# Stabiltiy for Planar Trusses

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# Definition of Stability of a Structure

A stable structure can support any general loading without the entire structure or any component part of the structure moving as a rigid body.  The equations of equilibrium provide the theoretical basis for the assessment of the stability of a structure.

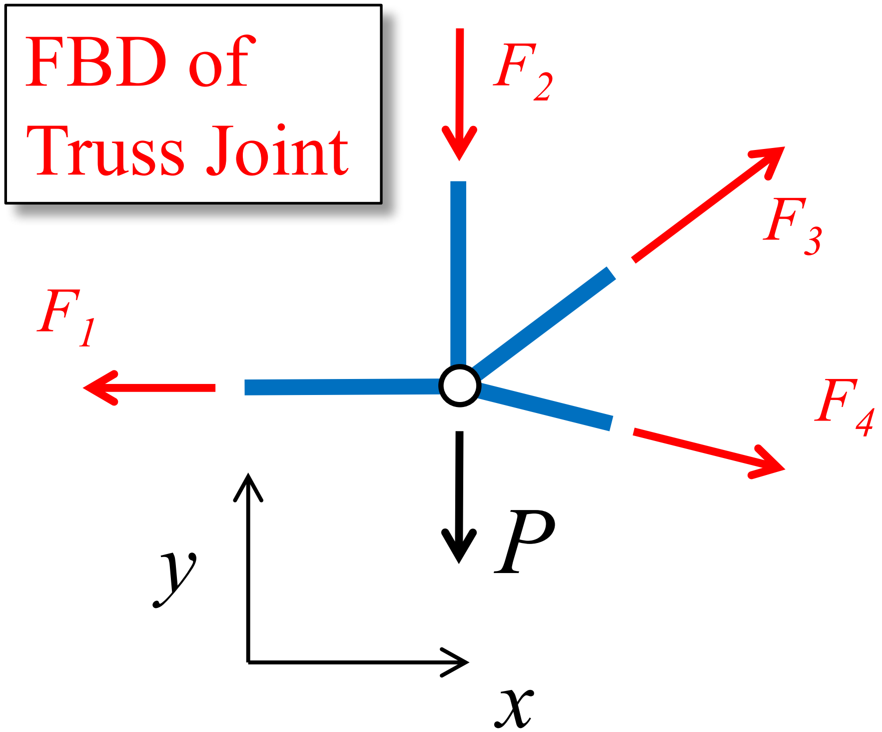
There are two conditions that cause instability:

1. **Partial Constraints;**
2. **Improper Constraints.**

# Assessing the Stability of a Planar Truss

The assessment of the stability of a truss follows the same process as the assessment for a general planar structure but can be simplified in certain steps due to: 1) truss members carrying only axial force; 2) there are two equations of equilibrium available per FBD of each truss joint.

FBD of Truss Joint




One unknown internal force per truss member

Two equations of equilibrium are available per truss joint

$$\sum F_x = 0 \qquad \sum F_y = 0$$

# Assessing the Stability of a Planar Truss

The assessment of the stability of a truss should follow the following steps:

1. The entire truss must be cut at all external supports (e.g. pins, rollers, fixed supports);
2. A free-body diagram of the entire truss structure must be assessed for stability;
3. Free-body diagrams of component pieces and/or truss joints should be drawn and assessed for stability.

If any of the assessments in Steps 2 or 3 yields and instability, then the truss is deemed unstable.

# Assessing Truss Instability Due to Partial Constraints

Let:

$b$ = total number of truss members;

r = total number of truss reactive forces;

$j$ = total number of truss joints;

then;

$b + r$ = total number of unknown in the truss analysis problem;

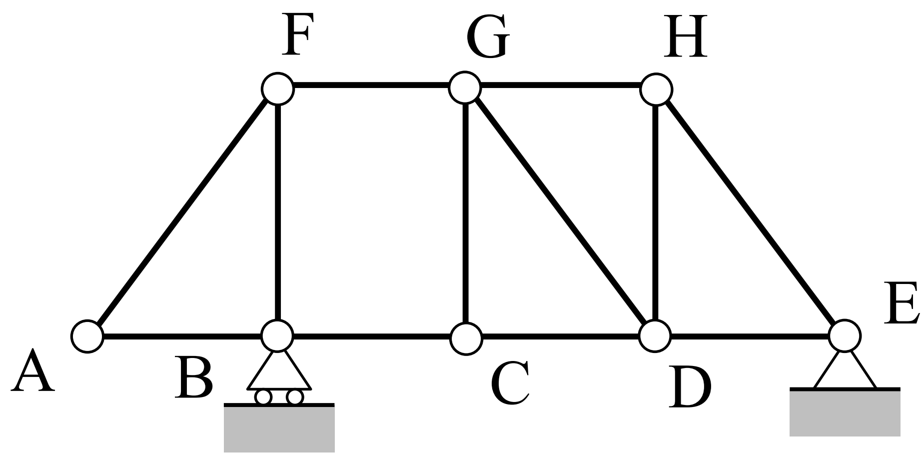
$2j$ = total number of independent equations of equilibrium available to solve for unknowns;

For planar trusses, if:

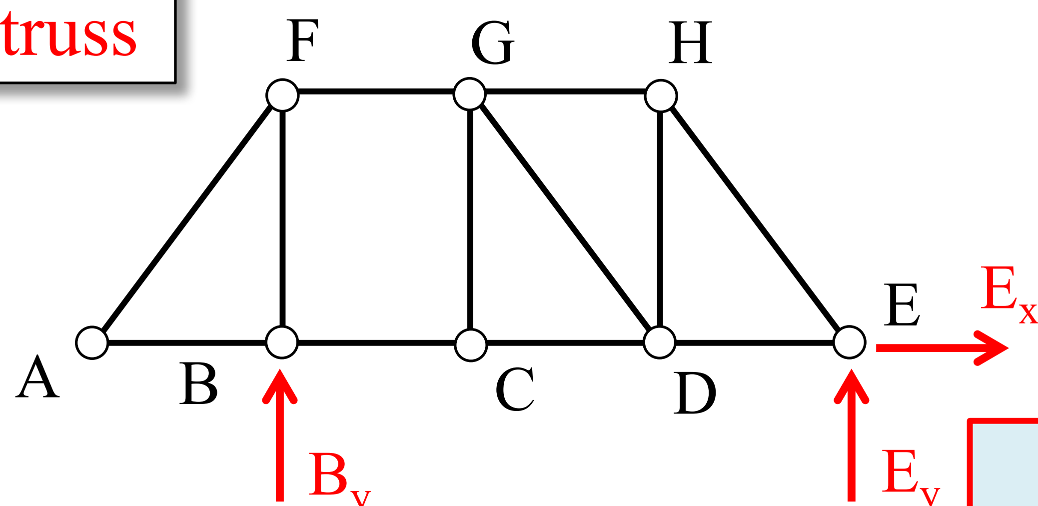
$$b + r < 2j$$

for the truss or any component part of the truss, then the truss is **Unstable** due to **Partial Constraints**

# Example of Instability due to Partial Constraints




FBD of entire truss




$b = 12$

$r = 3$

$12 + 3 = 15$

$2j = 2(8) = 16$

$15 < 16$

**Unstable**
Partial Constraints

# Assessing Instability Due to Improper Constraints

For planar trusses, if:

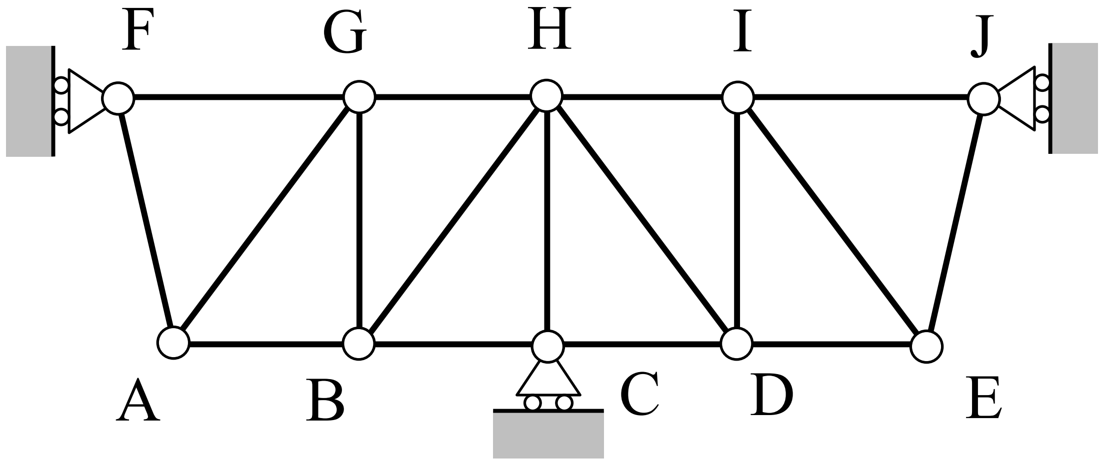
$$b + r \geq 2j$$

then the structure may be **Unstable** due to **Improper Constraints** if:

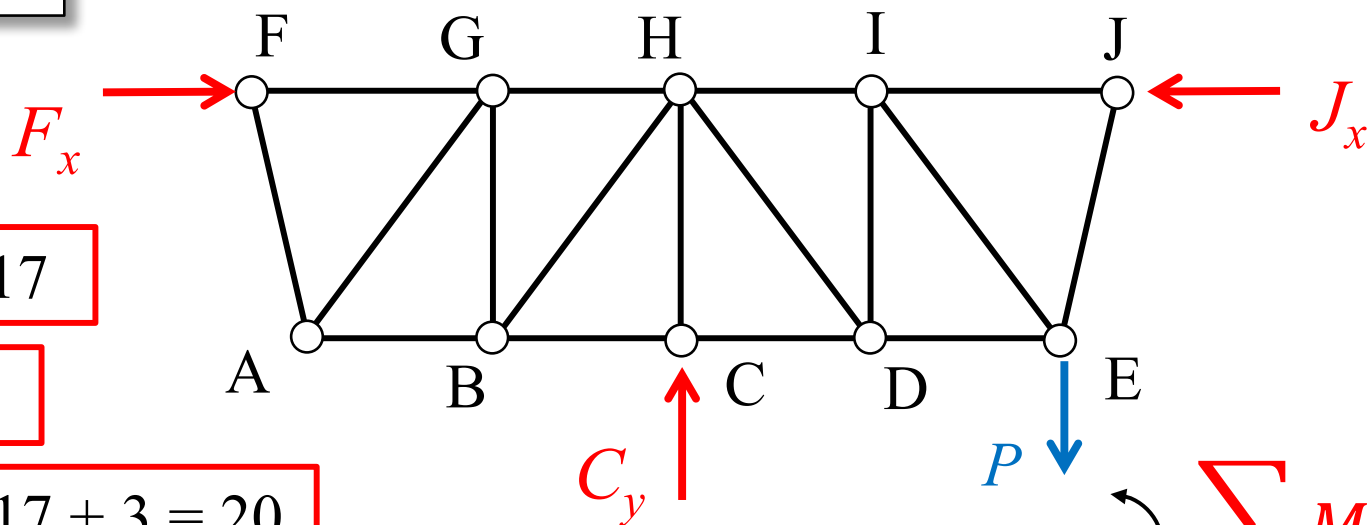
A. All of the reactive forces are parallel for the entire truss or any component part of the truss;
B. All of the reactive forces are collinear (intersect at one point) for the entire truss or any component part of the truss.

Note that checking for improper constraints follows the same process as for a general structure.

# Example of Instability due to Improper Constraints




FBD




$b = 17$

$r = 3$

$17 + 3 = 20$

$2j = 2(10) = 20$

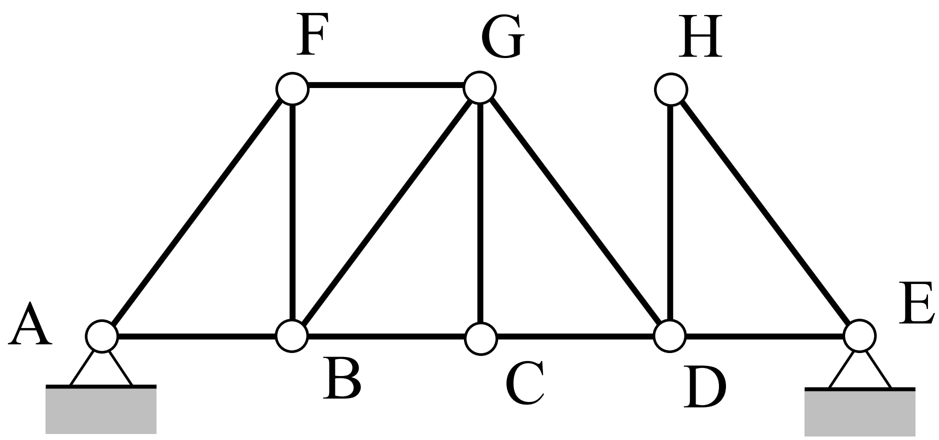
All reactive forces are concurrent

$+\circlearrowleft \sum M_H \neq 0$

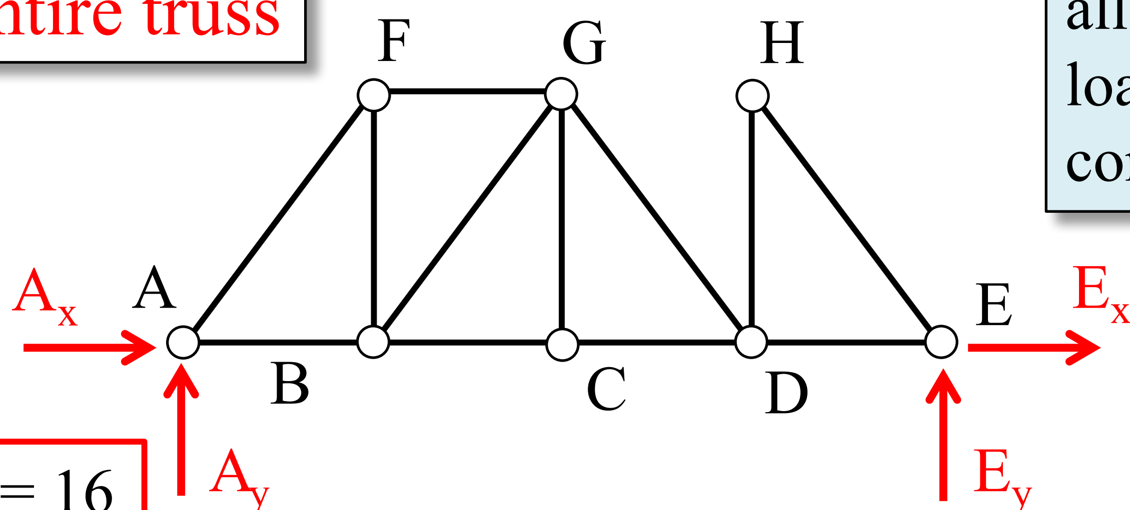
**Unstable**
Improper Constraints

# Example Problem

The truss shown has pin supports at A and E. Determine if the beam is stable under all possible loading conditions.




FBD of entire truss




$b = 12$

$r = 4$

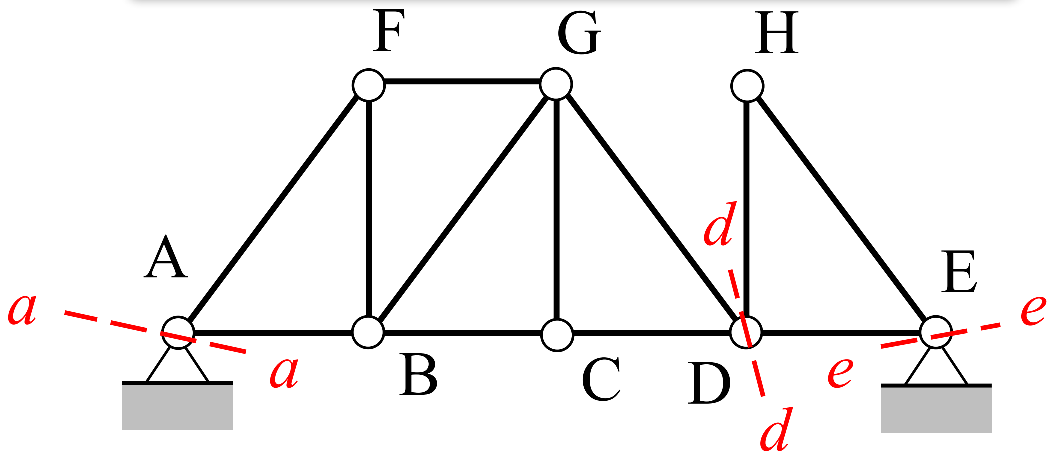
$2j = 2(8) = 16$

$12 + 4 = 16$

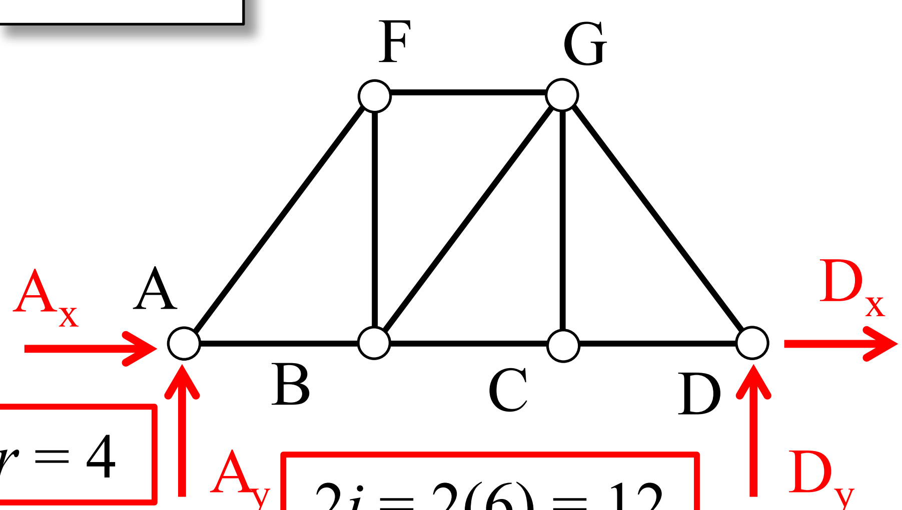
**OK**

Check component pieces of truss for stability

# Example Problem




FBDs

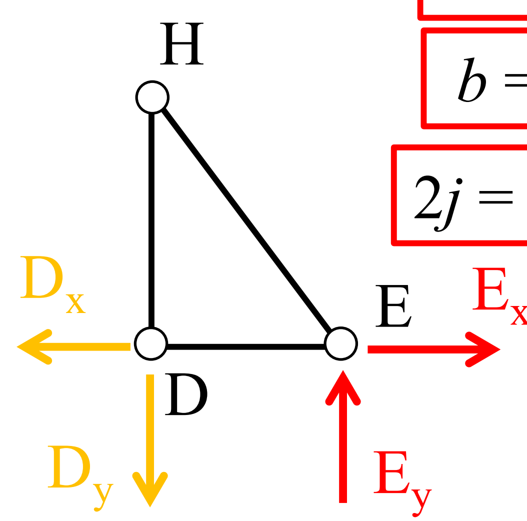



$r = 4$

$b = 9$

$2j = 2(6) = 12$

**OK**




$r = 4$

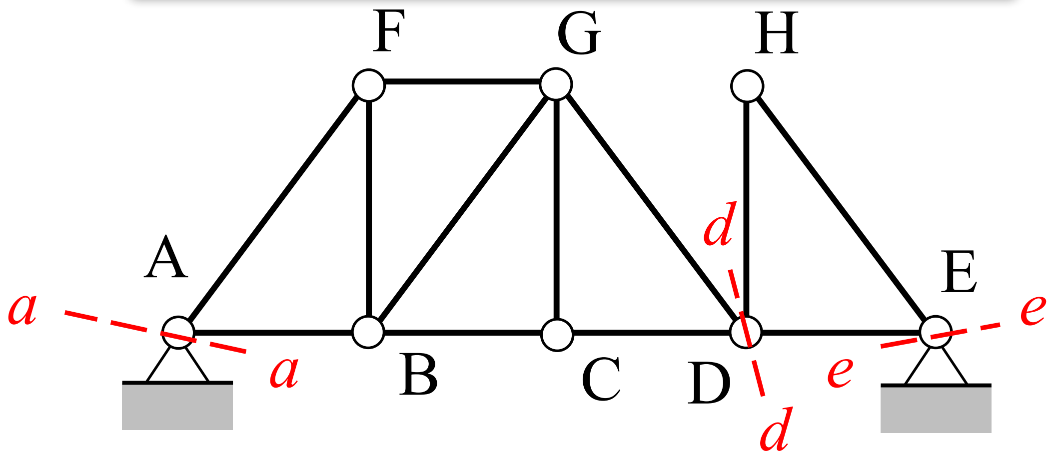
$b = 3$

$2j = 2(3) = 6$

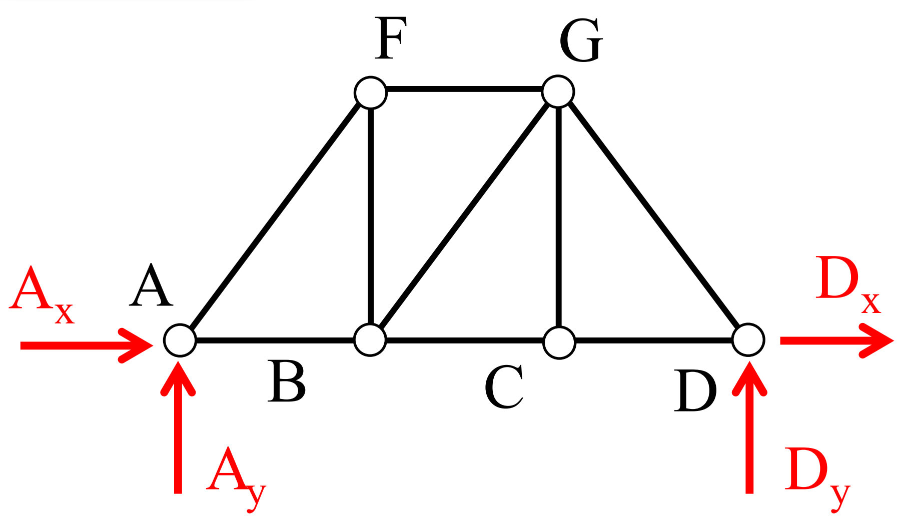
**OK**

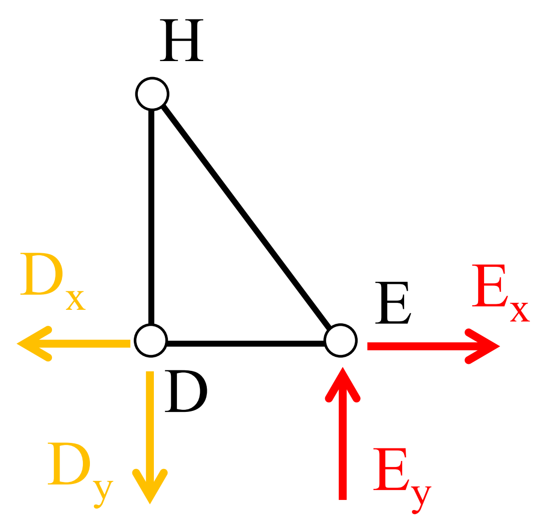
Check component pieces
For Improper Constraints

# Example Problem




FBDs

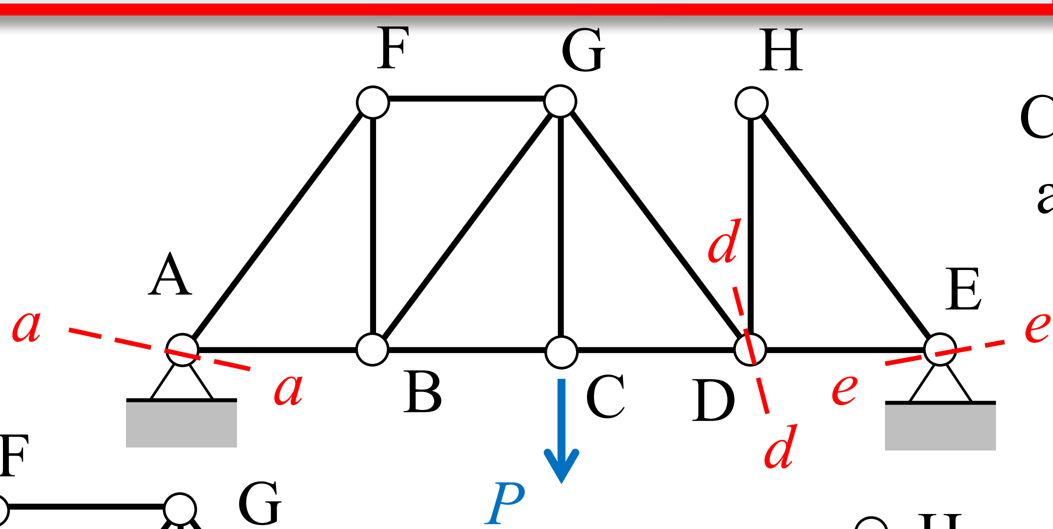



Note if $D_y \neq 0$ with no other load, then $\sum M_A \neq 0$

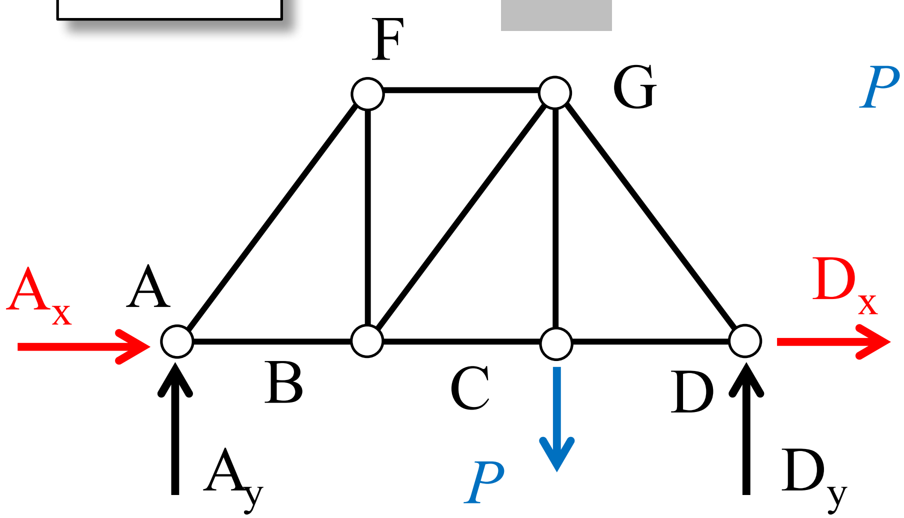
Note if $D_y \neq 0$ with no other load, then $\sum M_E \neq 0$

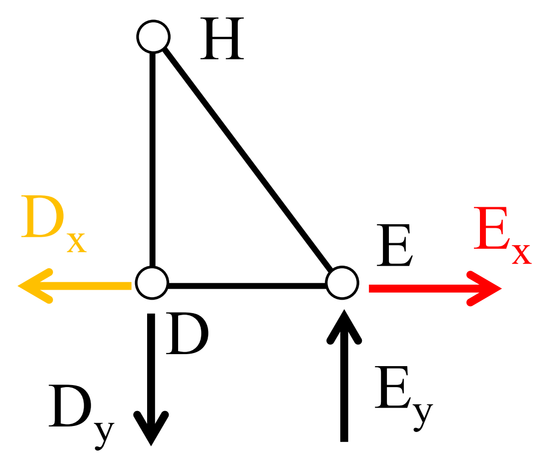
# Check Loading for Improper Constraints




Consider a load at joint C only

FBDs




$\circlearrowleft + \sum M_A = 0 \rightarrow D_y$

$+\uparrow \sum F_y = 0 \rightarrow A_y$

$\circlearrowleft + \sum M_E \neq 0$

**Unstable**
Improper Constraints

**Truss is Unstable**