Analysis of Truss Structures

- We will discuss the determinacy, stability, and analysis of statically determinate trusses

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Analysis of Truss Structures

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Analysis of Truss Structures

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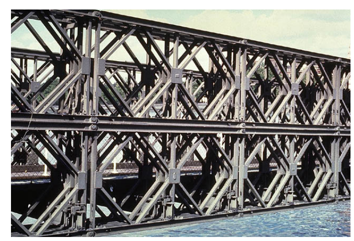
Analysis of Truss Structures



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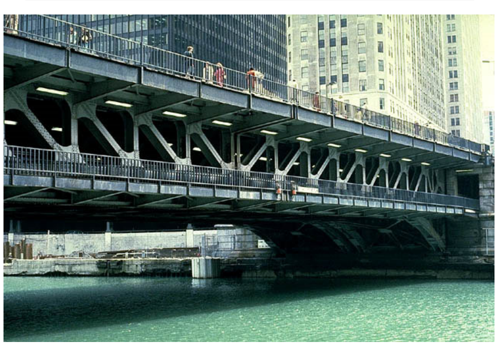

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Analysis of Truss Structures

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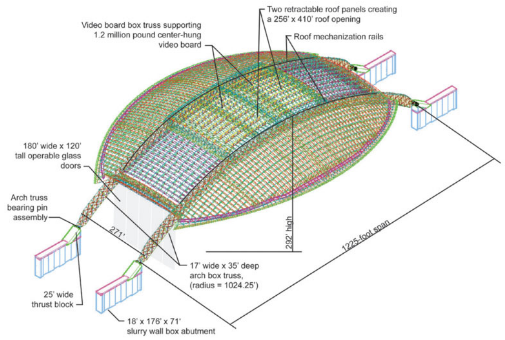

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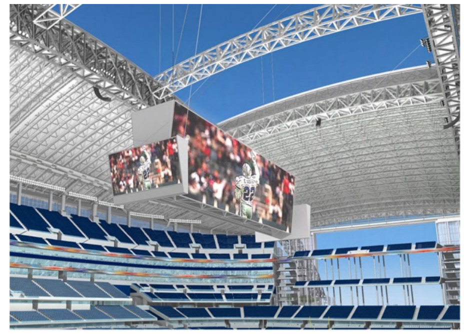

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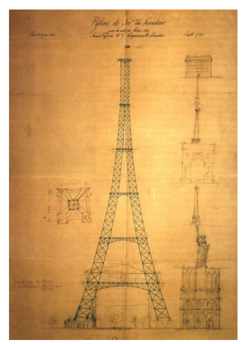
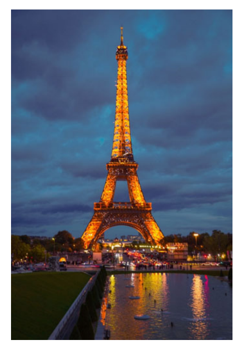
Analysis of Truss Structures





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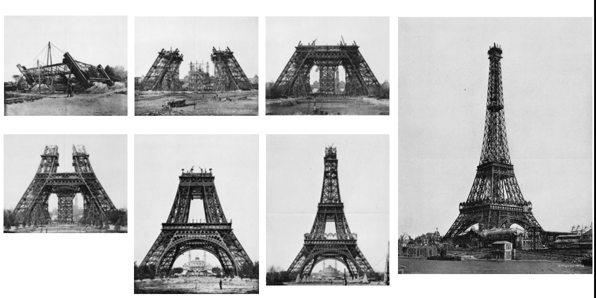

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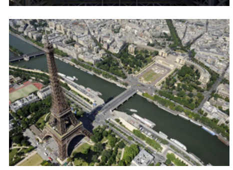

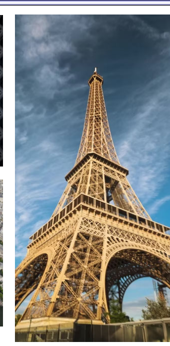

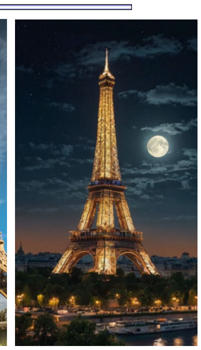

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Analysis of Truss Structures

Definition of a Truss

- A **truss** is a structure of slender members joined at their endpoints.
- Planar trusses lie in a single plane.
- Typically, the joint connections are formed by bolting or welding the end members to a common plate, called a *gusset plate.*

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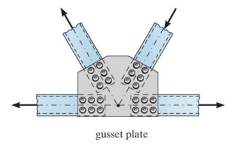
Analysis of Truss Structures

Examples of gusset plates





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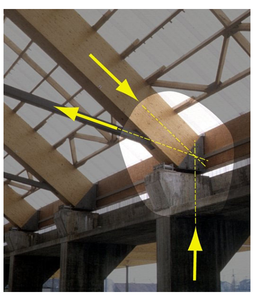
Analysis of Truss Structures

Idealized Pin Connections



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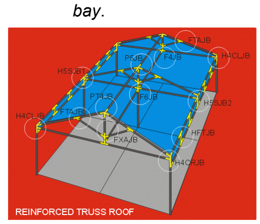
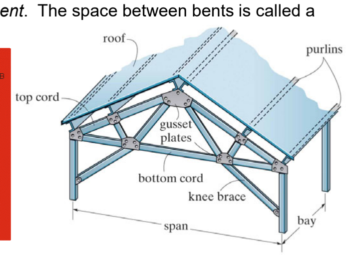
Analysis of Truss Structures

Common Roof Trusses

- **Roof trusses** - Generally, a series of purlins transmit the roof load to the truss. The roof truss, along with its supporting columns, is termed a *bent*. The space between bents is called a *bay*.





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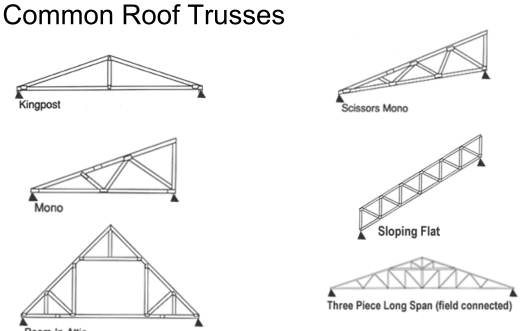
Analysis of Truss Structures

Common Roof Trusses



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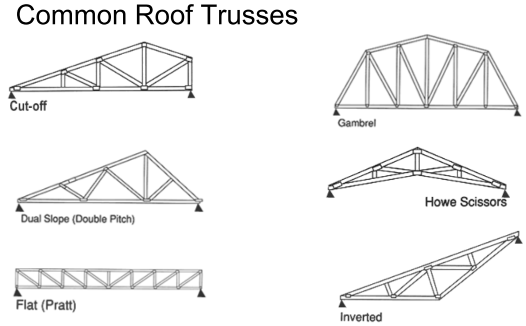
Analysis of Truss Structures

Common Roof Trusses



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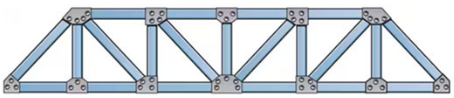
Analysis of Truss Structures

Common Bridge Trusses

- **Pratt Truss –** This truss was patented in 1844 by two Boston railway engineers, Caleb Pratt and his son, Thomas Willis Pratt.
- The design uses vertical beams for compression and horizontal beams to respond to tension.
- What is remarkable about this style is that it remained popular even as wood gave way to iron and even as iron gave way to steel.



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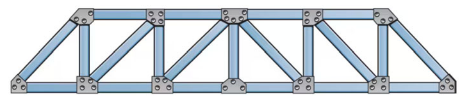
Analysis of Truss Structures

Common Bridge Trusses

- **Howe Truss -**The relatively rare Howe truss, patented in 1840 by Massachusetts millwright William Howe.
- It includes vertical members and diagonals that slope up towards the center, opposite the Pratt truss.
- Unlike the Pratt Truss, the diagonal web members are in compression and the vertical web members are in tension.



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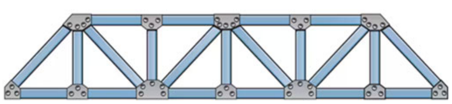
Analysis of Truss Structures

Common Bridge Trusses

- **Warren Truss -**The Warren truss, designed by James Warren and Willoughby Theobald Monzani, was patented in 1848.
- This truss consists of longitudinal members joined only by angled cross-members, forming alternately inverted equilateral triangle-shaped spaces along its length.
- No individual strut, beam, or tie is subject to bending or torsional straining forces but only to tension or compression.



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Analysis of Truss Structures

Common Bridge Trusses

- **Bridge trusses**: The deck transmits the load to a series of *stringers* and then to a set of *floor beams*.
- Two parallel trusses support the floor beams.
- The supporting trusses are connected top and bottom by *lateral bracing*.
- Additional stability may be provided by the *portal* and *sway* bracing

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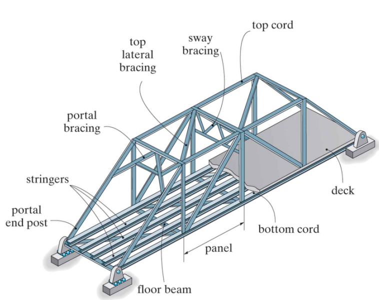
Analysis of Truss Structures

Common Bridge Trusses



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Analysis of Truss Structures

Common Bridge Trusses

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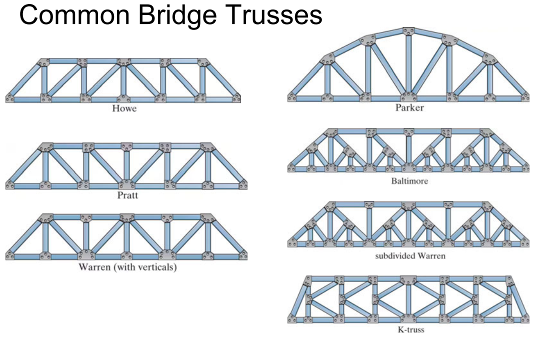
Analysis of Truss Structures

Common Bridge Trusses



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Analysis of Truss Structures

Common Bridge Trusses

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Analysis of Truss Structures

Assumptions for Truss Design

- To design both the members and connections of a truss, the *force* in each member for a given loading must be determined.
- Two crucial assumptions are made in truss analysis:
  - ***Truss members are connected by smooth pins***
  - ***All loading is applied at the joints of the truss***

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Analysis of Truss Structures

Smooth pins connect truss members

- The stress produced in these elements is called the *primary stress*.
- The pin assumption is valid for bolted or welded connections if the members are concurrent.
- However, since the connection does provide some rigidity, the bending introduced in the members is called *secondary stress*.
- Secondary stress analysis is not commonly performed

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Analysis of Truss Structures

All loading is applied at the joints of the truss

- Since the weight of each member is small compared to the member force, the member weight is often neglected.
- However, when the member weight is considered, it is applied at the end of each member.
- Because of these two assumptions, each truss member is a two-force member with either a compressive (C) or a tensile (T) axial force.
- Generally, compression members have a large cross-section to help with instability due to buckling.

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Determinacy of Coplanar Trusses

- Since all the elements of a truss are two-force members, the moment equilibrium is automatically satisfied.
- Therefore, two equilibrium equations exist for each joint, j, in a truss. If r is the number of reactions and b is the number of bar members in the truss, determinacy is obtained by

$b + r = 2j$	Determinate
$b + r > 2j$	Indeterminate

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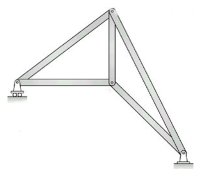
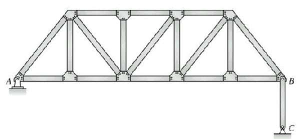
Determinacy of Coplanar Trusses



r = 3
b = 5 r+b=2j **determinate**
j = 4



r = 4
b = 18 r+b=2j **determinate**
j = 11

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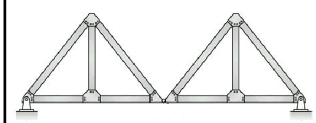
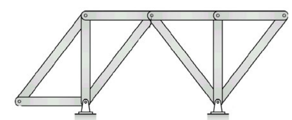
Determinacy of Coplanar Trusses



r = 4
b = 10 r+b=2j **determinate**
j = 7



r = 4
b = 10 r+b=2j **determinate**
j = 7

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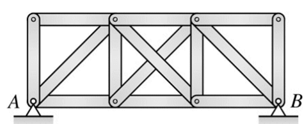
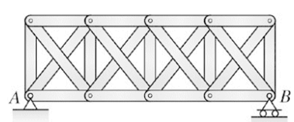
Determinacy of Coplanar Trusses



r = 4
b = 14 r+b>2j **indeterminate**
j = 8



r = 3
b = 21 r+b>2j **indeterminate**
j = 10

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Stability of Coplanar Trusses

- If ***b + r < 2j***, a truss will be ***unstable***, which means the structure will collapse since there are insufficient reactions to constrain all the joints.
- A truss may also be unstable if ***b + r* ≥ *2j***. In this case, stability will be determined by inspection

b + r < 2j	***Unstable***
b + r* ≥ *2j	***Unstable*** if reactions are concurrent, parallel, or collapsible mechanics

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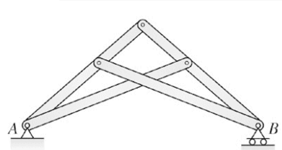
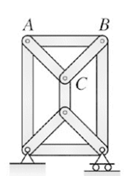
Stability of Coplanar Trusses



r = 3
b = 6 r+b<2j **unstable**
j = 5



r = 3
b = 9 r+b=2j **unstable**
j = 6

Section ABC is supported by three parallel links

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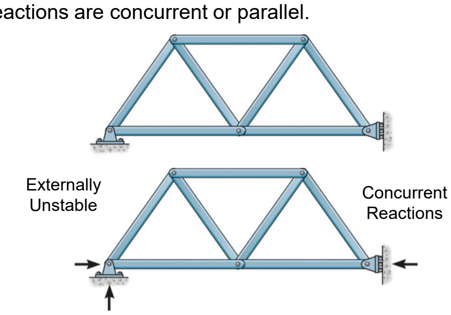
Stability of Coplanar Trusses

External stability - a structure (truss) is externally unstable if its reactions are concurrent or parallel.



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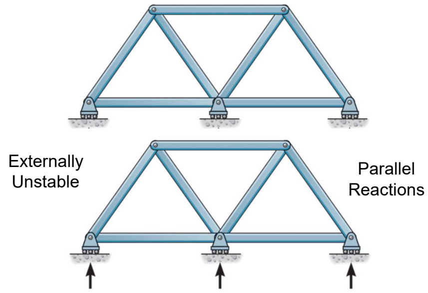
Stability of Coplanar Trusses

External stability - a structure (truss) is externally unstable if its reactions are concurrent or parallel.



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Stability of Coplanar Trusses

Internal stability - may be determined by inspection of the arrangement of the truss members.

- A *simple* truss will always be internally stable
- The stability of a *compound* truss is determined by examining how the simple trusses are connected
- The stability of a *complex* truss can often be difficult to determine by inspection.
- In general, the stability of any truss may be checked by performing a complete analysis of the structure. If a unique solution can be found for the set of equilibrium equations, then the truss is stable

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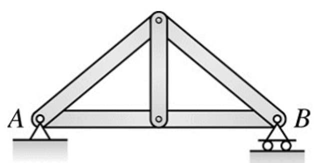
Stability of Coplanar Trusses

Internal stability



Externally stable

Internally stable

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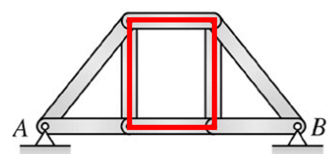
Stability of Coplanar Trusses

Internal stability

Collapsible mechanism



Externally stable

Internally unstable

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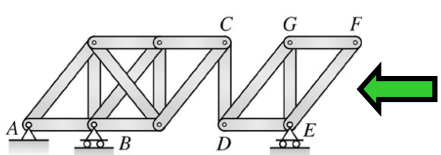
Stability of Coplanar Trusses

Internal stability

Collapsible mechanism



Externally stable

Internally unstable

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End of Trusses - Part 1

Any questions?

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