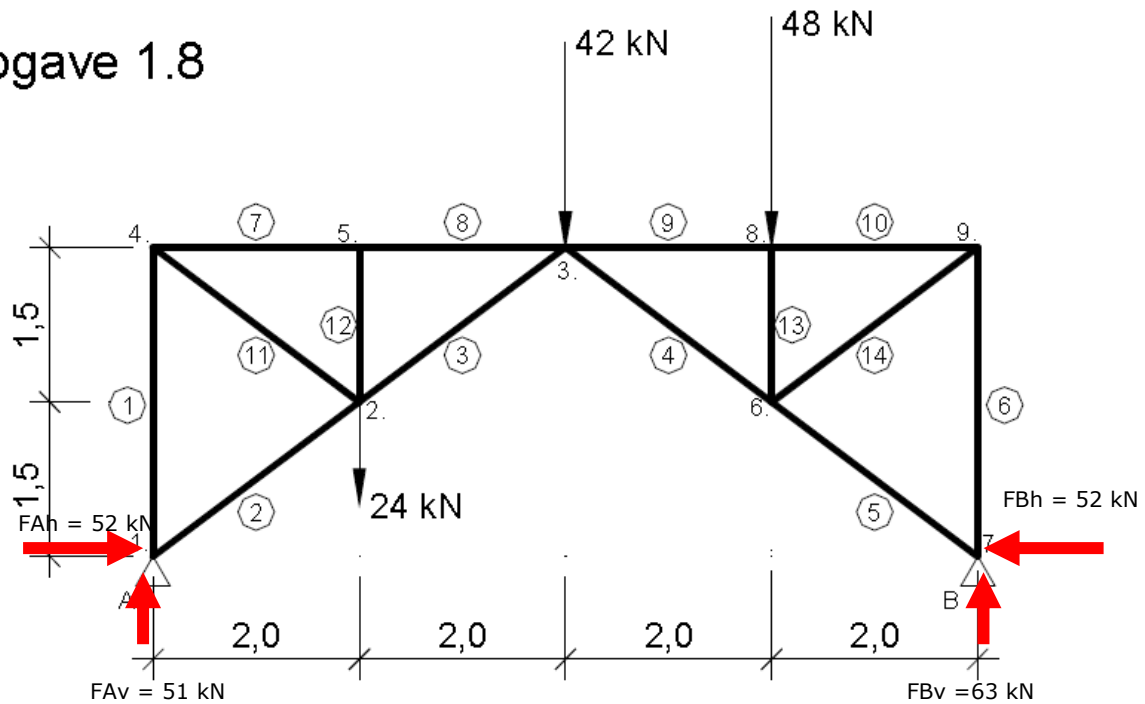


Opgave 1.8



14 Staven

9 knopen

$$S \geq 2k - 3$$

$$S = (2 \times 9) - 3$$

$$S = 15$$

Aantal staven kleiner dan 15.

Het vakwerk is niet statisch bepaald, niet vormvast en niet plaatsvast.

Het blijkt hier te handelen om een samengesteld vakwerk.

Deze kunnen we kinematisch bepaald maken door extra reactiekrachten toe te voegen.

Er geldt dan $S = 2k - r$

Voorwaarde is dan wel dat elk van de samenstellende delen statisch bepaald zijn.

$$S = 2k - r$$

$$S = (2 \times 9) - 4$$

$$S = 14$$

We moeten dus 4 reactiekrachten toevoegen om het raamwerk vormvast en plaatsvast te krijgen.

$$\sum M \text{ tov } A = 0$$

$$-(24 \times 2) - (42 \times 4) - (48 \times 6) + 8FBv = 0$$

$$FBv = 63 \text{ kN}$$

$$\sum V = 0$$

$$FAv = 24 + 42 + 48 - 63$$

$$FAv = 51 \text{ kN}$$

Linker deel

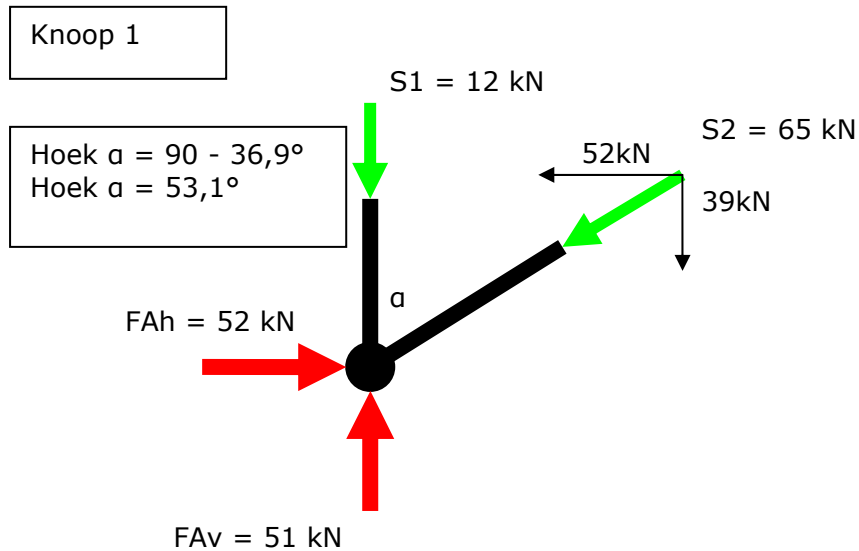
$$\sum M \text{ tov } K3 = 0$$

$$FAh \times 3 - (51 \times 4) + (24 \times 2) = 0$$

$$FAh = 52 \text{ kN}$$

$$\begin{aligned}\Sigma H &= 0 \\ F_{Av} - F_{Bh} &= 0 \\ 52 - F_{Bh} &= 0 \\ F_{Bh} &= 52 \text{ kN}\end{aligned}$$

2 vertical en 2 horizontale reactiekrachten. Het raamwerk is nu vormvast en plaatsvast.



$$\begin{aligned}\Sigma H &= 0 \\ F_{Ah} - S_{2h} &= 0 \\ 52 - S_{2h} &= 0 \\ S_{2h} &= 52 \text{ kN} \\ S_{2v} &= \tan(36,9^\circ) \times 52 = 39 \text{ kN} \\ S_2 &= 52 / \cos(36,9^\circ) = 65 \text{ kN}\end{aligned}$$

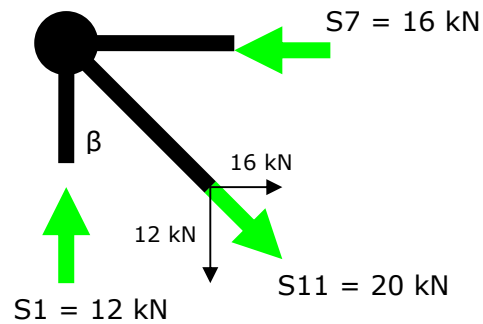
Druk

$$\begin{aligned}\Sigma V &= 0 \\ -F_{Av} + S_1 + S_{2v} &= 0 \\ -51 + S_1 + 39 &= 0 \\ S_1 &= 12 \text{ kN}\end{aligned}$$

Druk

Knoop 4

Hoek $\beta = 53,1^\circ$



$$\Sigma V = 0$$

$$-S1 + S11v = 0$$

$$-12 + S11v = 0$$

$$S11v = 12 \text{ kN}$$

$$S11h = \tan(53,1^\circ) \times 12 = 16 \text{ kN}$$

$$S11 = \sqrt{12^2 + 16^2}$$

$$S11 = 20 \text{ kN} \downarrow$$

Trek

$$\Sigma H = 0$$

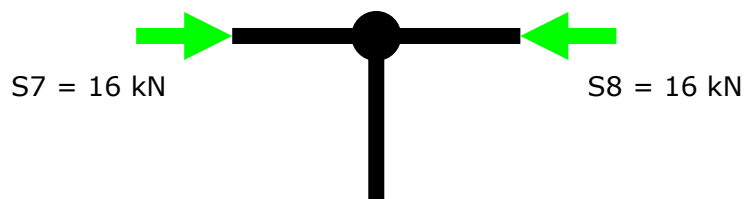
$$S11h - S7 = 0$$

$$16 - S7 = 0$$

$$S7 = 16 \text{ kN} \leftarrow$$

Druk

Knoop 4



$$\Sigma H = 0$$

$$S7 - S8 = 0$$

$$16 - S8 = 0$$

$$S8 = 16 \text{ kN} \leftarrow$$

Druk

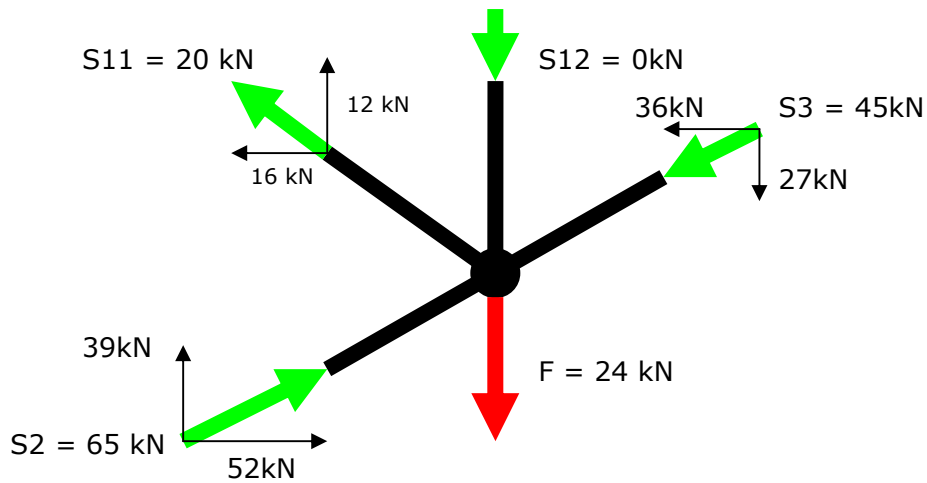
$$\Sigma V = 0$$

$$F - S12 = 0$$

$$0 - S12 = 0$$

$$S12 = 0 \text{ kN, Nulstaaf}$$

Knoop 2



Staf 12 is een nulstaaf: Zie daarvoor knooppunt 5.

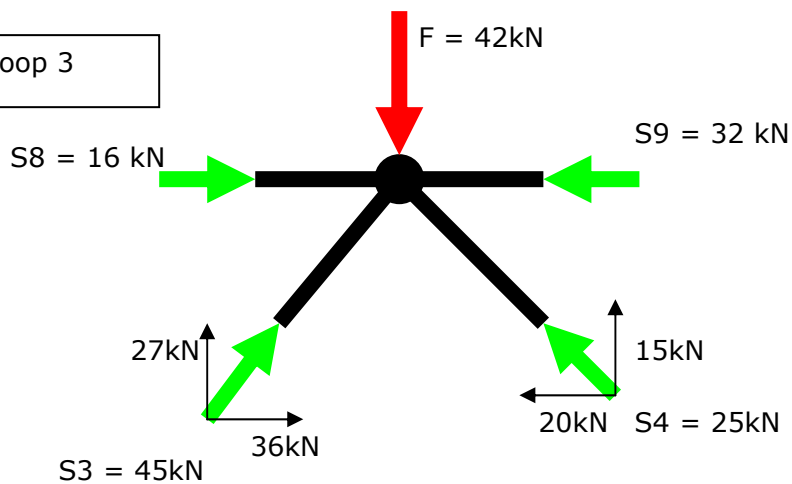
- Drie staven in een onbelaste knooppunt waarvan er twee in elkaars verlengde liggen dan moet de derde staaf (S12) een nulstaaf zijn.

$$\begin{aligned} \Sigma V &= 0 \\ -S_{2v} - S_{11v} + F + S_{12} + S_{3v} &= 0 \\ -39 - 12 + 24 + 0 + S_{3v} &= 0 \\ S_{3v} &= 27 \text{ kN} \downarrow \end{aligned}$$

$$\begin{aligned} S_{3h} &= 27 / \tan(36,9^\circ) \\ S_{3h} &= 36 \text{ kN} \leftarrow \\ S_3 &= \sqrt{27^2 + 36^2} \\ S_3 &= 45 \text{ kN} \downarrow \end{aligned}$$

Druk

Knoop 3



$$\begin{aligned} \Sigma V &= 0 \\ -S_{3v} + F - S_{4v} &= 0 \\ -27 + 42 - S_{4v} &= 0 \end{aligned}$$

$$S_{4v} = 15 \text{ kN} \uparrow$$

$$S_{4h} = 15 / \tan(36,9^\circ) = 20 \text{ kN} \leftarrow$$

$$S_4 = \sqrt{15^2 + 20^2}$$

$$S_4 = 25 \text{ kN} \uparrow$$

Druk

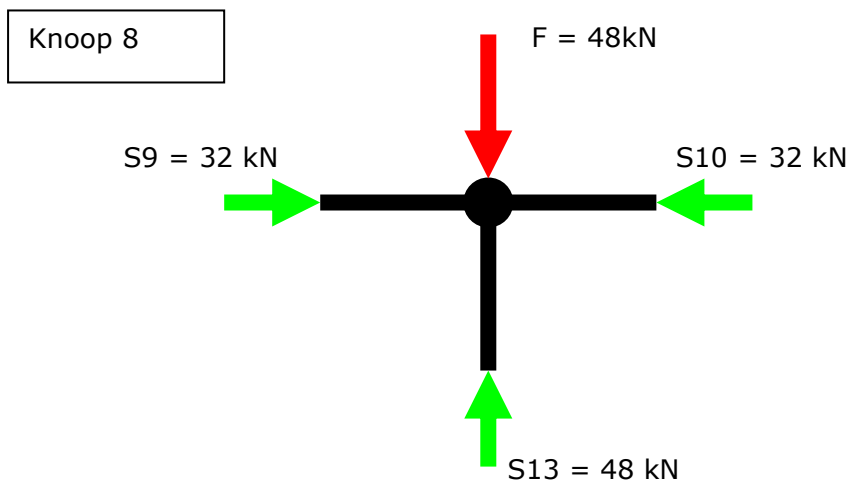
$$\Sigma H = 0$$

$$S_8 + S_{3h} - S_{4h} - S_9 = 0$$

$$16 + 36 - 20 - S_9 = 0$$

$$S_9 = 32 \text{ kN} \leftarrow$$

Druk



$$\Sigma V = 0$$

$$F - S_{13} = 0$$

$$48 - S_{13} = 0$$

$$S_{13} = 48 \text{ kN} \uparrow$$

Druk

$$\Sigma H = 0$$

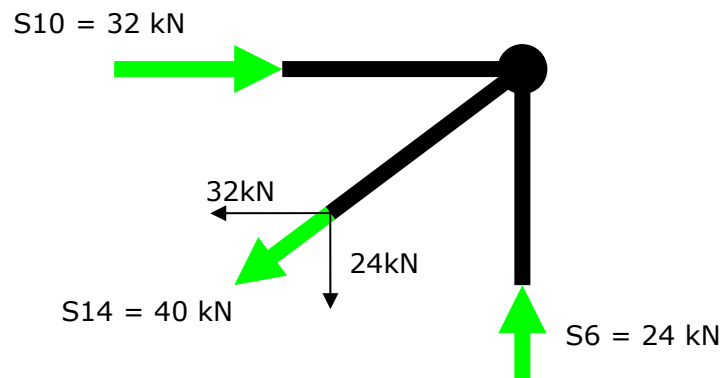
$$S_9 - S_{10} = 0$$

$$32 - S_{10} = 0$$

$$S_{10} = 32 \text{ kN} \leftarrow$$

Druk

Knoop 9



$$\begin{aligned}\Sigma H &= 0 \\ S_{10} - S_{14h} &= 0 \\ 32 - S_{14h} &= 0 \quad \downarrow \\ S_{14h} &= 32 \text{ kN} \quad \downarrow\end{aligned}$$

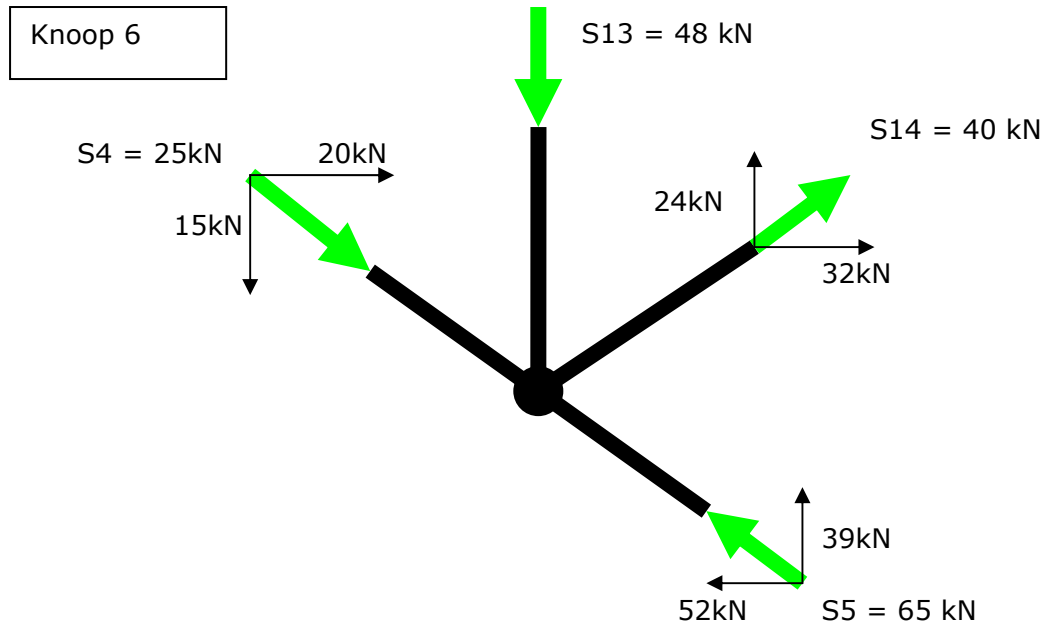
$$\begin{aligned}S_{14v} &= \tan(36,9) \times 32 \\ S_{14v} &= 24 \text{ kN} \quad \leftarrow\end{aligned}$$

$$S_{14} = \sqrt{32^2 + 24^2}$$

$$S_{14} = 40 \text{ kN} \quad \downarrow$$

trek

$$\begin{aligned}\Sigma V &= 0 \\ S_{14v} - S_6 &= 0 \\ 24 - S_6 &= 0 \\ S_6 &= 24 \text{ kN} \quad \uparrow \\ \text{Druk} &\end{aligned}$$



$$\Sigma V = 0$$

$$S_{4v} + S_{13} - S_{14v} - S_{5v} = 0$$

$$15 + 48 - 24 - S_{5v} = 0$$

$$S_{5v} = 39 \text{ kN} \uparrow$$

$$S_{5h} = 39 / \tan(36,9^\circ)$$

$$S_{5h} = 52 \text{ kN} \leftarrow$$

$$S_5 = \sqrt{39^2 + 52^2}$$

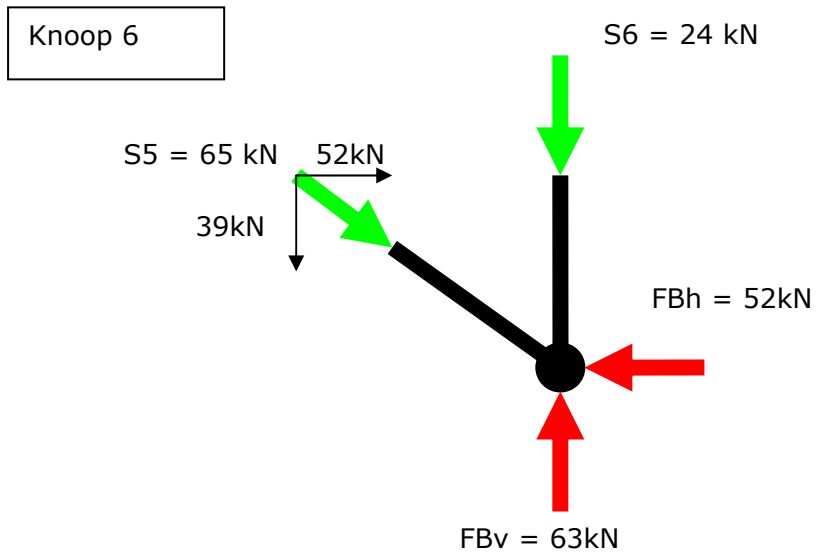
$$S_5 = 65 \text{ kN} \uparrow$$

Druk

$$\Sigma H = 0$$

$$S_{4h} + S_{14h} - S_{5h} = 0$$

$$20 + 32 - 52 = 0$$



$$\Sigma H = 0$$

$$S_{5h} - FB_h = 0$$

$$52 - 52 = 0$$

$$\Sigma V = 0$$

$$S_{5v} + S_6 - FB_v = 0$$

$$39 + 24 - 63 = 0$$