Stability

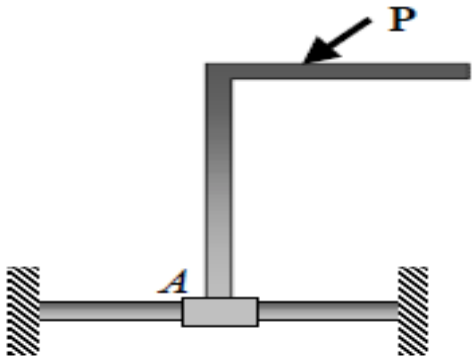
- To ensure equilibrium (stability) of a structure or its members:
  - Must satisfy equilibrium EQs
  - Members must be properly held or constrained by their supports
  - There is a unique set of values for reaction forces and internal forces

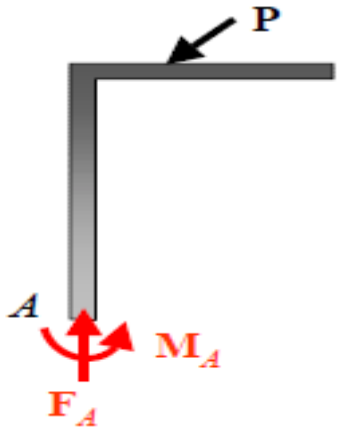
Determinacy and Stability

– Partial constraints

- Fewer reactive forces than equilibrium EQs
- Some equilibrium EQs will not be satisfied

Partial Constrains



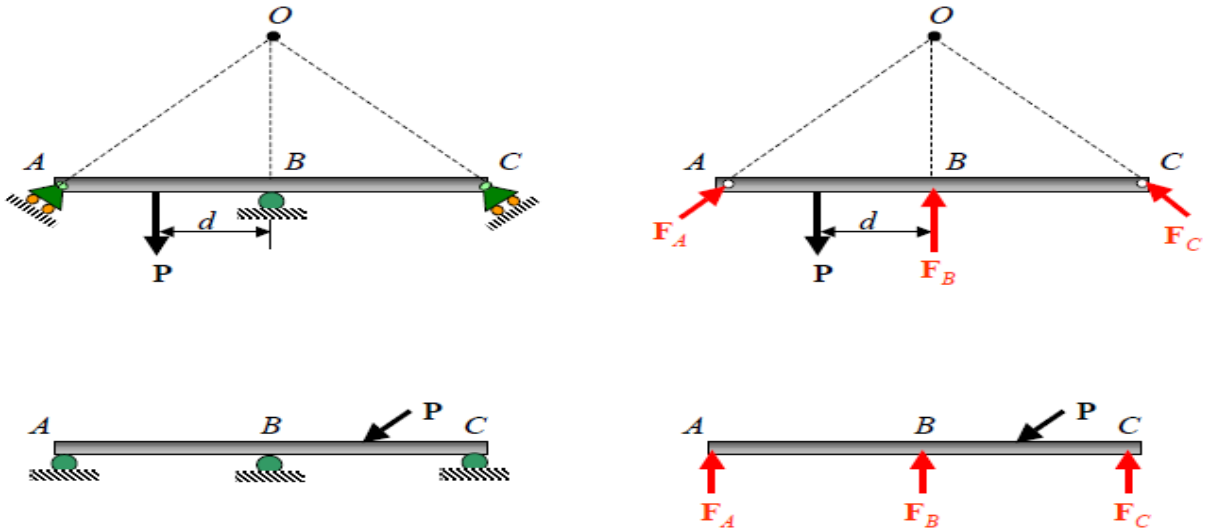


Determinacy and Stability

– Improper constraints

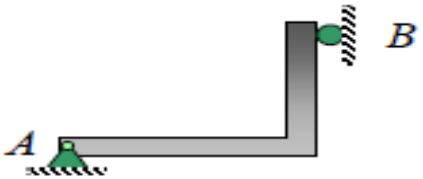
- In some cases, unknown forces may equal equilibrium EQs
- However, instability or movement of structure could still occur

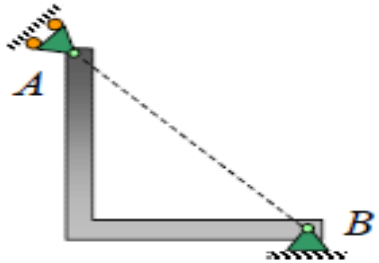
Improper Constraints

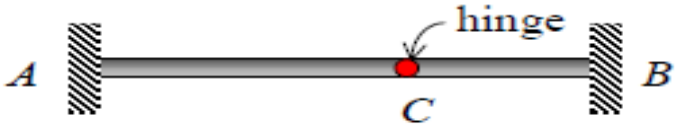


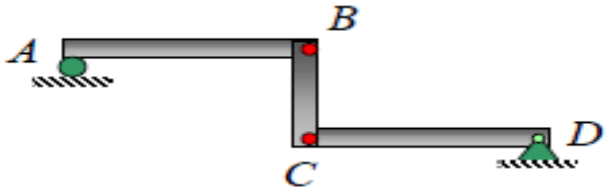
Example 2-4

Classify each of the structures in the figure below as stable or unstable. The structures are subjected to arbitrary external loads that are assumed to be known.

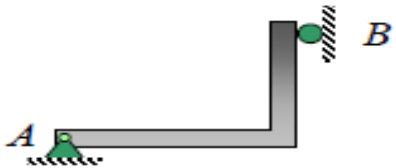


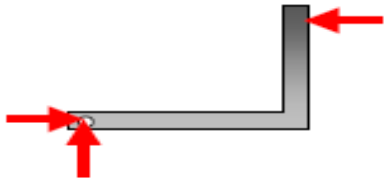




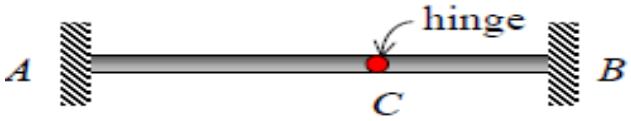


SOLUTION



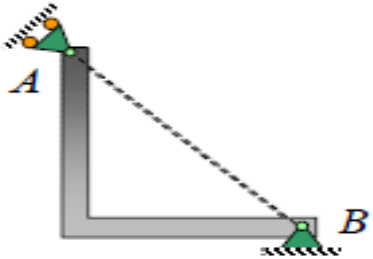


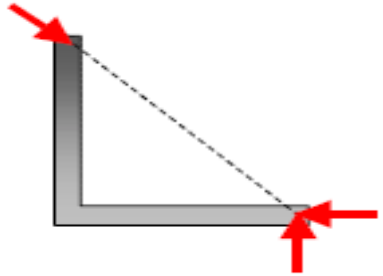
The member is ***stable*** since the reactions are non-concurrent and nonparallel.
It is also statically **determinate**.



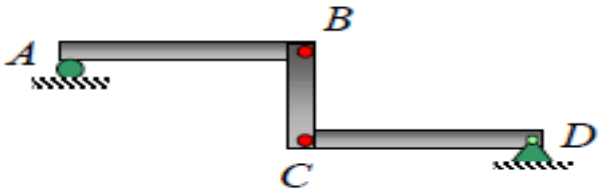
The compound beam is ***stable***. It is also **indeterminate** to the second degree.

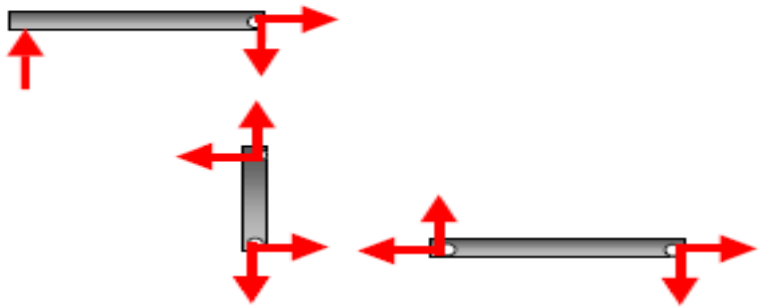
The compound beam is ***unstable*** since the three reactions are all parallel.





The member is ***unstable*** since the three reactions are concurrent at B.

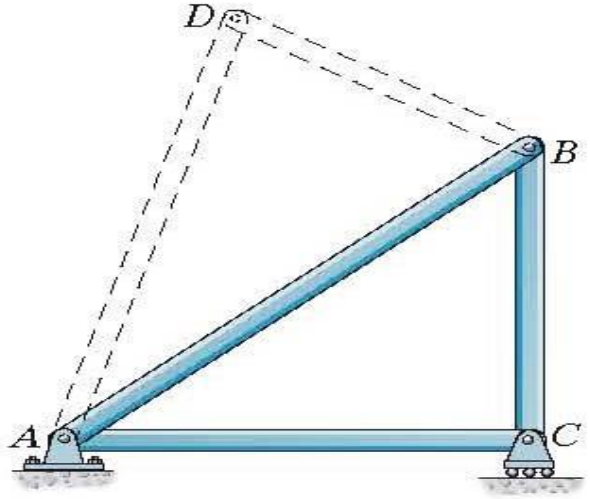




The structure is ***unstable*** since $r = 7$, $n = 3$, so that, $r < 3n$, $7 < 9$. Also, this can be seen by inspection, since AB can move horizontally without restraint.

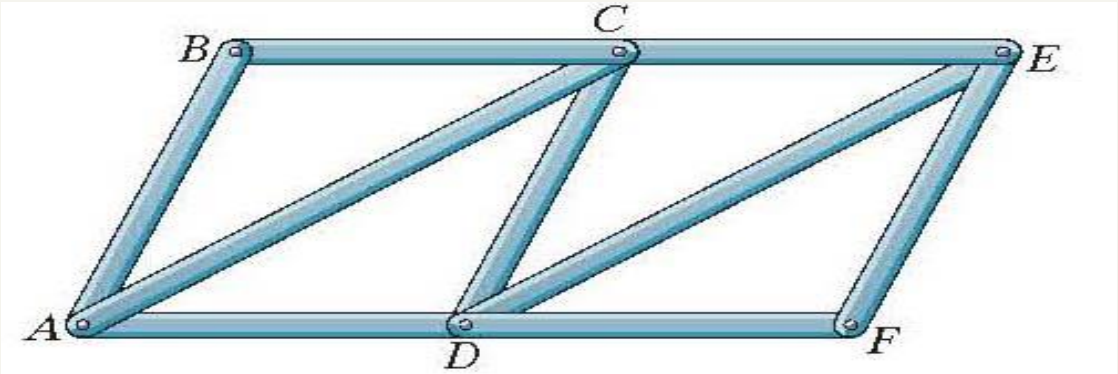
Classification of Coplanar Trusses

- Simple , Compound or Complex Truss
- Simple Truss
  - To prevent collapse, the framework of a truss must be rigid
  - The simplest framework that is rigid or stable is a triangle



Classification of Coplanar Trusses

- Simple Truss
  - A simple truss is the basic “stable” triangle element is ABC
  - The remainder of the joints D, E & F are established in alphabetical sequence



simple truss

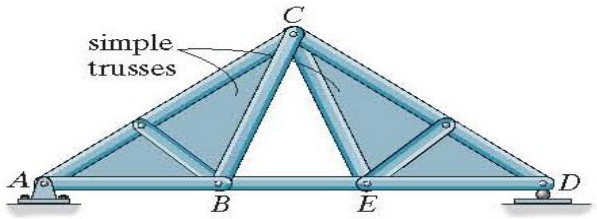
Classification of Coplanar Trusses

- Compound Truss: connecting 2 or more simple trusses
  - ❖ ***Type 1:***

  Connected by a common joint & bar
  - ❖ ***Type 2:***

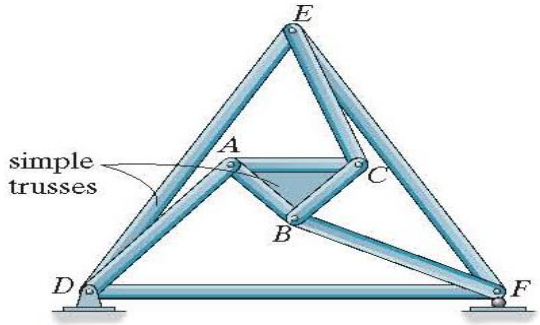
  Joined by 3 bars
  - ❖ ***Type 3:***

  Main + secondary



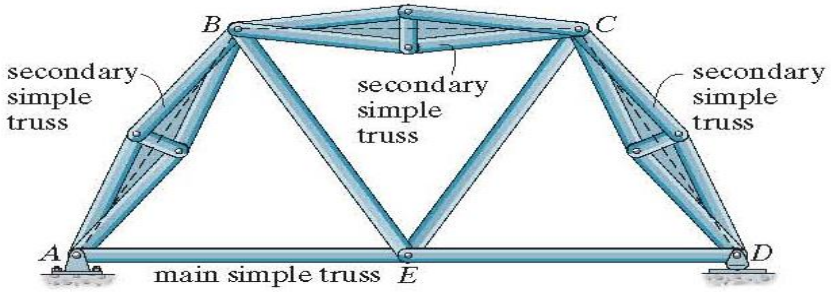
compound truss

(a)



compound truss

(b)

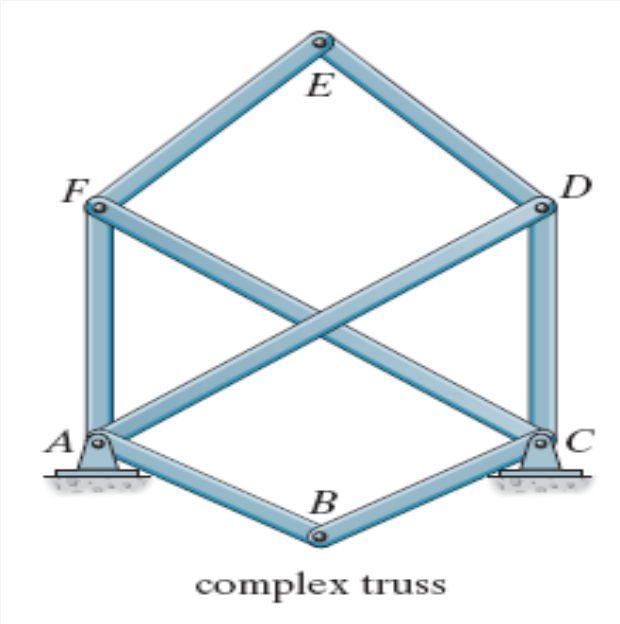


compound truss

(c)

Classification of Coplanar Trusses

- Complex Truss
  - A complex truss is one that cannot be classified as being either simple or compound



complex truss

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Classification of Coplanar Trusses

- Determinacy
  - Comparing no. of unknowns and no. of equilibrium eqns
  - No. of unknowns = no. of members (member forces) ***b***+
    no. of external support reactions ***r***
  - Each joint provides 2 equilibrium eqns. $\sum F_x = 0$ and $\sum F_y = 0$
  - For ***j*** joints, there are 2*j* Eqns.

$$\left.\begin{array}{ll} b + r = 2j & \text{statically determinate} \\ b + r > 2j & \text{statically indeterminate} \end{array}\right\} \text{stable/unstable}$$

$$b + r < 2j \quad \text{unstable}$$

Classification of Coplanar Trusses

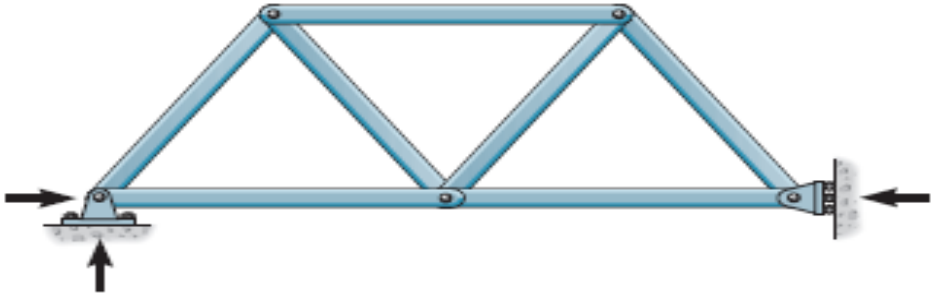
- Stability
  - A truss can still be unstable even if it is statically determinate or statically indeterminate
  - Stability will have to be determined either through inspection or

$$\left.\begin{array}{ll} b+r=2j & \text{statically determinate} \\ b+r>2j & \text{statically indeterminate} \end{array}\right\} \text{stable/unstable}$$

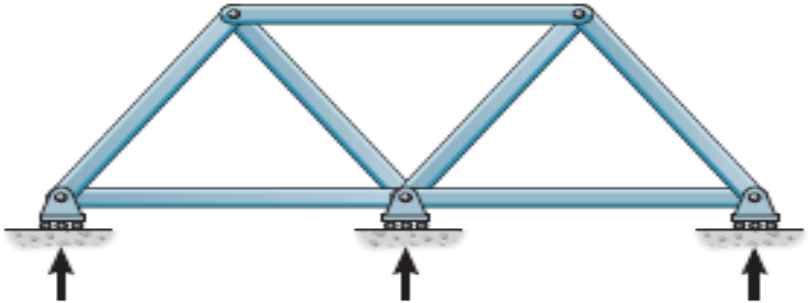
$$b+r<2j \quad \text{unstable}$$

Classification of Coplanar Trusses

- Stability
  - External Stability
    - A structure is externally unstable if all of its reactions are **concurrent** or **parallel**



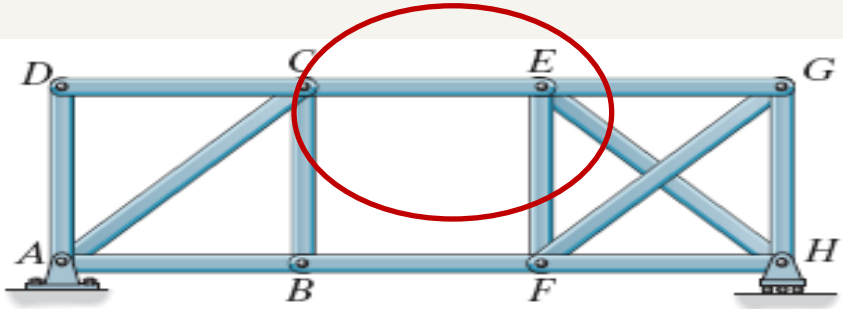
unstable concurrent reactions

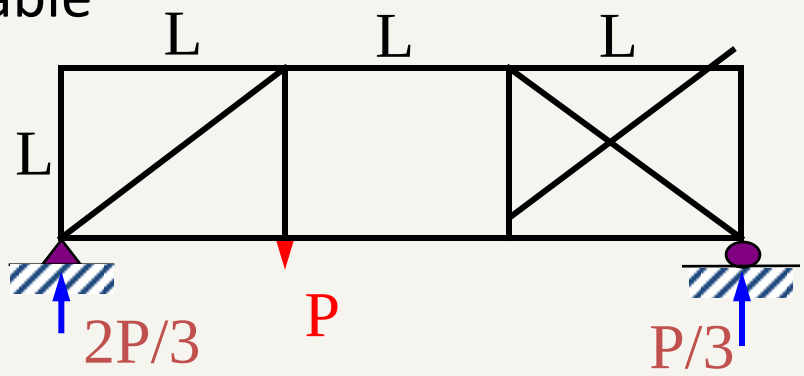


unstable parallel reactions

Classification of Coplanar Trusses

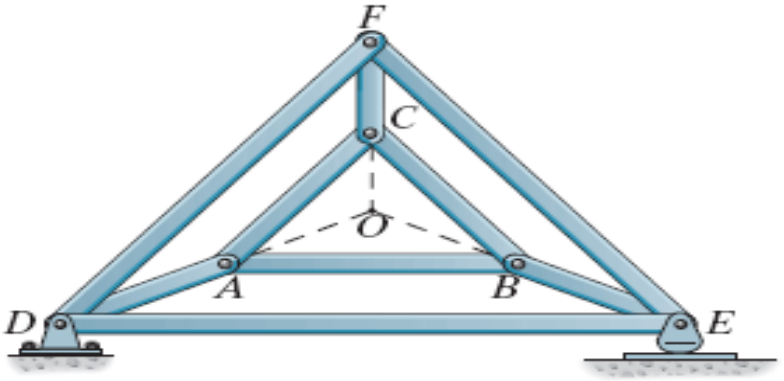
- Internal Stability
  - The internal stability can be checked by careful inspection of the arrangement of its members
  - A simple truss will always be internally stable
  - If a truss is constructed so that it does not hold its joints in a fixed position, it will be unstable





Classification of Coplanar Trusses

- Internal Stability
  - To determine the internal stability of a compound truss, it is necessary to identify the way in which the simple truss are connected together
  - The truss shown is unstable since the inner simple truss ABC is connected to DEF using 3 bars which are concurrent at point O



Classification of Coplanar Trusses

– Internal Stability

- For complex truss, it may not be possible to tell by inspection if it is stable
- The instability of any form of truss may also be noticed by using a computer to solve the 2j simultaneous Eqns. for the joints of the truss
- If inconsistent results are obtained, the truss is unstable or have a critical form