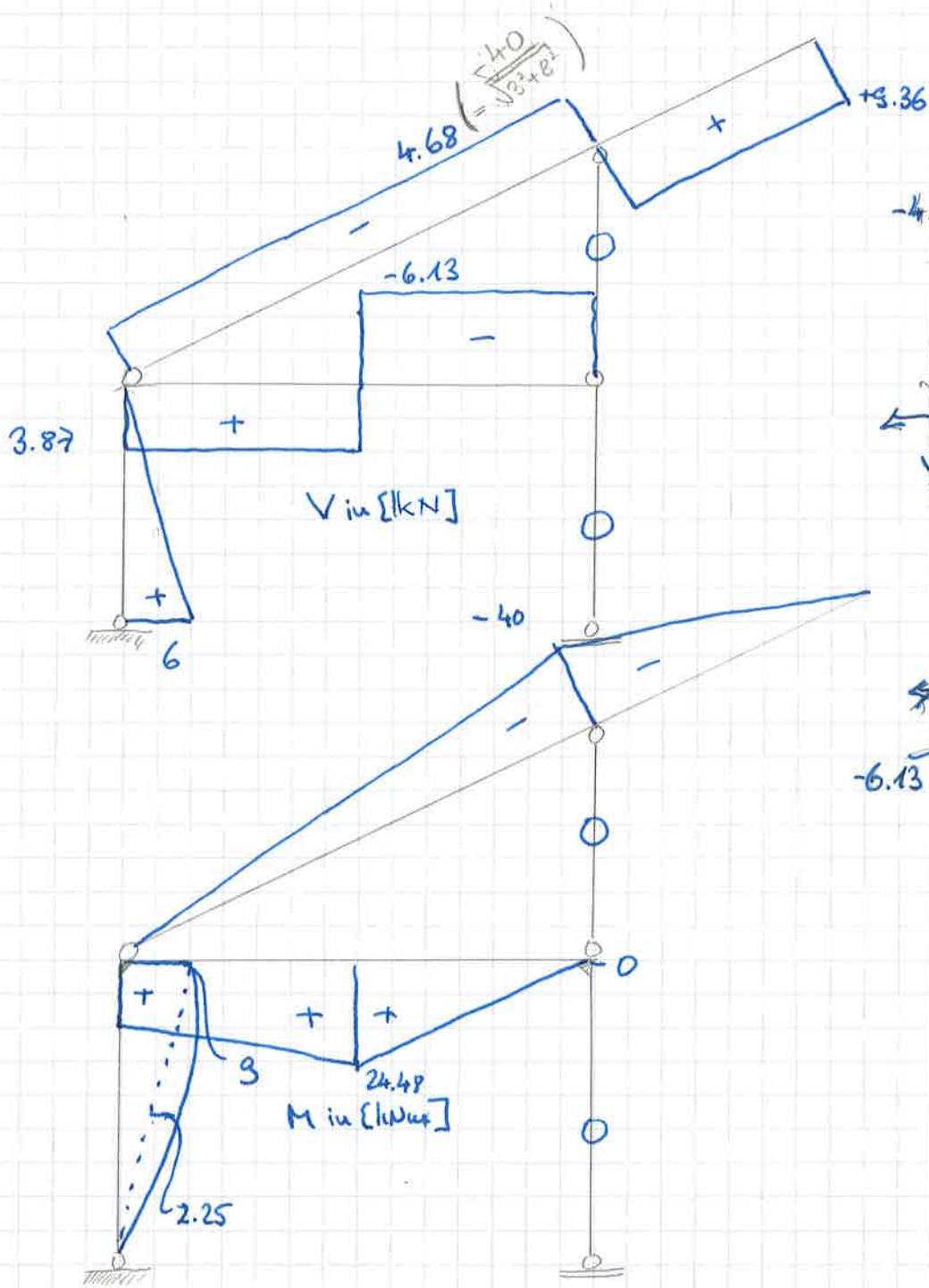
c) Schnittgrößenverläufe



$$\alpha = \arctan\left(\frac{1.5}{4}\right) = 20.56^\circ$$

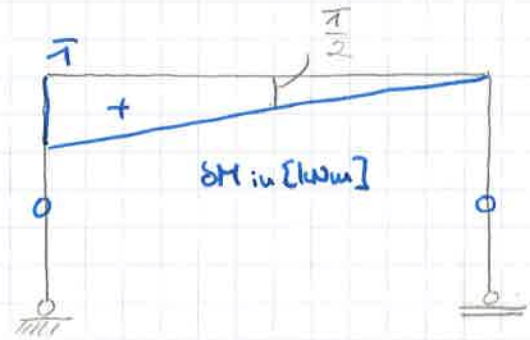
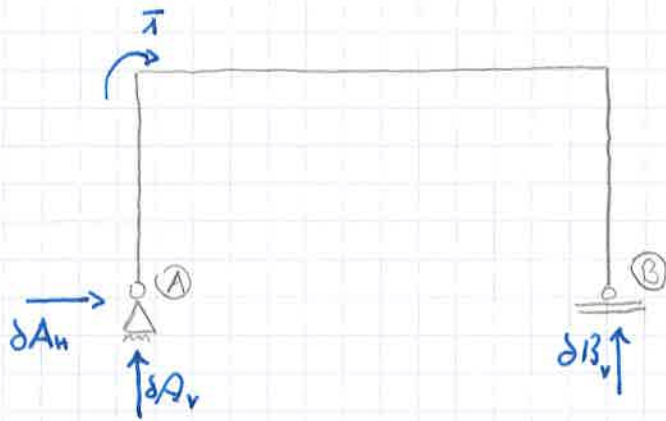
9.36 kN
 $P_1 = 10 \text{ kN}$
 3.51 kN

④



c) Verschiebung a):

⑤



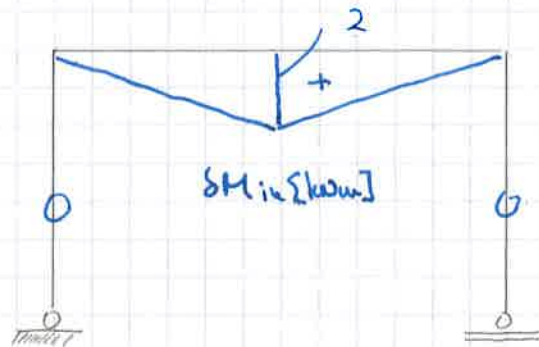
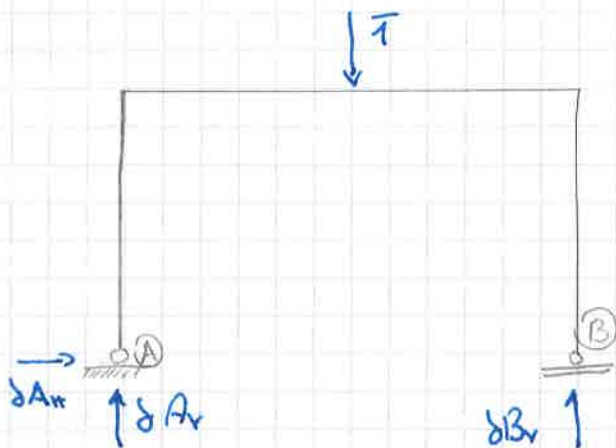
$$\delta B_V = \frac{\bar{1}}{8}$$

$$\delta A_V = -\frac{\bar{1}}{8}$$

$$\delta A_H = 0$$

$$\varphi_A = \frac{1}{EI} \left(\frac{1}{6} \cdot 4 \cdot (2 \cdot 9 \cdot \bar{1} + 5 \cdot \frac{\bar{1}}{2} + 24.48 \cdot \bar{1} + 2 \cdot 24.48 \cdot \frac{\bar{1}}{2}) + \frac{1}{3} \cdot 4 \cdot 24.48 \cdot \frac{\bar{1}}{2} \right) = 6.336 \cdot 10^{-3} \text{ rad}$$

Verschiebung b):



$$\delta B_V = \frac{\bar{1}}{8} (\bar{1} \cdot 4) = \frac{\bar{1}}{2}$$

$$\delta A_V = \frac{\bar{1}}{2}$$

$$\delta A_H = 0$$

$$w_B = \frac{1}{EI} \left(\frac{1}{3} \cdot 4 \cdot 2 \cdot 15.48 + \frac{1}{2} \cdot 4 \cdot 2 \cdot 9 + \frac{1}{3} \cdot 4 \cdot 24.48 \cdot 2 \right) = 0.0143 \text{ m}$$

⑥

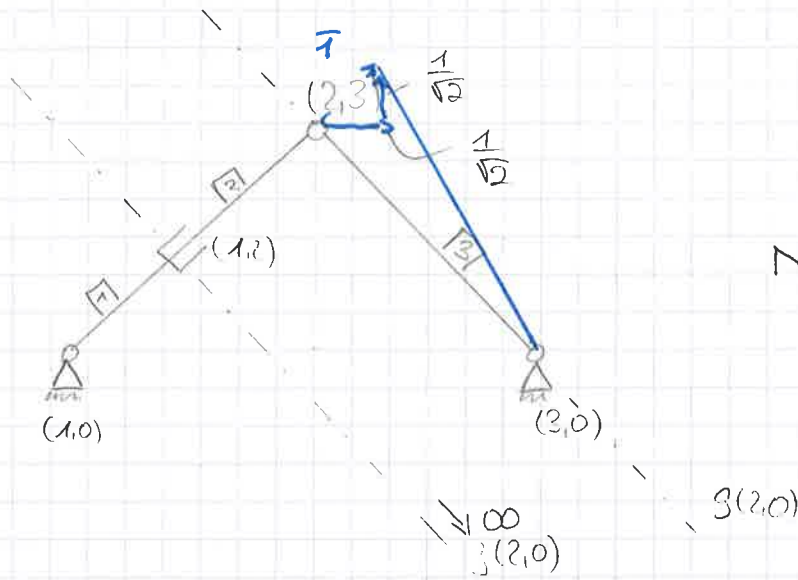
$$A_H = -7.50 \cdot 0.7 + 15 \cdot 0.2 = -2.25 \text{ kN}$$

$$B_v = -9 \cdot \bar{1} - 15 \cdot \frac{\bar{1}}{2} = -16.5 \text{ kN}$$

c) Pendelotab $\Rightarrow V = 0$

c)

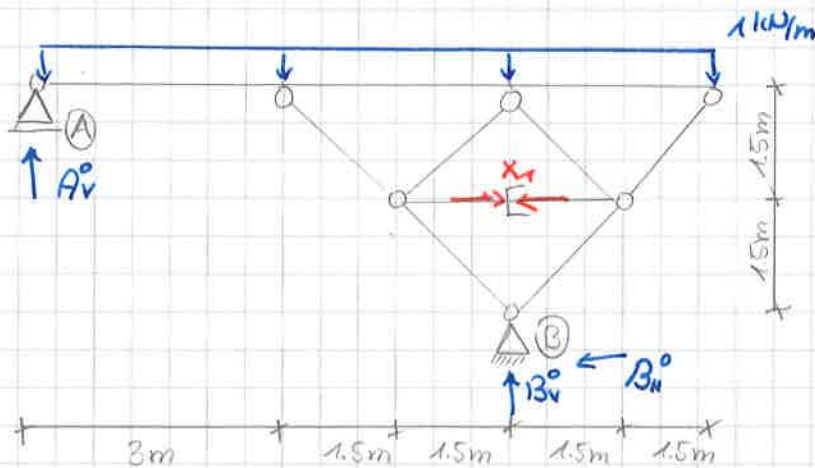
7



$$N = -15 \cdot \frac{1}{\sqrt{2}} = -10.61 \text{ kN}$$

Aufgabe 4

Statisch bestimmtes Hauptsystem



a) $n = 1$

$$A_v^0 = \frac{1}{6} (1 \cdot 9 \cdot 1.5) = 2.25 \text{ kN}$$

$$B_v^0 = -2.25 + 1 \cdot 9 = 6.75 \text{ kN}$$

$$B_H^0 = 0$$

b) Momentenverlauf LSF



Mom in [kNm]

Momentenverlauf ESF



M_{ES} in [kNm]

Flexibilitäten

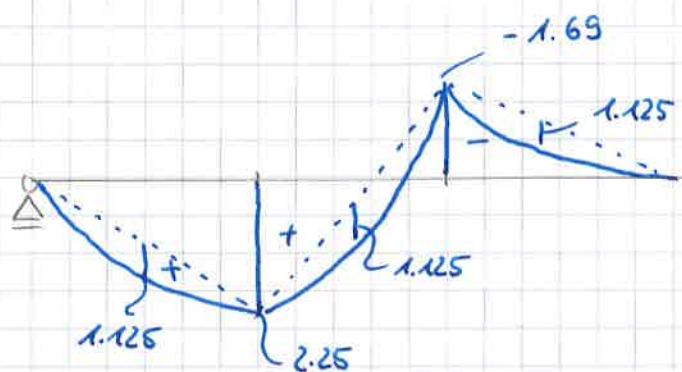
$$d_{10} = \frac{1}{EI} \left(-\frac{1}{6} (1+0.5) 2.25 \cdot 1.5 \cdot 6 - 2 \cdot \frac{5}{12} \cdot 1.5 \cdot 4.50 \cdot 3 \right) = -\frac{21.94}{EI}$$

$$d_{11} = \frac{1}{EI} \left(2 \cdot \frac{1}{3} \cdot (-1.5)^2 \cdot 3 \right) = \frac{4.50}{EI}$$

$$X_1 = -\frac{(-21.94)}{4.50} = 4.875$$

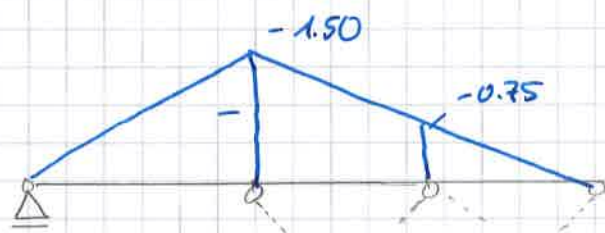
3

Momentenverlauf



$M(x)$ in [kNm]

c) Horizontale Verformung am Lager A:



$SH(x)$ in [kNm]

$$\begin{aligned}
 u_A &= \frac{1}{EI} \left(-\frac{1}{3} \cdot 3 \cdot 1.50 \cdot 2.25 - \frac{1}{3} \cdot 3 \cdot 1.50 \cdot 1.125 \right. \\
 &\quad + \frac{1}{6} (2 \cdot 1.50 \cdot (-2.25) + 0.75 \cdot 1.69 \cdot 2 + 1.50 \cdot 1.69 - 0.75 \cdot 2.25) \cdot 2 \\
 &\quad + \frac{1}{3} \cdot 1.69 \cdot 0.75 \cdot 3 - \frac{1}{3} \cdot 0.95 \cdot 1.125 \cdot 3 \\
 &\quad \left. - \frac{2}{3} \cdot 1.125^2 \cdot 3 \right) = -8.86 \cdot 10^{-3} \text{ m}
 \end{aligned}$$