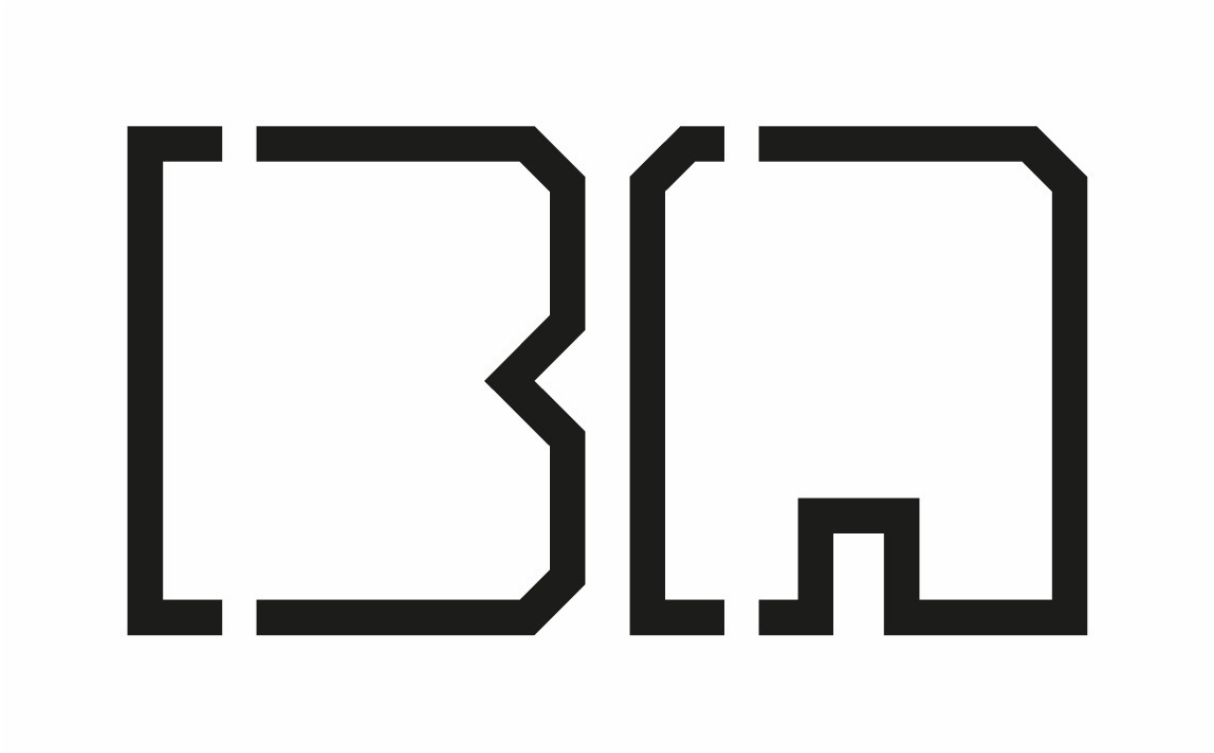
Politechnika Lubelska

Wydział Budownictwa i Architektury



Mechanika Teoretyczna

Projekt 2

Wykonał:

……..

Sprawdził:

dr inż. Jakub Gontarz

2025

PRZYKŁADOWY TEMAT

Imię i Nazwisko: .....

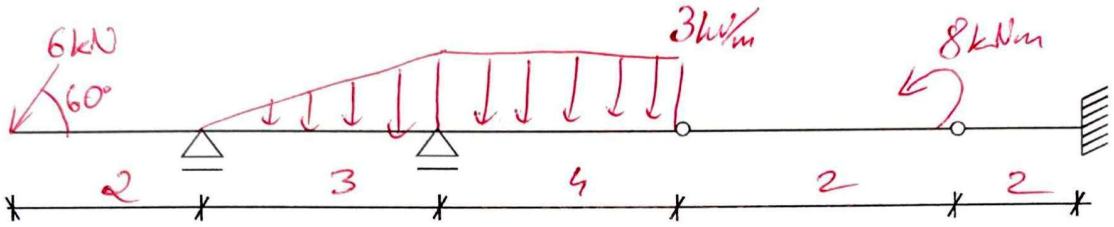
Grupa: .....

PROJEKT NR 1

MECHANIKA TEORETYCZNA

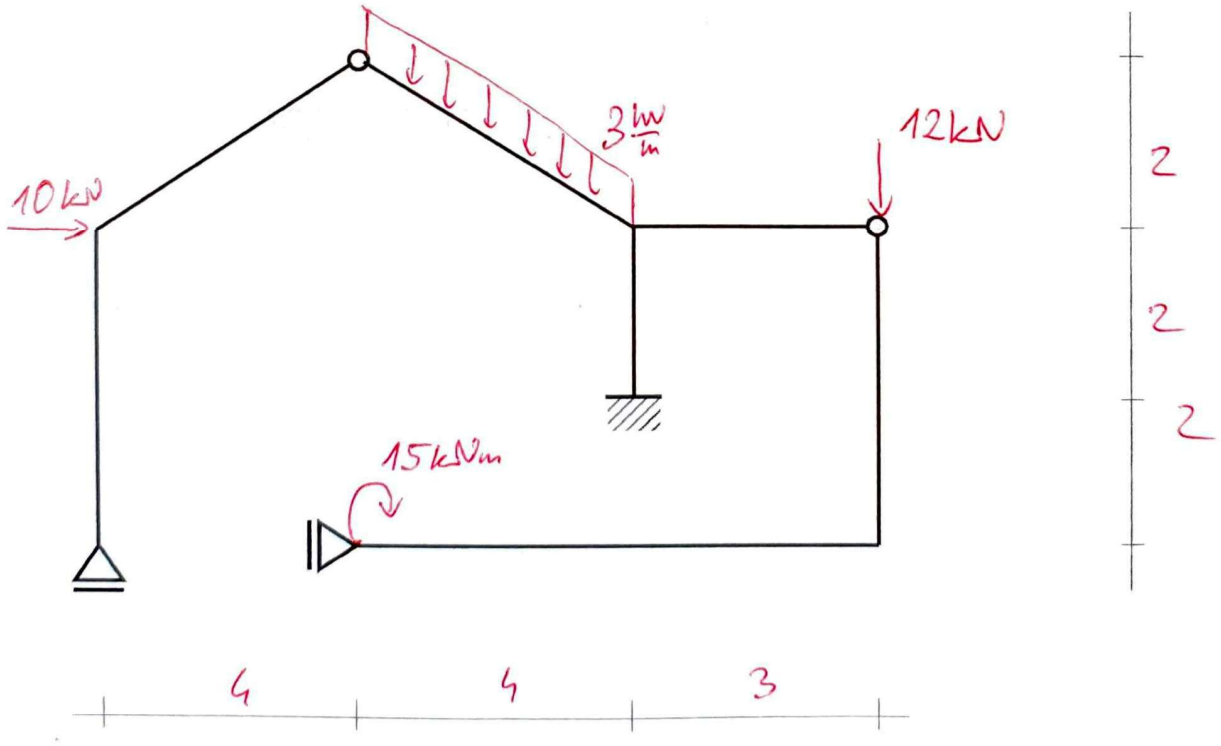
ZADANIE 1.

Obliczyć reakcje podporowe w belce.



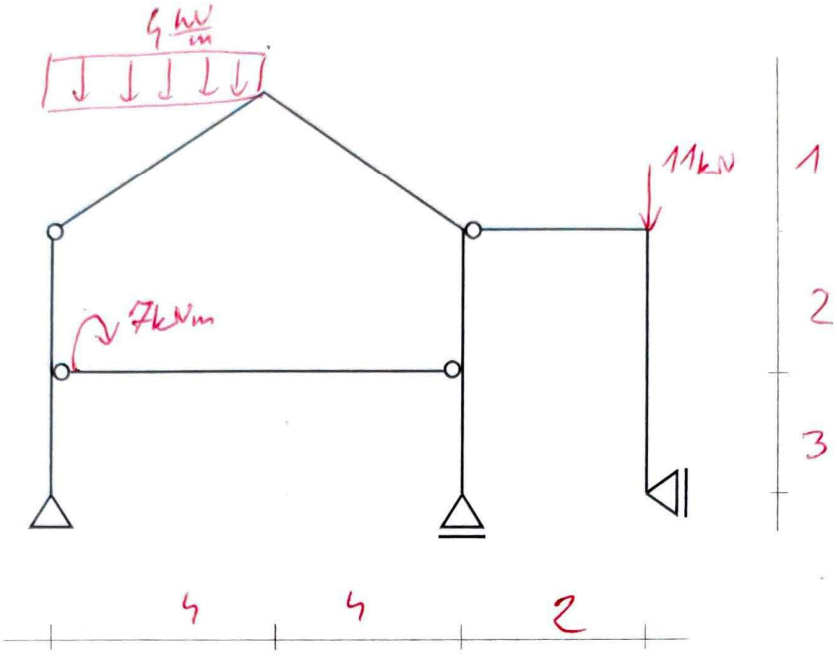
ZADANIE 2.

Obliczyć reakcje podporowe w ramie.



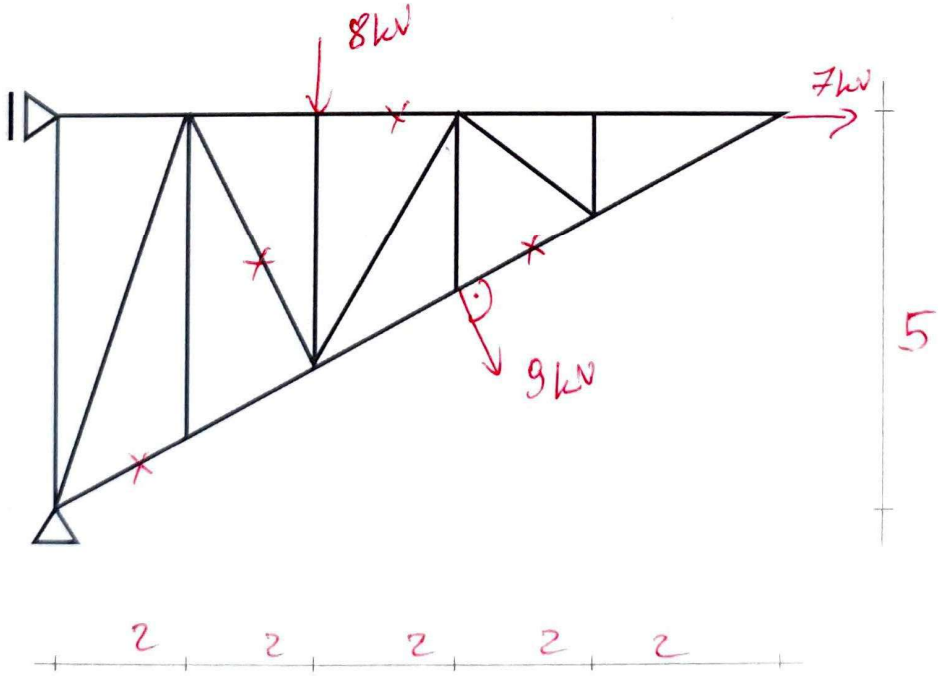
ZADANIE 3.

Obliczyć siły w ściągu.

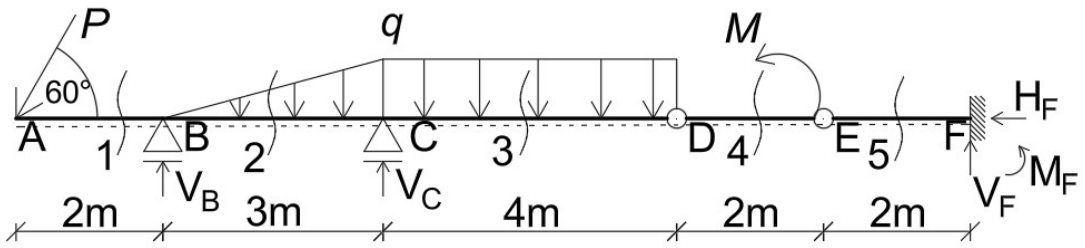


ZADANIE 4.

Obliczyć siły wewnętrzne w kratownicy metodą równoważenia węzłów.
Wykonać sprawdzenie metodą Rittera w zaznaczonych prętach.



Zadanie 1: Belka - siły wewnętrzne



$\mathbf{kNm} := \mathbf{kN} \cdot \mathbf{m}$

$P := 6\ \mathbf{kN}$

$M := 8\ \mathbf{kNm}$

$q := 3\ \frac{\mathbf{kN}}{\mathbf{m}}$

Reakcje policzono w pierwszej części projektu:

$V_B := -3.173\ \mathbf{kN}$

$V_C := 28.869\ \mathbf{kN}$

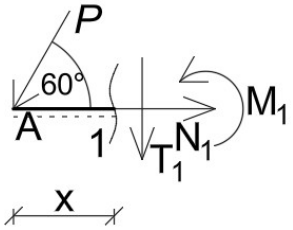
$V_F := -4\ \mathbf{kN}$

$M_F := 8\ \mathbf{kNm}$

$H_F := -3\ \mathbf{kN}$

Liczenie sił wewnętrznych:

Pręt 1 x∈(0;2)m



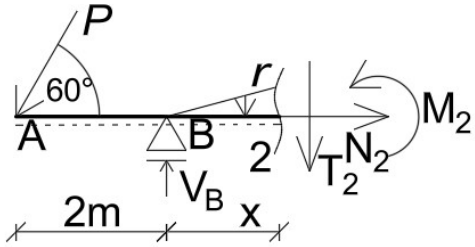
$N_1 := P \cdot \cos(60°) = 3\ \mathbf{kN}$

$T_1 := -P \cdot \sin(60°) = -5.196\ \mathbf{kN}$

$M_1(x) := -P \cdot \sin(60°) \cdot x$

$M_1(0\ \mathbf{m}) = 0\ \mathbf{kNm} \qquad M_1(2\ \mathbf{m}) = -10.392\ \mathbf{kNm}$

Pręt 2 x∈(0;3)m $\qquad r(x) := q \cdot \frac{x}{3\ \mathbf{m}}$



$N_2 := P \cdot \cos(60°) = 3\ \mathbf{kN}$

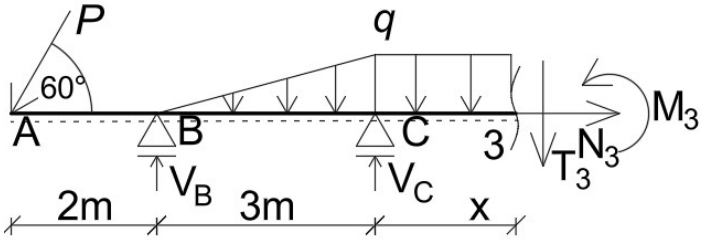
$T_2(x) := -P \cdot \sin(60°) + V_B - \frac{1}{2}\, r(x) \cdot x$

$M_2(x) := -P \cdot \sin(60°) \cdot (x + 2\ \mathbf{m}) + V_B \cdot x - \frac{1}{2}\, r(x) \cdot x \cdot \frac{1}{3}\, x$

$T_2(0\ \mathbf{m}) = -8.369\ \mathbf{kN} \qquad T_2(3\ \mathbf{m}) = -12.869\ \mathbf{kN}$

$M_2(0\ \mathbf{m}) = -10.392\ \mathbf{kNm} \qquad M_2(3\ \mathbf{m}) = -40\ \mathbf{kNm}$

Pręt 3 x∈(0;4)m



$N_3 := P \cdot \cos(60°) = 3\ \mathbf{kN}$

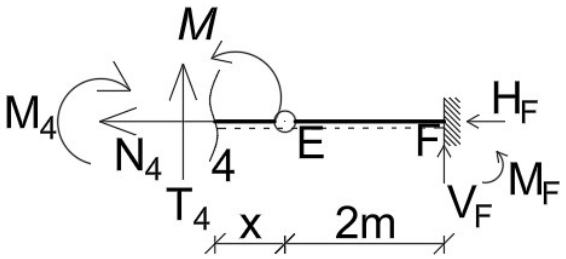
$T_3(x) := -P \cdot \sin(60°) + V_B - \frac{1}{2}\, q \cdot 3\ \mathbf{m} + V_C - q \cdot x$

$M_3(x) := -P \cdot \sin(60°) \cdot (x + 5\ \mathbf{m}) + V_B \cdot (x + 3\ \mathbf{m}) - \frac{1}{2}\, q \cdot 3\ \mathbf{m} \cdot (x + 1\ \mathbf{m}) + V_C \cdot x - q \cdot x \cdot \frac{1}{2}\, x$

$T_3(0\ \mathbf{m}) = 16\ \mathbf{kN} \qquad T_3(4\ \mathbf{m}) = 4\ \mathbf{kN}$

$M_3(0\ \mathbf{m}) = -40\ \mathbf{kNm} \qquad M_3(4\ \mathbf{m}) = 0\ \mathbf{kNm}$

Pręt 4 x∈(0;2)m



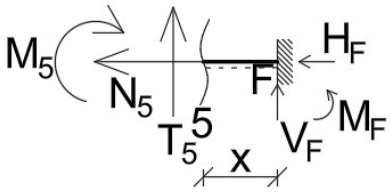
$N_4 := -H_F = 3\ \mathbf{kN}$

$T_4 := -V_F = 4\ \mathbf{kN}$

$M_4(x) := V_F \cdot (x + 2\ \mathbf{m}) + M + M_F$

$M_4(0\ \mathbf{m}) = 8\ \mathbf{kNm} \qquad M_4(2\ \mathbf{m}) = 0\ \mathbf{kNm}$

Pręt 5 x∈(0;2)m



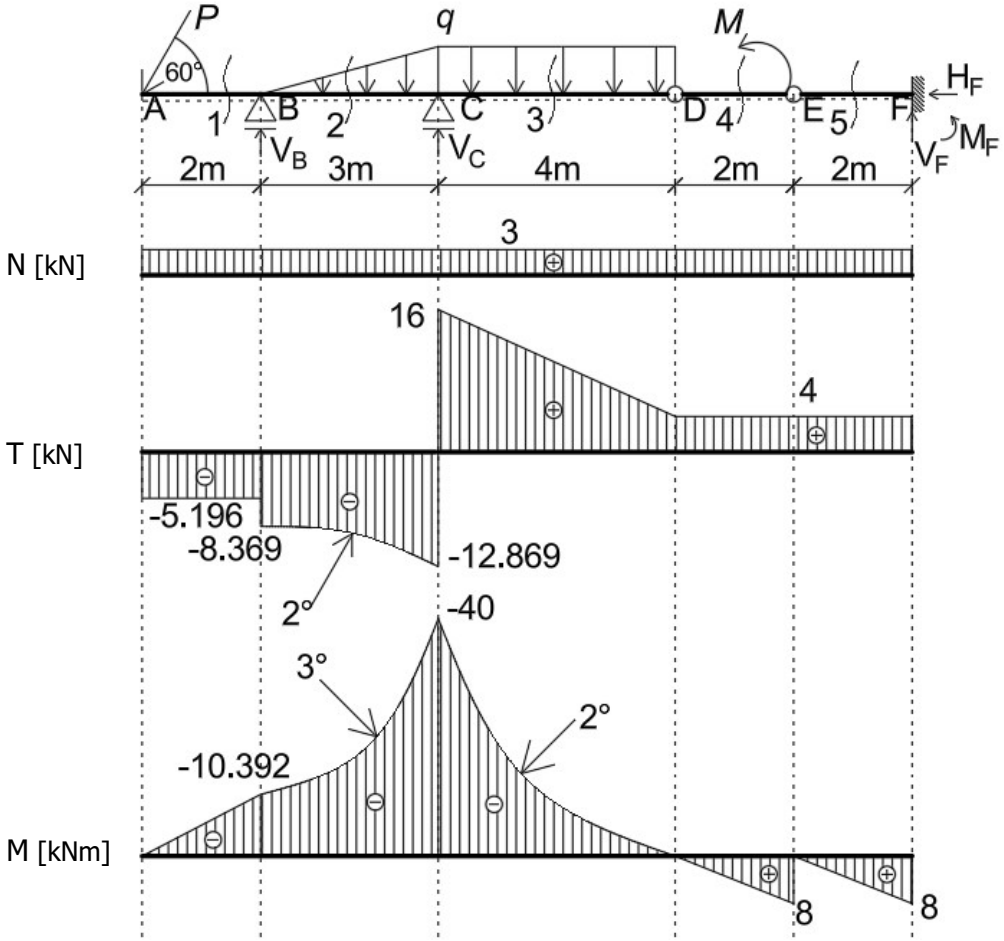
$N_5 := -H_F = 3\ \mathbf{kN}$

$T_5 := -V_F = 4\ \mathbf{kN}$

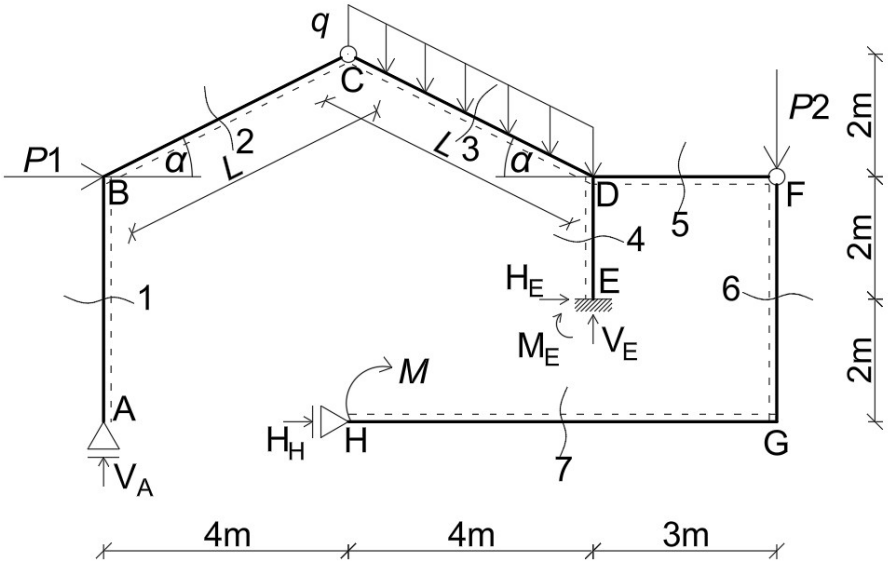
$M_5(x) := V_F \cdot x + M_F$

$M_5(0\ \mathbf{m}) = 8\ \mathbf{kNm} \qquad M_5(2\ \mathbf{m}) = 0\ \mathbf{kNm}$

Wykresy:



Zadanie 2: Rama - siły wewnętrzne



$P1 := 10\ \mathbf{kN}$

$P2 := 12\ \mathbf{kN}$

$M := 15\ \mathbf{kNm}$

$q := 3\ \frac{\mathbf{kN}}{\mathbf{m}}$

$L := \sqrt{(4\ \mathbf{m})^2 + (2\ \mathbf{m})^2} = 4.472\ \mathbf{m}$

$sin\alpha := \frac{2\ \mathbf{m}}{L} = 0.447$

$cos\alpha := \frac{4\ \mathbf{m}}{L} = 0.894$

Reakcje policzono w pierwszej części projektu:

$V_A := 5\ \mathbf{kN}$

$V_E := 20.416\ \mathbf{kN}$

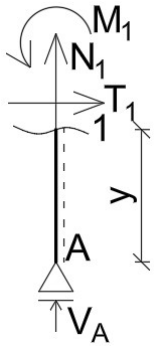
$H_H := 3.75\ \mathbf{kN}$

$H_E := -13.75\ \mathbf{kN}$

$M_E := -76.669\ \mathbf{kNm}$

Liczenie sił wewnętrznych:

Pręt 1 y∈(0;4)m

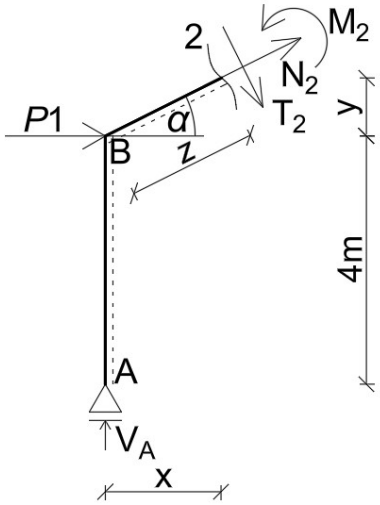


$N_1 := -V_A = -5\ \mathbf{kN}$

$T_1 := 0\ \mathbf{kN}$

$M_1 := 0\ \mathbf{kNm}$

Pręt 2 x∈(0;4)m $y(x) := \frac{2}{4}\,x$ $z(x) := \frac{L}{4}\,x$



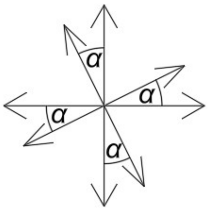
$N_2 := -V_A \cdot sin\alpha - P1 \cdot cos\alpha = -11.18\ \mathbf{kN}$

$T_2 := V_A \cdot cos\alpha - P1 \cdot sin\alpha = 0\ \mathbf{kN}$

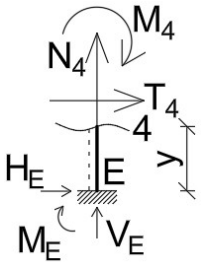
$M_2(x) := V_A \cdot x - P1 \cdot y(x)$

$M_2(0\ \mathbf{m}) = 0\ \mathbf{kNm}$ $M_2(4\ \mathbf{m}) = 0\ \mathbf{kNm}$

schemat pomocniczy składowych sił:



Pręt 4 y∈(0;2)m



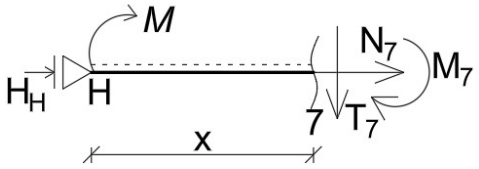
$N_4 := -V_E = -20.416\ \mathbf{kN}$

$T_4 := -H_E = 13.75\ \mathbf{kN}$

$M_4(y) := -M_E + H_E \cdot y$

$M_4(0\ \mathbf{m}) = 76.669\ \mathbf{kNm}$ $M_4(2\ \mathbf{m}) = 49.169\ \mathbf{kNm}$

Pręt 7 x∈(0;7)m

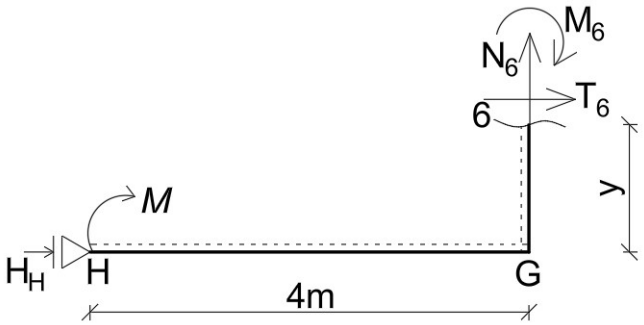


$N_7 := -H_H = -3.75\ \mathbf{kN}$

$T_7 := 0\ \mathbf{kN}$

$M_7 := -M = -15\ \mathbf{kNm}$

Pręt 6 y∈(0;4)m



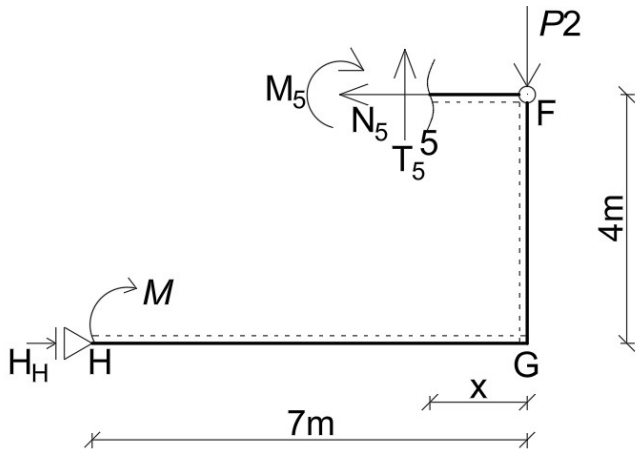
$N_6 := 0\ \mathbf{kN}$

$T_6 := -H_H = -3.75\ \mathbf{kN}$

$M_6(y) := -M + H_H \cdot y$

$M_6(0\ \mathbf{m}) = -15\ \mathbf{kNm}$ $M_6(4\ \mathbf{m}) = 0\ \mathbf{kNm}$

Pręt 5 x∈(0;3)m



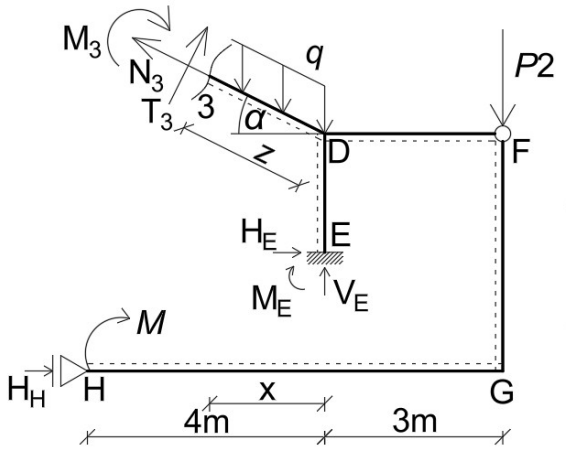
$N_5 := H_H = 3.75\ \mathbf{kN}$

$T_5 := P2 = 12\ \mathbf{kN}$

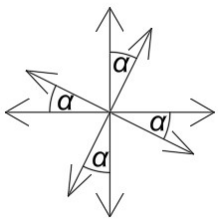
$M_5(x) := -M + H_H \cdot 4\ \mathbf{m} - P2 \cdot x$

$M_5(0\ \mathbf{m}) = 0\ \mathbf{kNm}$ $M_5(3\ \mathbf{m}) = -36\ \mathbf{kNm}$

Pręt 3 x∈(0;4)m $y(x) := \frac{2\ \mathbf{m}}{4\ \mathbf{m}}\ x$ $z(x) := \frac{L}{4\ \mathbf{m}}\ x$



schemat pomocniczy składowych sił:



$N_3(x) := H_H \cdot cos\alpha + P2 \cdot sin\alpha + q \cdot z(x) \cdot sin\alpha + H_E \cdot cos\alpha - V_E \cdot sin\alpha$

$T_3(x) := -H_H \cdot sin\alpha + P2 \cdot cos\alpha + q \cdot z(x) \cdot cos\alpha - H_E \cdot sin\alpha - V_E \cdot cos\alpha$

$M_3(x) := -M + H_H \cdot (y(x) + 4\ \mathbf{m}) - P2 \cdot (x + 3\ \mathbf{m}) - q \cdot z(x) \cdot \frac{x}{2} + H_E \cdot (y(x) + 2\ \mathbf{m}) + V_E \cdot x - M_E$

$N_3(0\ \mathbf{m}) = -12.708\ \mathbf{kN}$ $N_3(4\ \mathbf{m}) = -6.708\ \mathbf{kN}$

$T_3(0\ \mathbf{m}) = -3.055\ \mathbf{kN}$ $T_3(4\ \mathbf{m}) = 8.945\ \mathbf{kN}$

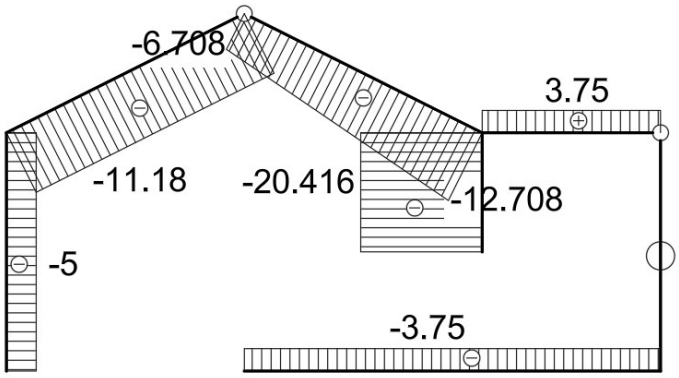
$M_3(0\ \mathbf{m}) = 13.169\ \mathbf{kNm}$ $M_3(4\ \mathbf{m}) = 0\ \mathbf{kNm}$

ekstremum momentów:

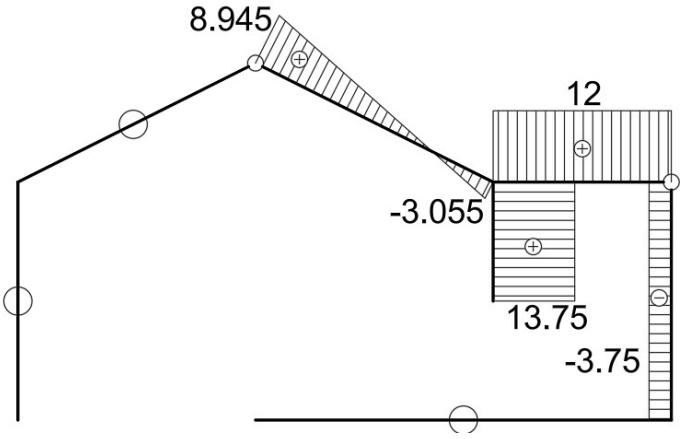
$T_3(x) = 0$ $x_{max} := \frac{H_H \cdot sin\alpha - P2 \cdot cos\alpha + H_E \cdot sin\alpha + V_E \cdot cos\alpha}{q \cdot \frac{L}{4\ \mathbf{m}} \cdot cos\alpha} = 1.018\ \mathbf{m}$ $M_3(x_{max}) = 14.909\ \mathbf{kNm}$

Wykresy:

N [kN]



T [kN]



M [kNm]