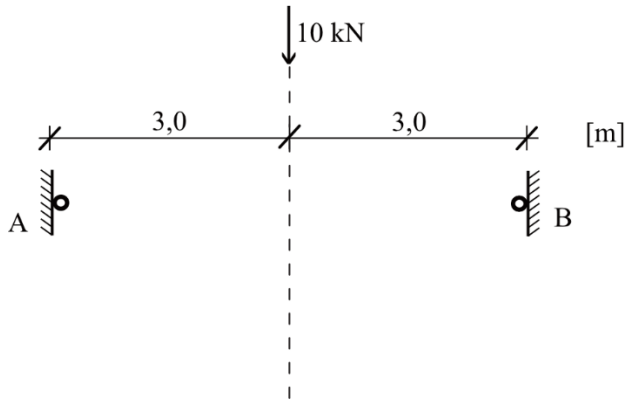
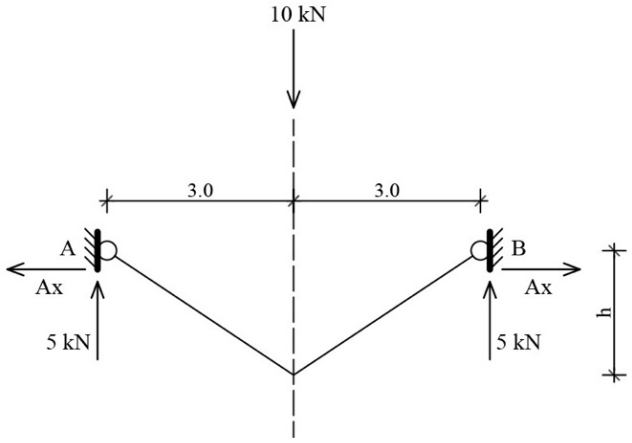
9.1. Between the given A and B supports a lamp has to be hanged in on a cable. The weight of the lamp is 10 kN. The horizontal position of the lamp is marked by the dashed line. **Design** a possible cable shape, regarding



- the maximal allowed vertical distance of the lamp from the supports: 2m
- the maximal allowed force in the cable: 15kN!

Draw the **shape of the cable**, give the **support reactions**, give the **vertical distance** of the lamp from the supports, and give the **length of the cable**! **Check** the maximal vertical distance and the force in the cable whether it fulfils the requirement or not!

The shape of the cable:



Equilibrium equations:

$$\sum M_A = 0 \implies A_y = B_y = 5\ kN$$
$$\sum F_x = 0 \implies A_x = B_x$$

Geometry: there is only normal force in the cable, meaning that the reaction support force should be parallel to the cable. From similar triangles:

$$\frac{h}{3} = \frac{5}{A_x}$$

The limitations of the exercise:

$$h \leq 2\ m$$
$$5^2 + A_x^2 \leq 20^2$$

We can choose either h or A_x arbitrarily to satisfy the limitations and the other parameter can be calculated from the geometry equations.

Let's have the vertical distance of the lamp from the supports $h = 2\ m$!

Then $A_x = \frac{5 \cdot 3}{2} = 7{,}5\ kN$.

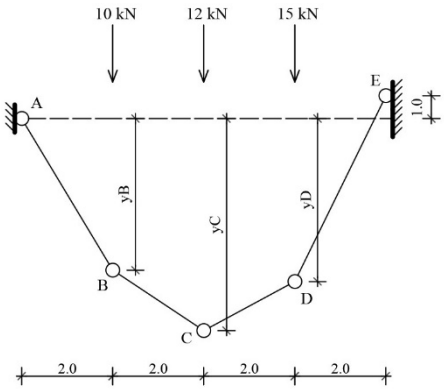
From here the support reaction force (max. 20kN):

$$A = \sqrt{5^2 + 7{,}5^2} = 9{,}01\ kN \leq 20$$

The length of the cable:

$$2 \cdot \sqrt{3^2 + 2^2} = 7{,}2\ m$$

9.2. Determine the y_B, y_C, y_D heights if the horizontal component of the reaction support force at support A is $5\ kN$! (VR)



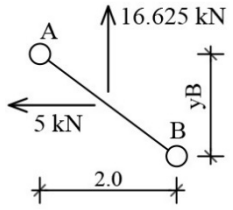
We utilize the fact, that the internal force in the cable is parallel to the cable. The vertical components of the reaction support forces can be calculated without the heights and the horizontal component is given. Starting from the supports, the geometry of the cable can be calculated from the internal forces.

Vertical support reactions:

$$\sum M_A = 0 \implies 10 \cdot 2 + 12 \cdot 4 + 15 \cdot 6 + 5 \cdot 1 - E_y \cdot 8 = 0 \implies E_y = 20{,}375\ kN\ \uparrow$$

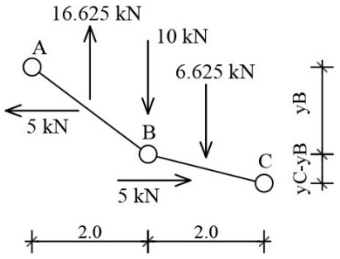
$$\sum M_D = 0 \implies 15 \cdot 2 + 12 \cdot 4 + 10 \cdot 6 - 5 \cdot 1 - A_y \cdot 8 = 0 \implies A_y = 16{,}625\ kN\ \uparrow$$

Equilibrium of the A-B segment from similar triangles:



$$\frac{y_B}{16{,}625} = \frac{2}{5} \implies y_B = 6{,}65\ m$$

B-C segment:

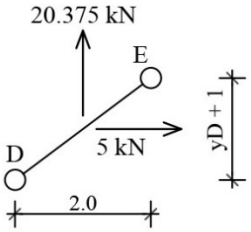


$$\frac{y_C - y_B}{6{,}625} = \frac{2}{5}$$

$$y_C - y_B = 2{,}65\ m$$

$$y_C = 2{,}65 + 6{,}65 = 9{,}3\ m$$

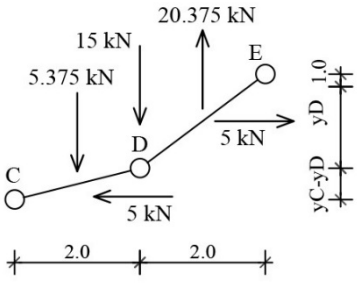
D-E segment:



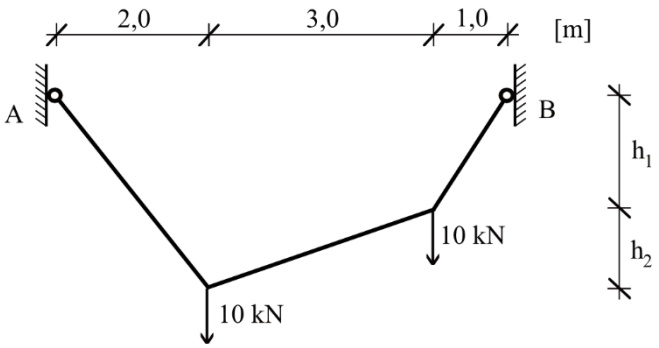
$$\frac{y_D + 1}{20{,}375} = \frac{2}{5} \implies y_D + 1 = 8{,}15 \implies y_D = 7{,}15\ m$$

All the hegihts have been calculated, but we can check whether the calculations are correct by checking the geometry of the C-D segment:

$$\frac{y_C - y_D}{5{,}375} = \frac{2}{5} \implies y_C - y_D = 2{,}15 \implies y_C = 9{,}3\ m\ \ OK!$$



9.3. A cable with an unknown length is given with the loads. Determine the h_1, h_2 heights if the reaction support force at support B is 15 kN!



Vertical reaction support forces:

$$\sum M_A = 0 \implies 10 \cdot 2 + 10 \cdot 5 - B_y \cdot 6 = 0$$
$$\implies B_y = 11{,}67\ kN \uparrow$$

$$A_y = 20 - 11{,}67 = 8{,}33\ kN \uparrow$$

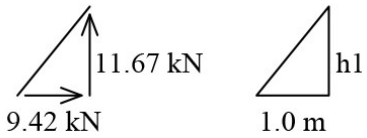
Horizontal reaction support forces from the geometry:

$$\sqrt{11{,}67^2 + B_x^2} = 15 \implies B_x = 9{,}42\ kN \rightarrow$$

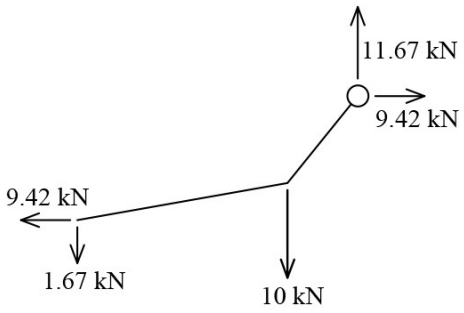
$$A_x = 9{,}42\ kN \leftarrow$$

h_1 from the geometry:

$$h_1 = \frac{11{,}67}{9{,}42} \cdot 1 = 1{,}24\ m$$



Equilibrium of the right part of the cable:



h_2 from the geometry:

$$h_2 = \frac{1{,}67}{9{,}42} \cdot 3 = 0{,}53\ m$$