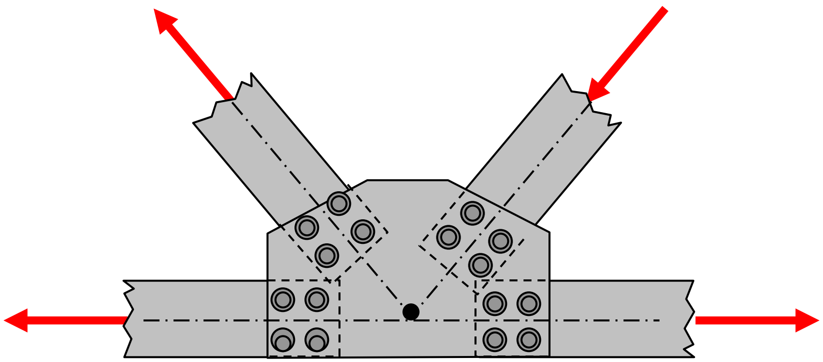
وزارت علوم، تحقیقات و فناوری

دانشگاه سوره

سازه های نو

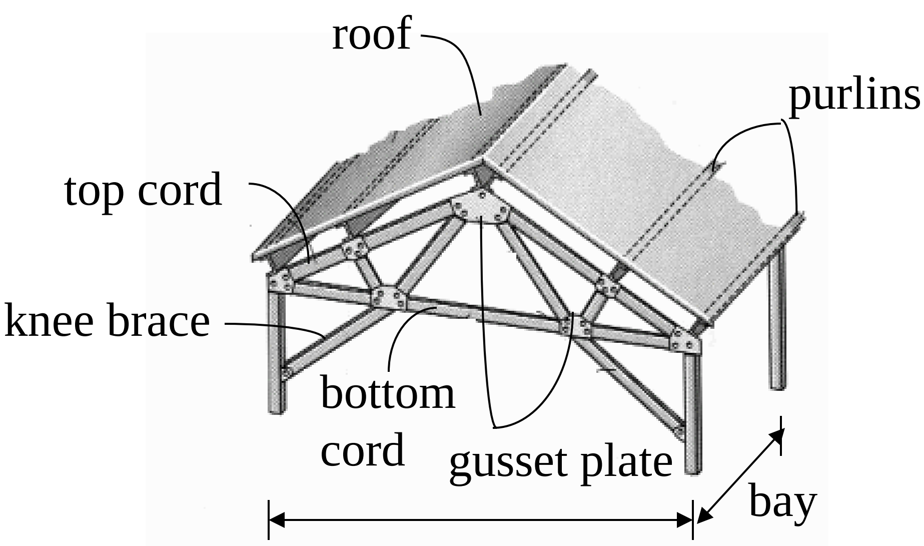
سازه های خرپایی

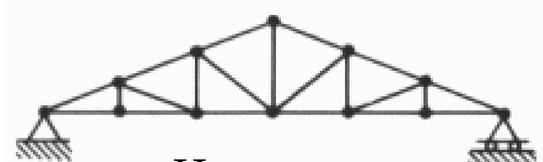
Common Types of Trusses



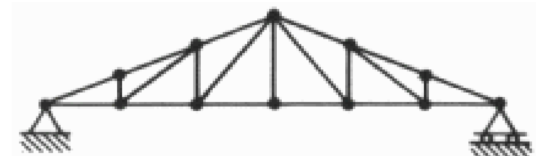
gusset plate

- **Roof Trusses**

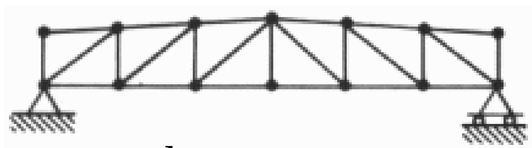




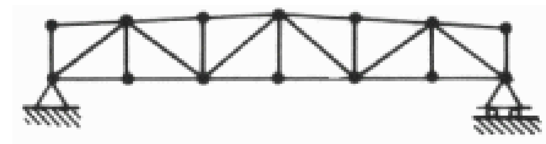
Howe truss



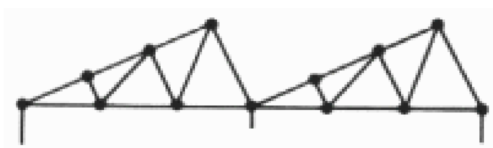
Pratt truss



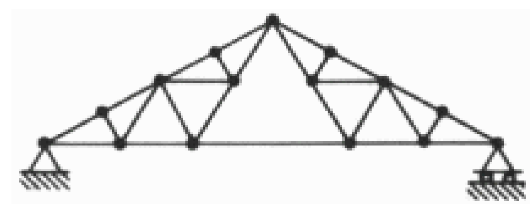
howe truss



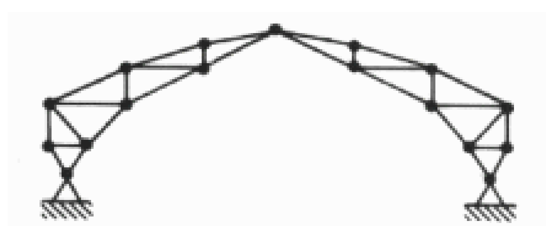
Warren truss



saw-tooth truss

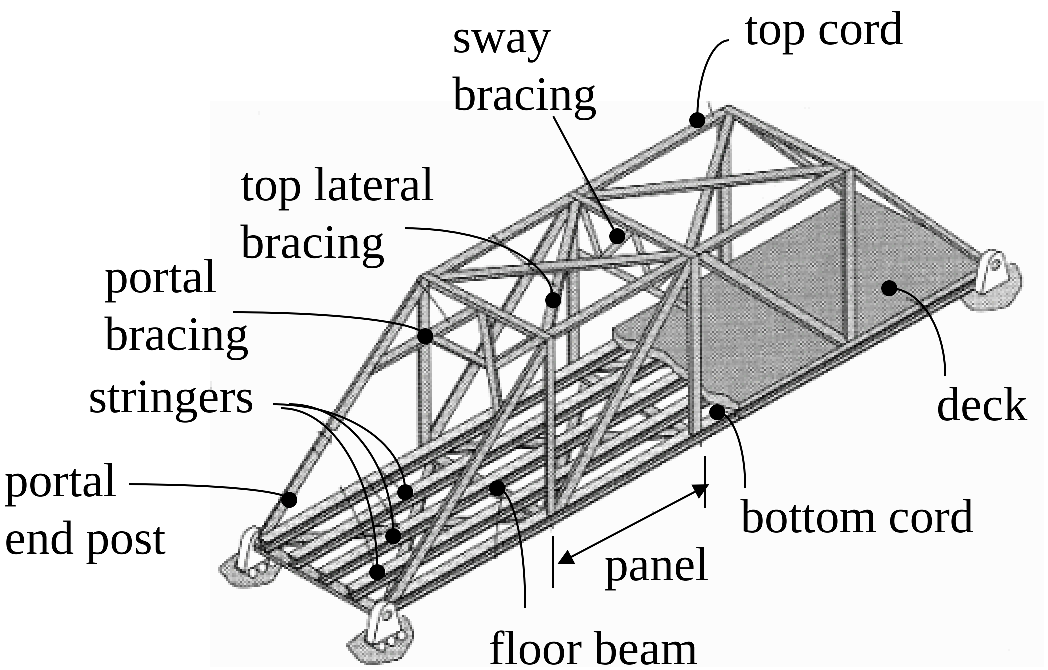


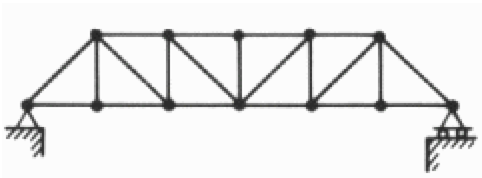
Fink truss



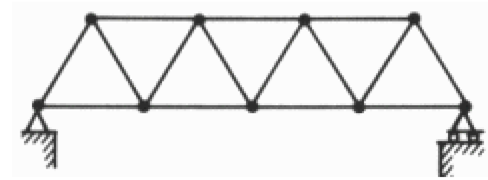
three-hinged arch

Bridge Trusses

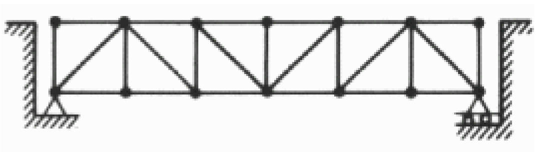




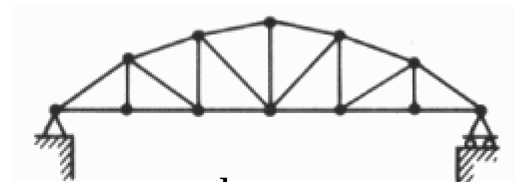
trough Pratt truss



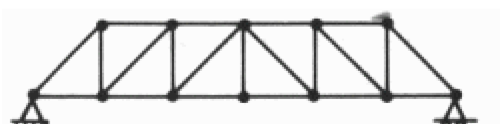
Warren truss



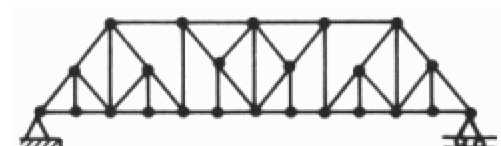
deck Pratt truss



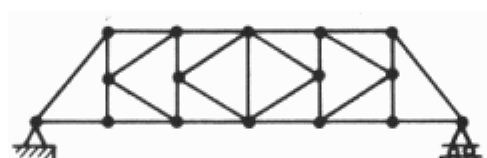
parker truss
(pratt truss with curved chord)



Howe truss



baltimore truss



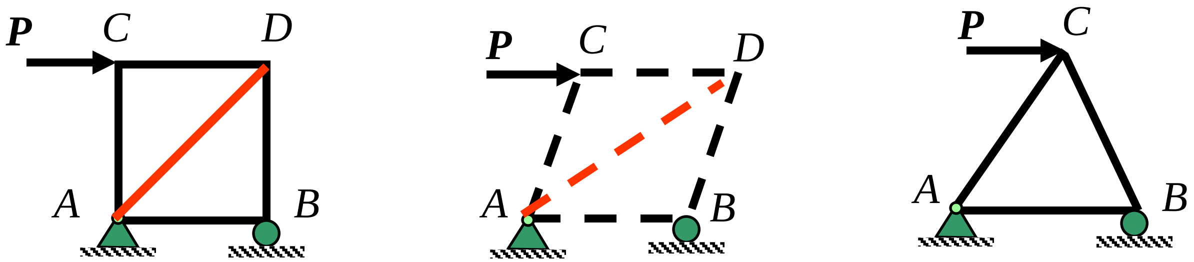
K truss

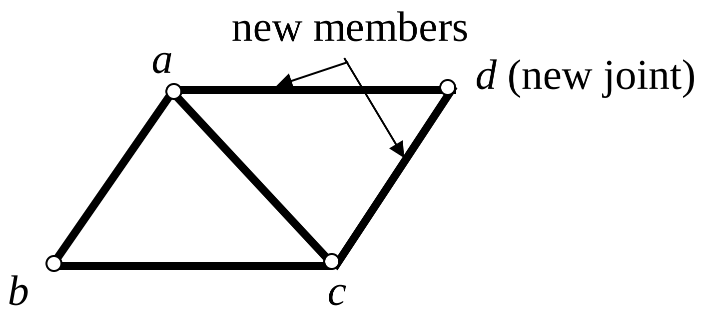
Assumptions for Design

- **All members are connected at both ends by smooth frictionless pins.**
- **All loads are applied at joints (member weight is negligible).**
- **Notes**:
  - Centroids of all joint members coincide at the joint.
  - All members are straight.
  - All load conditions satisfy Hooke’s law.

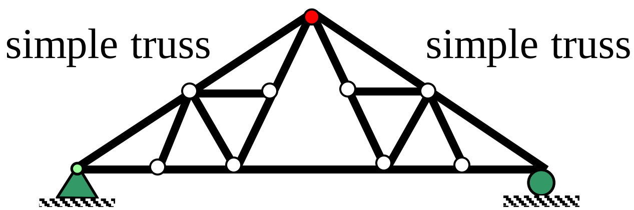
Classification of Coplanar Trusses

- **Simple Trusses**

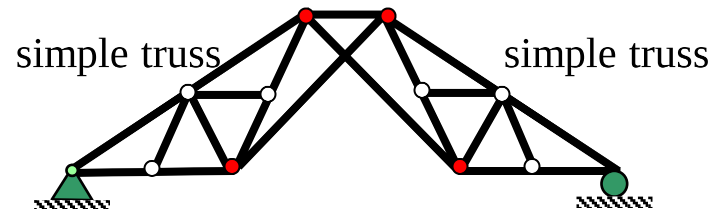




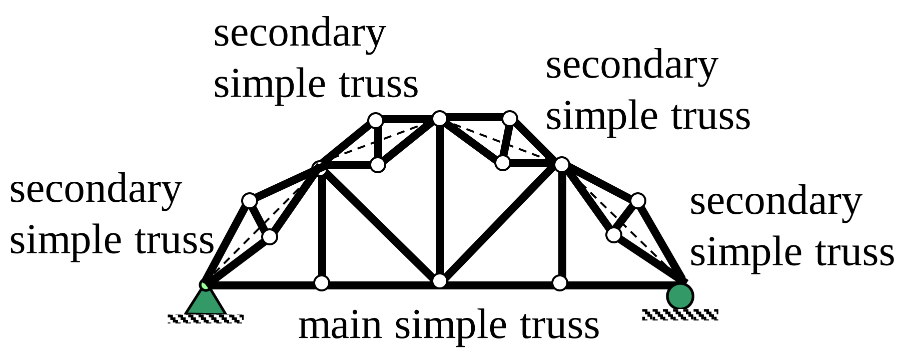
- **Compound Trusses**



Type 1

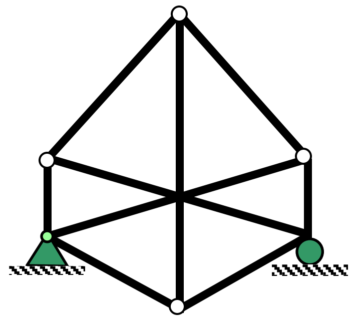


Type 2



Type 3

- **Complex Trusses**



- **Determinacy**

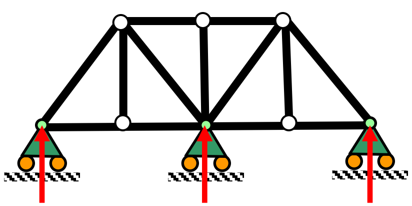
$b + r = 2j$	statically determinate
$b + r > 2j$	statically indeterminate

In particular, the degree of indeterminacy is specified by the difference in the numbers $(b + r) - 2j$.

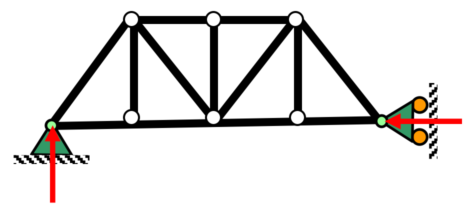
- **Stability**

$b + r < 2j$	unstable
$b + r \geq 2j$	unstable if truss support reactions are concurrent or parallel or if some of the components of the truss form a collapsible mechanism

<u>External Unstable</u>

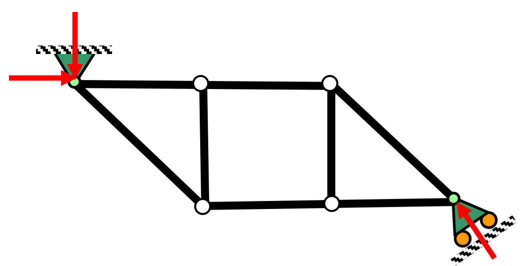


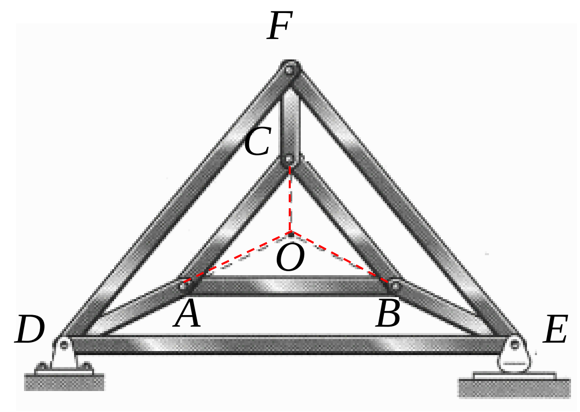
Unstable-parallel reactions



Unstable-concurrent reactions

Internal Unstable

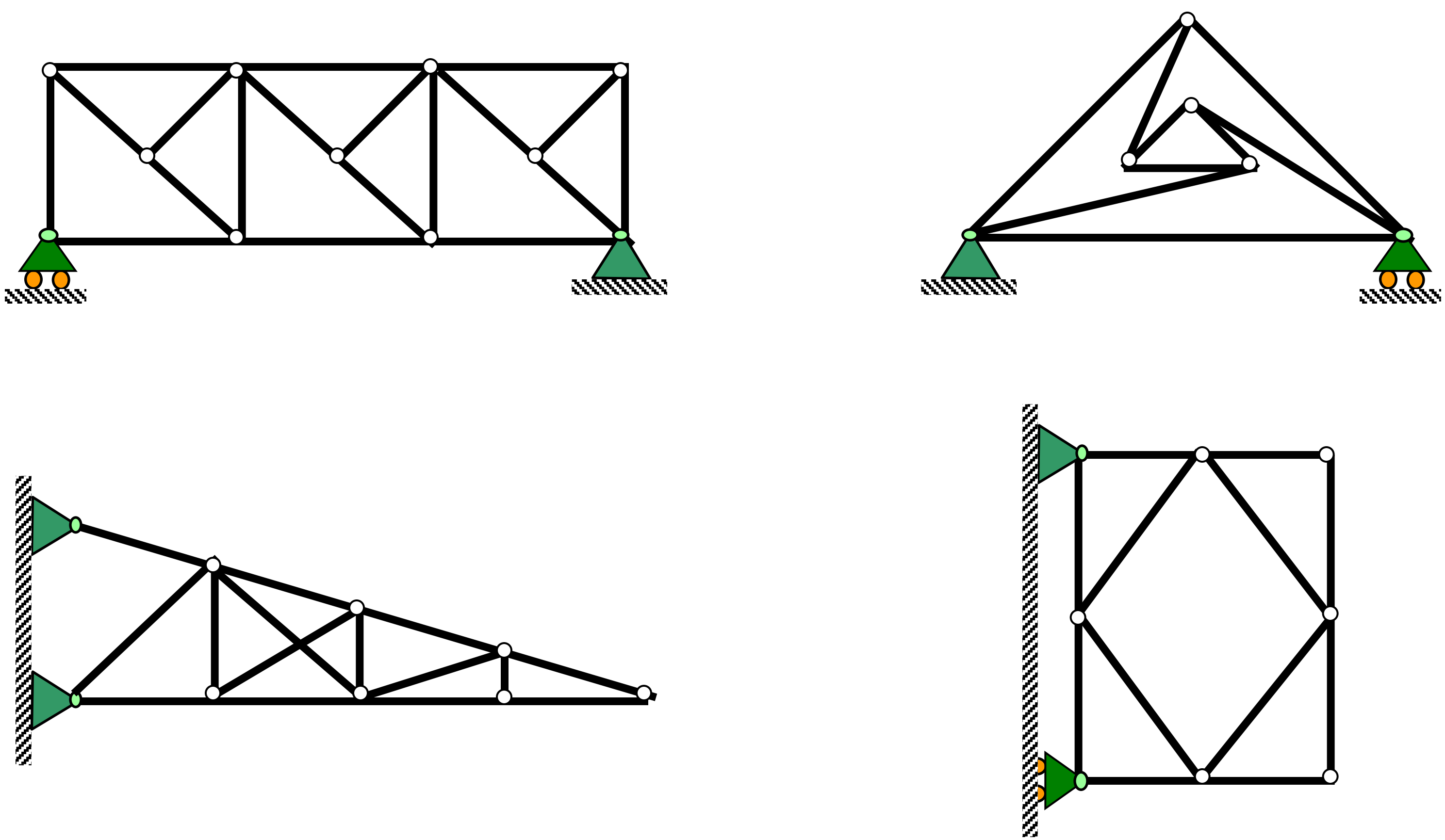




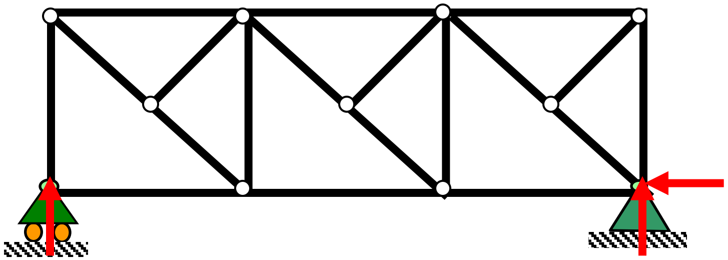
AD, *BE*, and *CF* are concurrent at point *O*

Example 3-1

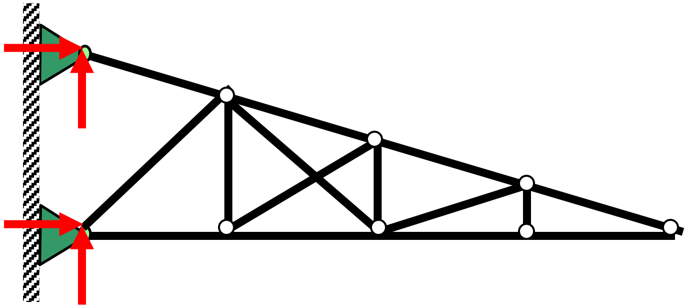
Classify each of the trusses in the figure below as stable, unstable, statically determinate, or statically indeterminate. The trusses are subjected to arbitrary external loadings that are assumed to be known and can act anywhere on the trusses.



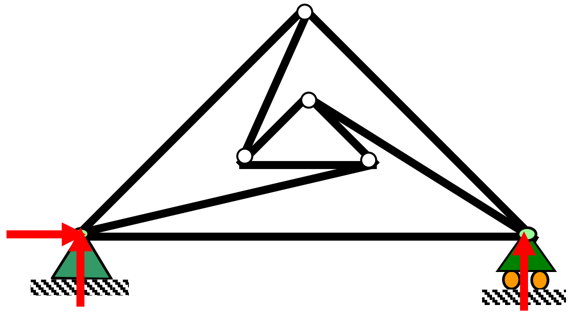
SOLUTION



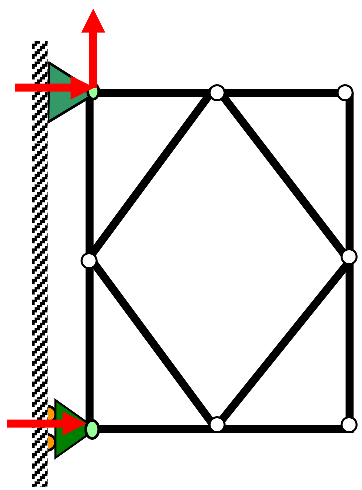
Externally stable, since the reactions are not concurrent or parallel. Since $b = 19$, $r = 3$, $j = 11$, then $b + r = 2j$ or $22 = 22$. Therefore, the truss is *statically determinate*. By inspection the truss is *internally stable*.



Externally stable. Since $b = 15$, $r = 4$, $j = 9$, then $b + r > 2j$ or $19 > 18$. The truss is *statically indeterminate* to the first degree. By inspection the truss is *internally stable*.



Externally stable. Since b = 9, r = 3, j = 6, then $b + r = 2j$ or 12 = 12. The truss is *statically determinate*. By inspection the truss is *internally stable*.



Externally stable. Since b = 12, r = 3, j = 8, then $b + r < 2j$ or 15 < 16. The truss is *internally unstable.*

- Method of Joints
- Method of Sections

Method of Joints

- If a truss is in equilibrium, then each of its joints must also be in equilibrium

- The method of joints consists of satisfying the equilibrium conditions for the forces exerted "on the pin" at each joint of the truss

- Truss members are all straight two-force members lying in the same plane
  - The force system acting at each pin is coplanar and concurrent (intersecting)
  - Rotational or moment equilibrium is automatically satisfied at the joint, only need to satisfy $\sum Fx = 0$, $\sum Fy = 0$

Procedure for Analysis

- Draw the free-body diagram of a joint having at least one known force and at most two unknown forces (may need to first determine external reactions at the truss supports)

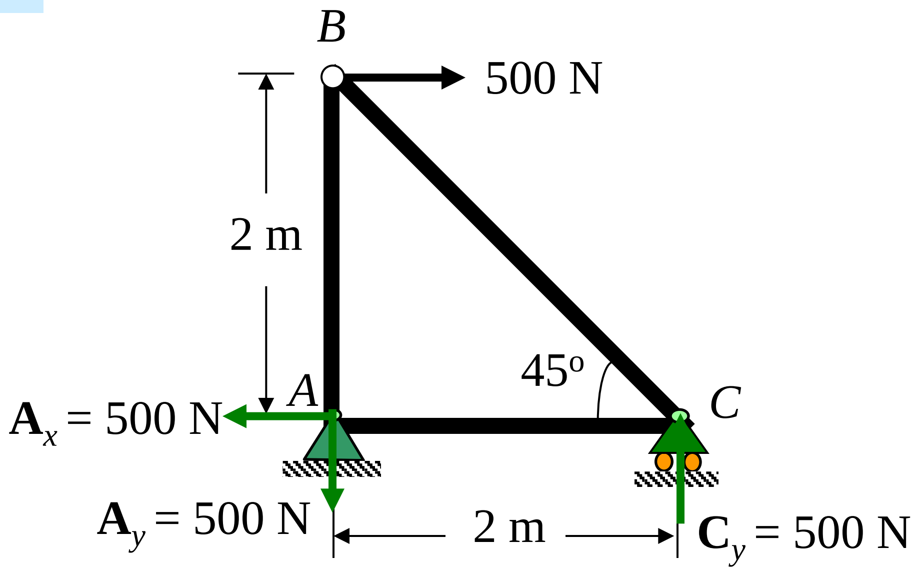
- Establish the sense of the unknown forces
  - Always assume the unknown member forces acting on the joint's free-body diagram to be in tension (pulling on the "pin")
  - Assume what is believed to be the correct sense of an unknown member force
  - In both cases a negative value indicates that the sense chosen must be reversed

- Orient the x and y axes such that the forces can be easily resolved into their x and y components
- Apply $\sum F_x = 0$ and $\sum F_y = 0$ and solve for the unknown member forces and verify their correct sense
- Continue to analyze each of the other joints, choosing ones having at most two unknowns and at least one known force

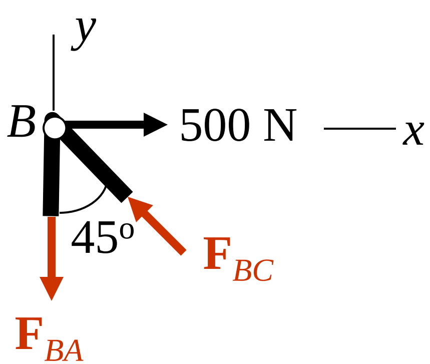
- Members in compression “push” on the joint and members in tension “pull” on the joint

- Mechanics of Materials and building codes are used to size the members once the forces are known

The Method of Joints



Joint B



$\xrightarrow{+}\ \Sigma F_x = 0:$

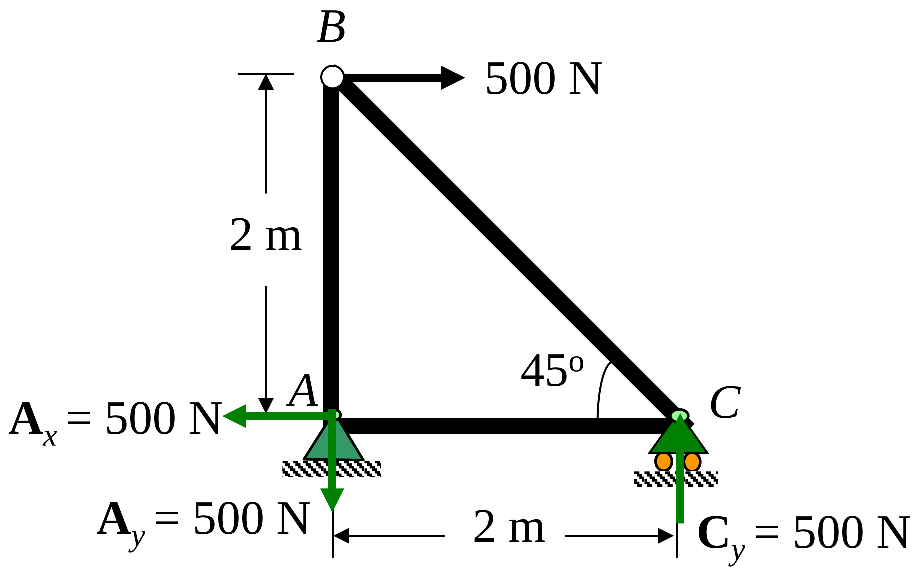
$500 - F_{BC}\sin 45^{o} = 0$

$F_{BC} = 707.11\text{ N (C)}$

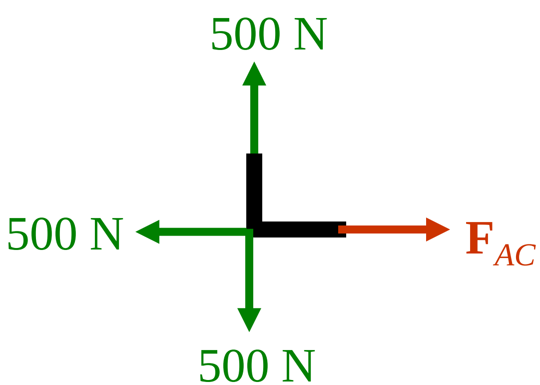
$+\uparrow\ \Sigma F_y = 0:$

$-F_{BA} + F_{BC}\cos 45^{o} = 0$

$F_{BA} = 500\text{ N (T)}$



Joint A



$\xrightarrow{+} \Sigma F_x = 0:$

$500 - F_{AC} = 0$

$F_{AC} = 500$ N (T)

Method of Sections

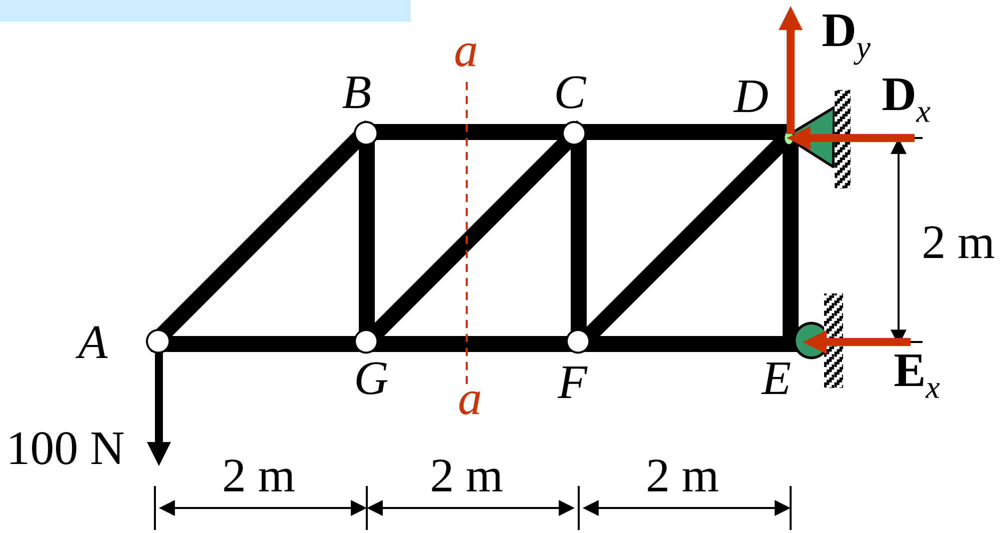
- Based on the principle that if a body is in equilibrium, then any part of the body is also in equilibrium
- Procedure for analysis
  - Section or “cut” the truss through the members where the forces are to be determined
  - Before isolating the appropriate section, it may be necessary to determine the truss’s external reactions (then 3 equs. of equilibrium can be used to solve for unknown member forces in the section).

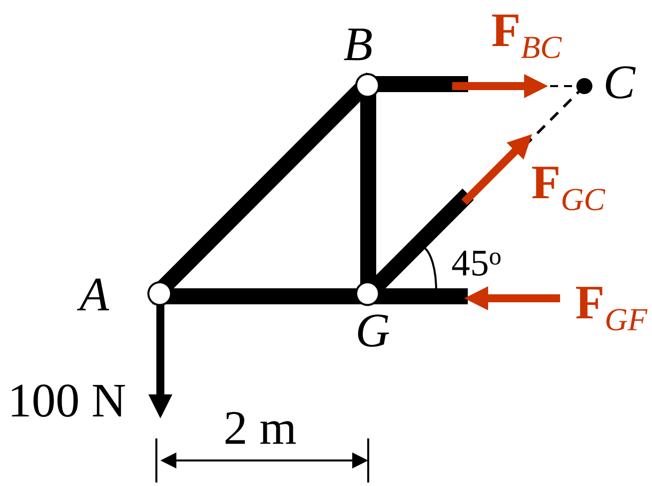
- Draw the free-body diagram of that part of the sectioned truss that has the least number of forces acting on it

- Establish the sense of the unknown member forces

- Apply 3 equations of equilibrium trying to avoid equations that need to be solved simultaneously
  - Moments should be summed about a point that lies at the intersection of the lines of action of two unknown forces
  - If two unknown forces are parallel – sum forces perpendicular to the direction of these unknowns

The Method of Sections





$\circlearrowleft + \; \Sigma M_G = 0:$

$100(2) - F_{BC}(2) = 0$

$F_{BC} = 100 \text{ N (T)}$

$+\uparrow \; \Sigma F_y = 0:$

$-100 + F_{GC}\sin 45^\circ = 0$

$F_{GC} = 141.42 \text{ N (T)}$

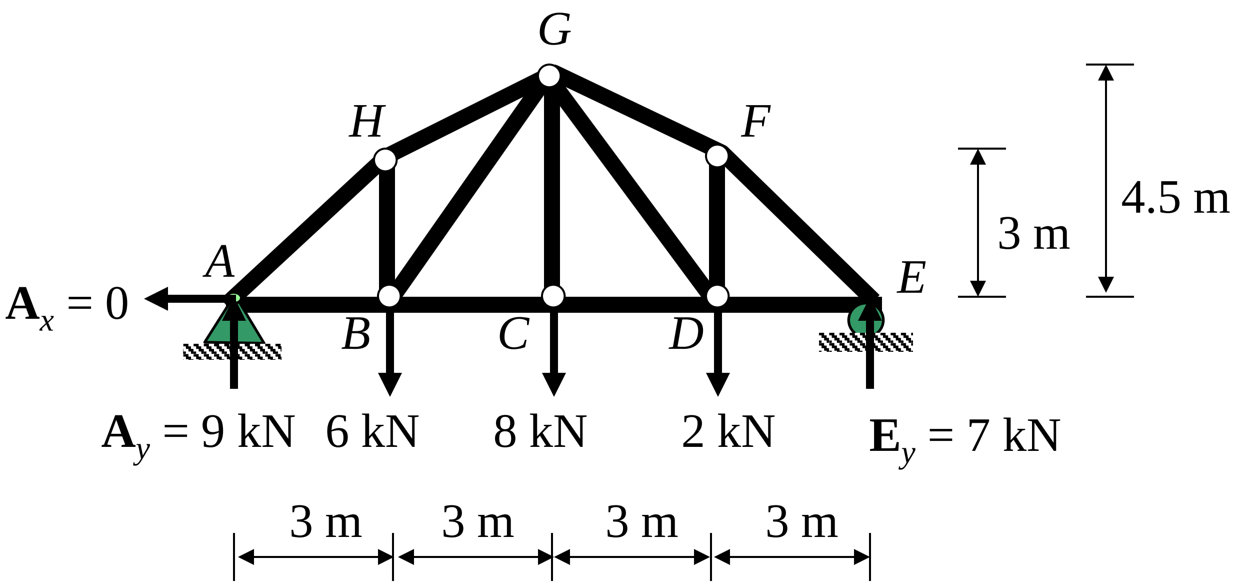
$\circlearrowleft + \; \Sigma M_C = 0:$

$100(4) - F_{GF}(2) = 0$

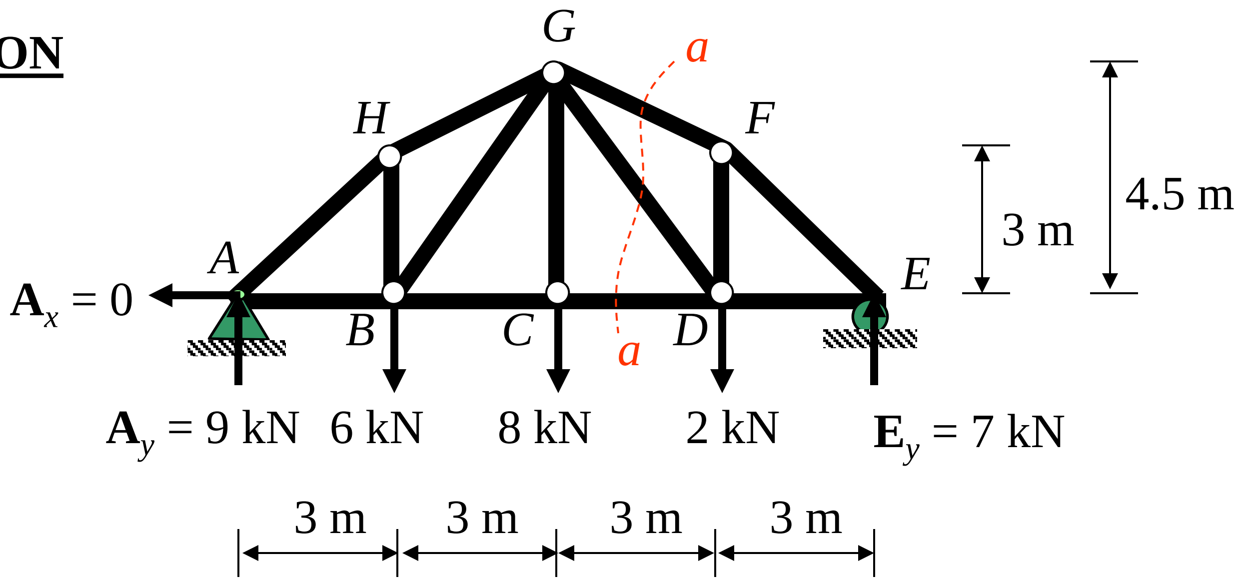
$F_{GF} = 200 \text{ N (C)}$

Example 3-6

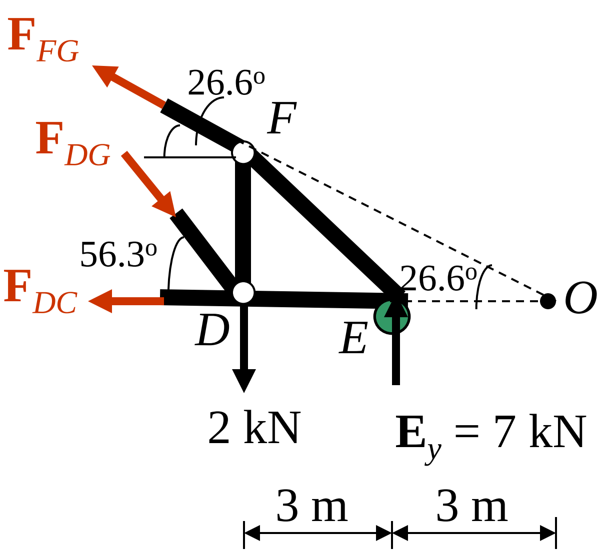
Determine the force in members *GF* and *GD* of the truss shown in the figure below. State whether the members are in tension or compression. The reactions at the supports have been calculated.



SOLUTION



Section a-a



$\overset{+}{\circlearrowleft} \; \Sigma M_D = 0:$

$$F_{FG}\cos 26.6^{o}(3) + 7(3) = 0,$$

$$F_{FG} = -7.83 \text{ kN (C)}$$

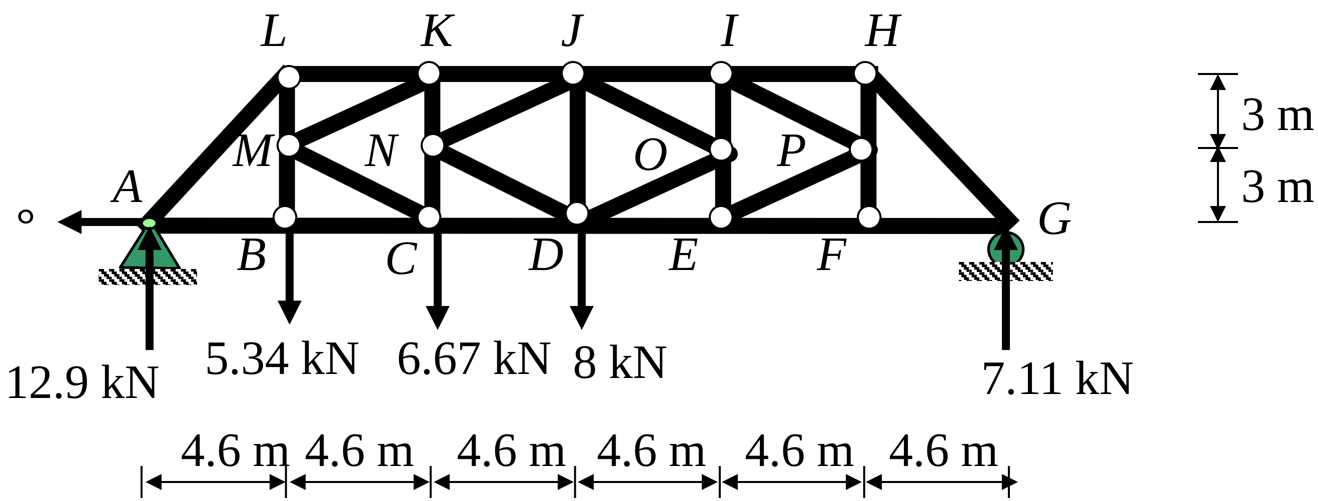
$\overset{+}{\circlearrowleft} \; \Sigma M_O = 0:$

$$-\,7(3) + 2(6) + F_{DG}\sin 56.3^{o}(6) = 0,$$

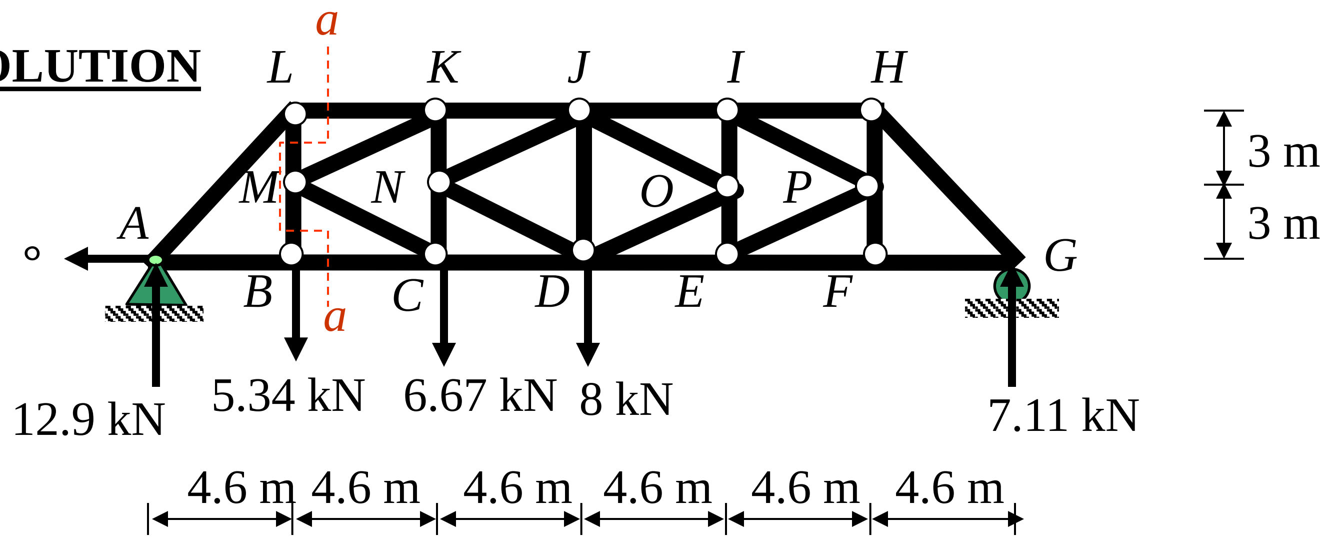
$$F_{DG} = 1.80 \text{ kN (C)}$$

Example 3-7

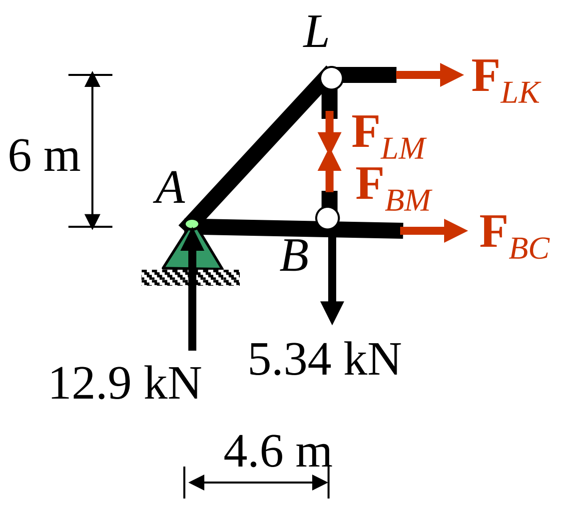
Determine the force in members *BC* and MC of the K-truss shown in the figure below. State whether the members are in tension or compression. The reactions at the supports have been calculated.



SOLUTION



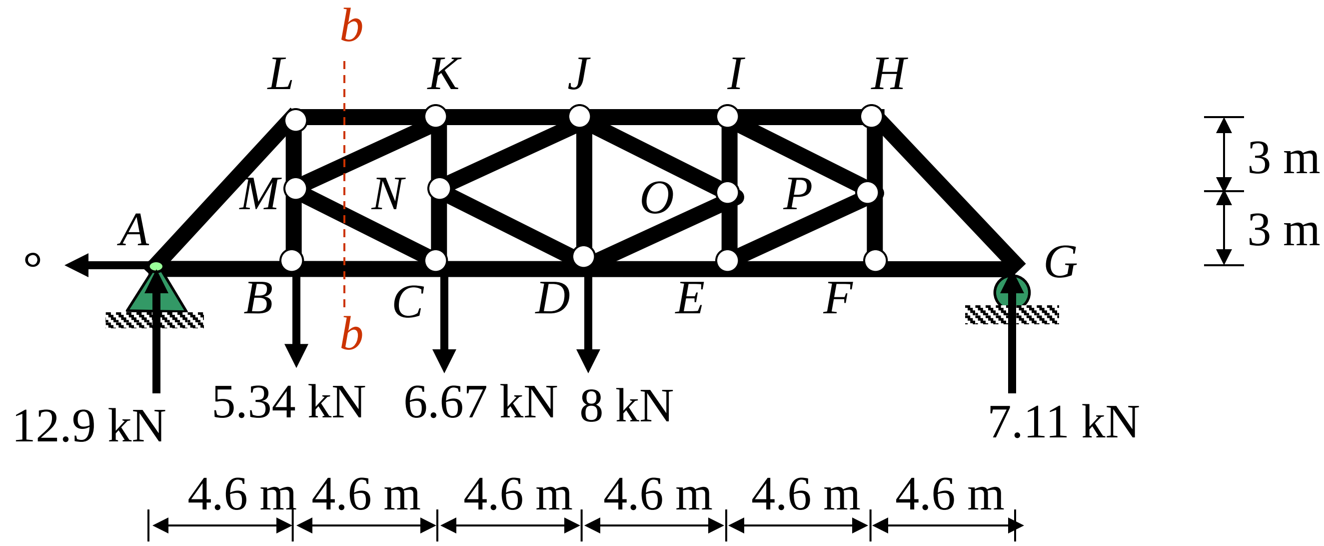
Section a-a

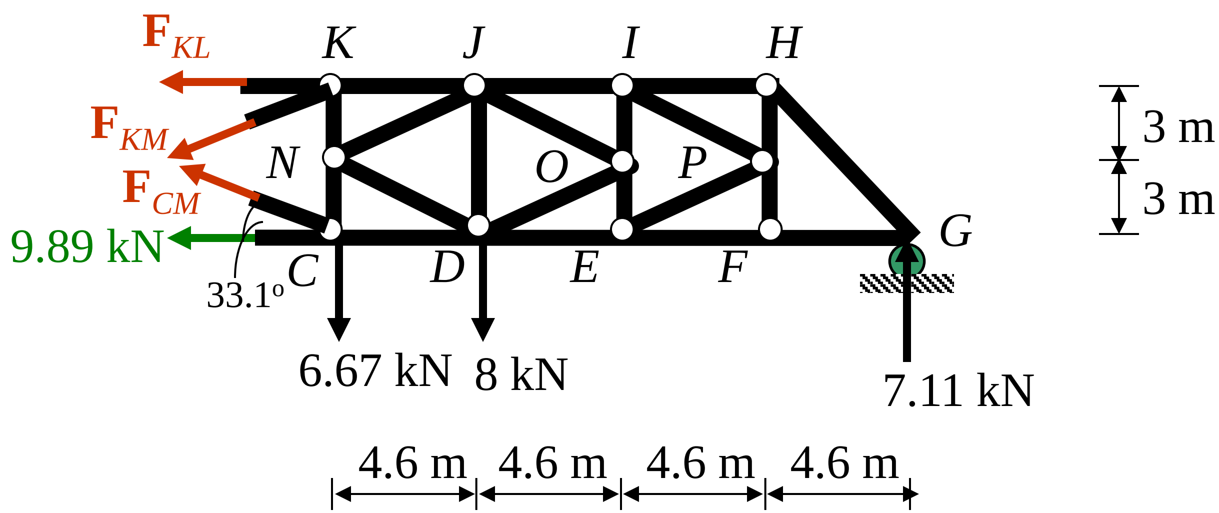


$$+\circlearrowleft \Sigma M_L = 0:$$

$$F_{BC}(6) - 12.9(4.6) = 0,$$

$$F_{BC} = 9.89 \text{ kN (T)}$$





$+\circlearrowleft \Sigma M_K = 0$: $\quad -F_{CM}\cos 33.1^{\circ}(6) - 9.89(6) - 8(4.6) + 7.11(18.4) = 0$

$F_{CM} = 6.90\text{ kN (T)}$