07 Method of Joints

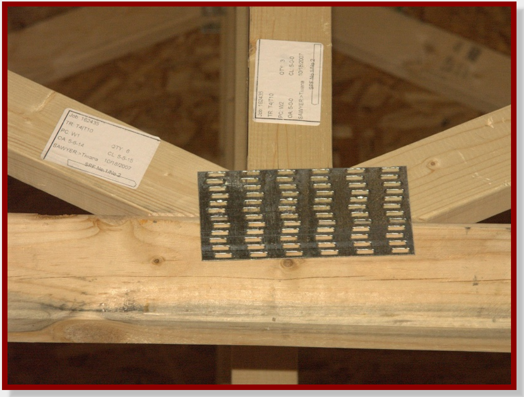
Engineering Statics

Updated on: October 16, 2025

Trusses are the most common method to support residential roof systems

Trusses

- Truss members are cut to length and laid out on a flat surface.
- Truss connectors are pressed in at the joints of the truss members.



- The truss connectors must be applied under proper pressure provided by a roller press in a factory.
- Damaged connectors **must not** be reinstalled with a hammer!

Trusses

- Trusses are delivered to site, often banded together.

- Careful storage is required before installation.

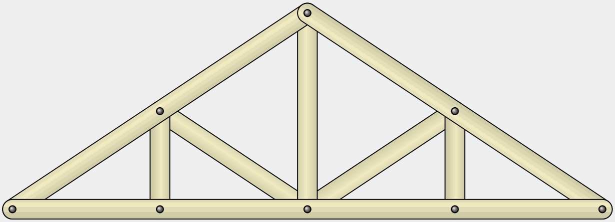
Trusses

- These trusses are built from heavy timbers and will be left exposed as an architectural feature.
- These may be fitted on site or manufactured off-site using computer numerically controlled (CNC) machinery

Trusses

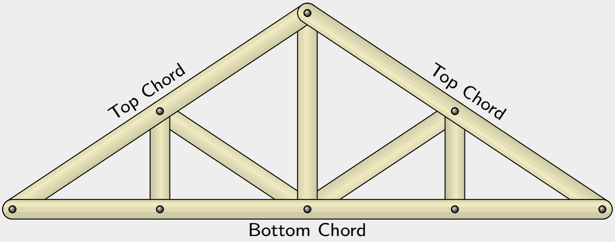
- This beautiful truss holds up the roof of an octagonal tower in an old church in the small village of Stoney Middleton, Derbyshire, England.

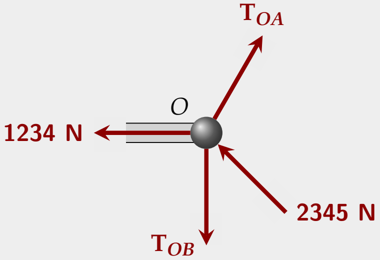
- A truss is a structure of slender two-force members with pinned connections at their end points.



Trusses

- A truss is a structure of slender two-force members with pinned connections at their end points.
- Although the top and bottom chords may be continuous in roof trusses, they are not designed to support heavy transverse loads so for our analysis we consider the top and bottom **chords** to be be comprised of separate two-force members connected at each joint.



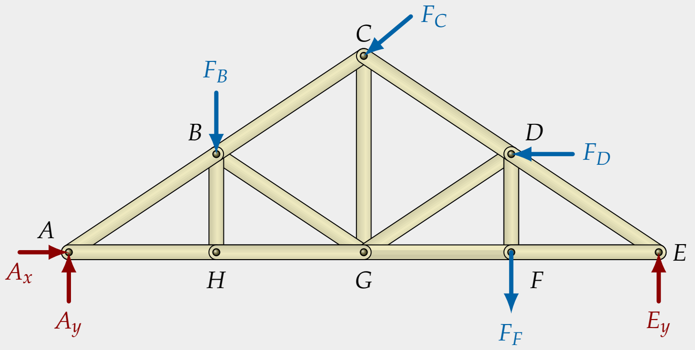


These are internal forces, exposed by 'cutting' the members to analyze the forces at a joint.

Arrowhead towards the joint indicates compression of 2345N

Arrowhead away from the joint indicates tension (1234N, $\mathbf{T}_{OA}$ and $\mathbf{T}_{OB}$).

If tension or compression is unknown, assume the member is in tension. Then, if the result is negative, the assumption of tension was incorrect and the member is actually in compression.



- Forces are applied only at member end connections, so the members are **two-force members**
- The forces in two-force members are directed along a line from where the forces are applied. In this case, since the members are straight, the forces (tension or compression) are directed along the truss member itself.
- Trusses are often used to support roofs and bridges

Truss Bridges

Truss Bridges

A Camelback Pratt Truss bridge design, Montana, U.S.

Subway Bridge, Chicago, Illinois

Pinned Connections

Pinned Connections

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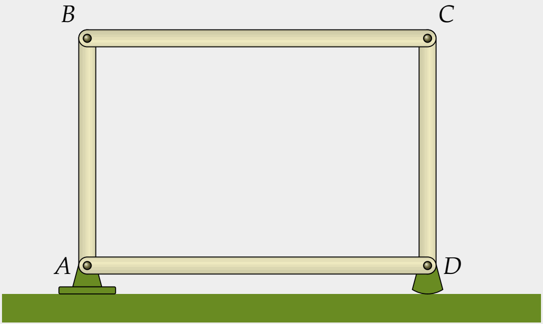
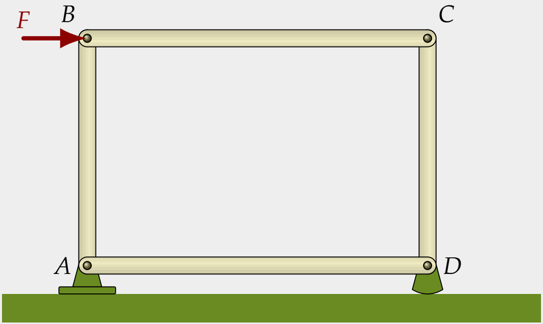


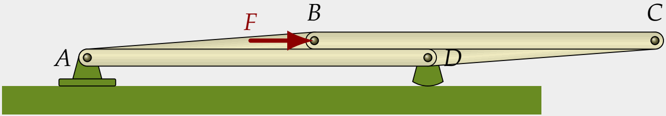
- Pinned connections offer no resistance to rotation.

Pinned Connections



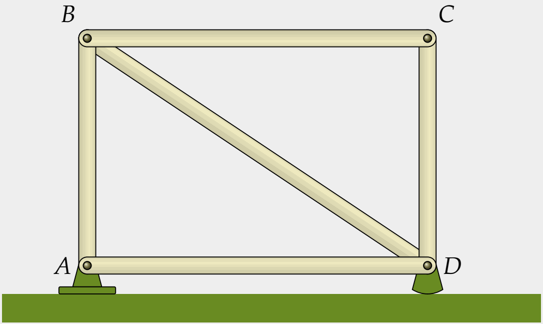
- Pinned connections offer no resistance to rotation.
- A force applied at B...

Pinned Connections



- Pinned connections offer no resistance to rotation.
- A force applied at B...meets no resistance.

Pinned Connections



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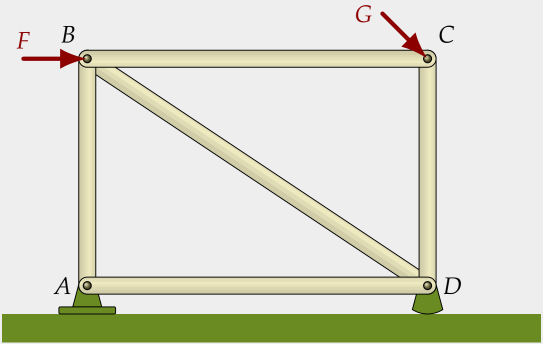
- A force applied at B...meets no resistance.
- The addition of a diagonal member will create two triangles which are stable shapes;

Pinned Connections



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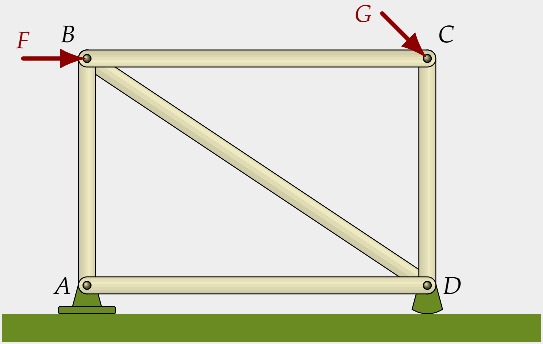
- The addition of a diagonal member will create two triangles which are stable shapes; now the frame can support horizontal and vertical loads.

Pinned Connections



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- A force applied at B...meets no resistance.
- The addition of a diagonal member will create two triangles which are stable shapes; now the frame can support horizontal and vertical loads.
- Trusses are made up of (strong) triangles.

Pinned Connections

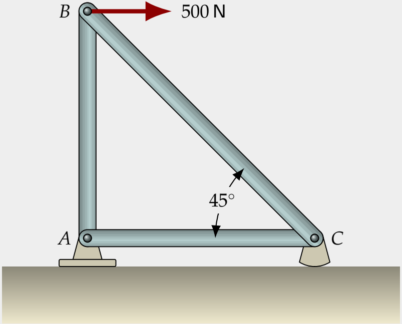
Diagonal bracing could have prevented this.

Truss and Bridge Supports - Pinned Connection

Truss and Bridge Supports - Rollers

The Method of Joints

- To analyze or design a truss, we need to determine the force in each truss member.



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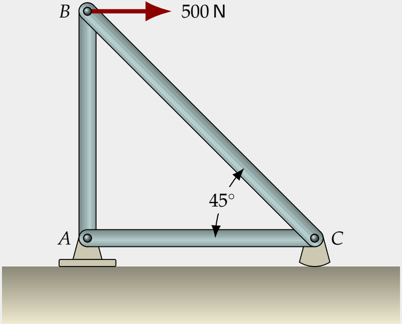
- The method we shall use here is the **Method of Joints**.



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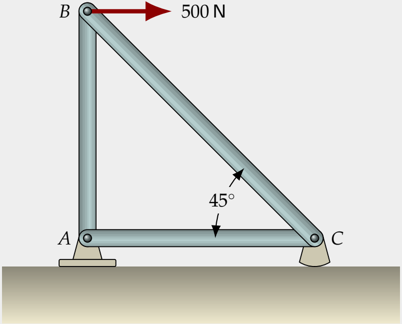
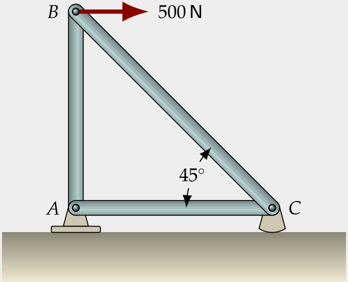
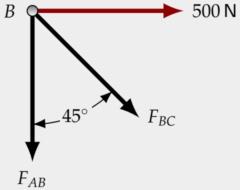
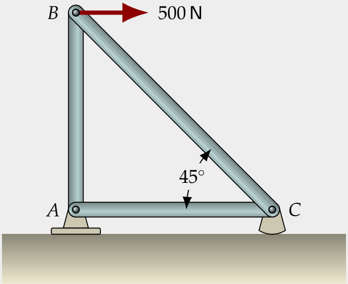
- If the entire truss is in equilibrium, then each of its joints is also in equilibrium (otherwise the joint would be in motion and the truss could not be in equilibrium).

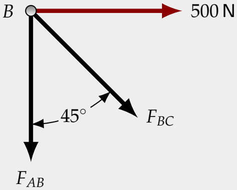




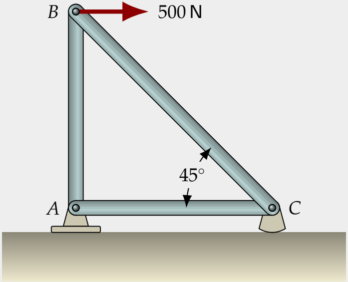


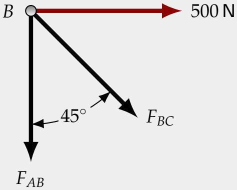
- A free-body diagram of each joint is drawn. Unknown forces are generally drawn in tension (i.e., with the arrowhead away from the joint); a negative result (from solving the system) then indicates compression.





- A free-body diagram of each joint is drawn. Unknown forces are generally drawn in tension (i.e., with the arrowhead away from the joint); a negative result (from solving the system) then indicates compression.
- Each joint is a concurrent force problem so moments do not help. Use $\Sigma F_x = 0$ and $\Sigma F_y = 0$ to analyze a joint with at most two unknowns.





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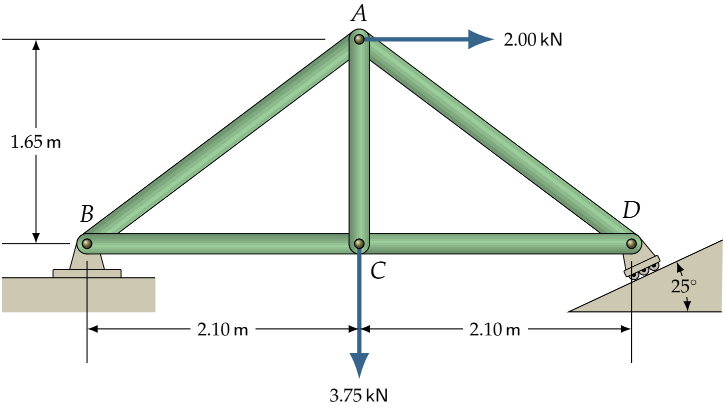
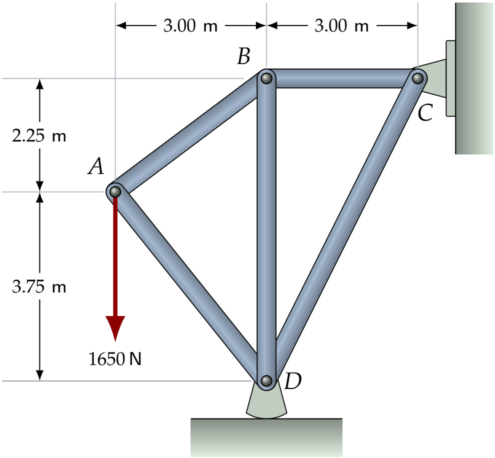
- Each joint is a concurrent force problem so moments do not help. Use $\Sigma F_x = 0$ and $\Sigma F_y = 0$ to analyze a joint with at most two unknowns.
- At least one force must be known at a joint to determine unknown forces.

Example 1



Determine the force in each truss member.

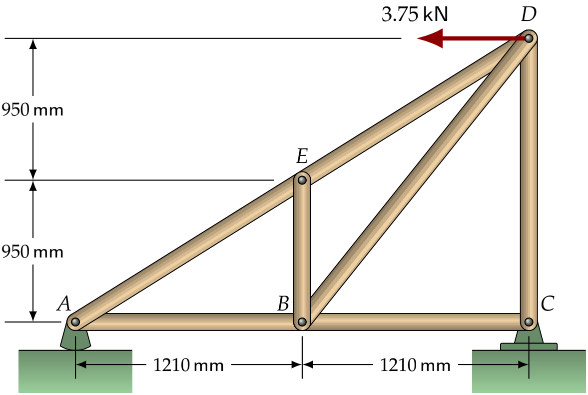
Example 2



Determine the force in each truss member.

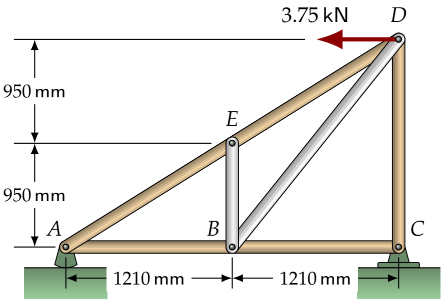
(A full solution to this example is provided for your reference and can be downloaded here.
Refer to Example 2.)

Example 3



Determine the force in each truss member.

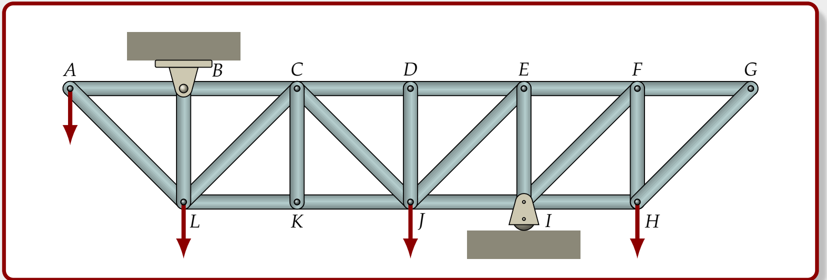
Zero-Force Members



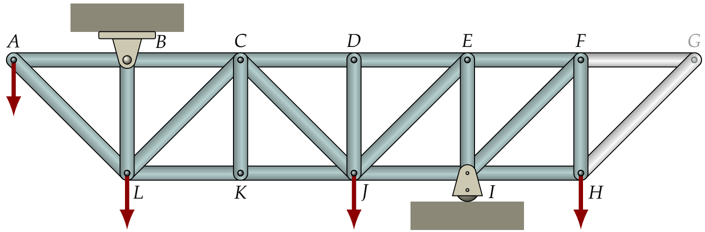
There may be members in a truss that have no internal force, as seen in the previous example.

Zero-force members may be used to increase the stability of the truss during construction or to add support if the loading is changed.

Identifying zero-force members can greatly simplify the analysis of a truss.



1. Any two member joint, where the two members are not parallel and there is no externally applied load or reaction, the two members are zero-force members. (Why? Do you see any?)



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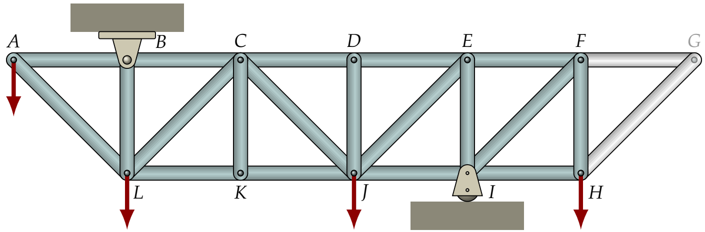
Recognizing Zero-Force Members



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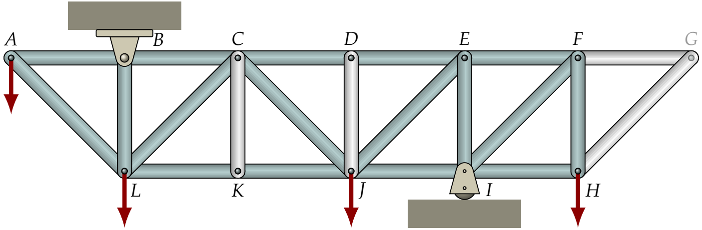
Recognizing Zero-Force Members



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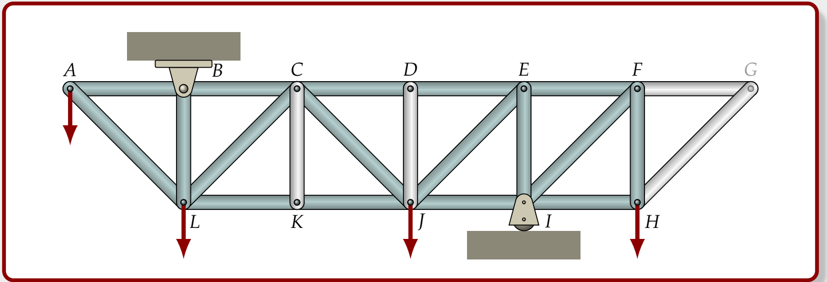

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Any more?

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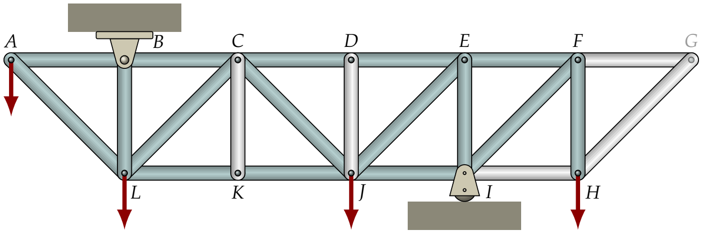

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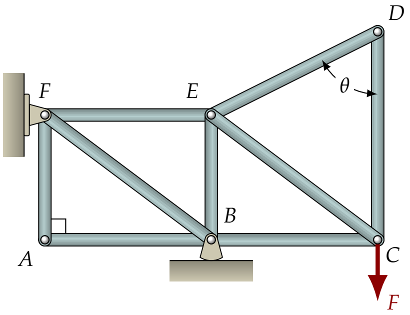
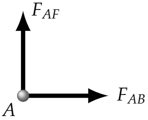
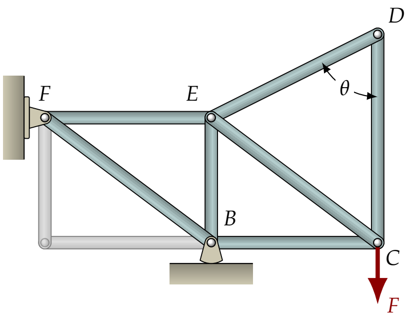


Joint A



$$\Sigma F_x = F_{AB} = 0$$
$$\Sigma F_y = F_{AF} = 0$$

Zero-Force Members



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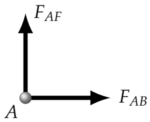
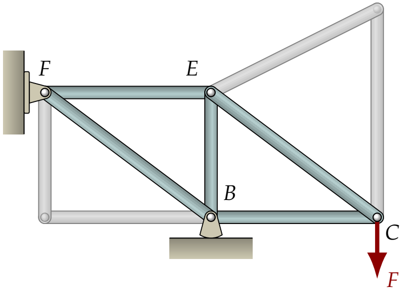


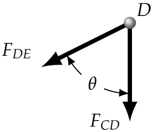
$$\Sigma F_x = F_{AB} = 0$$
$$\Sigma F_y = F_{AF} = 0$$

AB and AF are zero-force members.

Zero-Force Members



Joint D

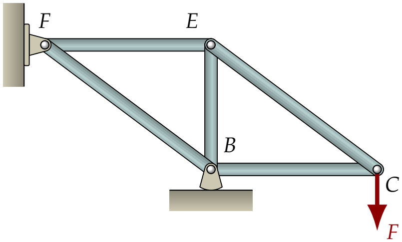


$$\Sigma F_x = F_{DE}\sin\theta = 0$$

$$\Rightarrow F_{DE} = 0$$

$$\Sigma F_y = -F_{CD} = 0$$

Zero-Force Members



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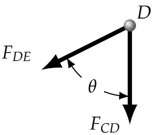
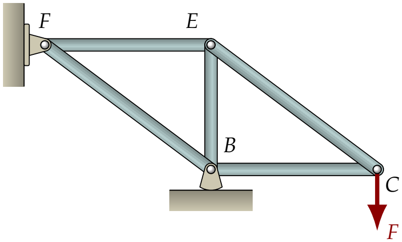


$$\Sigma F_x = F_{DE} \sin\theta = 0$$
$$\Rightarrow F_{DE} = 0$$
$$\Sigma F_y = -F_{CD} = 0$$

CD and *DE* are zero-force members.

Zero-Force Members



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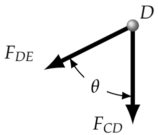
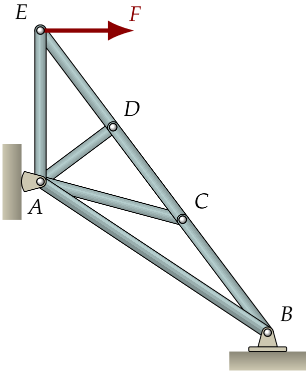


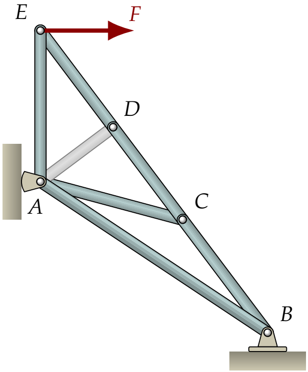
$$\begin{aligned} \Sigma F_x &= F_{DE} \sin\theta = 0 \\ \Rightarrow F_{DE} &= 0 \\ \Sigma F_y &= -F_{CD} = 0 \end{aligned}$$

We can disregard all zero-force members and solve the simpler truss *BCEF*.

Zero-Force Members



Truss members BC, CD and DE are collinear.
Are there any zero-force members?

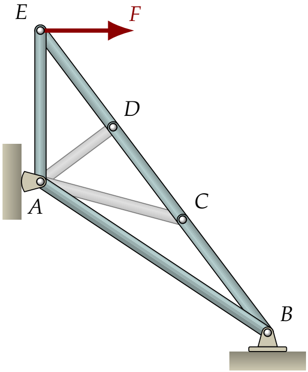


Truss members BC, CD and DE are collinear.

Are there any zero-force members?

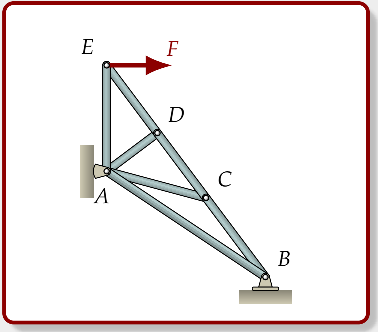
AD is a zero-force member.

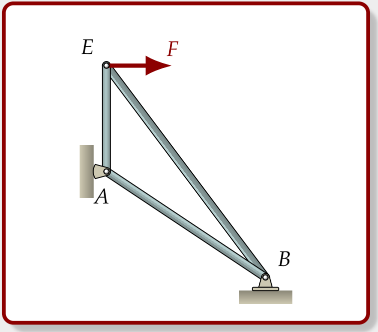
Zero-Force Members



Truss members BC, CD and DE are collinear.
Are there any zero-force members?
AD is a zero-force member.
So is AC.

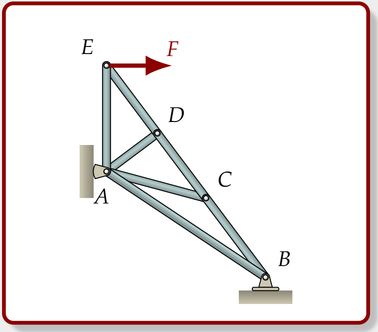
Zero-Force Members

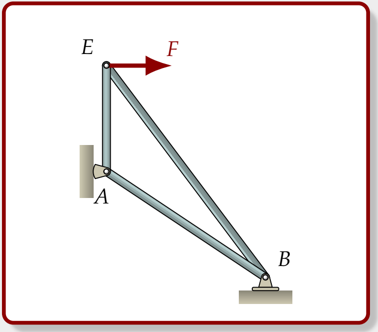




If AC and AD are zero-force members, why not just omit them from the structure altogether and have a single member from B to E?

Zero-Force Members





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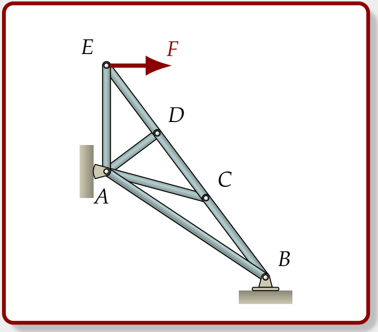
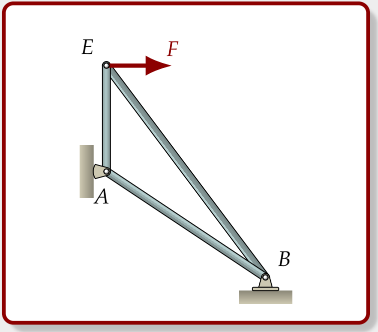
Of course, all designs are different, but here BE is long and slender, and the force F will cause it to be in compression. If the load is too high, BE will buckle. (You will learn about the buckling of columns in your strength of materials course.)

Zero-Force Members





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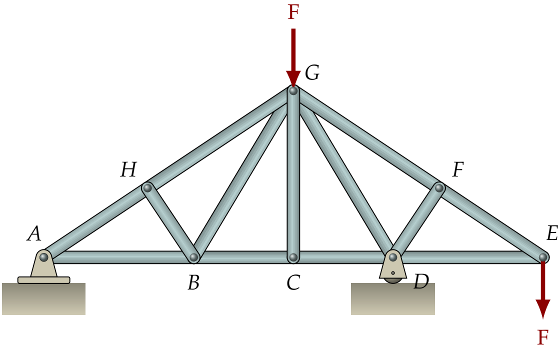
Braces at C and D can increase the load before buckling by up to nine times.

Zero-Force Members



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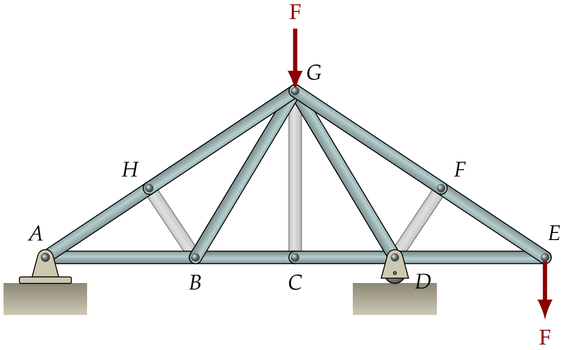
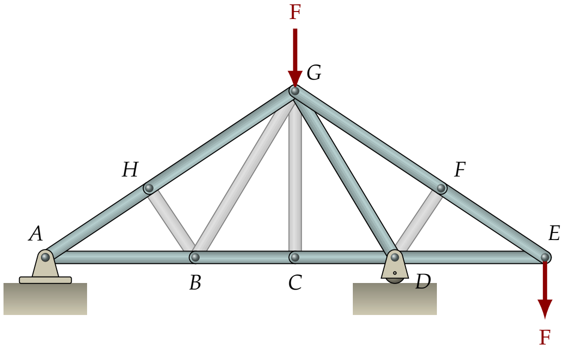
Zero-Force Members



Truss members BC, CD and DE are collinear. As are AH and GH. And EF and FG. Are there any zero-force members?

BH, CG and DF are zero-force members.

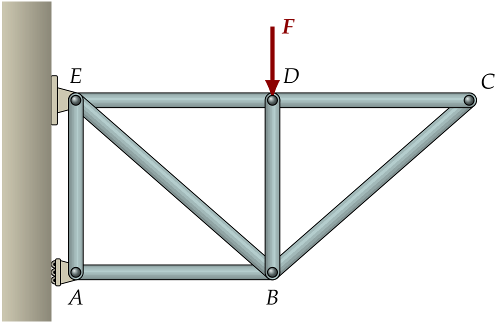
Zero-Force Members



Truss members BC, CD and DE are collinear. As are AH and GH. And EF and FG. Are there any zero-force members?

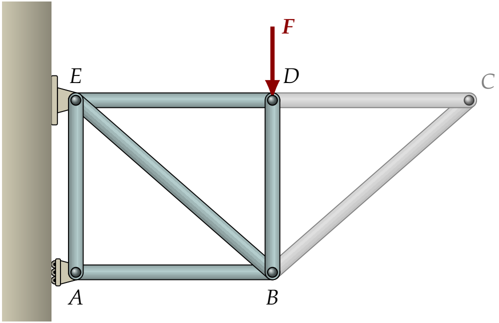
BH, CG and DF are zero-force members.
So is BG (because BH is a zero-force member).

Zero-Force Members



Are there any zero-force members?

Zero-Force Members



Are there any zero-force members?

BC and CD are zero-force members.

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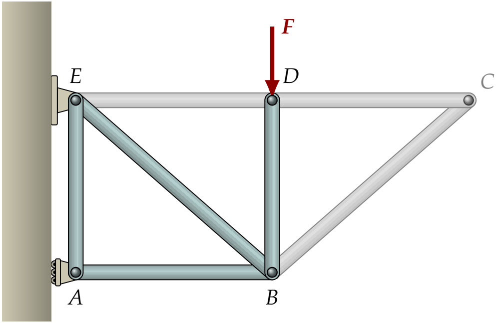

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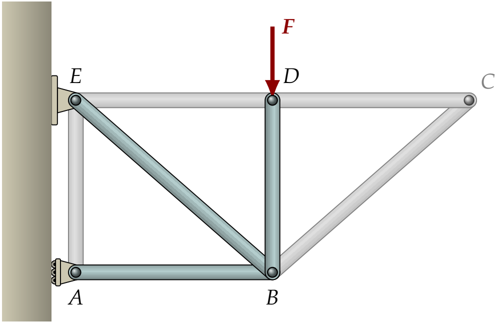
BC and CD are zero-force members.
DE is a zero-force member – because CD is.
Are there any more?

Zero-Force Members



Are there any zero-force members?

BC and CD are zero-force members.
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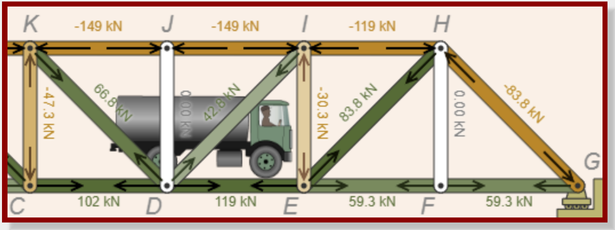
Are there any more?
AE is a zero-force member.

A Dynamically Changing Load Illustration



A truck is driving across a bridge. Notice that member FH is a zero-force member.

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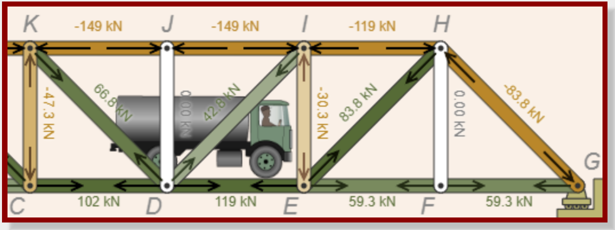
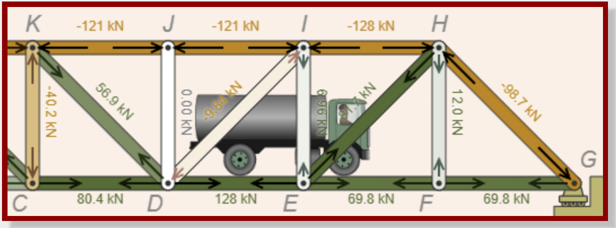


A truck is driving across a bridge. Notice that member FH is a zero-force member.

When the truck load crosses joint E, some of the load is transferred to joint F and member FH is no longer a zero-force member.



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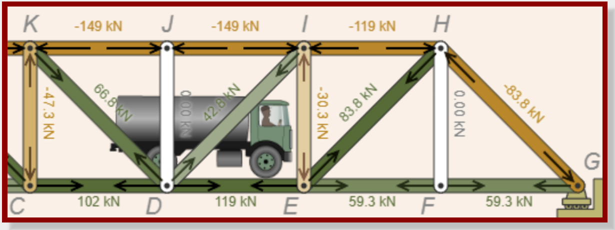

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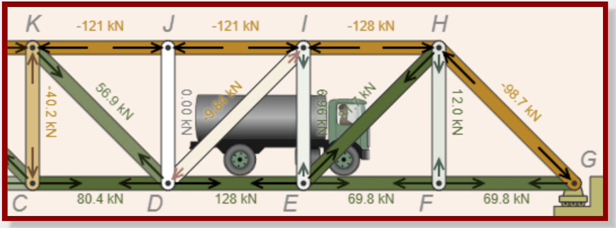
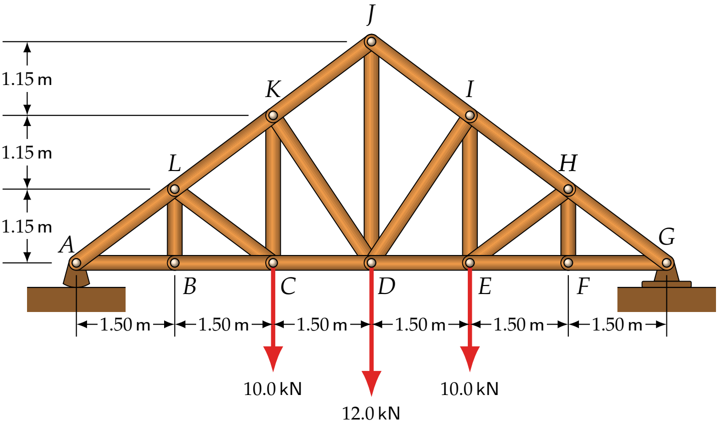


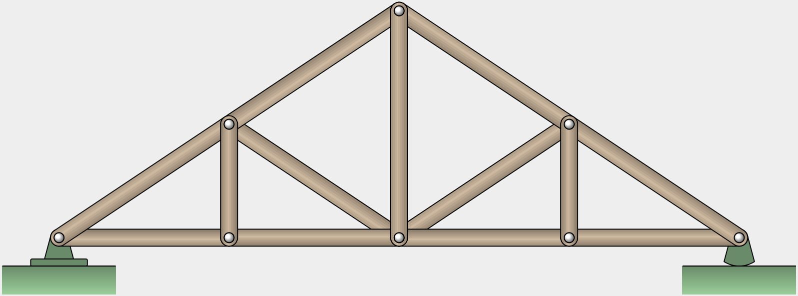
You can examine how internal forces and loadings change using the bridge simulation here.

Example 4



Determine the force in each truss member.

Types of Forces



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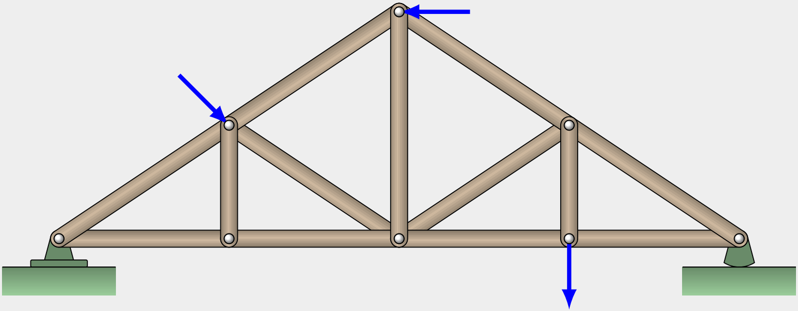

There are usually three types of forces present in a truss problem:

External forces which are **applied** to the truss, such as vehicles on a bridge, an air-conditioner on a roof, or forces such as snow load specified by the building code, etc.

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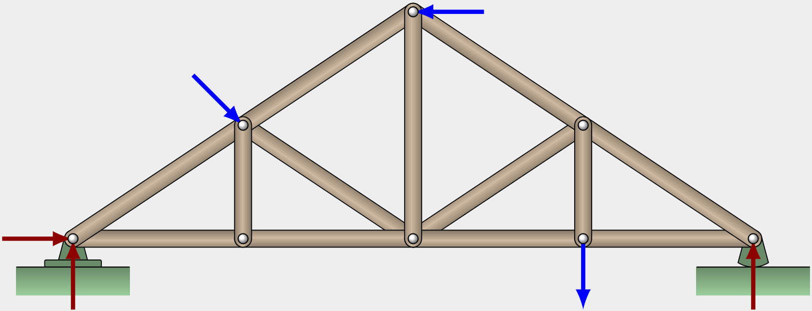

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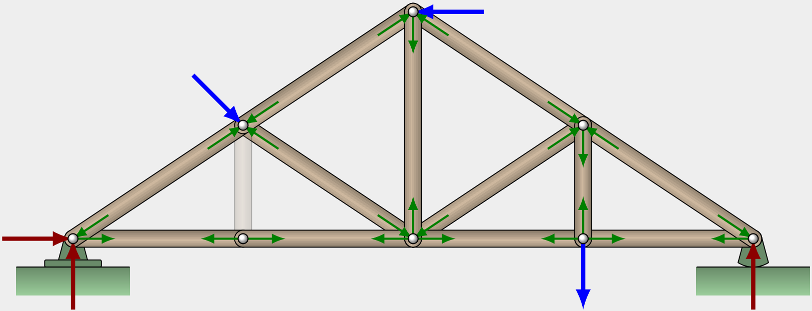

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Internal forces within the truss which are a result of the applied forces and the reactions at the supports. These are the forces we determine using the method of joints.

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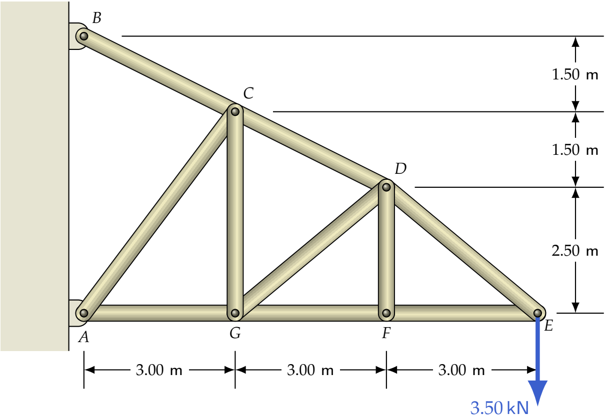
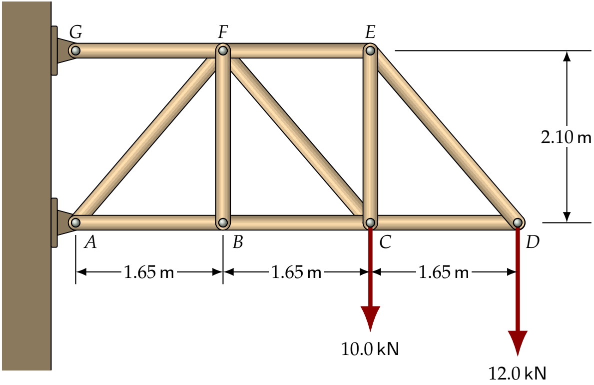
Example 5



Find the internal forces in each truss member.

(A full solution to this example is provided for your reference and can be downloaded here. Refer to Example 3.)

Exercise 1



Determine the force in each truss member.