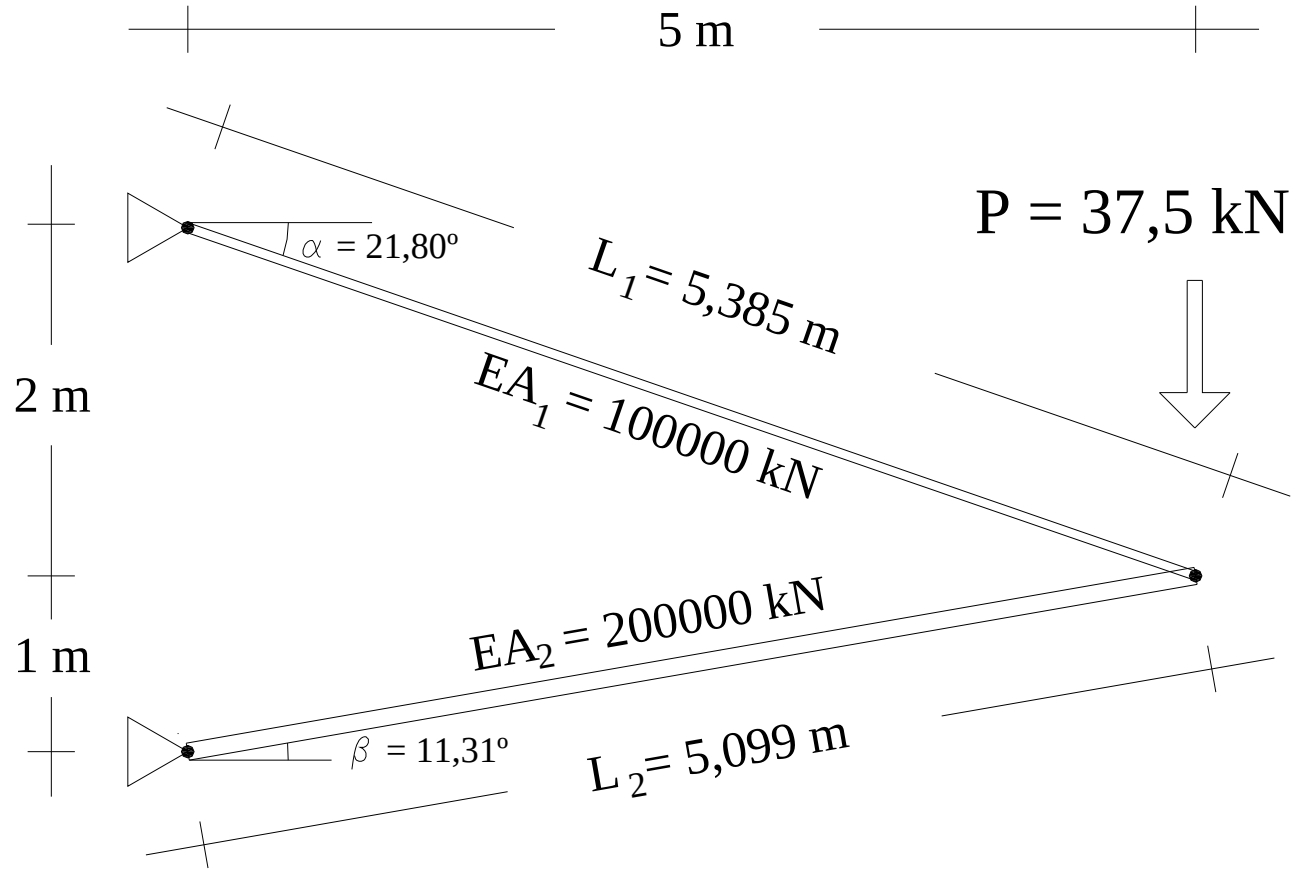
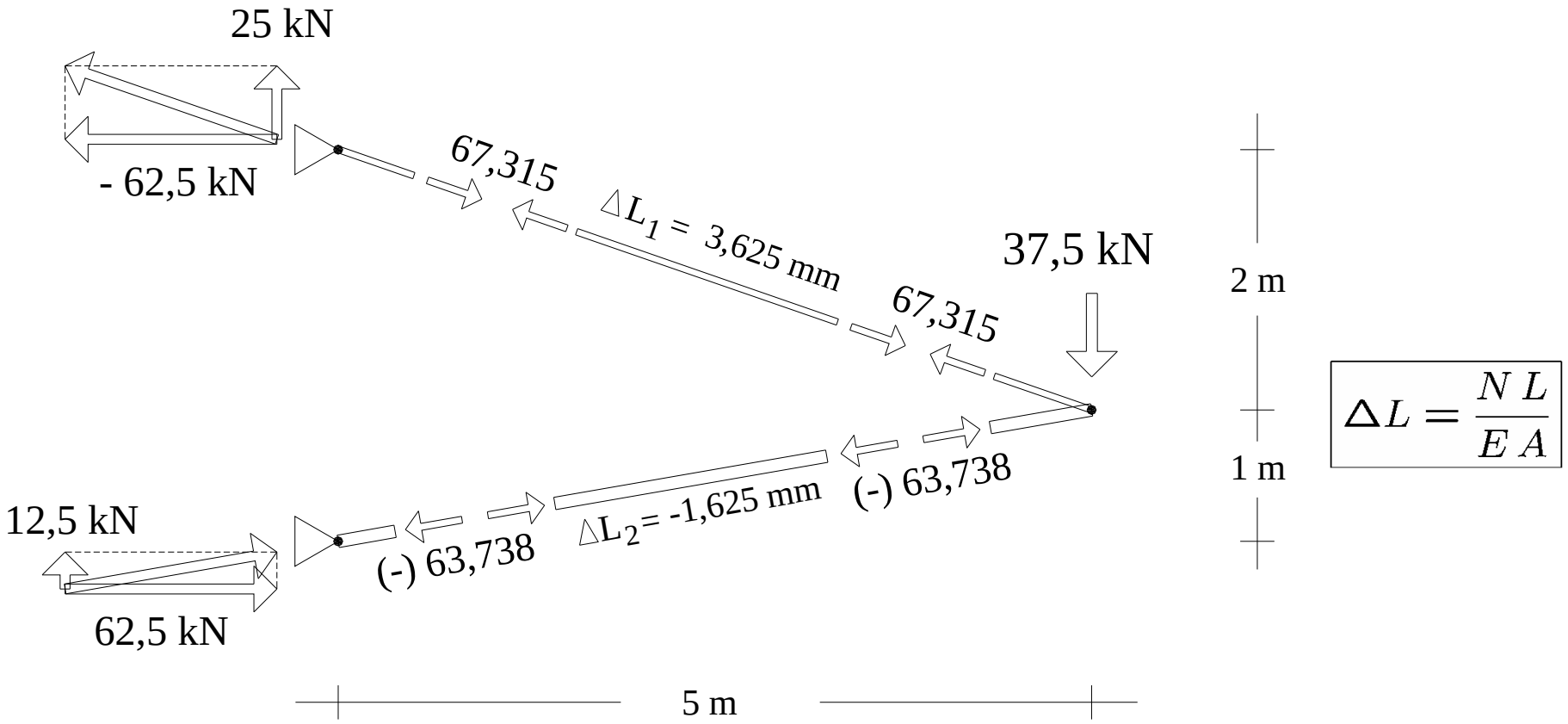
P.V.W. determination of movements: unit load method



¿ v ?

¿ u ?

“real” structure: axial deformations



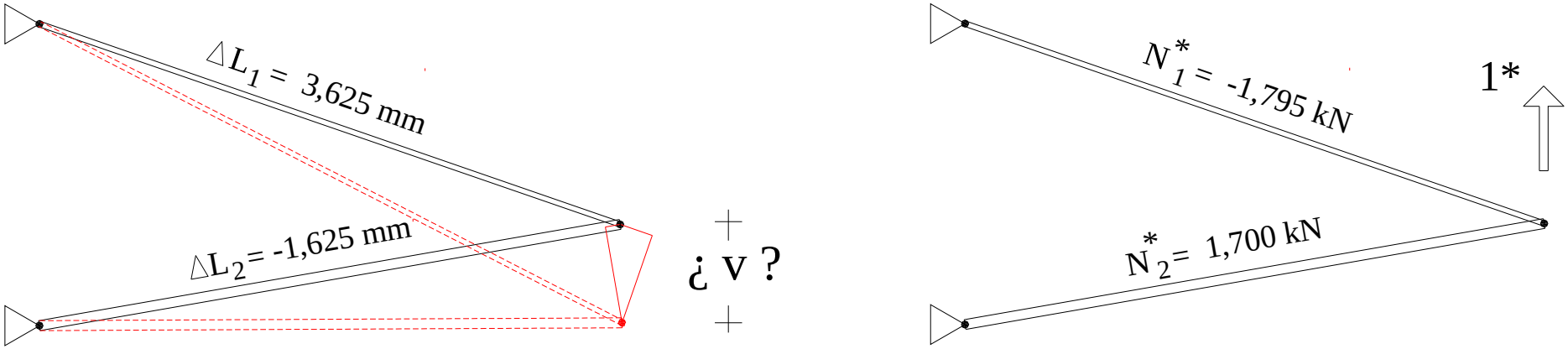
$$\Delta L_1 = \frac{N_1\,L_1}{E\,A_1} = \frac{67,314\,\text{kN}\cdot 5,385\ \text{m}}{100000\,\text{kN}} = \quad 0,003625\,\text{m} = \quad 3,625\,\text{mm}$$

$$\Delta L_2 = \frac{N_2\,L_2}{E\,A_2} = \frac{-63,738\,\text{kN}\cdot 5,099\,\text{m}}{200000\,\text{kN}} = -0,001625\,\text{m} = -1,625\,\text{mm}$$

determination of vertical movement, v

"REAL" STRUCTURE:
KINEMATICS (v, ΔL)
COMPATIBILITY

"VIRTUAL" STRUCTURE
STATICS (1*, N*)
EQUILIBRIUM



$$\text{EQUILIBRIUM} + \text{COMPATIBILITY} \Rightarrow \sum W_{ext} = \sum W_{int}$$

$$1^* \cdot v = \sum W_{ext} = \sum W_{int} = N_1^* \cdot \Delta L_1 + N_2^* \cdot \Delta L_2$$

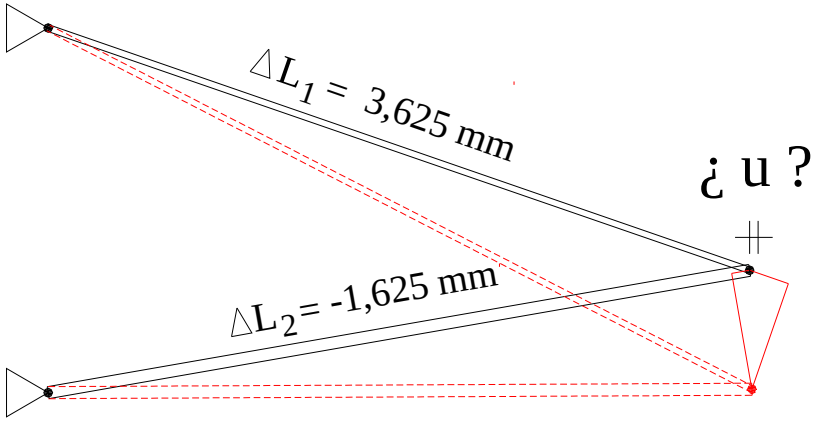
$$1^* \cdot v = -1,795\,\text{kN} \cdot 0,003625\,\text{m} + 1,700\,\text{kN} \cdot -0,001625\,\text{m}$$

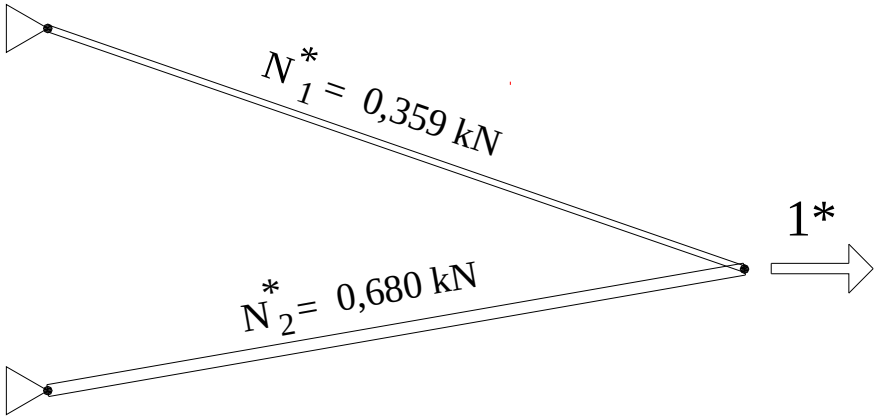
$$v = -0,009269\,\text{m} = -9,269\,\text{mm}$$

horizontal movement, u

"REAL" STRUCTURE:
KINEMATICS (v, $\triangle$L)
COMPATIBILITY

"VIRTUAL" STRUCTURE
STATICS (1*, N*)
EQUILIBRIUM





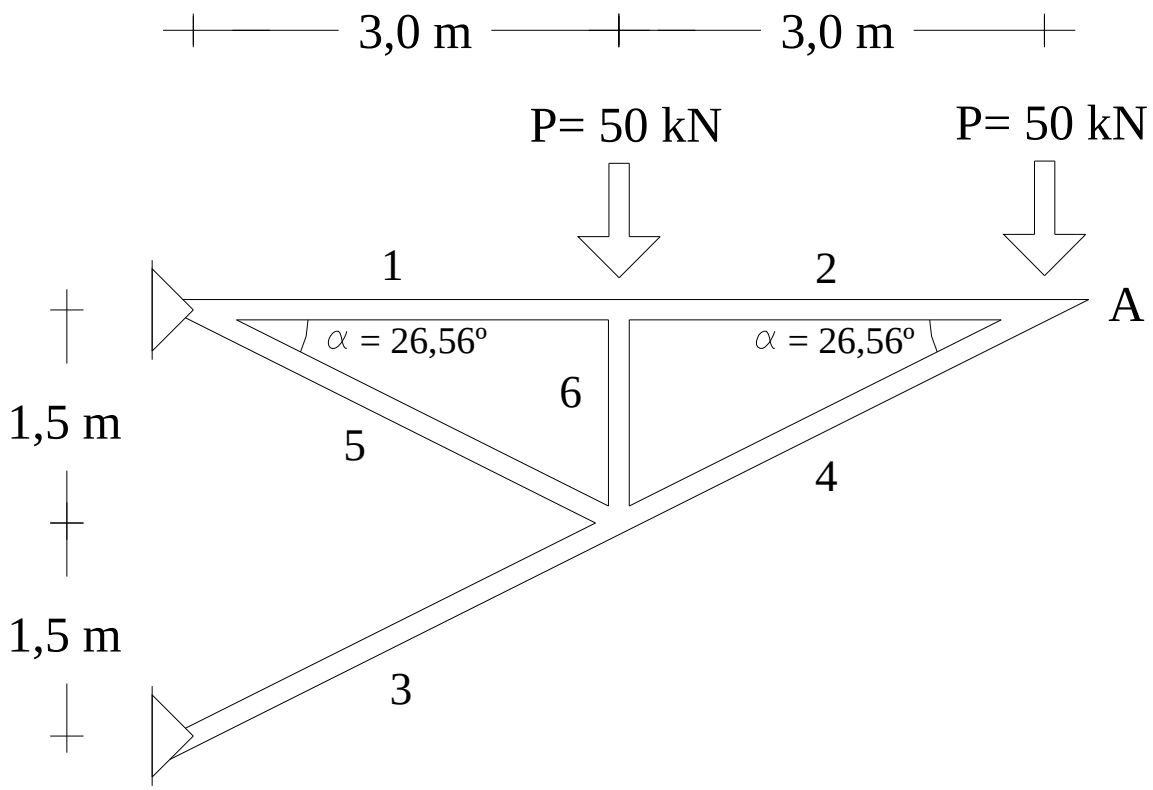
EQUILIBRIUM + COMPATIBILITY $\Rightarrow \sum W_{ext} = \sum W_{int}$

$$1^* \cdot u = \sum W_{ext} = \sum W_{int} = N_1^* \cdot \Delta L_1 + N_2^* \cdot \Delta L_2$$

$$1^* \cdot u = 0{,}359\,\text{kN} \cdot 0{,}003625\,\text{m} + 0{,}680\,\text{kN} \cdot -0{,}001625\,\text{m}$$

$$u = 0{,}000196\,\text{m} = 0{,}196\,\text{mm}$$

another example



¿ v_A ?

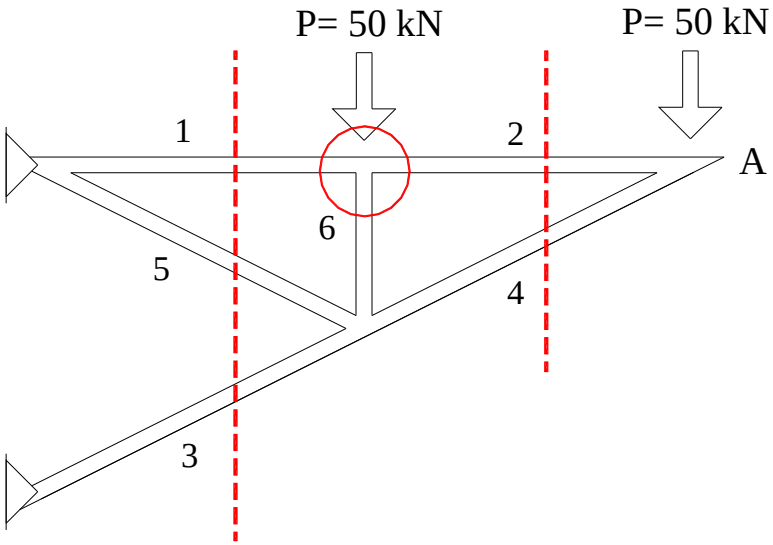
¿ u_A ?

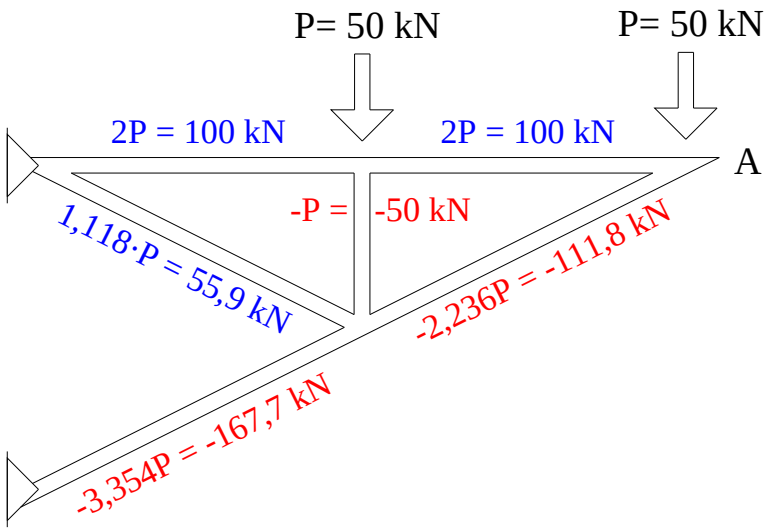
STEEL S-275 : $f_y = 275 \mathrm{N/mm^2}$; $E = 210000\,\mathrm{N/mm^2}$

MEMBERS : C.H.S. 125x4 mm ; $A_{\Phi\ 125.4} = 15,2\,\mathrm{cm^2}$

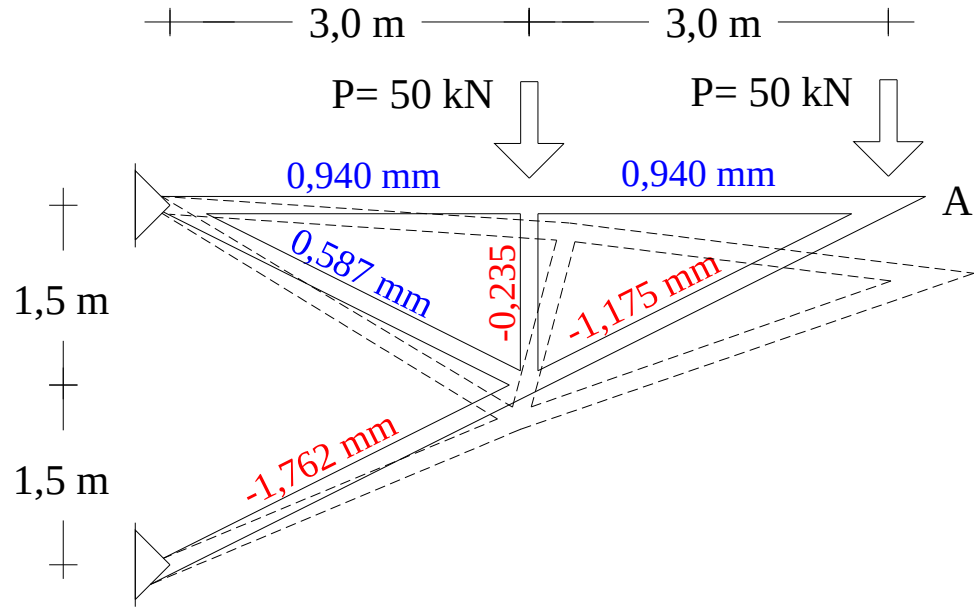
$$E\,A = 319200\,\mathrm{kN}$$

“real” structure: axial forces





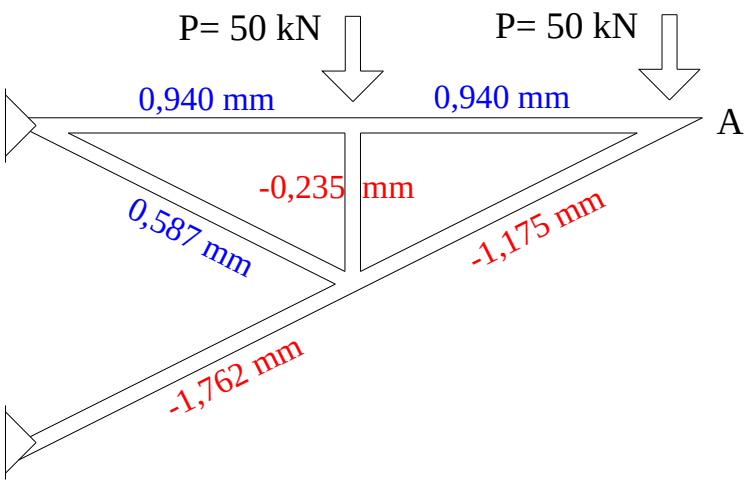
“real” structure: axial deformations



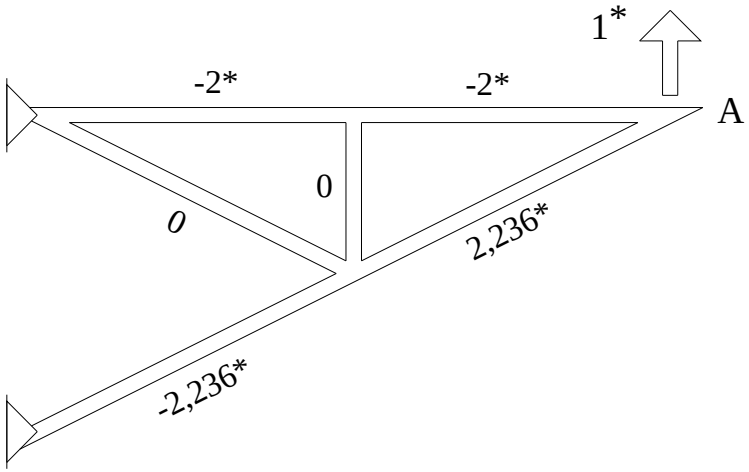
BARRA	N (kN)	L (m)	EA (kN)	ΔL = NL / EA (mm)
1	100	3	319200	0,940
2	100	3	319200	0,940
3	-167,7	3,354	319200	-1,762
4	-111,8	3,354	319200	-1,175
5	55,9	3,354	319200	0,587
6	-50	1,5	319200	-0,235

vertical movement calculation, v_A

"REAL" STRUCTURE: KINEMATICS; COMPATIBILITY



"VIRTUAL" STRUCTURE: STATICS; EQUILIBRIUM



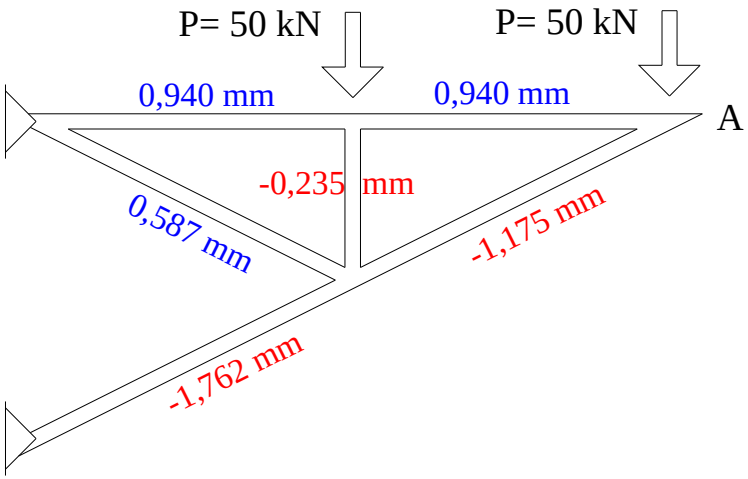
$$1^* \cdot v_A = \sum W_{ext} = \sum W_{int} = \sum_b N_b^* \cdot \Delta_b$$

BARRA	N_b^* (kN)	ΔL_b (m)	$N_b^* \cdot \Delta L_b$ (kN m)
1	-2	0,940 E-3	-1,880 E-3
2	-2	0,940 E-3	-1,880 E-3
3	2,236	-1,762 E-3	-2,627 E-3
4	2,236	-1,175 E-3	-3,940 E-3
5	0	0,587 E-3	0
6	0	-0,235 E-3	0
		$\sum W_{int} =$	**-10,327 E-3**

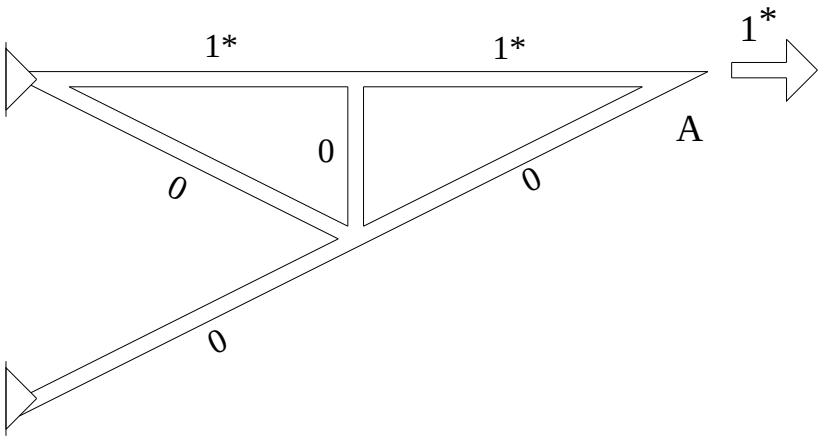
$$\boxed{v_A = -0,010327\,\text{m} = -10,327\,\text{mm}}$$

horizontal movement calculation, u_A

"REAL" STRUCTURE: KINEMATICS; COMPATIBILITY



"VIRTUAL" STRUCTURE: STATICS; EQUILIBRIUM



$$1^* \cdot u_A = \sum W_{ext} = \sum W_{int} = \sum_b N_b^* \cdot \Delta_b$$

BARRA	N_b^* (kN)	ΔL_b (m)	$N_b^* \cdot \Delta L_b$ (kN m)
1	1	0,940 E-3	0,940 E-3
2	1	0,940 E-3	0,940 E-3
3	0	-1,762 E-3	0
4		-1,175 E-3	0
5	0	0,587 E-3	0
6	0	-0,235 E-3	0
		$\sum W_{int} =$	**1,880 E-3**

$$\mathbf{u_A = 0,001880\,m = 1,880\,mm}$$