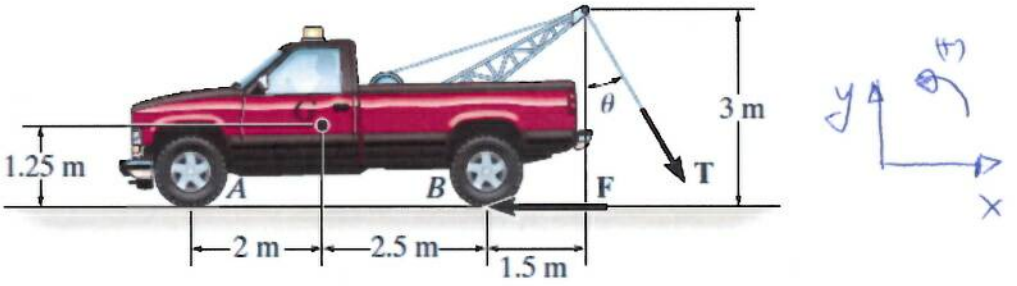
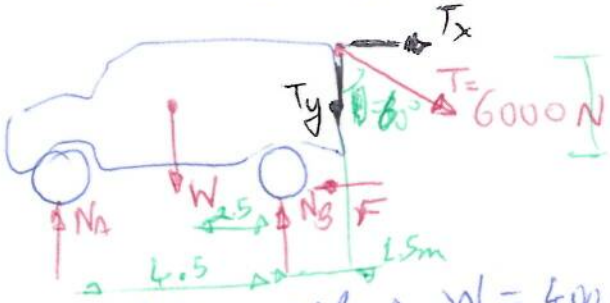
Exercise 10

The winch cable on a tow truck is subjected to a force of T=6 kN when the cable is directed at θ=60°. Determine the magnitudes of the total brake frictional force F for the rear set of wheels B and the total normal forces at both front wheels A and both rear wheels B for equilibrium. The truck has a total mass of 4 Mg and mass
center at G.



Solution

The free body diagram is shown in the following figure



$T_x = T \cdot \sin 60° = 6000 \cdot \sin 60° = 5196\,N$

$T_y = T \cdot \cos 60° = 6000 \cdot \cos 60° = 3000\,N$

The weight of the vehicle $W = 4000 \cdot 9.81 = 39240\,N$

The car is in equilibrium, therefore the conditions apply:

$\sum F_x = 0 \rightarrow -F + T_x = 0 \rightarrow -F + 6000 \cdot \sin 60° = 0$

$\rightarrow F = 5196\,N \approx 5.2\,kN$

$\sum M_B = 0 \rightarrow -M_{N_A} + M_W - M_{T_x} - M_{T_y} = 0 \rightarrow -N_A \cdot 4.5 + W \cdot 2.5 - T_x \cdot 3 - T_y \cdot 1.5 = 0$

$\rightarrow -N_A \cdot 4.5 + 39240 \cdot 2.5 - 5196 \cdot 3 - 3000 \cdot 1.5 = 0$

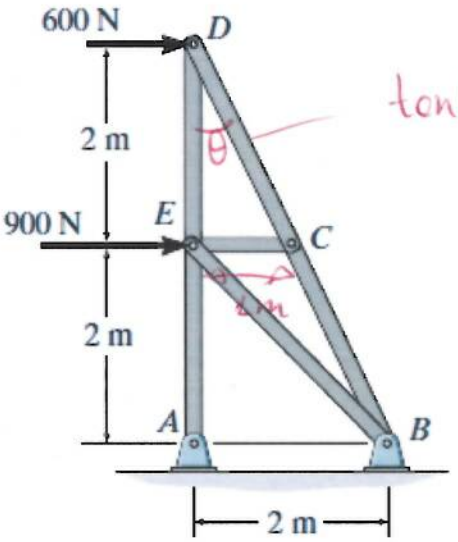
$\rightarrow N_A = 17336\,N$

$\sum F_y = 0 \rightarrow N_A - W + N_B - T_y = 0 \rightarrow 17336 - 39240 + N_B - 3000 = 0$

$\rightarrow N_B = 24904\,N$

Exercise 11

Determine the force in each member of the truss, and state if the members are in tension or compression..



EC = 1m (law of similarity)

$$\tan\theta = \frac{EC}{ED} = \frac{1}{2} = 0.5$$

$$\rightarrow \theta = 26.57°$$

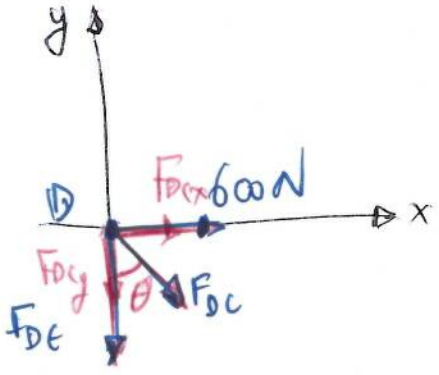
Solution

We will use the method of joints to solve the problem

Joint D has one known external force and two unknown member forces

The angle θ is 26.57°

The free body diagram of joint D is:



The joint is in equilibrium. Therefore,

$$\Sigma F_x = 0 \rightarrow F_{DC_x} + 600 = 0 \rightarrow F_{DC}\cdot\sin\theta + 600 = 0 \rightarrow 0.44\,F_{DC} + 600 = 0$$

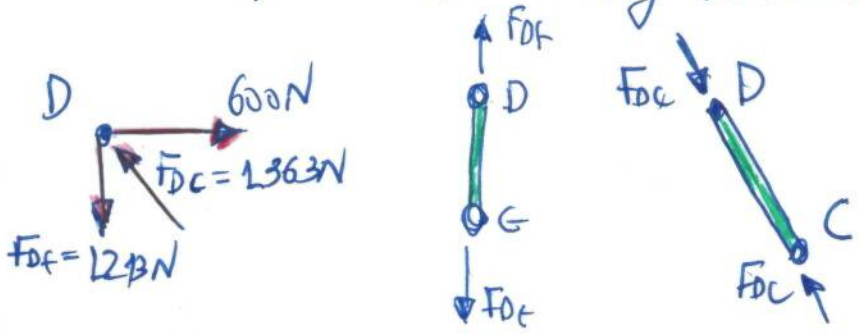
$$\rightarrow \boxed{F_{DC} = -1363\,N}$$

The negative sign means that F_{DC} has the opposite direction than the one assumed.

$$\Sigma F_y = 0 \rightarrow -F_{DE} - F_{DC_y} = 0 \rightarrow -F_{DE} - F_{DC}\cos\theta = 0 \rightarrow -F_{DE} - F_{DC}\cos 26.57 = 0$$

$$\rightarrow -F_{DE} - (-1363)0.89 = 0 \rightarrow \boxed{F_{DE} = 1208\,N}$$

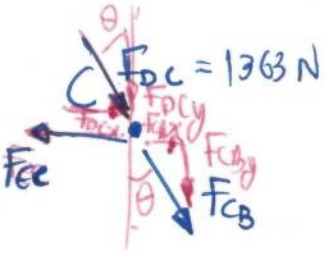
We have to redraw the FBD on joint D since one of the forces had wrong direction.



Member DC is in compression

Member DE is in tension

Now we will draw the FBD on joint C



The direction of force F_{DC} is known because it was found when applying the condition of equilibrium at point D.

The direction of forces F_{EC} and F_{CB} are assumed (not known).

We resolve F_{DC} and F_{CB} on their x and y components:

$$F_{DCx} = F_{DC} \cdot \sin\theta = 1363 \cdot \sin 26.57^\circ = 1363 \cdot 0.4473 = 609\ N$$

$$F_{DCy} = F_{DC} \cdot \cos\theta = 1363 \cos 26.57^\circ = 1363 \cdot 0.8944 = 1219\ N$$

$$F_{CBx} = F_{CB} \cdot \sin\theta = F_{CB} \sin 26.57^\circ = 0.4473 \cdot F_{CB}$$

$$F_{CBy} = F_{CB} \cdot \cos\theta = F_{CB} \cdot \cos 26.57^\circ = 0.8944 \cdot F_{CB}$$

Joint C is in equilibrium. The conditions of equilibrium are:

$$\Sigma F_x = 0 \rightarrow -F_{EC} + F_{DCx} + F_{CBx} = 0 \rightarrow -F_{EC} + 609 + F_{CBx} = 0$$

$$-F_{EC} + F_{CBx} = -609$$

$$-F_{EC} + 0.4473 F_{CB} = -609 \quad (1)$$

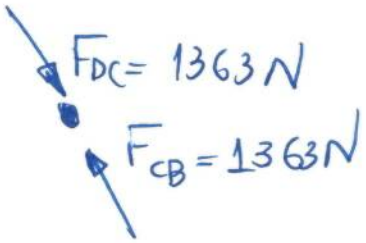
$$\Sigma F_y = 0 \rightarrow -F_{DCy} - F_{CBy} = 0$$

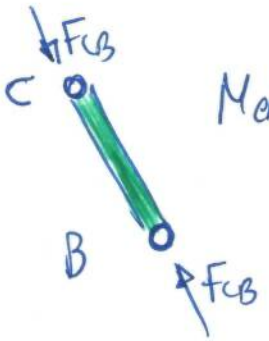
$$\rightarrow -1219 - 0.8944 F_{CB} = 0 \rightarrow \boxed{F_{CB} = -1363\ N}$$

The negative sign means that the direction of force F_{CB} is the opposite than the one assumed. By substituting $F_{CB} = -1341\ N$ in Equation (1)

$$(1) \rightarrow -F_{EC} + 0.4473 \cdot (-1341) = -609 \rightarrow \boxed{F_{EC} = 0}$$

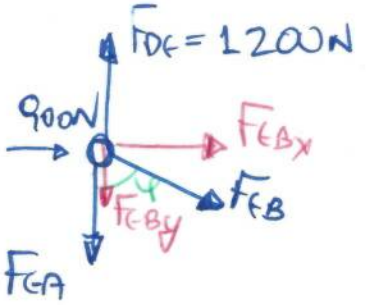
We have to redraw the FBD on joint C since one of the forces has opposite direction.





Member CB is in compression.

Now we will draw the FBD on joint E



$\varphi = 45°$, $\tan\varphi = \frac{AB}{EA} = \frac{2}{2} = 1$

The first condition of equilibrium gives:

$\Sigma F_x = 0 \rightarrow 900 + F_{EBx} = 0 \rightarrow F_{EBx} = -900\,N \rightarrow F_{EB}\sin 45° = -900\,N \rightarrow \boxed{F_{EB} = -1270\,N}$

The negative sign indicates that the force has the opposite direction.

$\Sigma F_y = 0 \rightarrow F_{DE} - F_{EA} - F_{EBy} = 0$

$1200 - F_{EA} - F_{EB}\cdot\cos 45° = 0$

$1200 - F_{EA} - (-1270)\cdot 0.707 = 0$

$\boxed{F_{EA} = 2100\,N}$