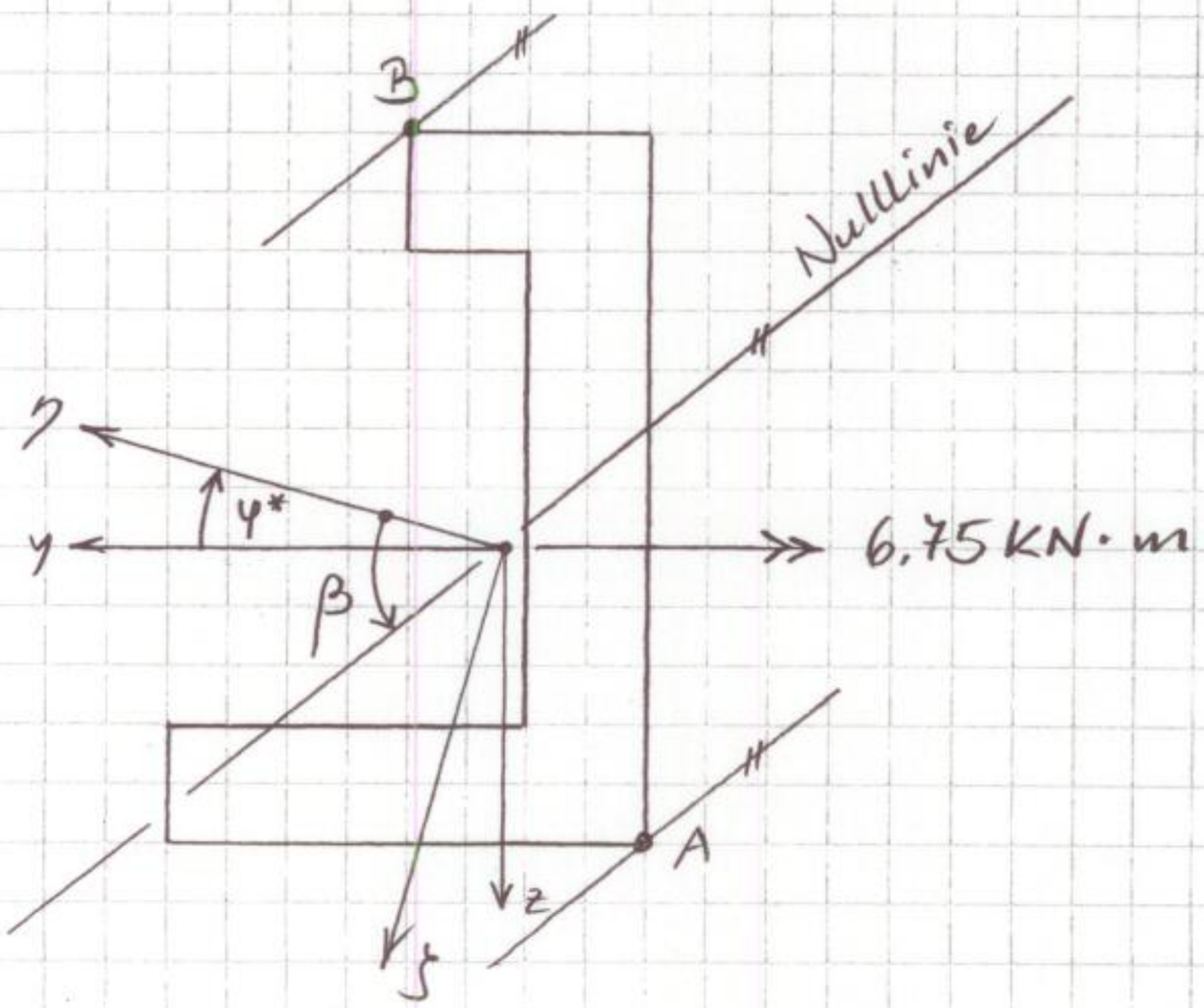
Aufgabe 1

1/ $\alpha = 180° + 15,52° = 195,52°$

$$\tan\beta = \frac{693,33\,cm^4}{134,93\,cm^4} \cdot \tan 195,52° = 1,427$$

$$\beta = 54,98°$$



2/ $M_{b\eta} = M_b \cdot \cos\alpha = 6,75\,kN\cdot m \cdot \cos 195,52° = -6,504\,kN\cdot m$

$M_{b\zeta} = M_b \cdot \sin\alpha = 6,75\,kN\cdot m \cdot \sin 195,52° = -1,806\,kN\cdot m$

Punkt A: $y_A = -2,4\,cm$; $z_A = 5\,cm$

$\eta_A = 5\,cm \cdot \sin(-15,52°) - 2,4\,cm \cdot \cos(-15,52°) = -3,65\,cm$

$\zeta_A = 5\,cm \cdot \cos(-15,52°) + 2,4\,cm \cdot \sin(-15,52°) = 4,18\,cm$

Punkt B: $y_B = 1,6\,cm$; $z_B = -7\,cm$

$\eta_B = -7\,cm \cdot \sin(-15,52°) + 1,6\,cm \cdot \cos(-15,52°) = 3,41\,cm$

$\zeta_B = -7\,cm \cdot \cos(-15,52°) - 1,6\,cm \cdot \sin(-15,52°) = -6,32\,cm$

$$\sigma_b^A = \frac{-6{,}504 \cdot 100\ kN \cdot cm}{693{,}33\ cm^4} \cdot 4{,}18\ cm$$

$$- \frac{(-1{,}806) \cdot 100\ kN \cdot cm}{134{,}93\ cm^4} \cdot (-3{,}65\ cm)$$

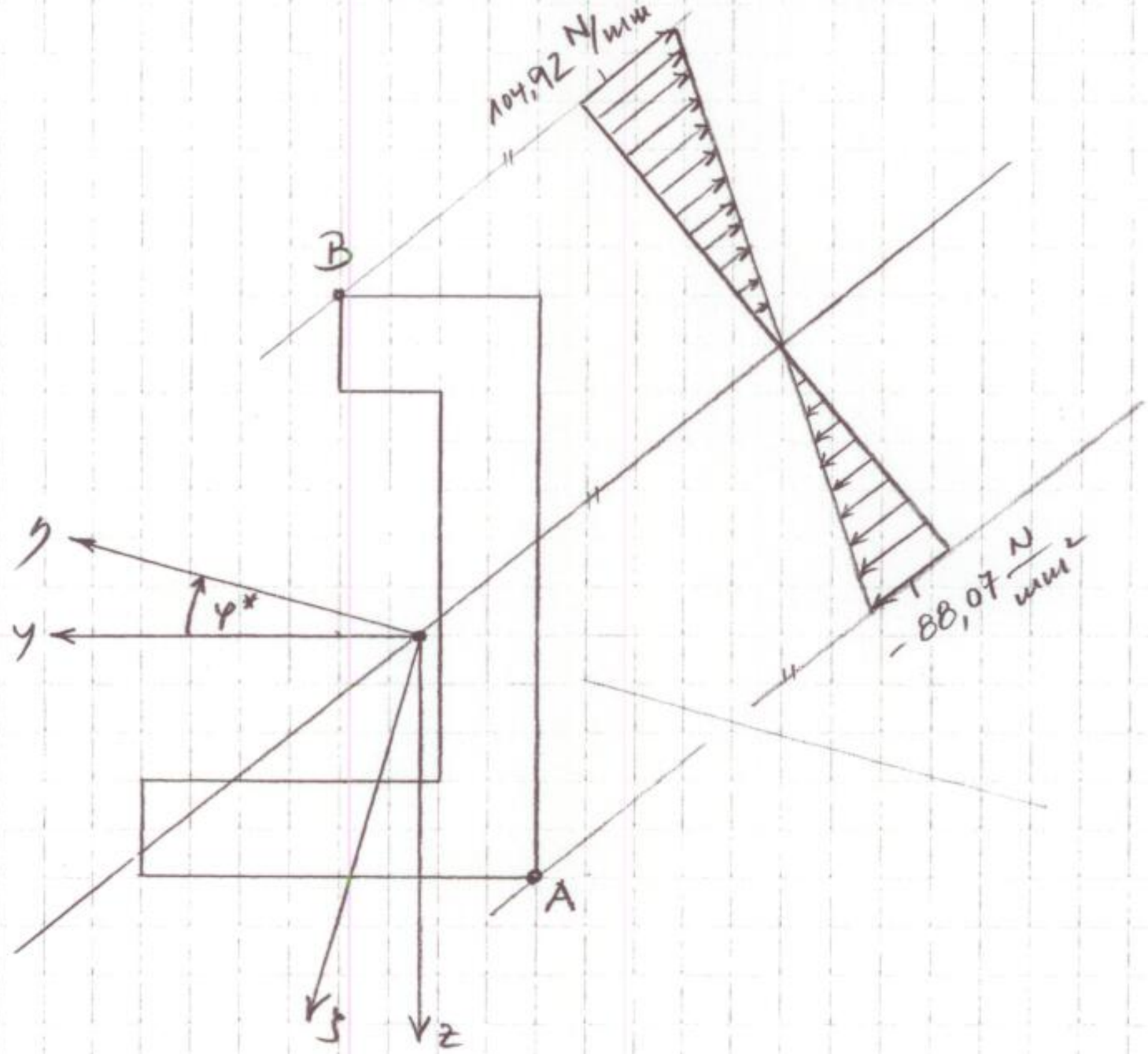
$$\sigma_b^A = -8{,}807\ \frac{kN}{cm^2} = -88{,}07\ \frac{N}{mm^2}$$

$$\sigma_b^B = \frac{-6{,}504 \cdot 100\ kN \cdot cm}{693{,}33\ cm^4} \cdot (-6{,}32\ cm)$$

$$- \frac{(-1{,}806) \cdot 100\ kN \cdot cm}{134{,}93\ cm^4} \cdot 3{,}41\ cm$$

$$\sigma_b^B = 10{,}492\ \frac{kN}{cm^2} = 104{,}92\ \frac{N}{mm^2}$$

3/



4) $M_{bzul} = 6.75 \frac{N}{mm^2} \cdot \frac{120 \frac{N}{mm^2}}{104,92 \frac{N}{mm^2}} = 7,72 \text{ kN} \cdot \text{m}$

$$M_b = \frac{q \cdot l^2}{8}$$

$$q_{zul} = \frac{8 \cdot M_{bzul}}{l^2} = \frac{8 \cdot 7.72 \text{ kN} \cdot \text{m}}{(3 \text{m})^2} = 6,86 \text{ kN/m}$$

Aufgabe 2

1/ $S_{y1} = 0$

$$S_{y2} = 18cm \cdot 4cm \cdot 13,3cm - \frac{\pi \cdot (4cm)^2}{2} \cdot \left(15,3cm - \frac{4 \cdot 4cm}{3 \cdot \pi}\right) = 615,74cm^3$$

$$S_{y3} = 615,74cm^3 + 18cm \cdot 7cm \cdot 7,8cm = 1598,54cm^3$$

$$S_{y4} = 1598,54cm^3 + 12cm \cdot 3cm \cdot 2,8cm + 2 \cdot \frac{3cm \cdot 3cm}{2} \cdot 3,3cm$$

$$S_{y4} = 1729,04cm^3$$

$$S_{y5} = 1729,04cm^3 + 12cm \cdot 5cm \cdot (-1,2cm) = 1657,04cm^3$$

$$S_{y6} = 1657,04cm^3 + 12cm \cdot 3cm \cdot (-5,2cm) + 2 \cdot \frac{3cm \cdot 3cm}{2} \cdot (-5,7cm)$$

$$S_{y6} = 1418,54\ cm^3$$

$$S_{y7} = 1418,54\ cm^3 + 18cm \cdot 5cm \cdot (-9,2cm) = 590,54\ cm^3$$

$$S_{y8} = 590,54cm^3 + 12cm \cdot 3cm \cdot (-13,2cm) + 2 \cdot \frac{3cm \cdot 3cm}{2} \cdot (-12,7cm)$$

$$S_{y8} = 1,04 \sim 0$$

Schnitt	S_y cm^3	b cm	τ kN/cm^2	τ N/mm^2
1	0	10	0	0
2	615,74	18	1,517	15,17
3	1598,54	18	3,939	39,39
4	1729,04	12	6,391	63,91
5	1657,04	12	6,125	61,25
6	1418,54	18	3,496	34,96
7	590,54	18	1,455	14.55
8	0	12	0	0

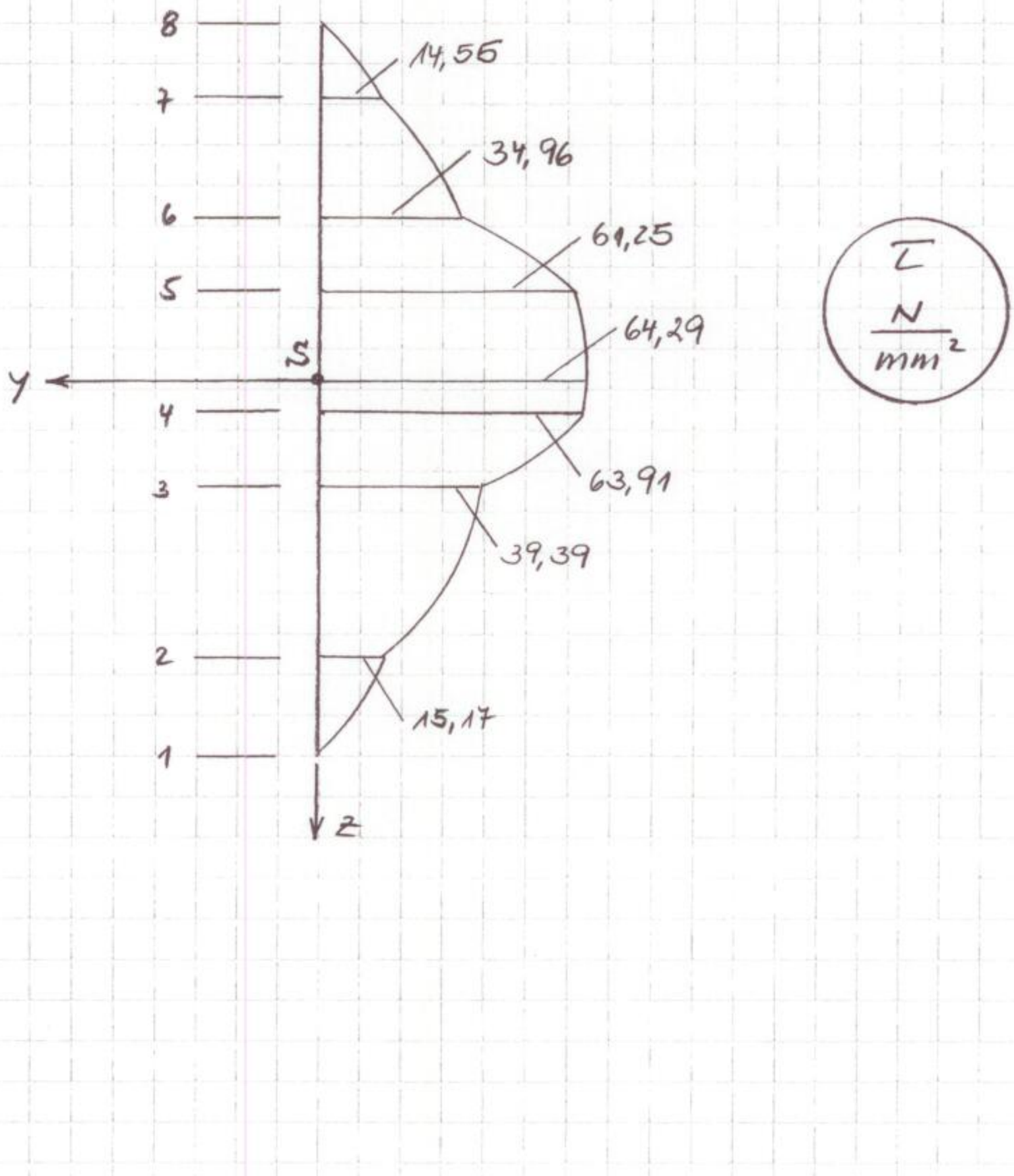
2) $S_{ymax} = S_y(z=0) = 1729{,}04\,cm^3 + 12cm \cdot 1{,}3cm \cdot \frac{1{,}3cm}{2}$

$S_{ymax} = 1739{,}18\,cm^3$

$$\tau_{max} = \frac{1500kN \cdot 1739{,}18cm^3}{33815cm^3 \cdot 12cm} = 6{,}429\,\frac{kN}{cm^2} = 64{,}29\,\frac{N}{mm^2}$$

in der Faser $z = 0$.

3/



Aufgabe 3

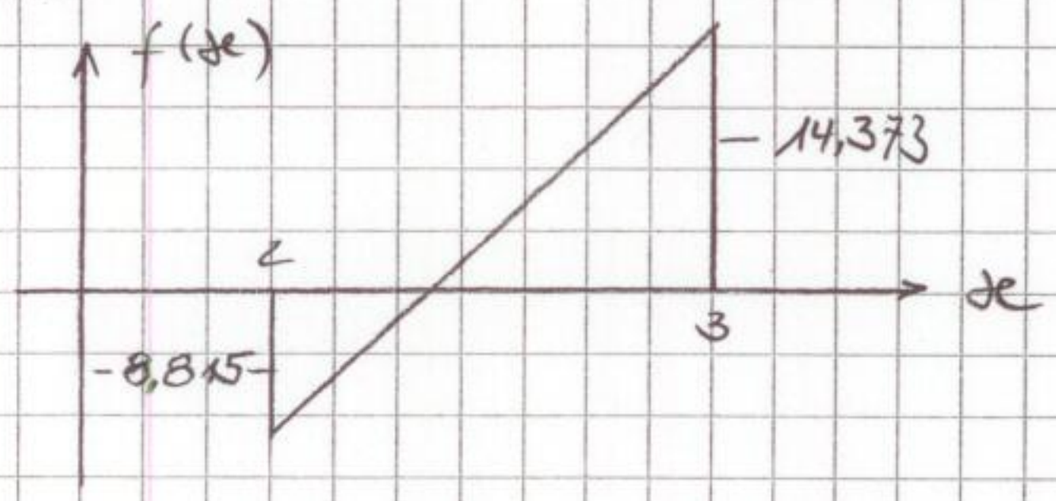
1) $\delta = \frac{100 \frac{N}{mm} \cdot (3000mm)^3}{2{,}1 \cdot 10^5 \frac{N}{mm^2} \cdot 320 \cdot 10^4 mm^4} = 4{,}018$

Knickbedingung: $f(x) = x^3 + 4{,}018 \cdot \tan x - 4{,}018 \cdot x = 0$

$f(x=2) = -8{,}815$

$f(x=3) = 14{,}373$

1. Iteration:

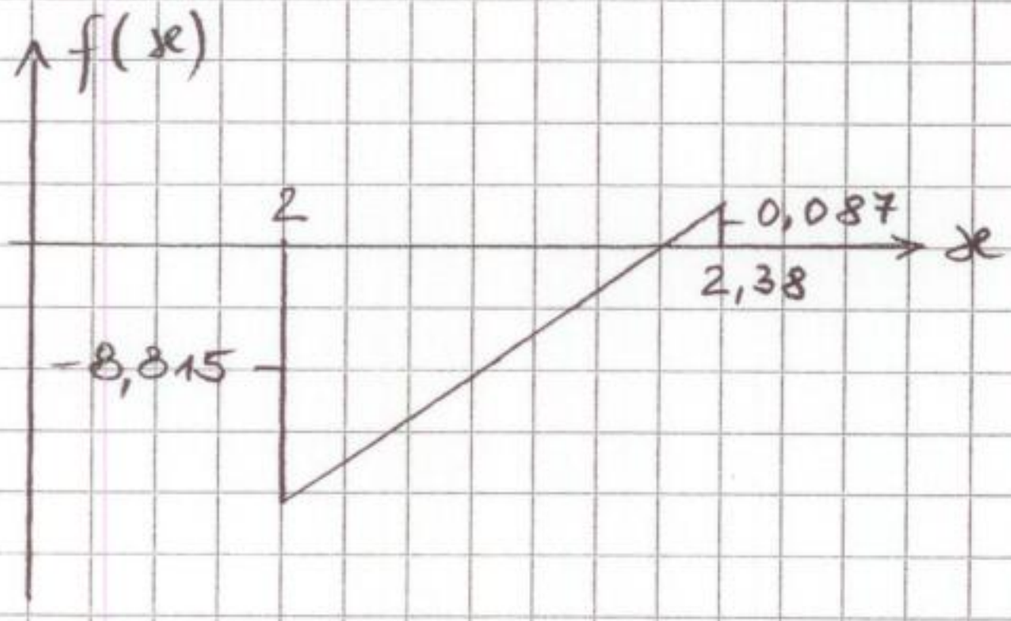


$\frac{\Delta x}{8{,}815} = \frac{1}{8{,}815 + 14{,}373}$; $\Delta x = 0{,}380$

$x_{Neu} = 2 + 0{,}380 = 2{,}380$

$f(x_{Neu}) = 0{,}087$

2. Iteration



$\frac{\Delta x}{8{,}815} = \frac{0{,}38}{8{,}815 + 0{,}087}$; $\Delta x = 0{,}376$

$\varkappa_{Neu} = 2,376$

$f(\varkappa_{Neu}) = 0,0047 \sim 0$

$$\varkappa = \sqrt{\frac{F_K}{E \cdot I}} \cdot l = 2,376$$

$$F_K = \frac{2,376^2 \cdot E \cdot I}{l^2}$$

$$F_K = \frac{2,376^2 \cdot 2,1 \cdot 10^5 \frac{N}{mm^2} \cdot 320 \cdot 10^4 mm^4}{(3000 mm)^2}$$

$$F_K = 421521\ N$$

$$\nu = \frac{421521\ N}{100000\ N} = 4,21$$

2) $$\frac{E \cdot I \cdot \pi^2}{S_K^2} = F_K$$

$$S_K = \sqrt{\frac{E \cdot I \cdot \pi^2}{F_K}} = \sqrt{\frac{2,1 \cdot 10^5 \frac{N}{mm^2} \cdot 320 \cdot 10^4 mm^4 \cdot \pi^2}{421521\ N}}$$

$$S_K = 3967 mm$$

$$i = \sqrt{\frac{I_y}{A}} = \sqrt{\frac{320 cm^4}{48 cm^2}} = 2,582 cm = 25,82 mm$$

$$\lambda = \frac{S_K}{i} = \frac{3967 mm}{25,82 mm} = 153,64 > \lambda_{grenz} = 105$$

elastische Rechnung o.k.