Engineering Mechanics

Continued…(4)

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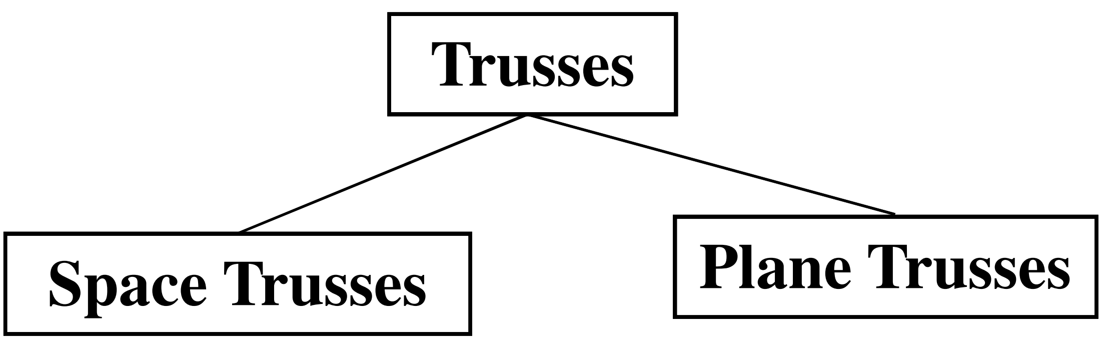
Introduction to Structural Mechanics

Truss

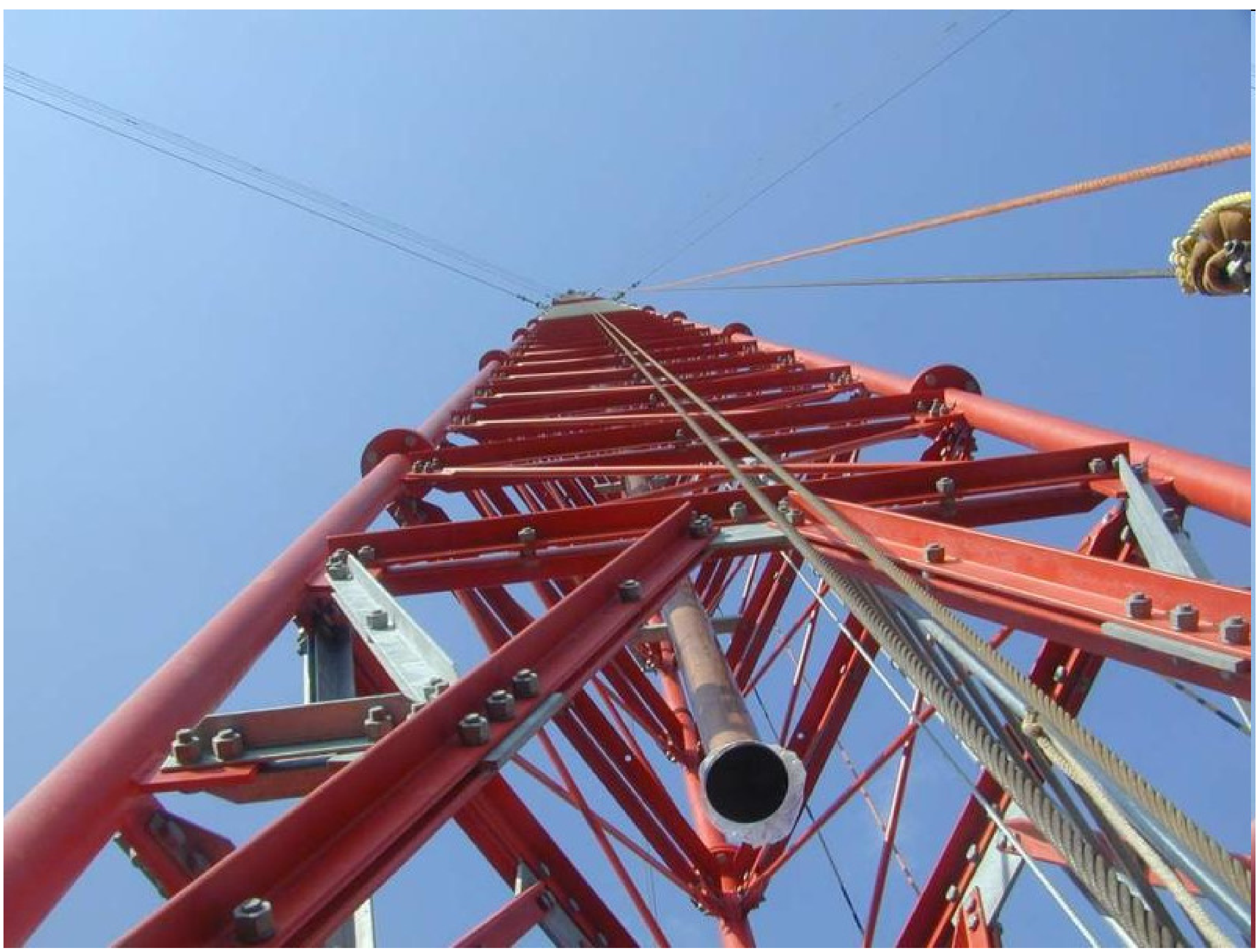
A structure made by joining members at their ends to support stationary and moving loads



A bridge truss

Truss for stadium

Transmission line tower



Communication towers

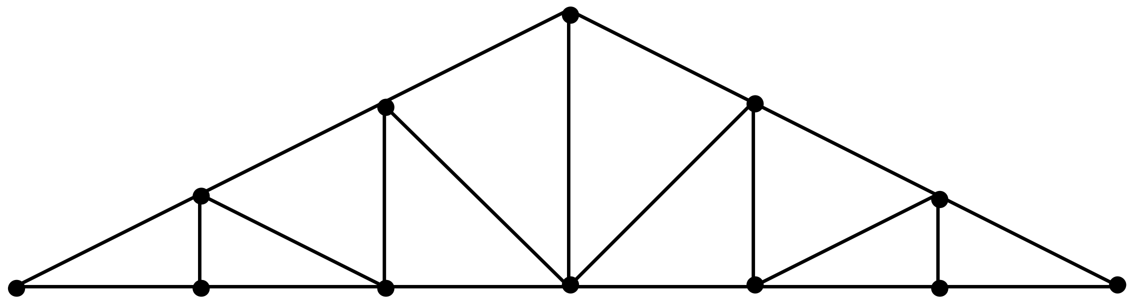
Transmission line tower

Transmission line tower—space truss

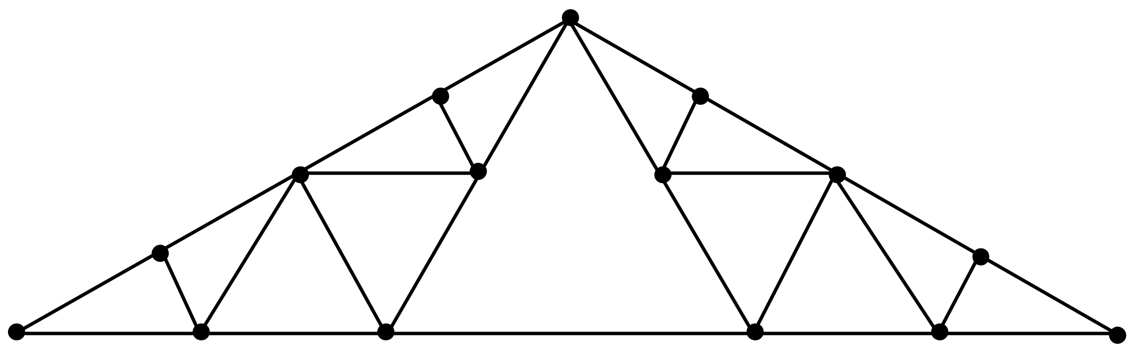
Bridge truss—plane truss

Truss for stadium

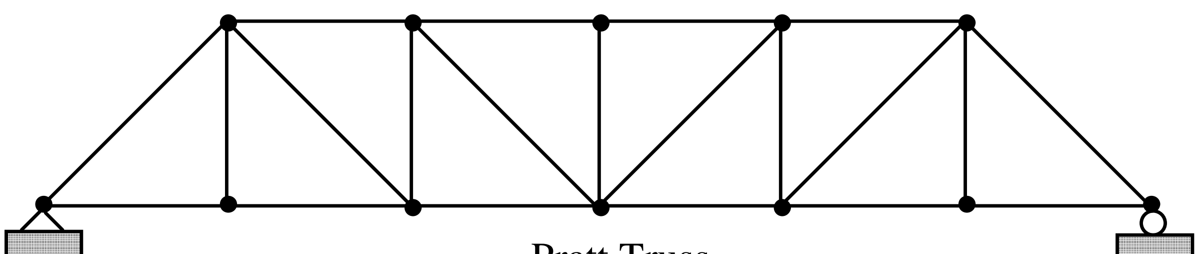
Bridge truss—plane truss



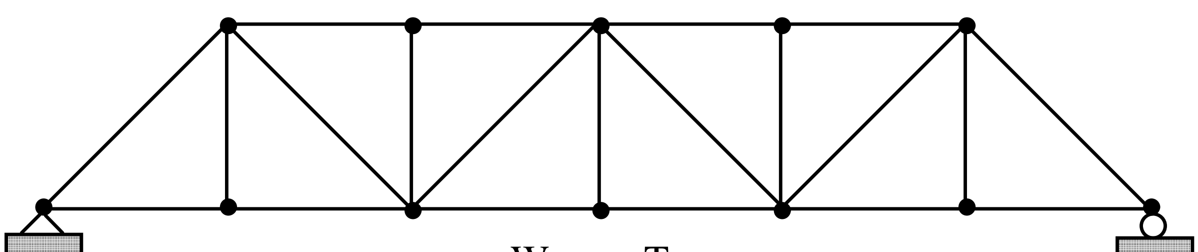
Howe Truss



Fink Truss



Pratt Truss



Warren Truss

National Institute of Technology Calicut

Simple plane truss

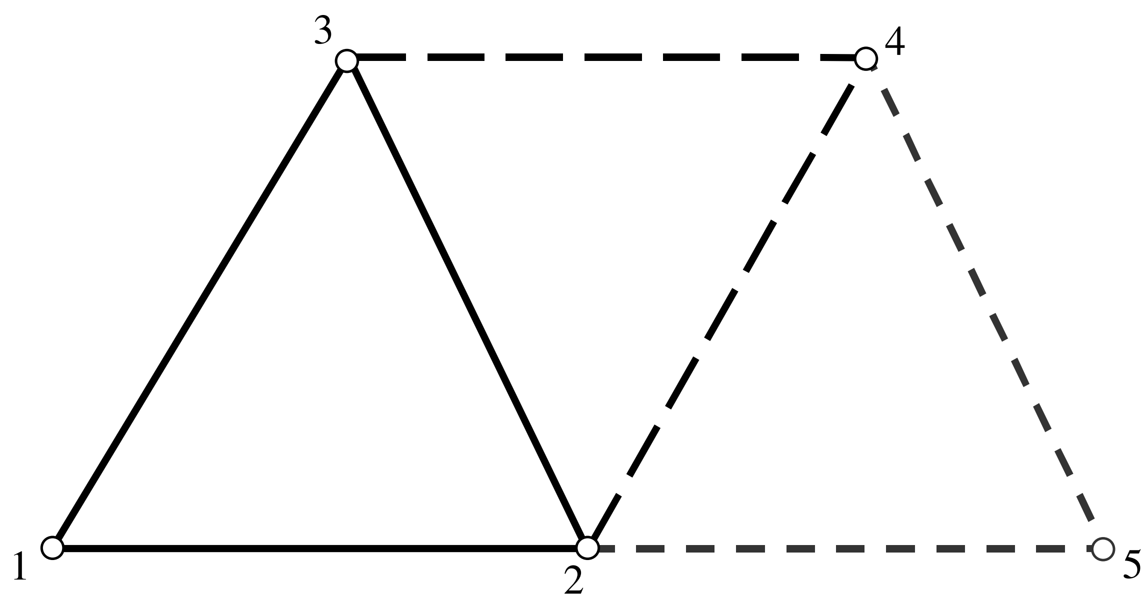
Made of triangles (or tetrahedra)

$m = 2j - 3$ (plane truss)

$m = 3j - 6$ (space truss)

m number of members;

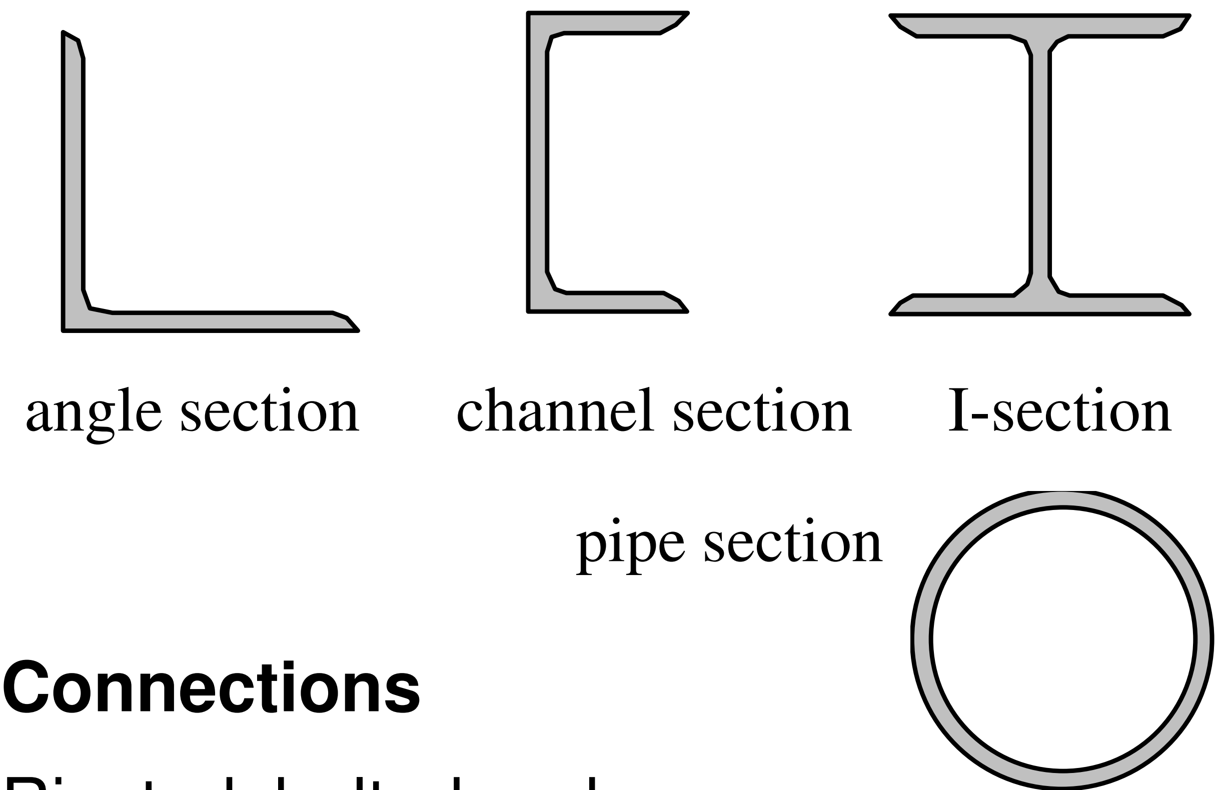
j number of joints;



If there are more members than $2j - 3$, it is "*internally statically indeterminate*";

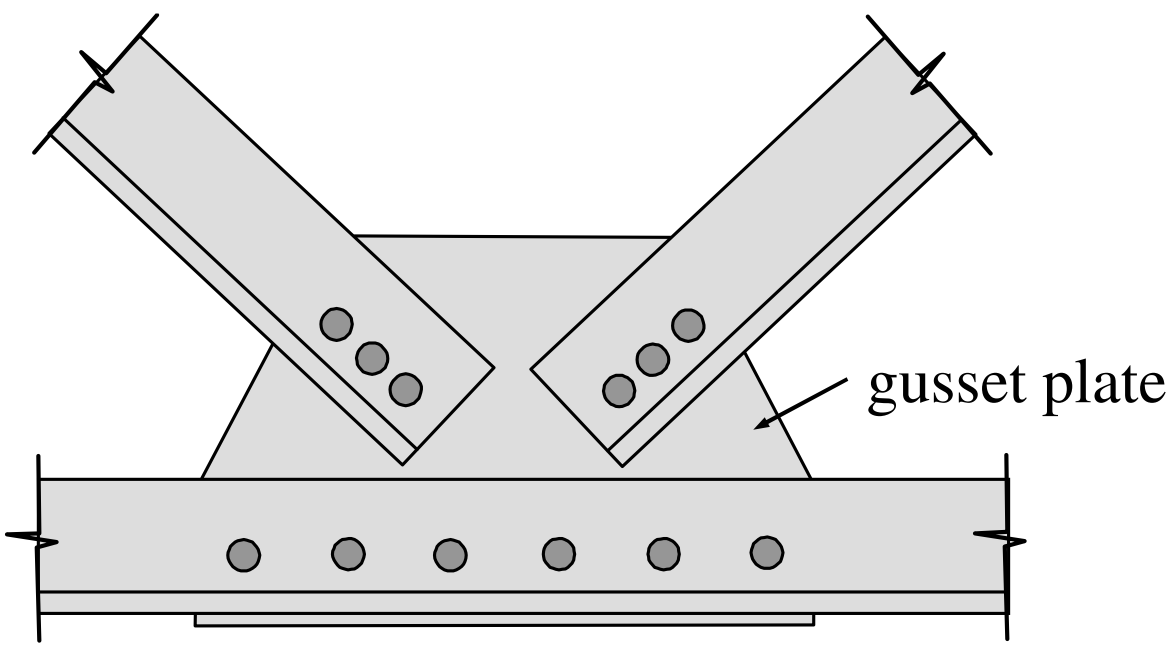
If there are more supports, it is "*externally statically indeterminate*"

Commonly used cross-sections

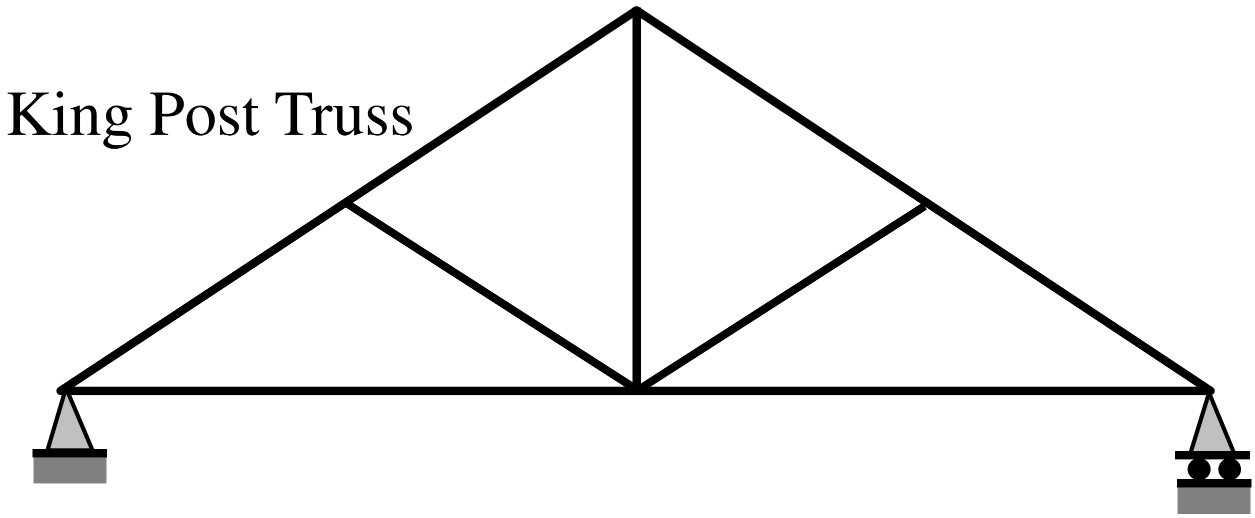


Connections

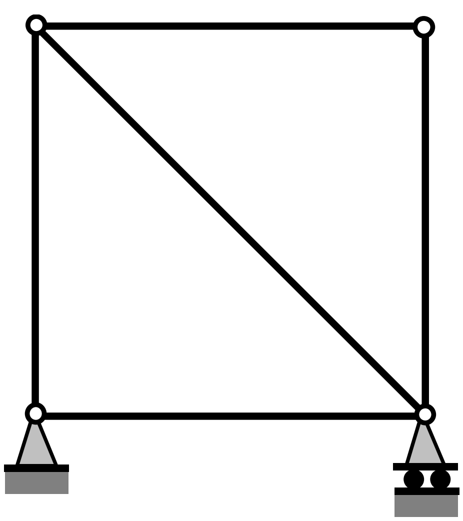
Riveted, bolted and welded



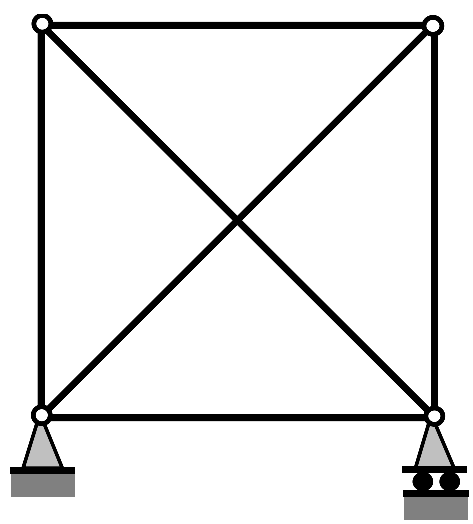
Static Determinacy—Internal and External



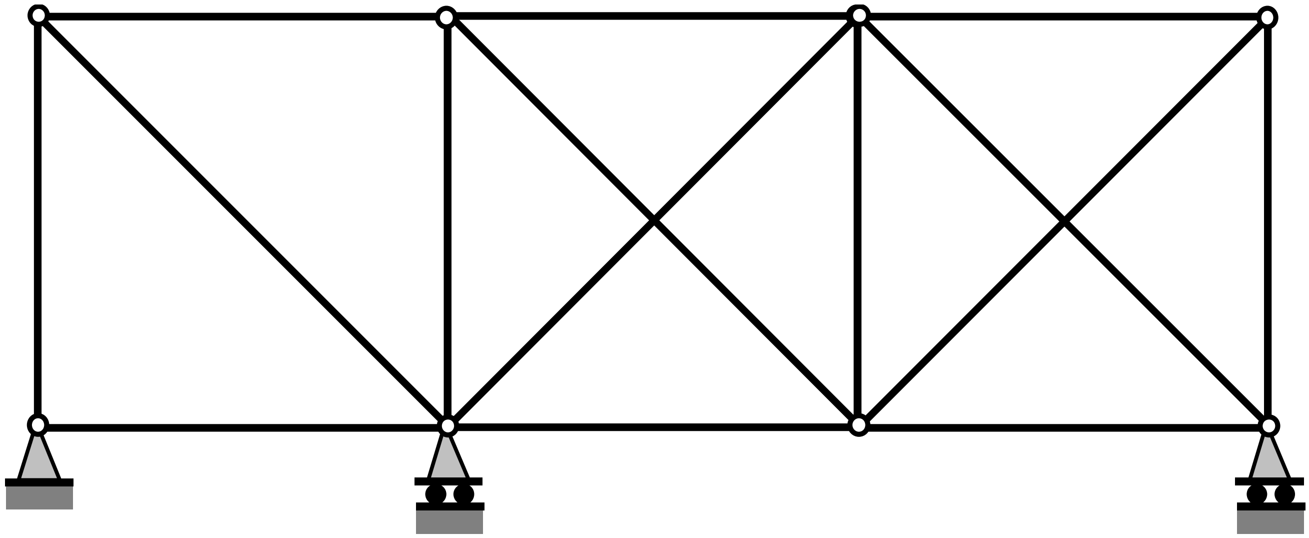
Internally and externally statically determinate truss



Statically determinate truss



Internally statically indeterminate



Both internally and externally indeterminate truss

Ideal Truss—Assumptions:

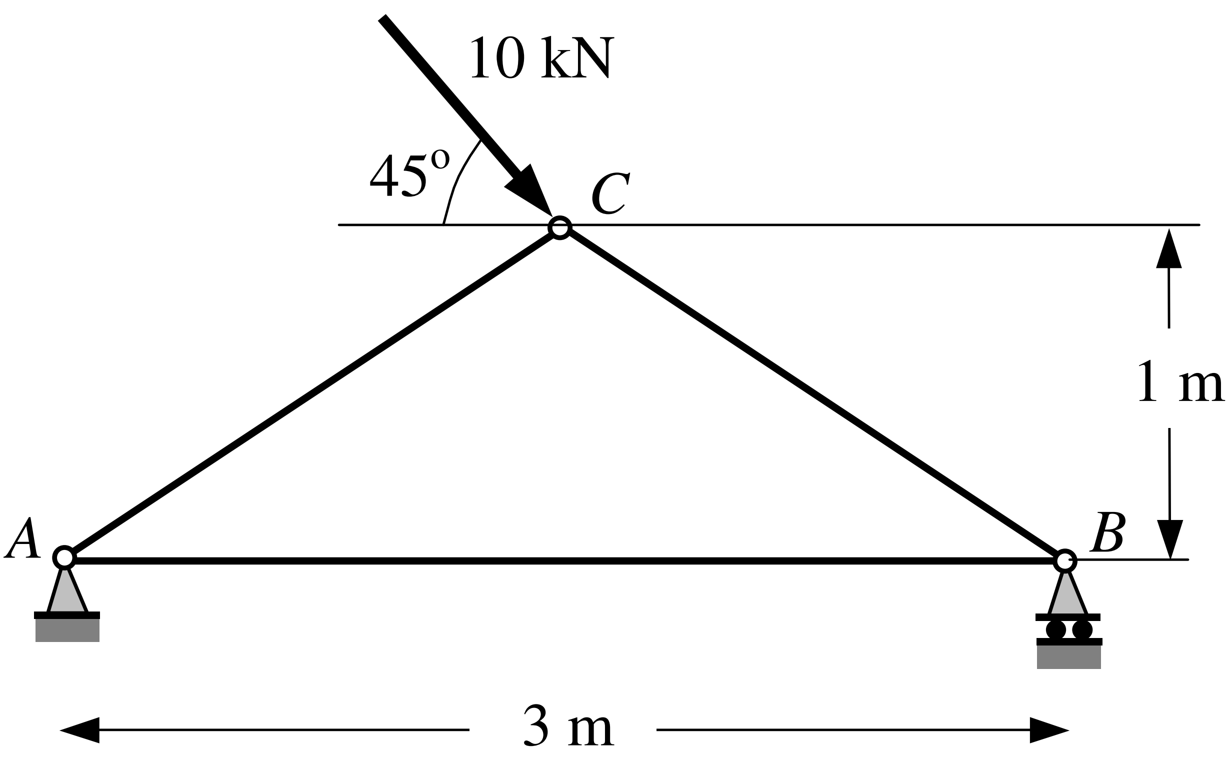
- Bars are connected at the ends by frictionless pin joints
- Axes of all members lie in one plane called the “middle plane” of the truss
- Loads are applied at the joints only, and they too lie in middle plane
- Self-weight of the truss members is neglected

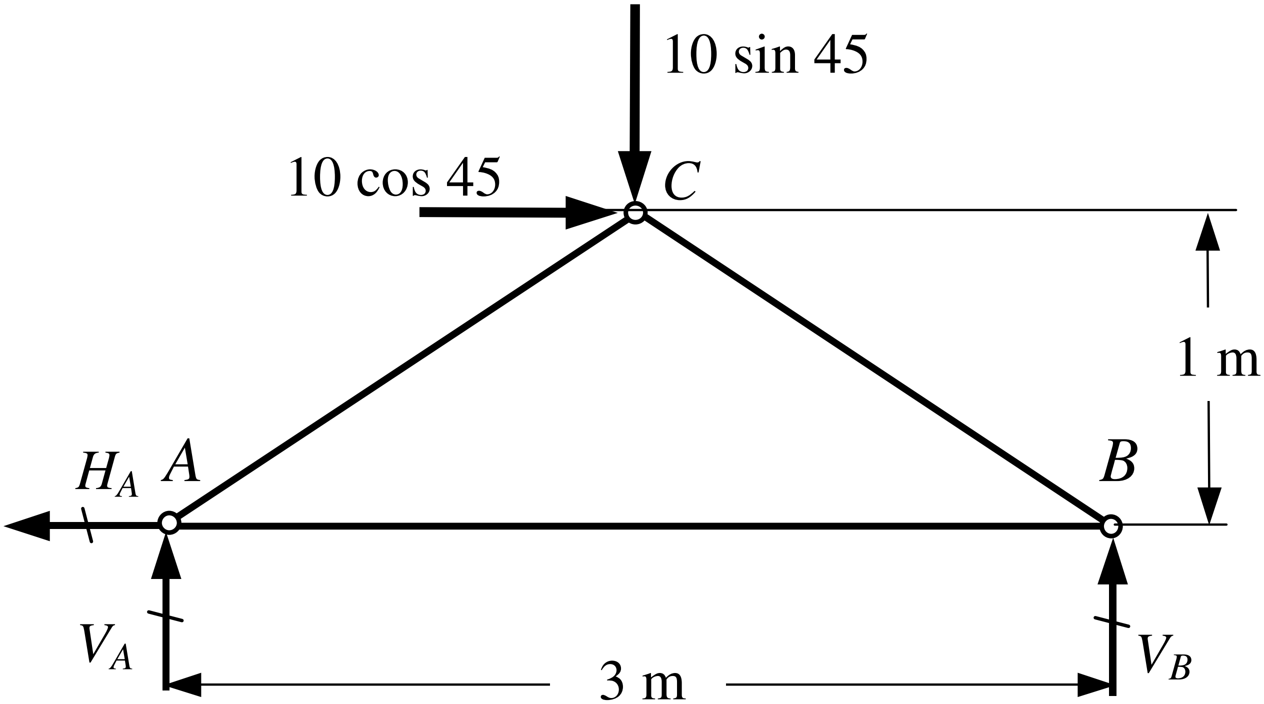
Analysis of Trusses

A Method of Joints

- Determine the support reactions first by using equations of equilibrium assuming the entire truss to be a rigid body
- Draw the free body diagrams of the pin joints

<u>Example</u>: Determine the member forces in the following truss.





1. Support Reactions:

$\Sigma F_x = 0$: $H_A = 10 \cos 45 = 7.071$ kN

$\Sigma M_A = 0$:

$3 V_B = 1.5 \times 10 \sin 45 + 1 \times 10 \cos 45$

$\therefore V_B = 5.8926$ kN

$\Sigma M_B = 0$:

$3 V_A = 1.5 \times 10 \sin 45 - 1 \times 10 \cos 45$

$\therefore V_A = 1.1785$ kN

Check: $\Sigma F_y = 0$: $V_A + V_B = 10 \sin 45$ ✓

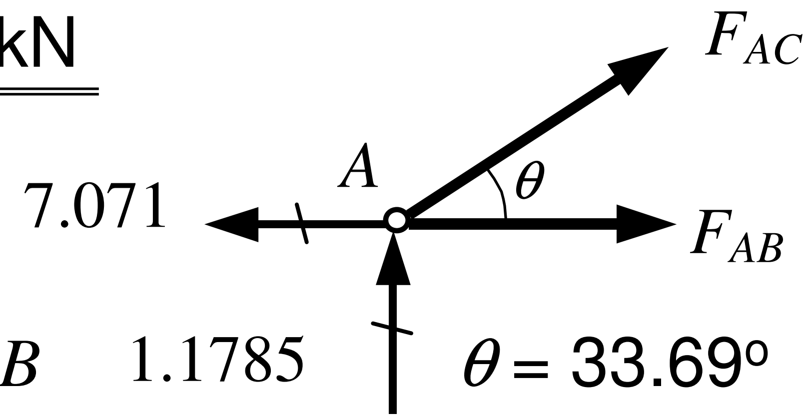
Joint A

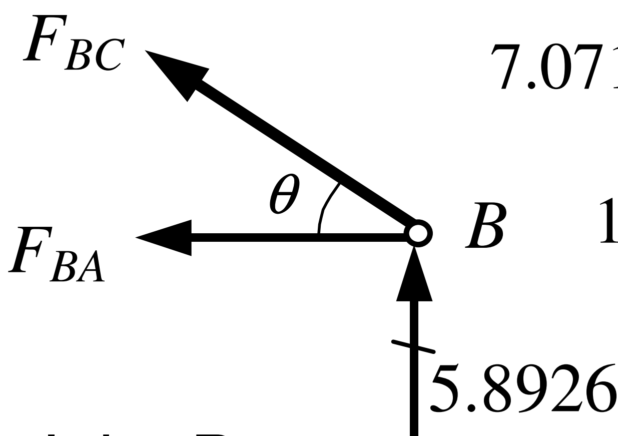
$\Sigma F_y = 0$: $F_{AC} \sin\theta + 1.1785 = 0$;

$\therefore F_{AC} = -2.125$ kN

$\Sigma F_x = 0$: $F_{AC} \cos\theta + F_{AB} = 7.071$;

$\therefore F_{AB} = 8.839$ kN





Joint B

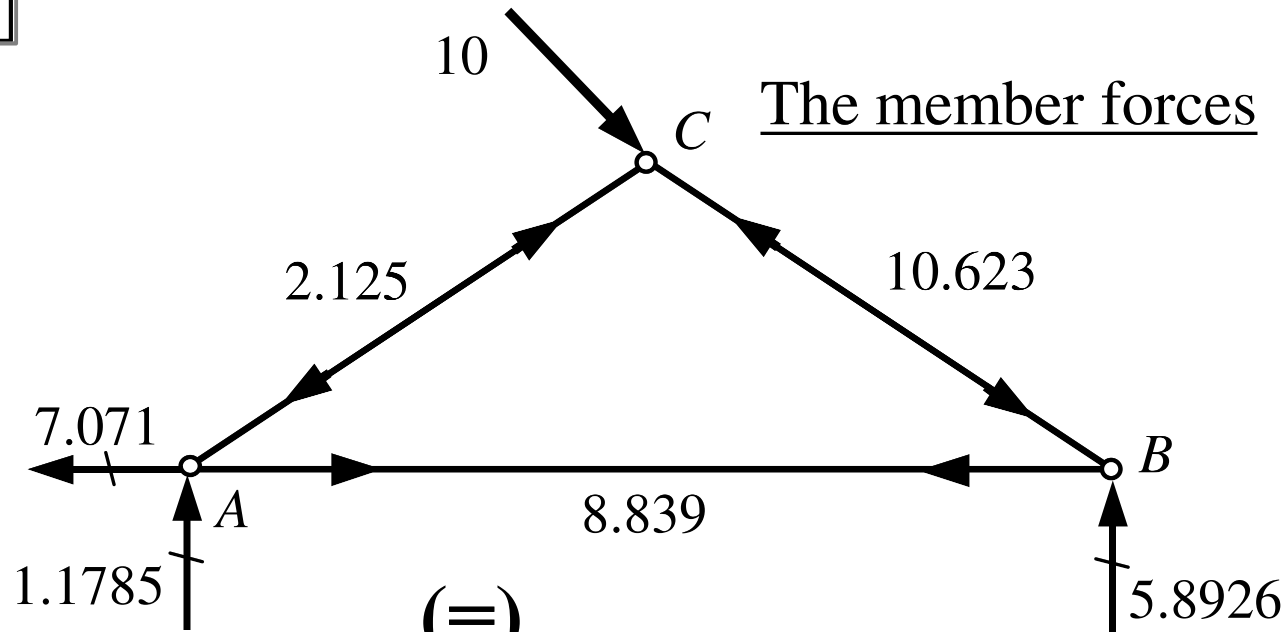
$\Sigma F_y = 0$: $F_{BC} \sin\theta + 5.8926 = 0$;

$\therefore F_{BC} = -10.623$ kN

$\Sigma F_x = 0$: $F_{BC} \cos\theta + F_{BA} = 0$;

$\Sigma \therefore F_{BA} = 8.839$ kN

The member forces



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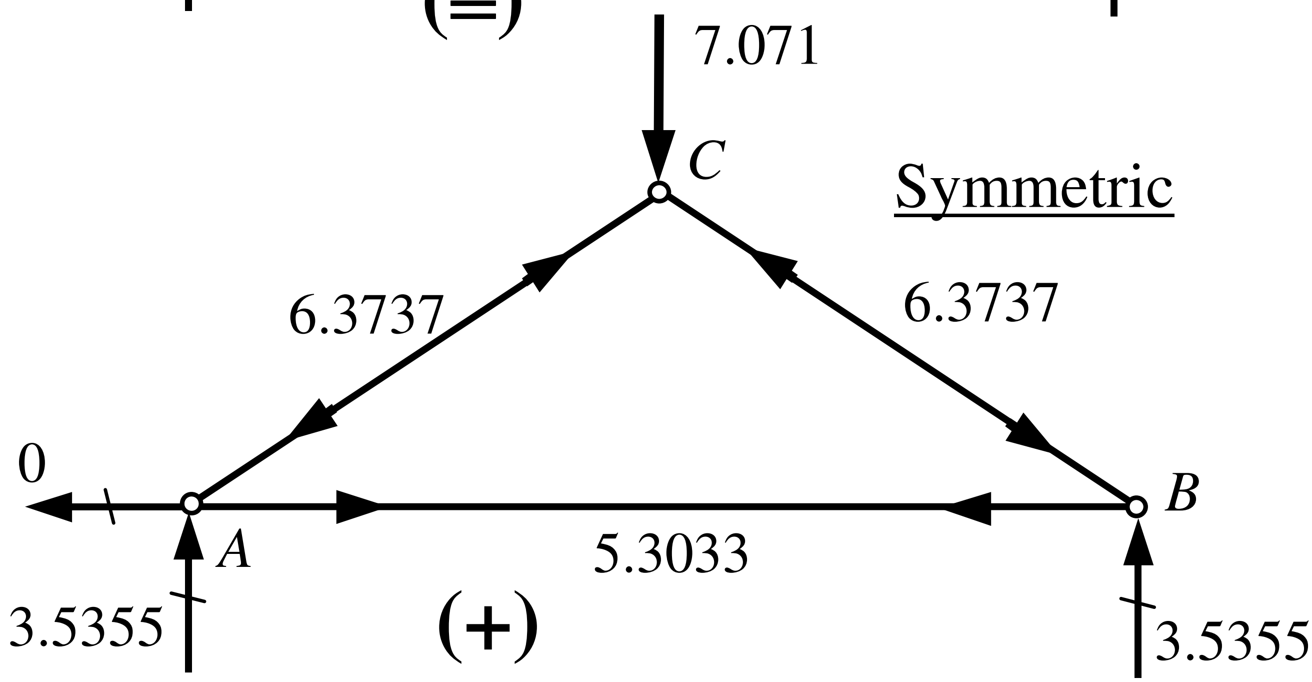
Symmetric



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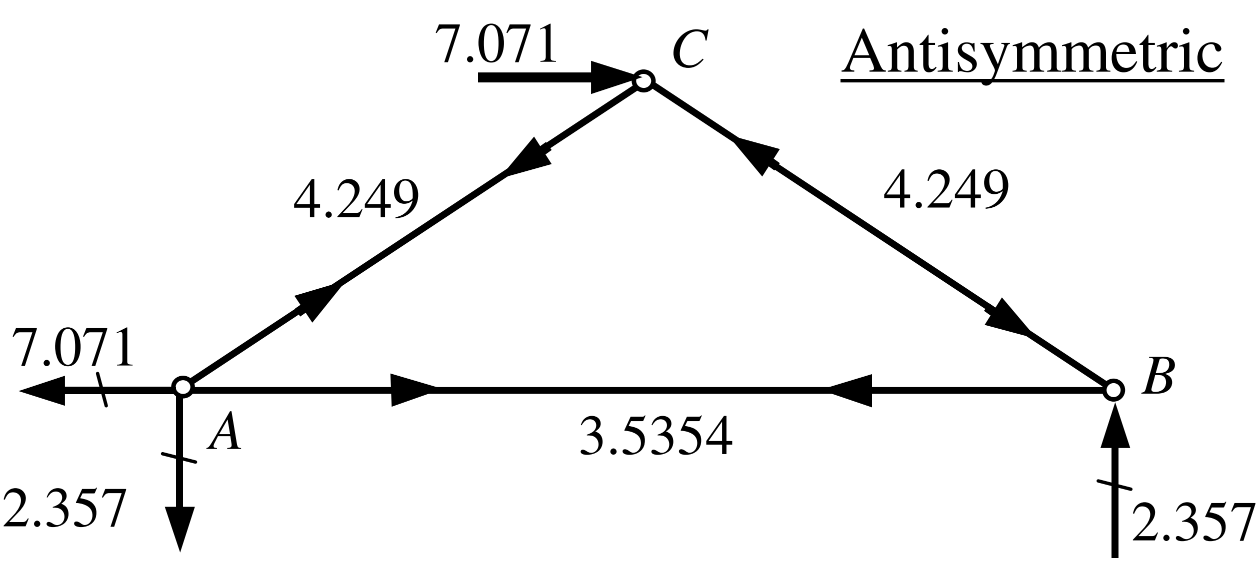
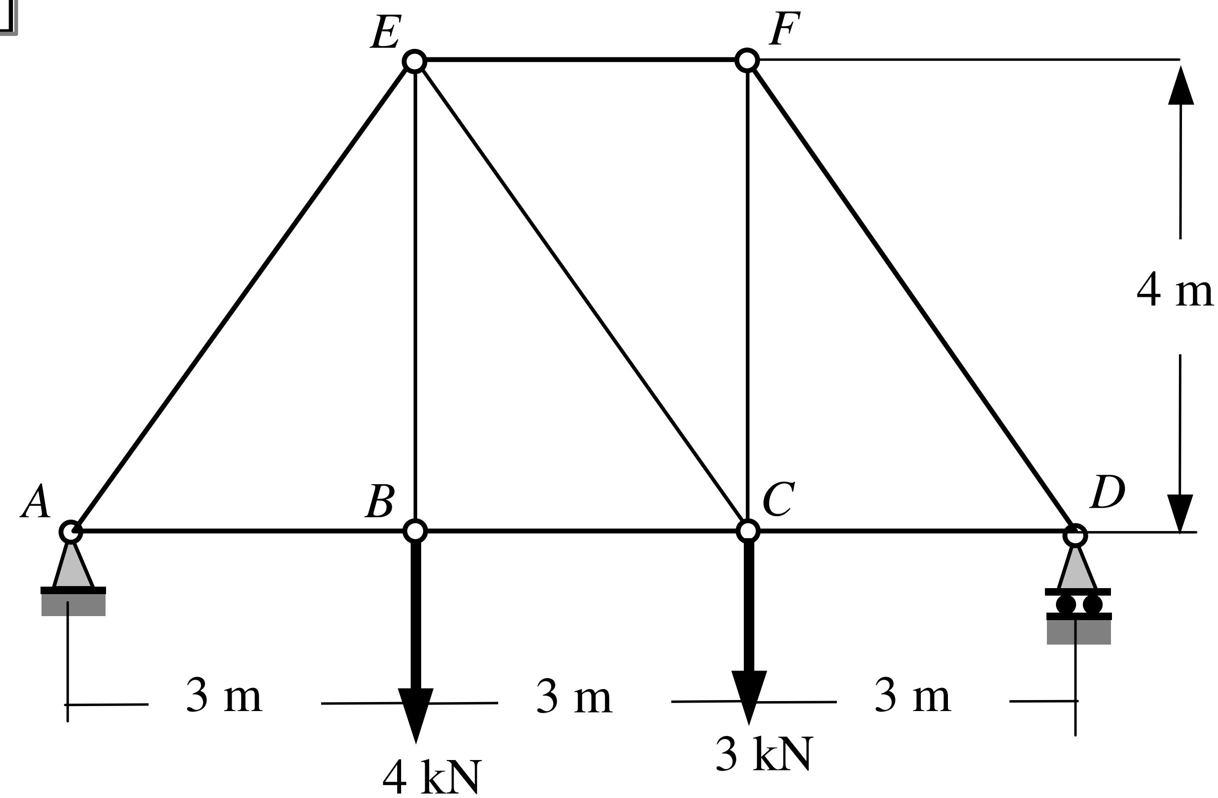
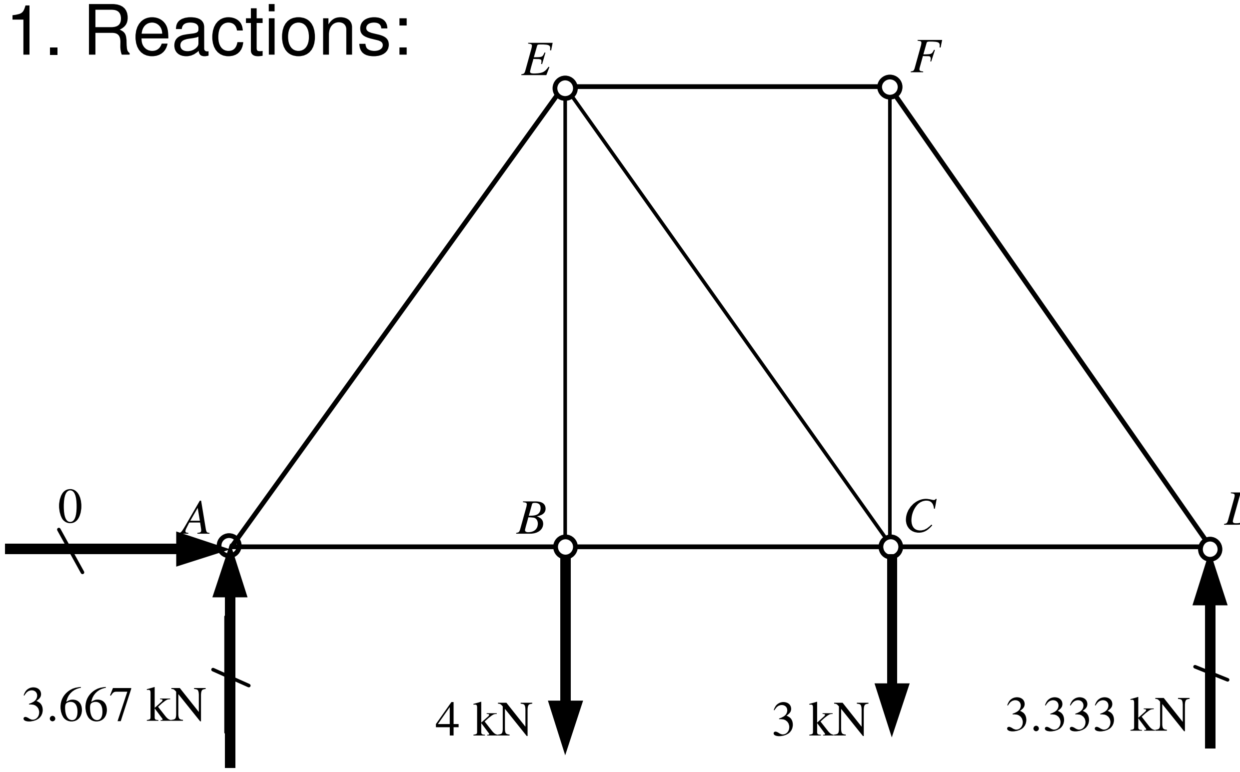
Antisymmetric





Exercise: Compute the member forces in the bridge truss shown above.

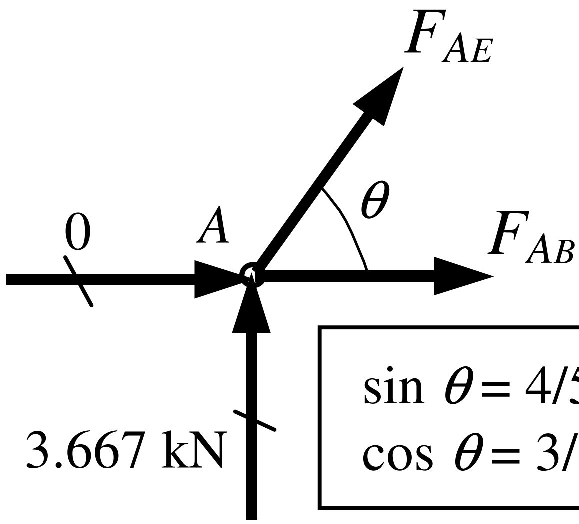
1. Reactions:



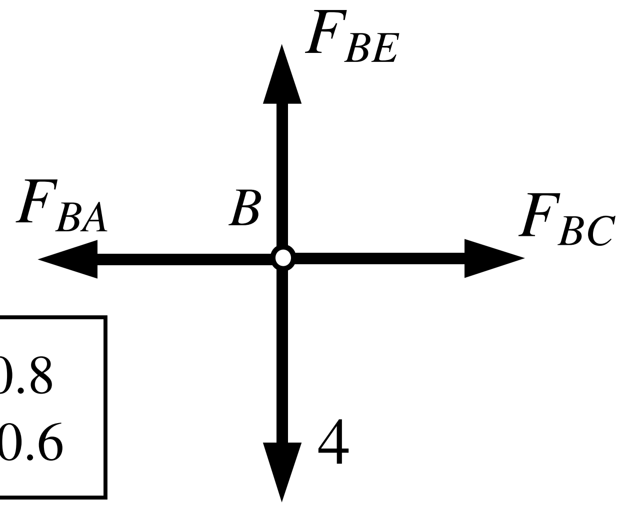
Joint A

$$F_{AE} = -3.667 \div \sin\theta = -4.5833 \text{ kN}$$

$$F_{AB} = -F_{AE}\cos\theta = 2.75 \text{ kN}$$



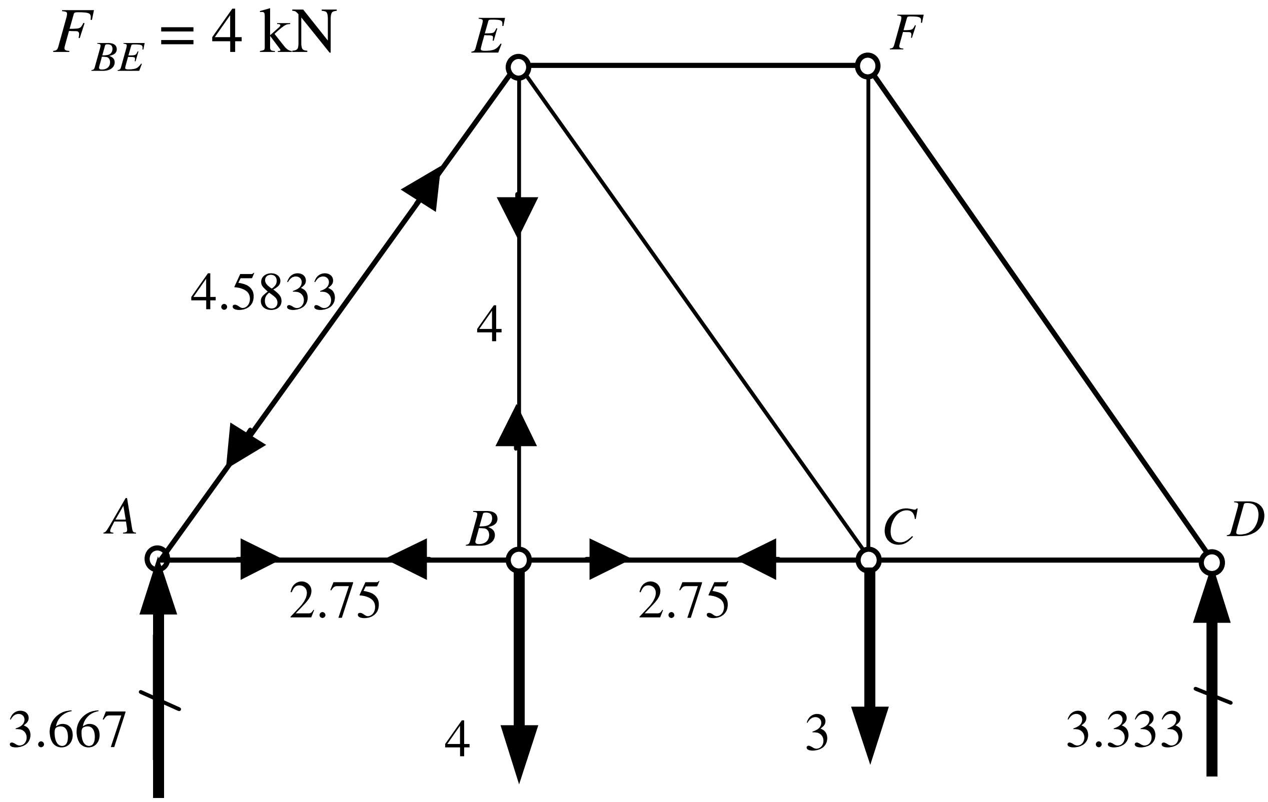
$\sin\theta = 4/5 = 0.8$
$\cos\theta = 3/5 = 0.6$



Joint B

$$F_{BC} = F_{BA} = 2.75 \text{ kN}$$

$$F_{BE} = 4 \text{ kN}$$

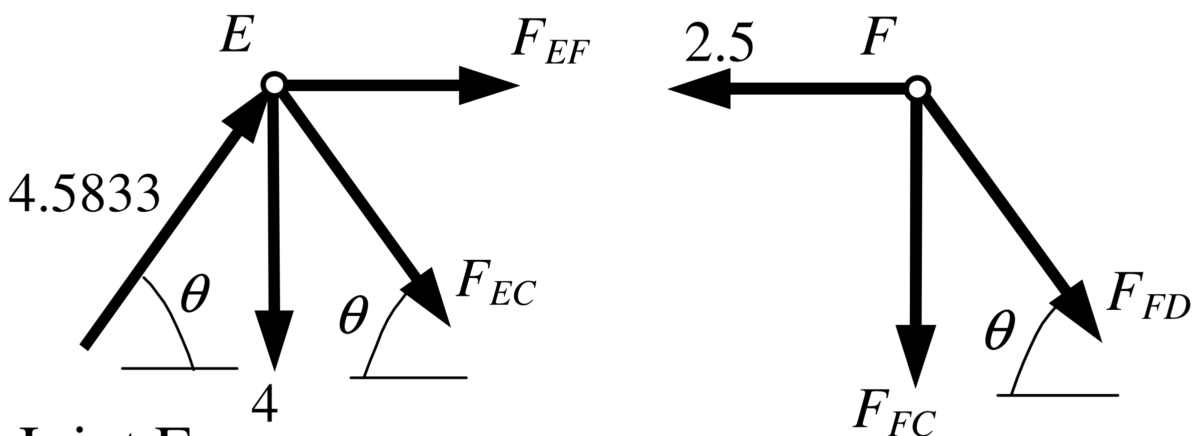


Joint E

$F_{EC} \sin\theta = 4.5833 \sin\theta - 4;$

$\therefore F_{EC} = -0.4167 \text{ kN}$

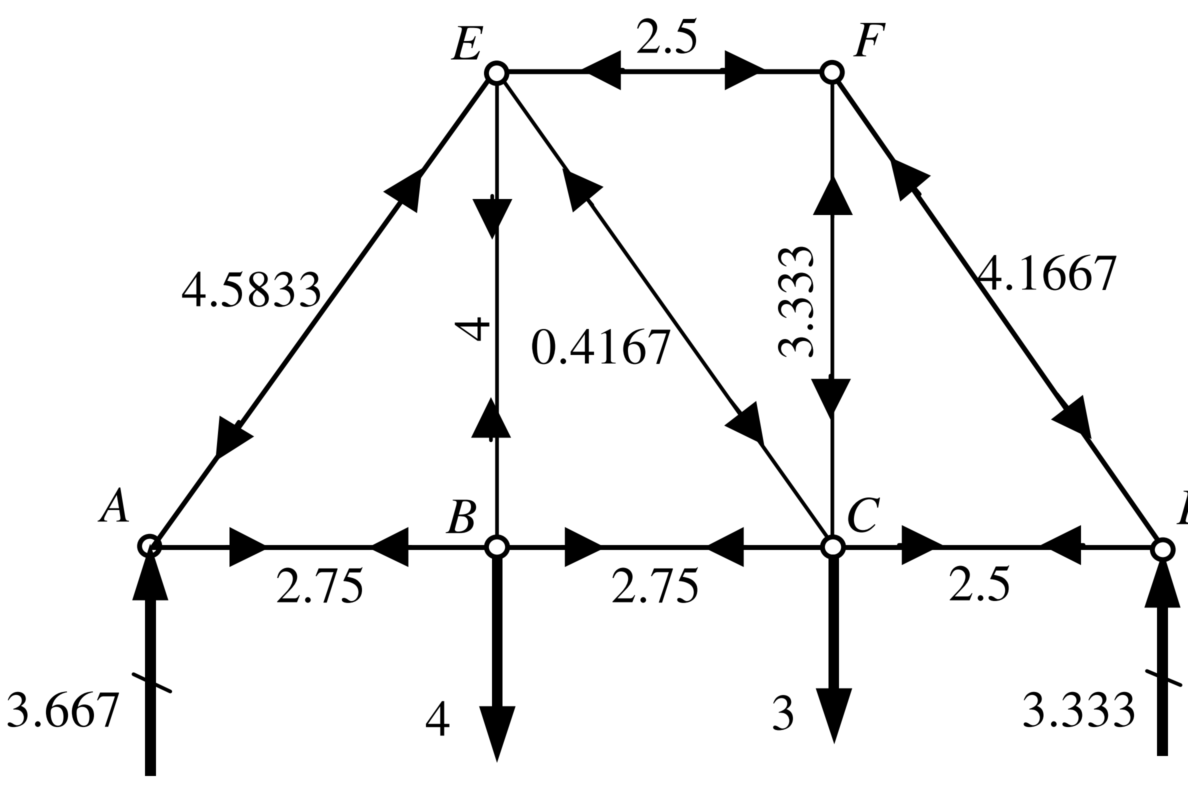
$F_{EF} = -(4.5833 + F_{EC}) \cos\theta = -2.5 \text{ kN}$



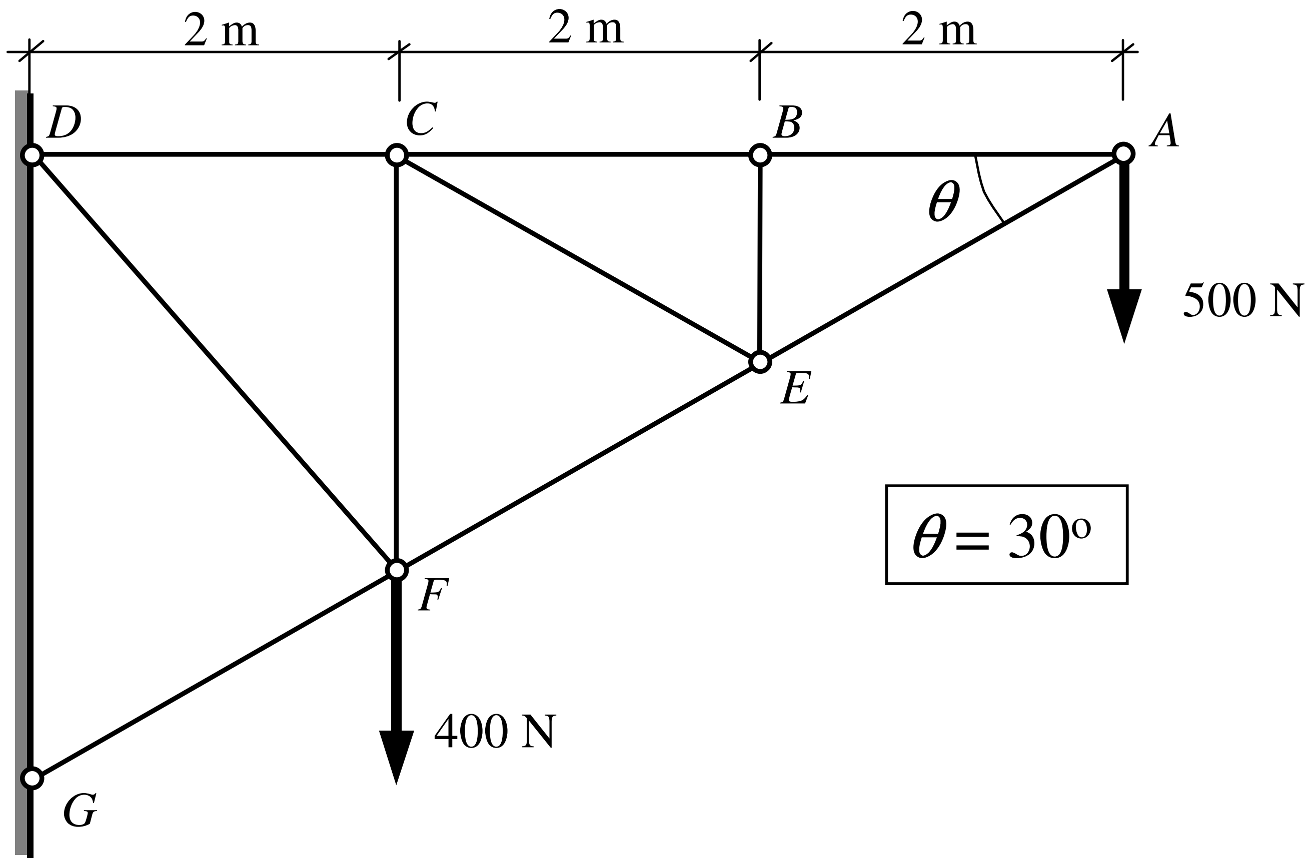
Joint F

$F_{FD} \cos\theta = 2.5;\ \therefore F_{FD} = 4.1667 \text{ kN}$

$F_{FC} = -F_{FD} \sin\theta = -3.333\text{kN}$

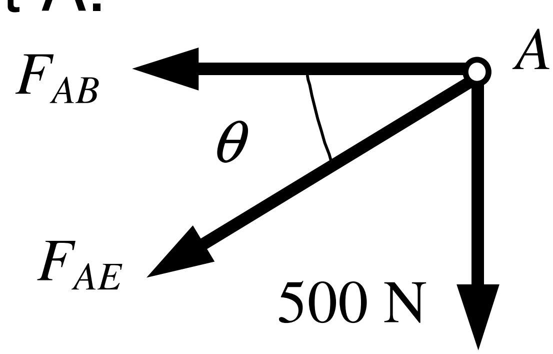


Exercise: Compute the member forces in the cantilever truss shown below.



It is not necessary to start the analysis with the determination of reactions for such cantilever trusses.

Instead, start with joint A.



Joint A

$F_{AE} \sin 30^{o} - 500 = 0;$

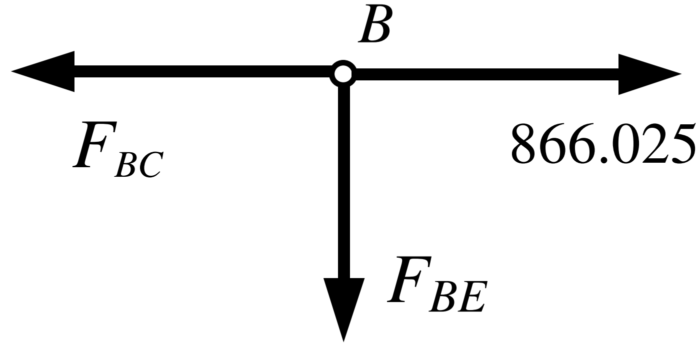
$\therefore\ F_{AE} = 1000 \text{ N}$

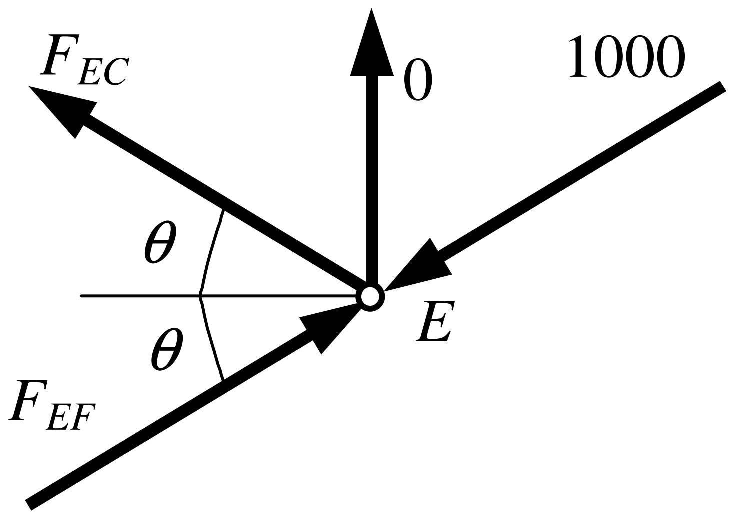
$F_{AB} = -F_{AE} \cos 30^{o} = -866.025 \text{ N}$

Joint B

$F_{BC} = 866.025$ N

$F_{BE} = 0$ N



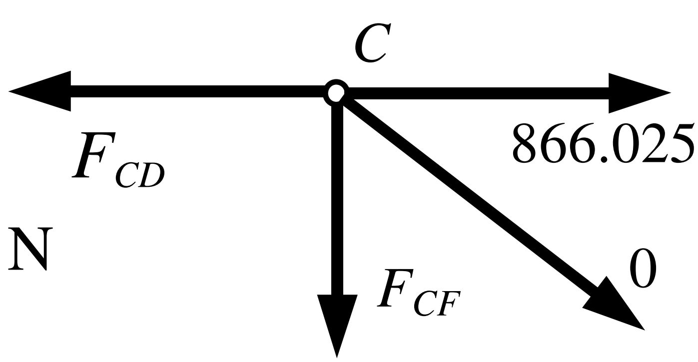


Joint E

$$F_{EC} \sin 30 + F_{EF} \sin 30 = 1000 \sin 30$$

$$F_{EC} \cos 30 - F_{EF} \cos 30 = -1000 \cos 30$$

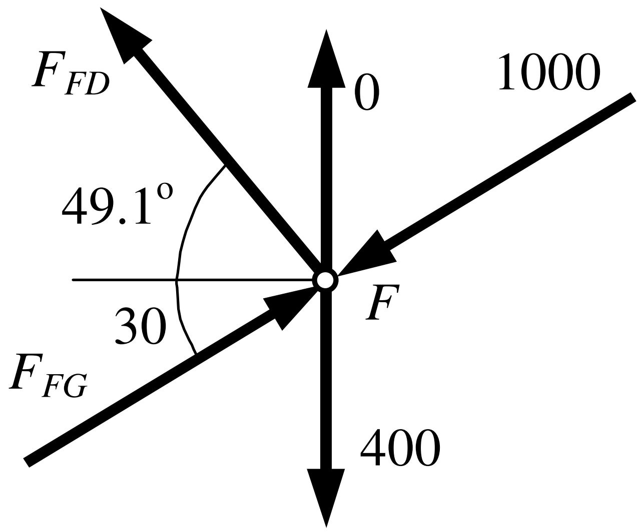
Solving, we get: $F_{EC} = 0$; and $F_{EF} = 1000$ N



Joint C

$F_{CD} = 866.025$ N

$F_{CF} = 0$



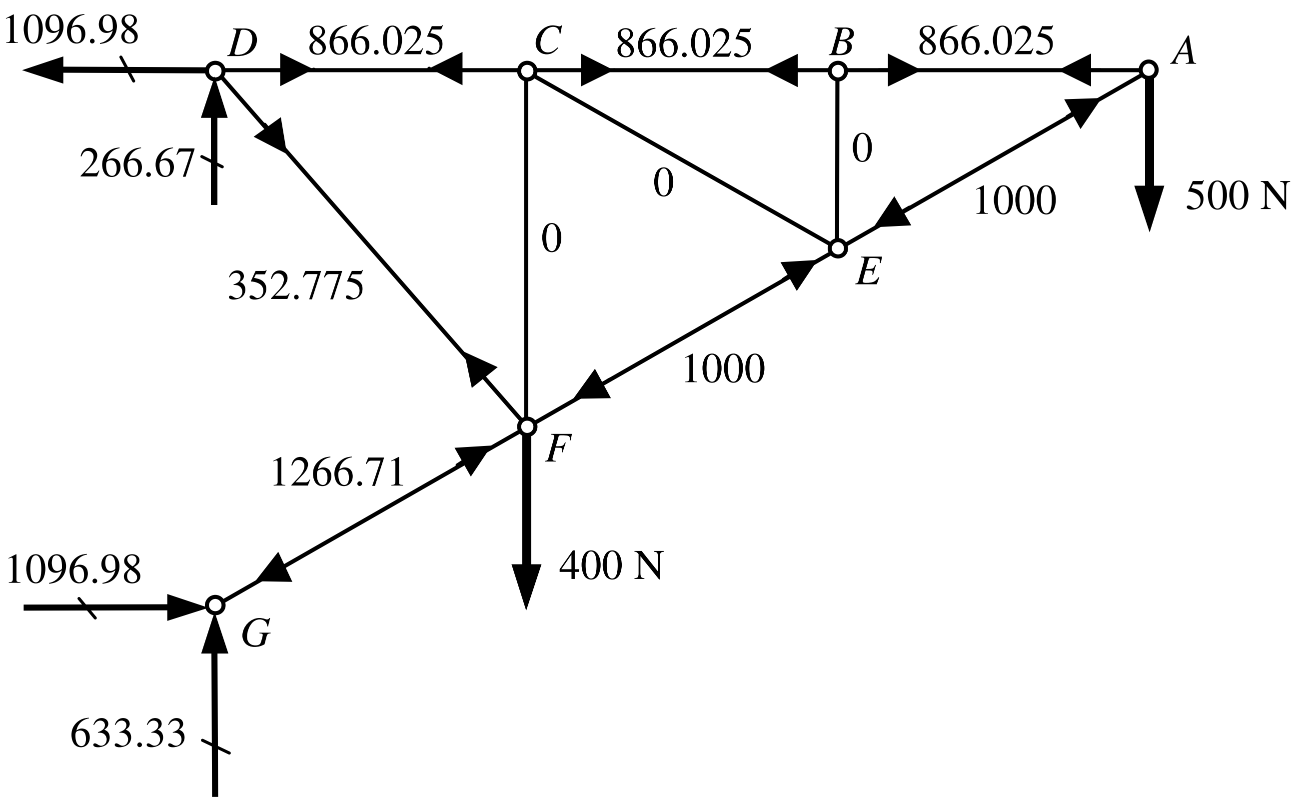
Joint F

$$F_{FD} \sin 49.1 + F_{FG} \sin 30 = 1000 \sin 30 + 400$$

$$F_{FD} \cos 49.1 - F_{FG} \cos 30 = -1000 \cos 30$$

Solving, we get: $F_{FD} = 352.775$ N; and

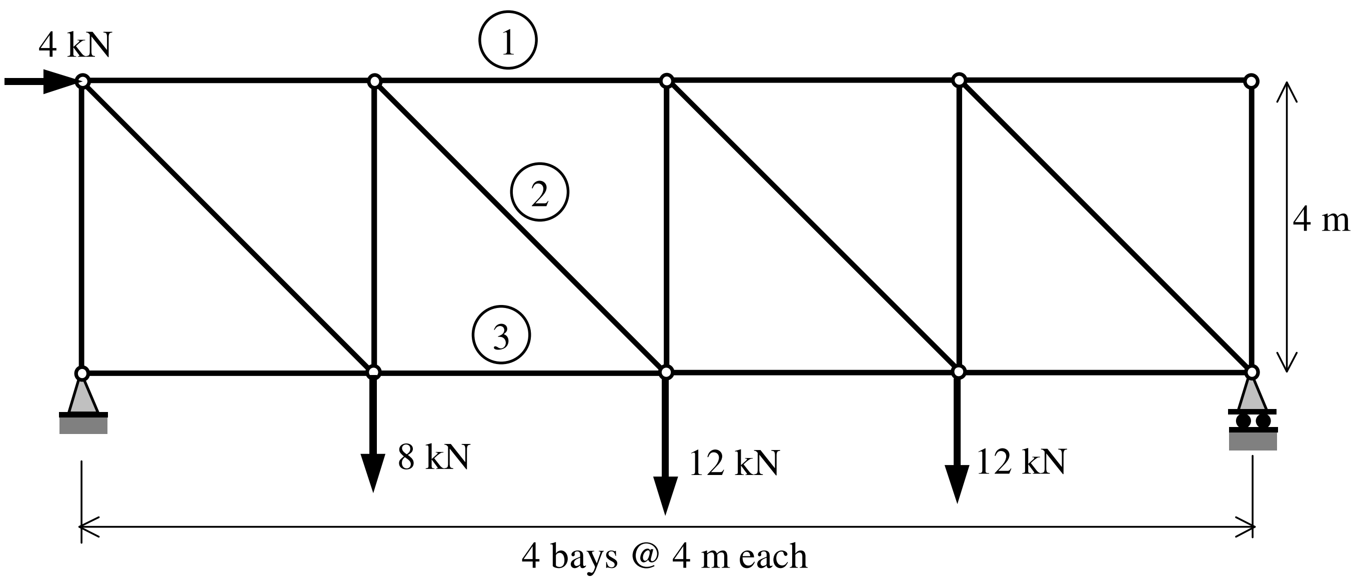
$F_{FG} = 1266.708$ N



B Method of Sections

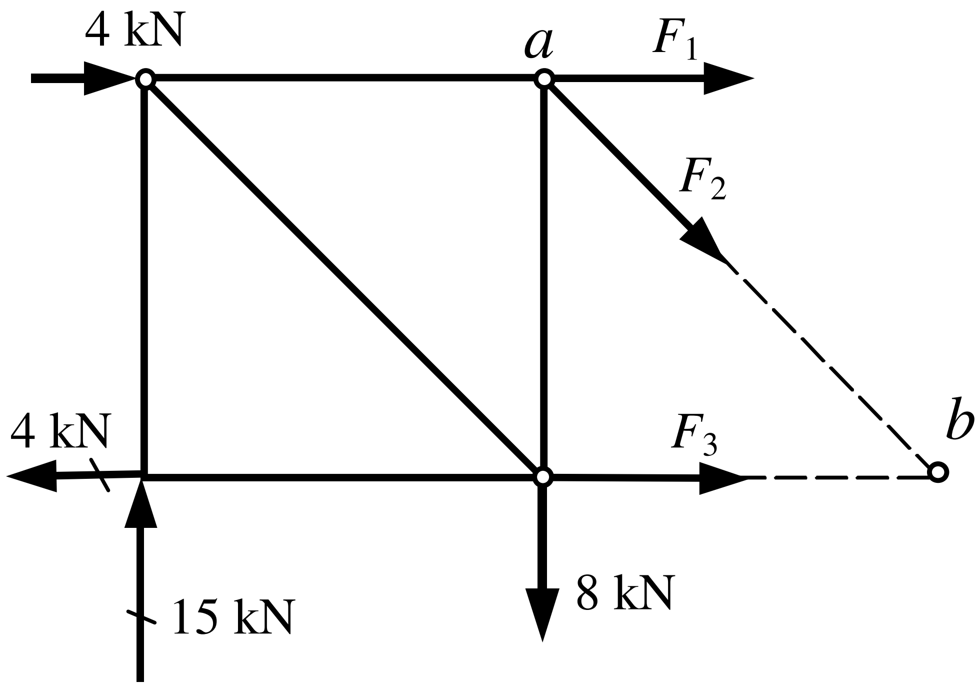
A cut section of the truss is considered. The equilibrium of part of the truss to one side of the cut is used to solve for the member forces.

Example: Determine the forces in members marked 1, 2 and 3 of the truss shown below.



Draw the free body diagram of the entire truss and determine the support reactions.

Make a cut through the three members; consider the free body diagram of the truss to the left of the cut.



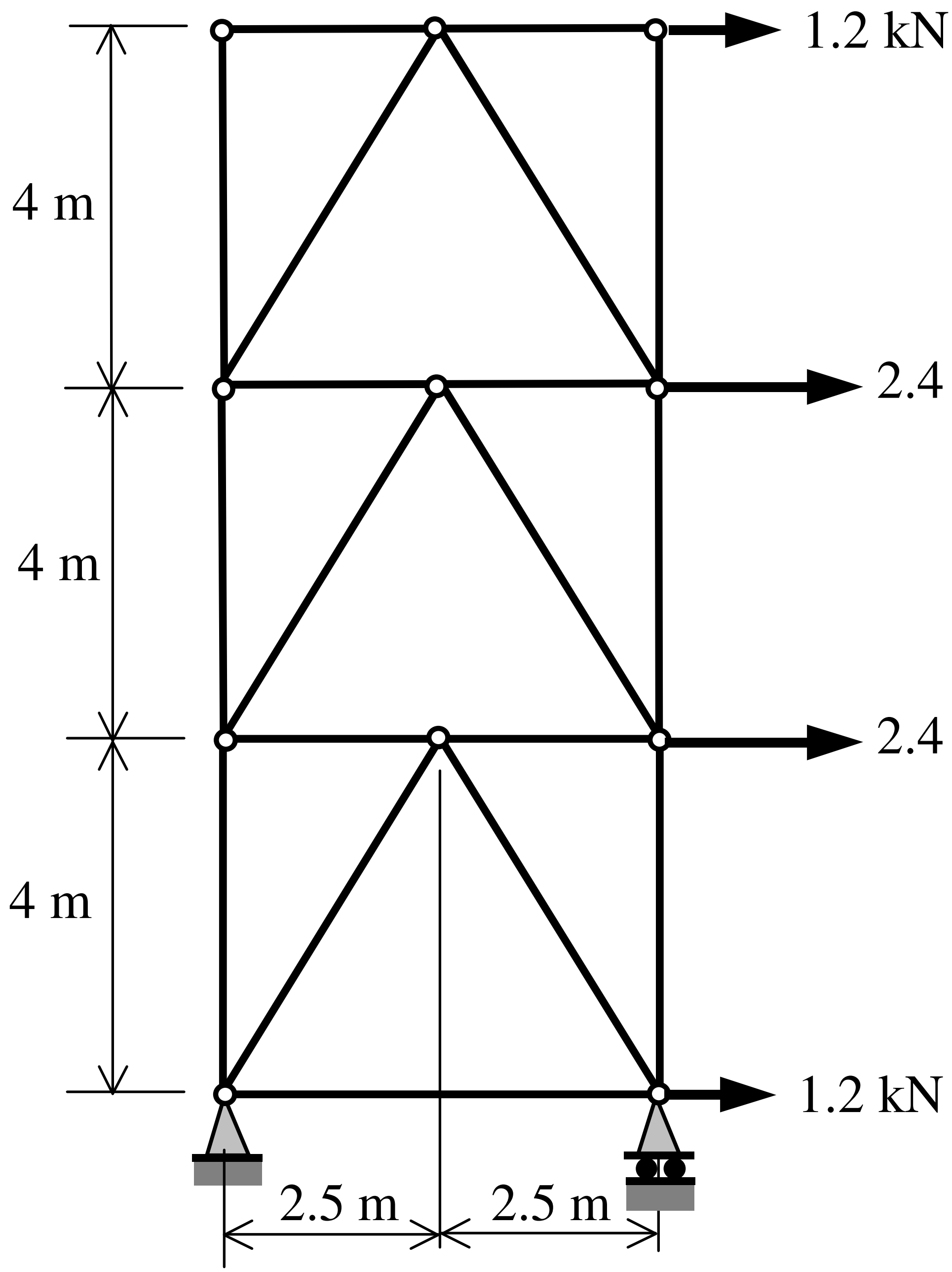
$\Sigma F_y = 0$: $F_2 \sin 45 = 15 - 8$; $\therefore$ $\boldsymbol{F_2 = 7\sqrt{2}}$ **kN**

$\Sigma M_a = 0$: $F_3 \times 4 = 4 \times 4 + 15 \times 4$; $\therefore$ $\boldsymbol{F_3 = 19}$ **kN**

$\Sigma M_b = 0$: $F_1 \times 4 + 4 \times 4 + 15 \times 8 - 8 \times 4$;

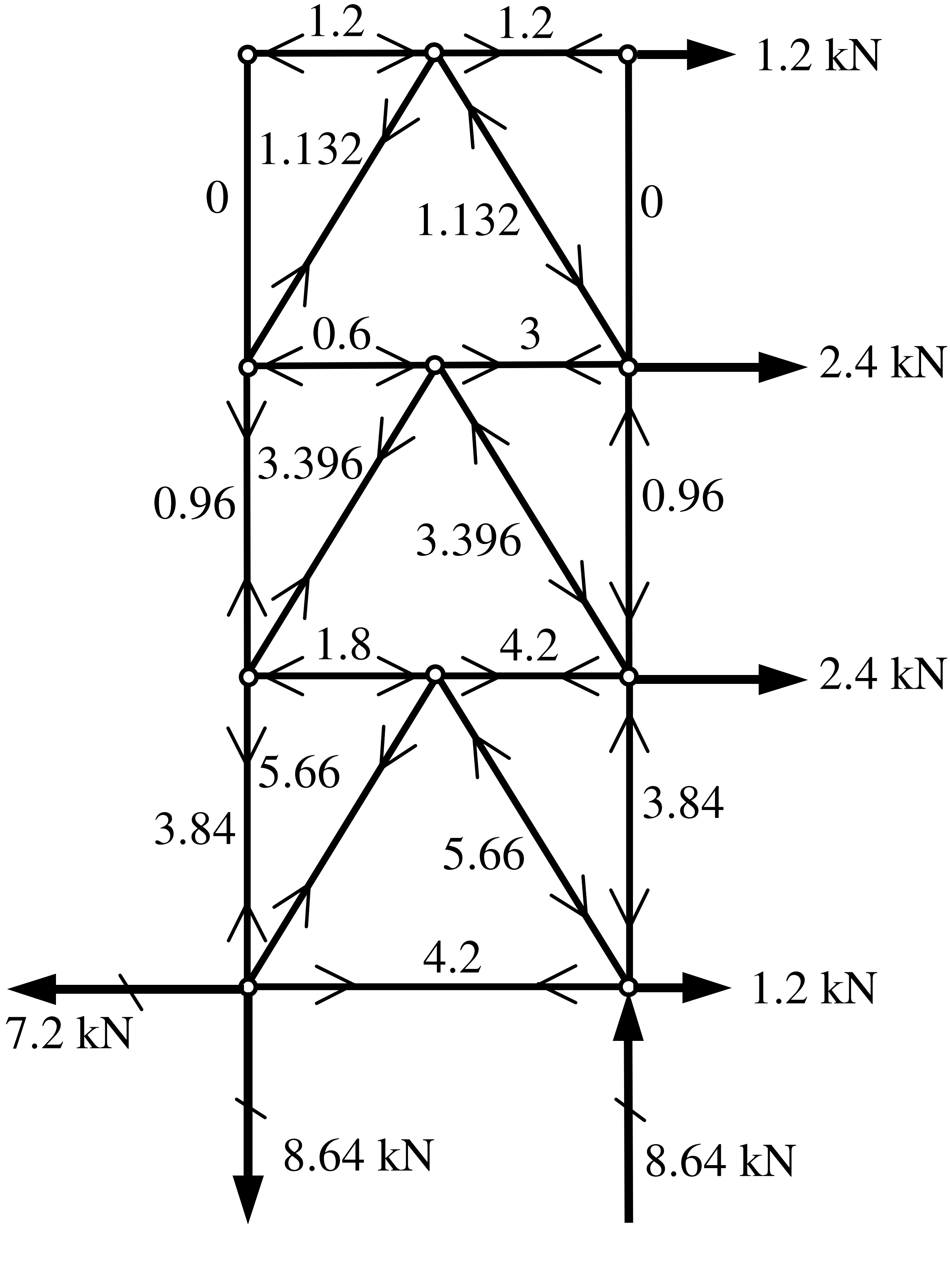
$\therefore$ $\boldsymbol{F_1 = -26}$ **kN**

Check $\Sigma F_x = 0$ ✓

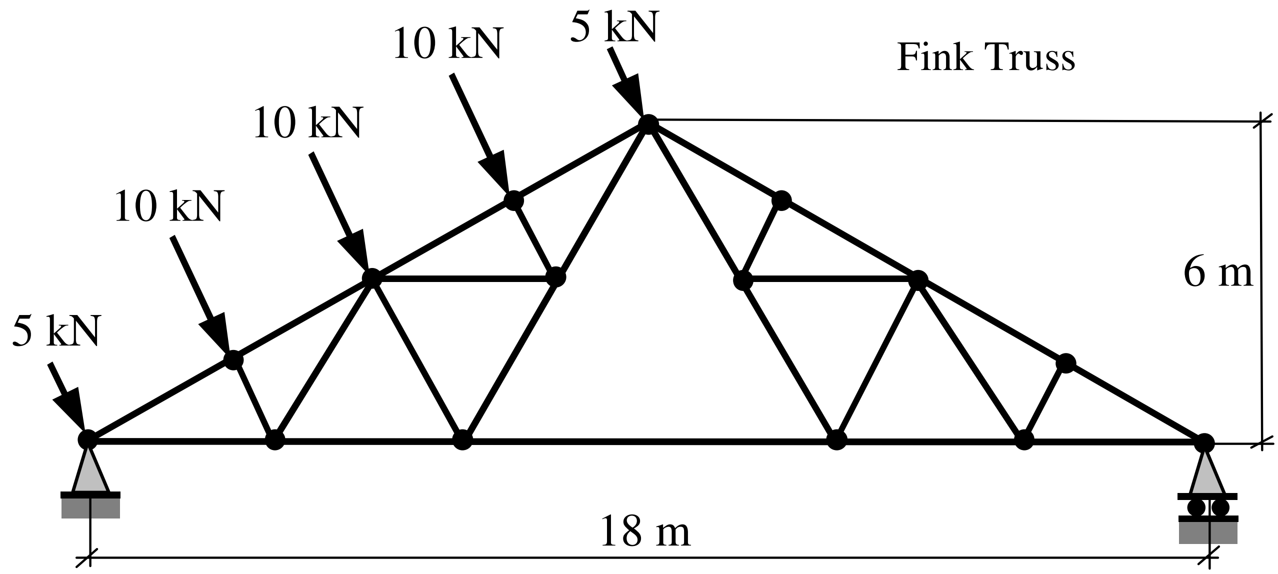


Exercise: Determine the bar forces in the truss shown above.

Answer:



1.2
1.2
1.2 kN
1.132
0
1.132
0
0.6
3
2.4 kN
3.396
0.96
3.396
0.96
1.8
4.2
2.4 kN
5.66
3.84
3.84
5.66
4.2
1.2 kN
7.2 kN
8.64 kN
8.64 kN



<u>Exercise1</u>: Determine the bar forces in the fink truss shown above.

<u>Exercise2</u>: Determine the bar forces in the pratt truss shown below.