Lecture 15

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To do ...

- **Happy Mid-Autumn festival**
- HW 11 ME due **Thurs**
- CATME mid-course survey due **Fri**
- HW 12 PL due **Tues**

Chapter 6: Structural Analysis

Main goals and learning objectives

- Determine the forces in members of a truss using the method of joints
- Determine zero-force members
- Determine the forces in members of a truss using the method of sections

Simple trusses

Trusses are commonly used to support roofs.

A more challenging question is, that for a given load, how can we design the trusses' geometry to minimize cost?

Scaffolding

An understanding of statics is critical for predicting and analyzing possible modes of failure.

Buckling of slender members in compression is always a consideration in structural analysis.

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Simple trusses

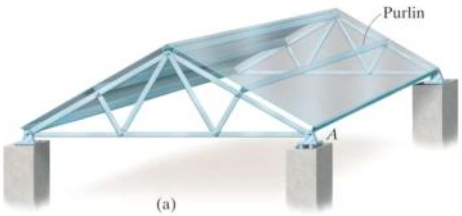
Truss:

- Structure composed of slender members joined together at end points
- Transmit loads to supports

Assumption of trusses

- Loading applied at joints, with negligible weight (If weight included, vertical and split at joints)
- Members joined by smooth pins

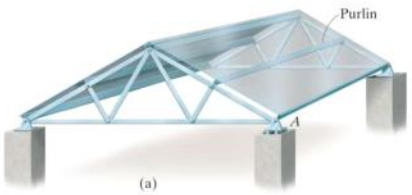
Result: all truss members are two-force members, and therefore the force acting at the end of each member will be directed along the axis of the member

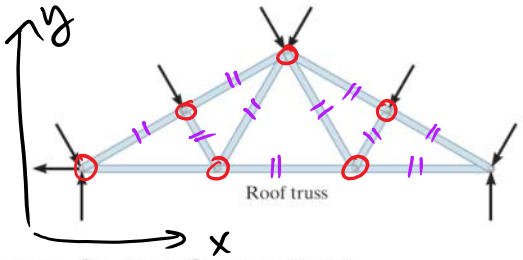


- behaves as a single object

- simplest truss is one triangle

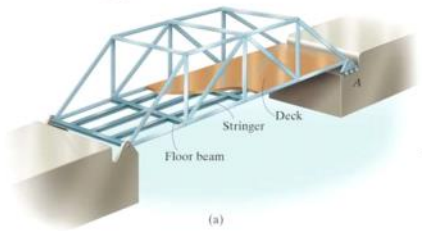
Roof trusses

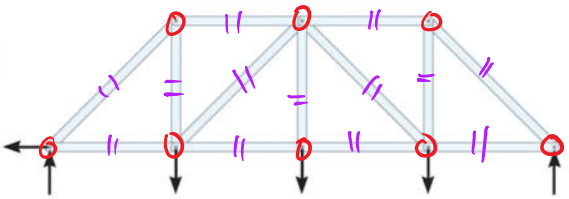




Load on roof transmitted to purlins, and from purlins to roof trusses at joints.

Bridge trusses





Load on deck transmitted to stringers, and from stringers to floor beams, and from floor beams to bridge trusses at joints.

Joints and members

7 joints

11 members

1. forces act at joints
2. in single plane

8 joints

13 members

Relation between members and joints

$$M = 2J - 3$$

if $J = 7$ then $M = 2(7) - 3 = 11$ members

if $J = 8$ then $M = 2(8) - 3 = 13$ members

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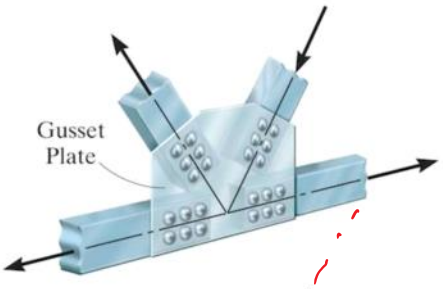
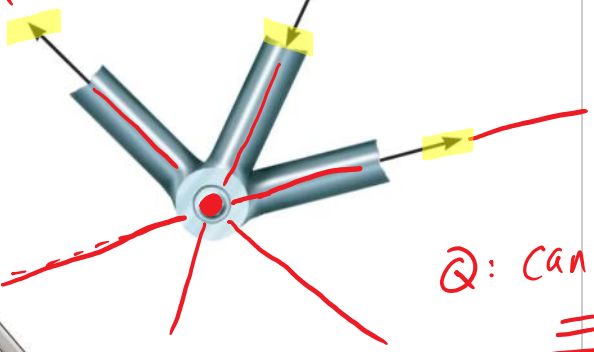
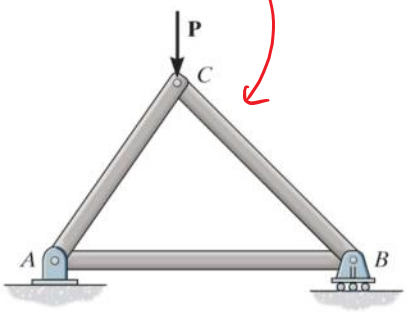
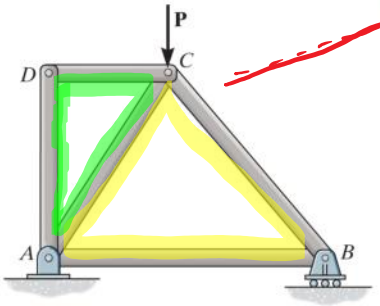
Truss joints

- Bolting or welding of the ends of the members to a gusset plates or passing a large bolt through each of the members
- Properly aligned gusset plates equivalent to pins (i.e., no moments) from coplanar, concurrent forces
- Simple trusses built from triangular members









Q: can this be in EM?

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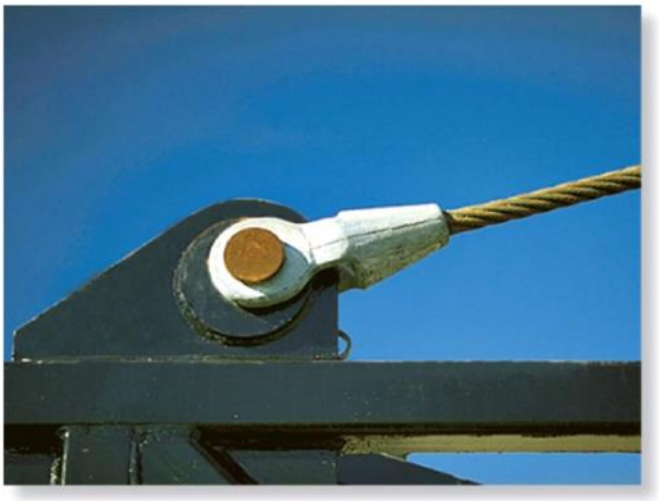

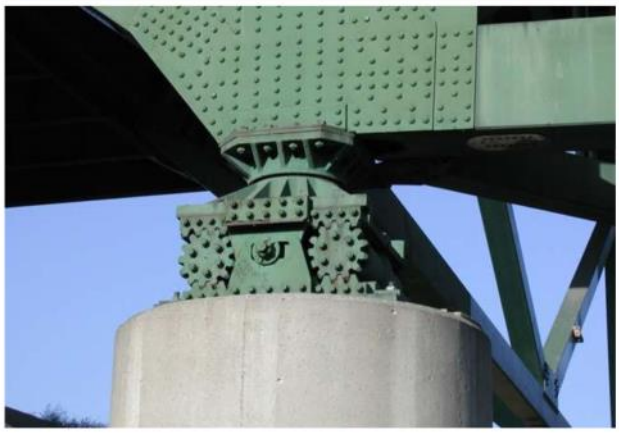

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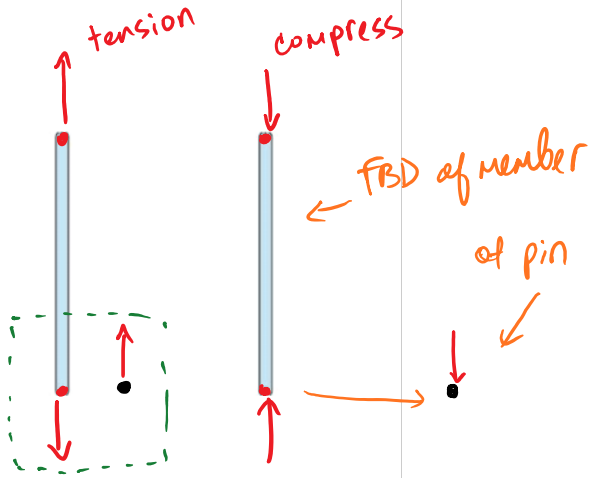
Method of joints

- Truss is in equilibrium ONLY if ALL individual pieces are in equilibrium
- Truss members are two-force members: equilibrium satisfied by equal, opposite, collinear forces

tension: elongate / pull

Compression: push

Procedure for analysis:



DETERMINE force in member

↳ pin exert equal And opposite force on A member.

1. DRAW FBD for truss And EACH joint
2. Start w/ joint w/ At least 1 known And 1-2 unknown
3. USE EoE

$\Sigma F_x = 0$
$\Sigma F_y = 0$
$\Sigma M_o = 0$

] Joints

] truss

number of unknowns that can be solved for ΣM is

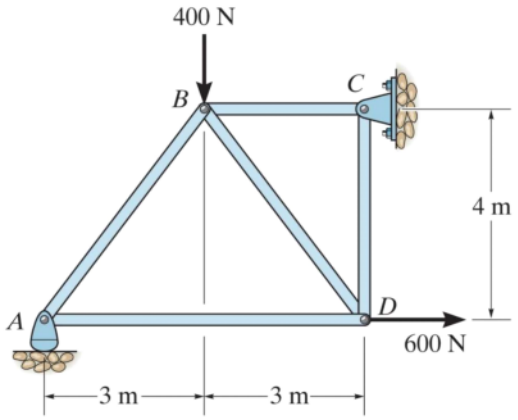
M- members
J- joints

$M + 3 = 2J$

if $M+3 > 2J$ then truss not A rigid structure

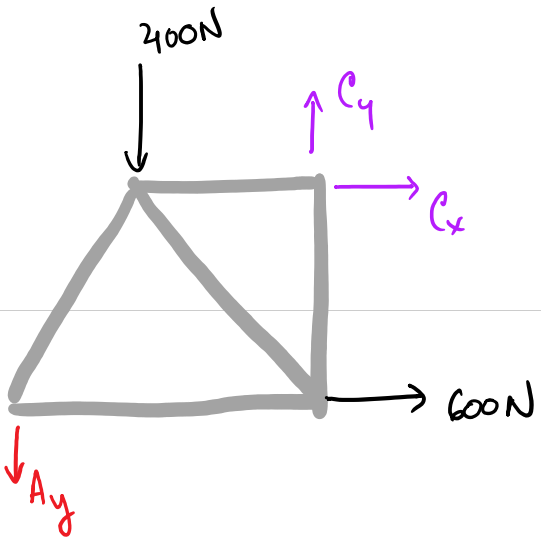
if $m+3 < 2j$ then truss statically indeterminate

4. Assume unknown forces are in tension
   - forces pull on the pin
     - positive forces → tension
       negative → compress.



Find the forces in each member of the truss. Determine if members are in tension or compression.

1. Draw FBD of truss
2. label external and reaction forces
3. DRAW FBD of joints
4. use EoE



Q: How many members/joints?

if J=4 then M= 2(4)-3 = 5

* ΣM of truss and support Rxns first!

ΣF_x: $600 + C_x = 0$ $\quad C_x = -600\ N$

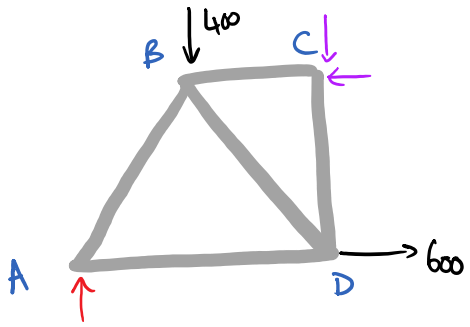
ΣF_y: $C_y - A_y - 400 = 0$

ΣM_C: $(3)(400) + 4(600) + A_y 6 = 0$

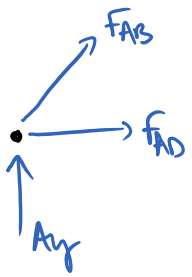
$$A_y = \frac{-3600}{6} = -600\ N$$

$$C_y = 400 + A_y = -200\ N$$

now analyze each joint! (b/c truss is in ΣM!)



FBD of joint A



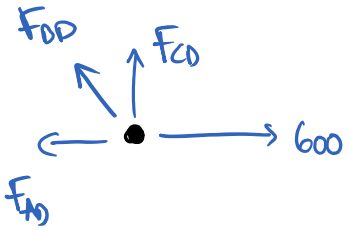
ΣF_x: $F_{AD} + \frac{3}{5} F_{AB} = 0$

ΣF_y: $\frac{4}{5} F_{AB} + A_y = 0$

$F_A \quad -\frac{5}{4} A_y = -750\,N\ (C)$

$F_{AD} = -\frac{3}{5} F_{AB} = 450\,N\ (T)$

FBD of joint D



ΣF_x: $600 - F_{AD} - \frac{3}{5} F_{BD} = 0$

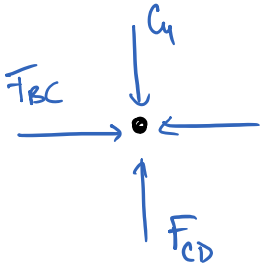
ΣF_y: $F_{CD} + \frac{4}{5} F_{BD} = 0$

$F_{BD} = \frac{5}{3}(600 - 450) = 250\,N\ (T)$

$F_{CD} = -\frac{4}{5} F_{BD} = -200\,N\ (C)$

FBD of joint C

FBD of joint C



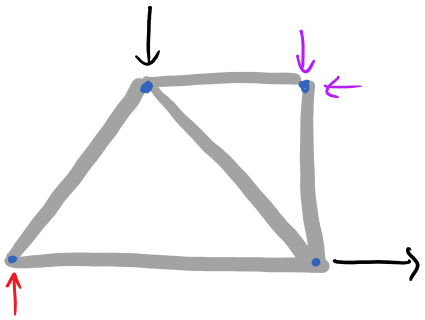
$\Sigma f_x: \quad F_{BC} - C_x = 0$

$\Sigma f_y: \quad F_{CD} - C_y = 0$

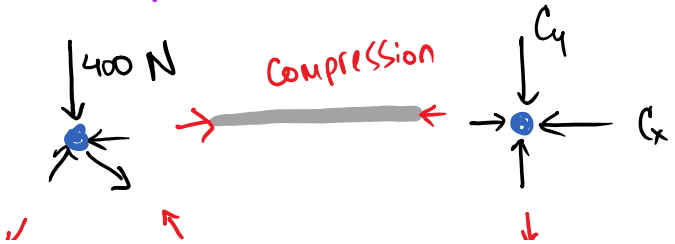
$F_{BC} = C_x = 600\ N$ (T)

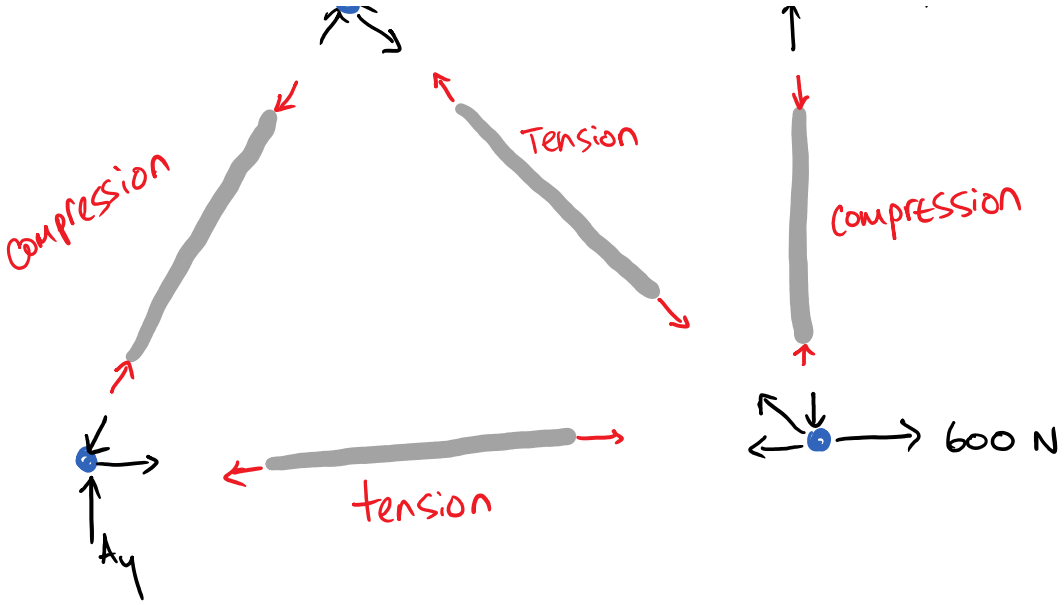
$F_{CD} = C_y = 200\ N$ (check)

So what does this MEAN...



In ΣM, the truss is a rigid structure, composed of rigid members, connected by smooth pins. for a given configuration and external loading, MEMBERS experience tension OR compression.




Compression
Tension
Compression
600 N
tension
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