Statics - TAM 211

Lecture 17

November 2, 2018

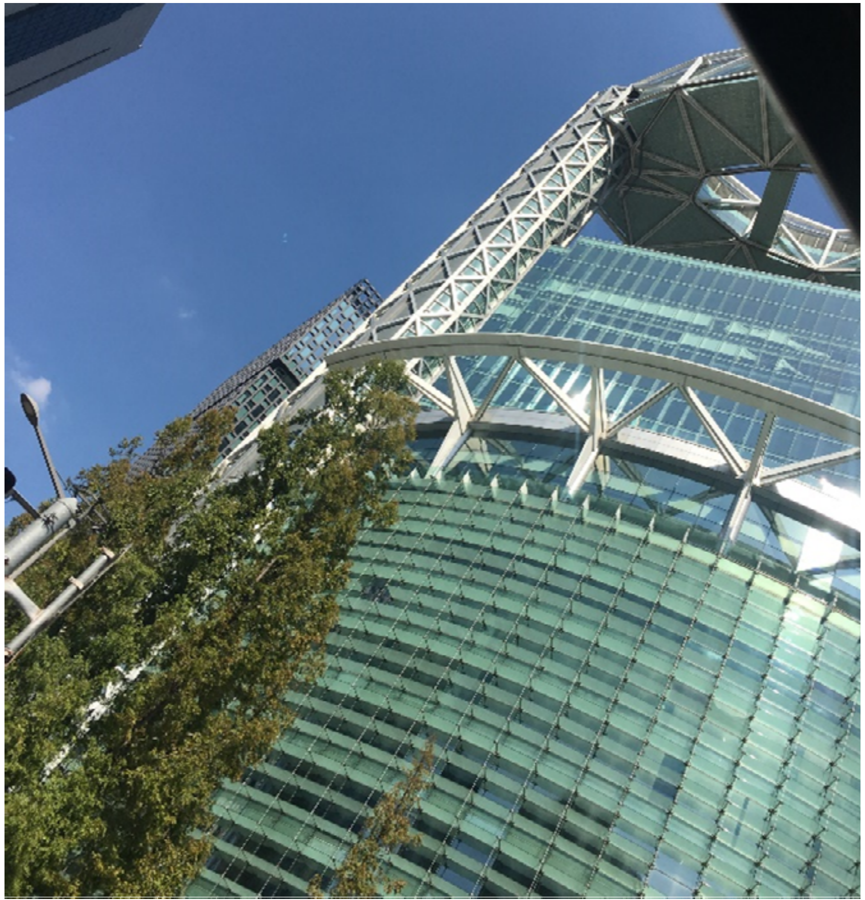
Announcements

❑ **Today's schedule**

- 8:00 am: Quiz 3, Chapter 5 (2D rigid bodies). On paper.
- 9:00 am: Lecture 17
- 10:00 am: Discussion section for ALL students

❑ Upcoming deadlines:

- Friday (11/2)
  - Written Assignment 6
- Tuesday (11/6)
  - Prairie Learn HW 7
- Friday (11/9)
  - Written Assignment 7



Chapter 6: Structural Analysis

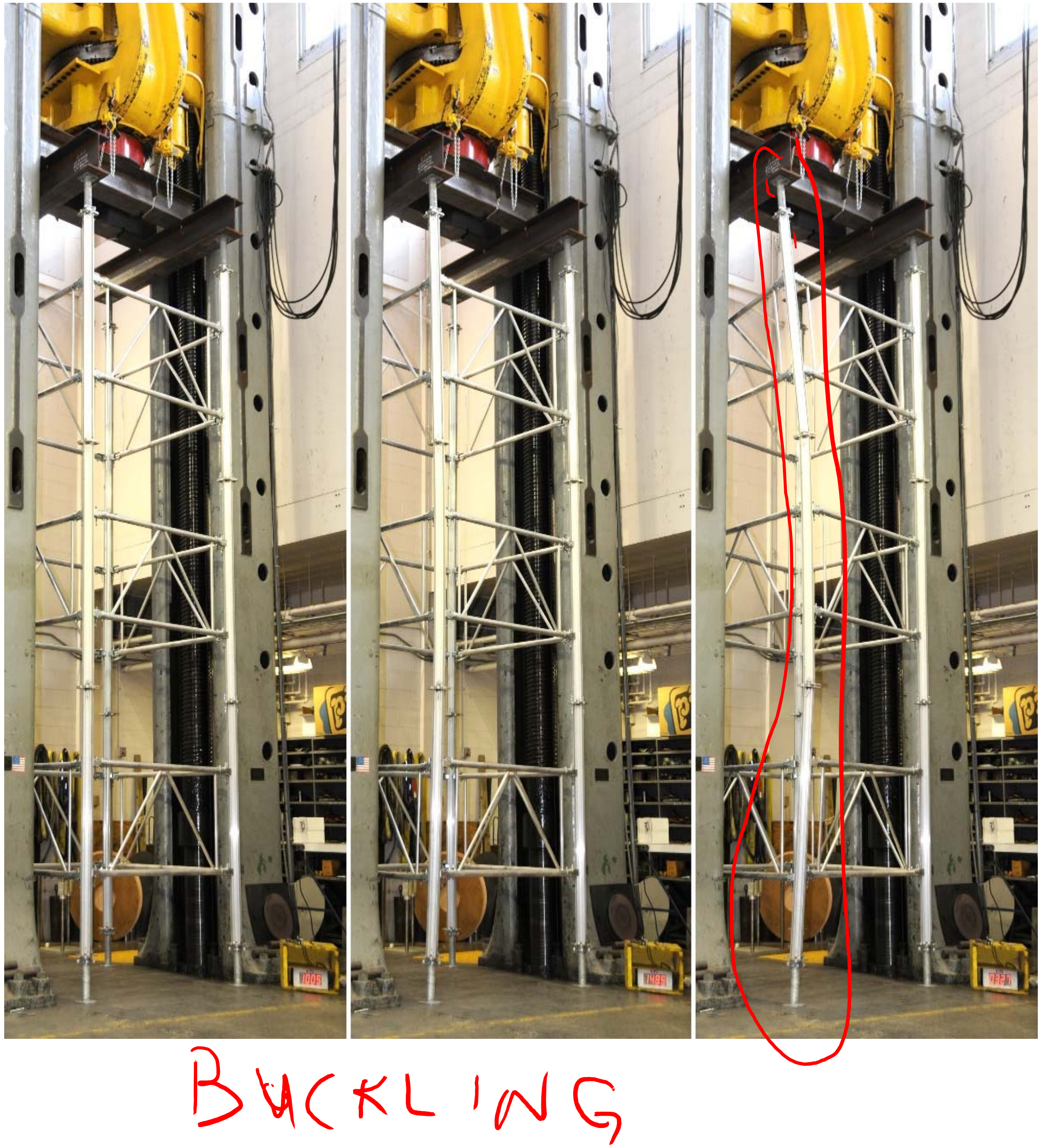
Goals and Objectives

- 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
- Determine the forces and moments in members of a frame or machine

Chapter 6: Structural Analysis

6 bridge failures from the CIVL 260 course on Nov. 25, 2009 (the ones that didn't fail were boring). Each of the 15 groups designed a bridge from a limited amount of wood to span 8 ft(2.44m) and support a minimum of 60 kg (132 lb). The bridges were tested by loading 10kg (22lb) sandbags one at a time up to 100kg (220lbs). https://youtu.be/EYGm4vKOvRE

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



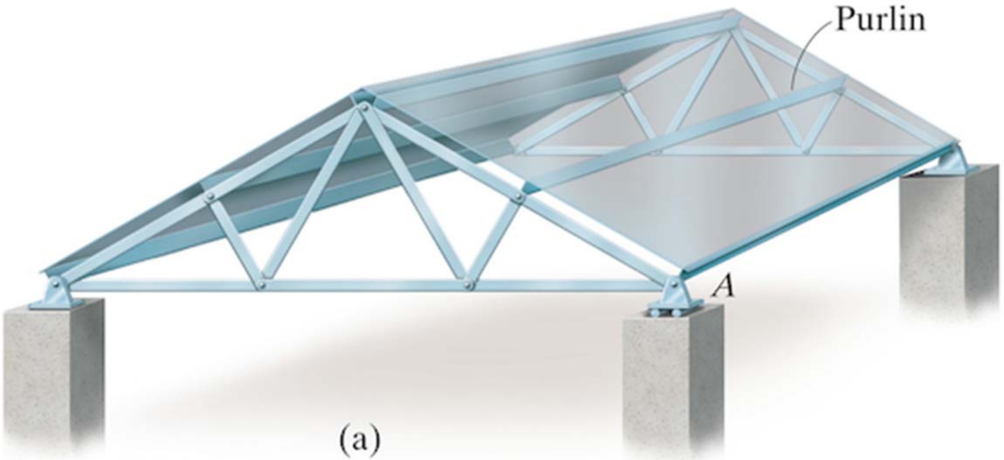
https://www.juliusmedia.com/wp-content/uploads/2012/12/st-kilda-beach-projection-frame1.jpg

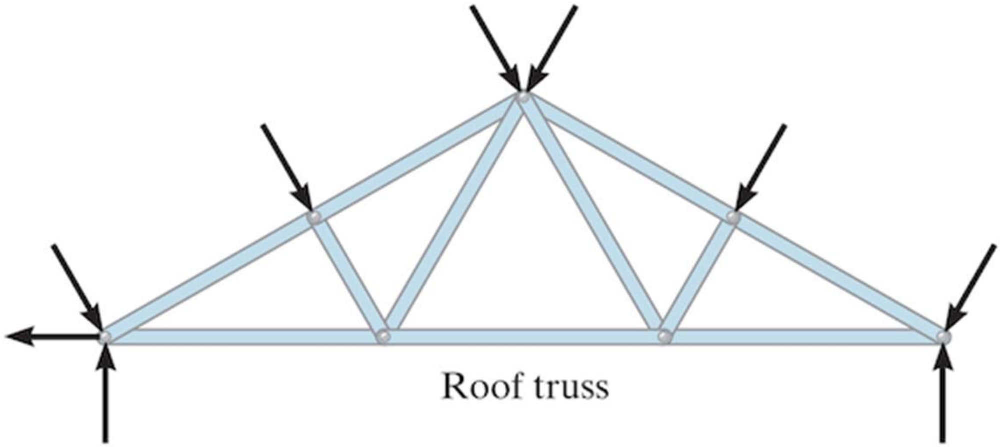
https://warrenforensics.com/wp-content/uploads/2013/08/Truss-blog-pic.jpg

Simple trusses

Trusses are commonly used to support roofs.

Simple trusses are built from **<u>triangular members</u>**



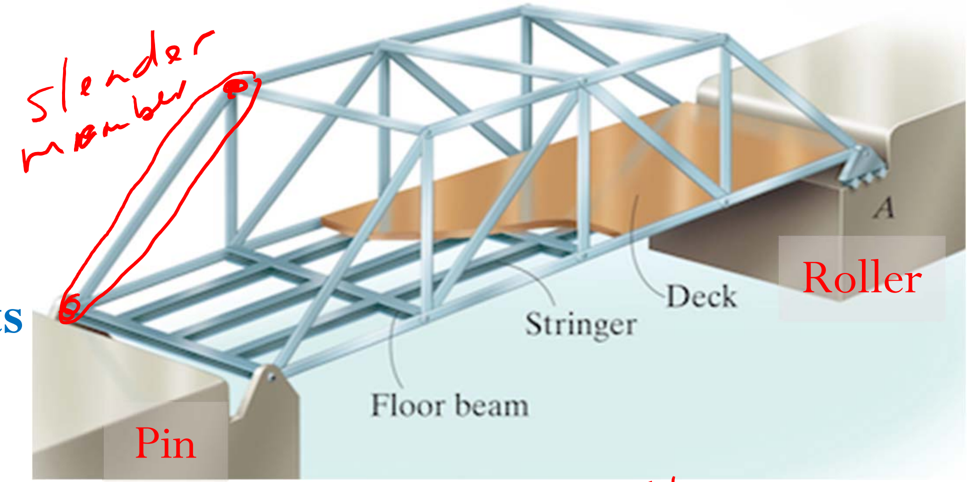


Load on roof transmitted to purlins, and from purlins to roof trusses at joints.

Simple trusses

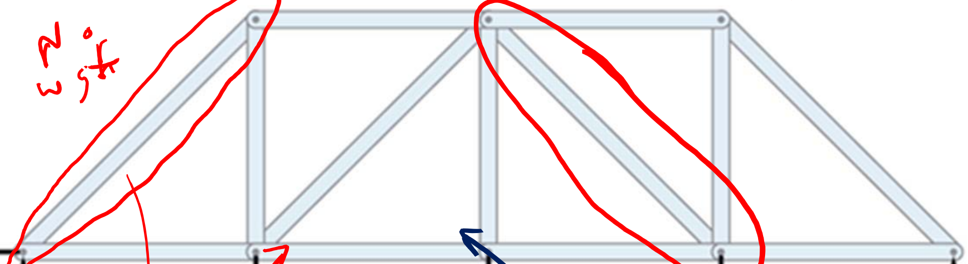
Truss:

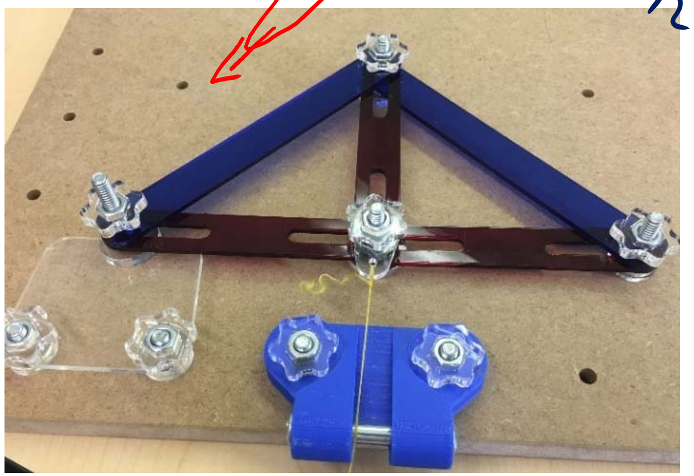
- **Structure composed of slender members joined together at end points**
- Transmit loads to supports



Assumption of trusses

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

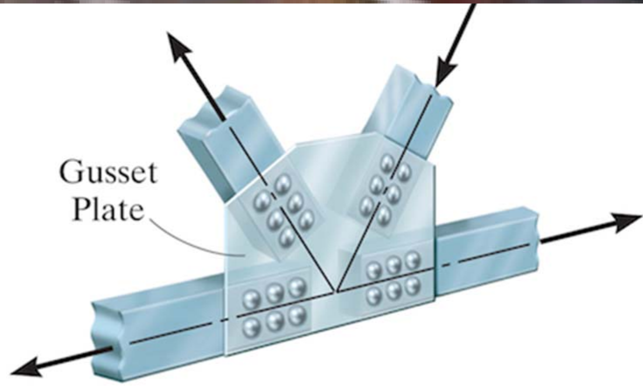


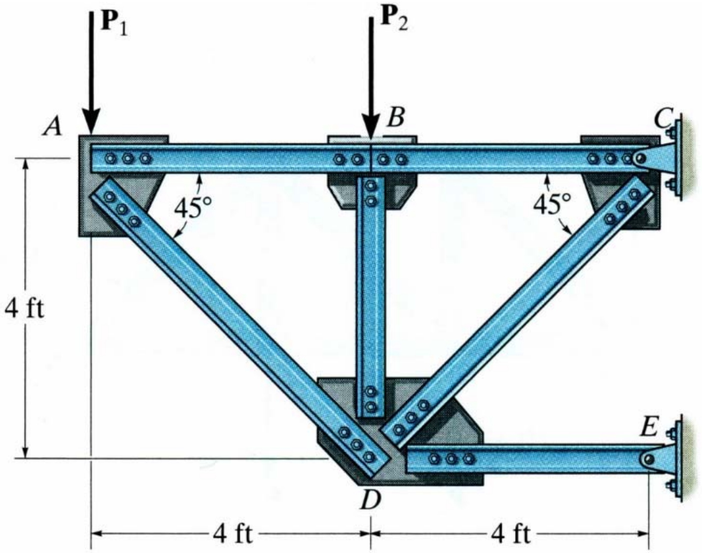


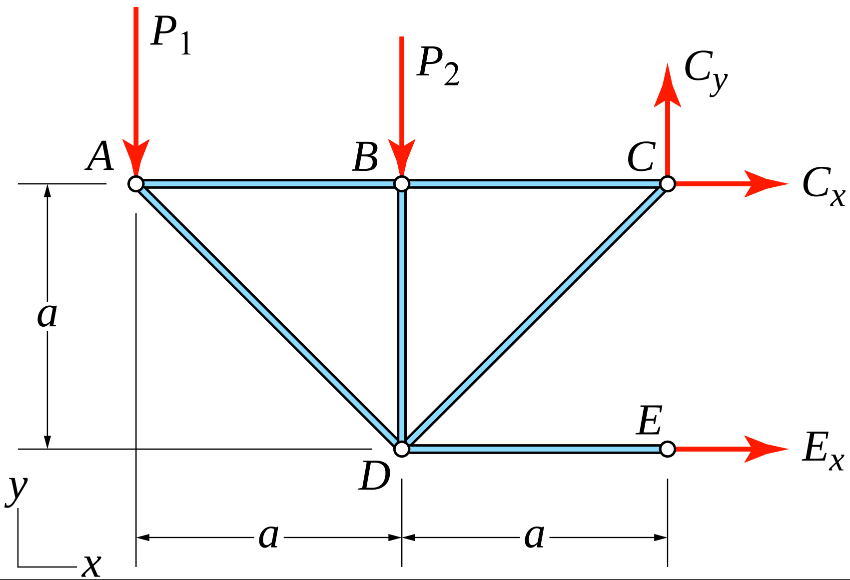
Result: all truss members are two-force members, and therefore the force acting at the end of each member will be directed along the axis of the member

Gusset Joints

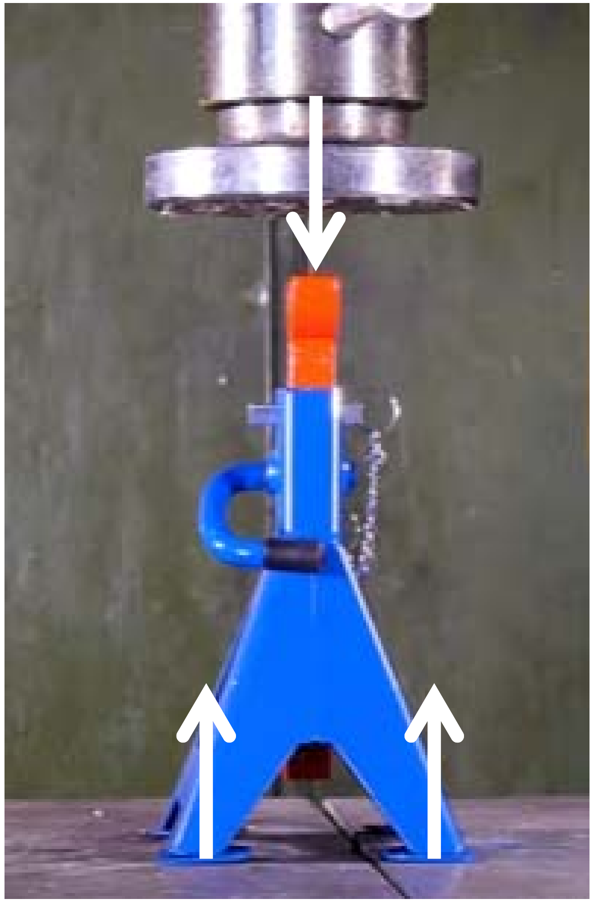
- Gusset Joint: Bolting or welding of ends of members to a gusset plate
- Properly aligned gusset plates are equivalent to pins (i.e., no moments) from coplanar, concurrent forces
- **Assume: gusset joints = pin joints**







Tension vs. Compression



Rigid bodies respond differently to tension versus compression.

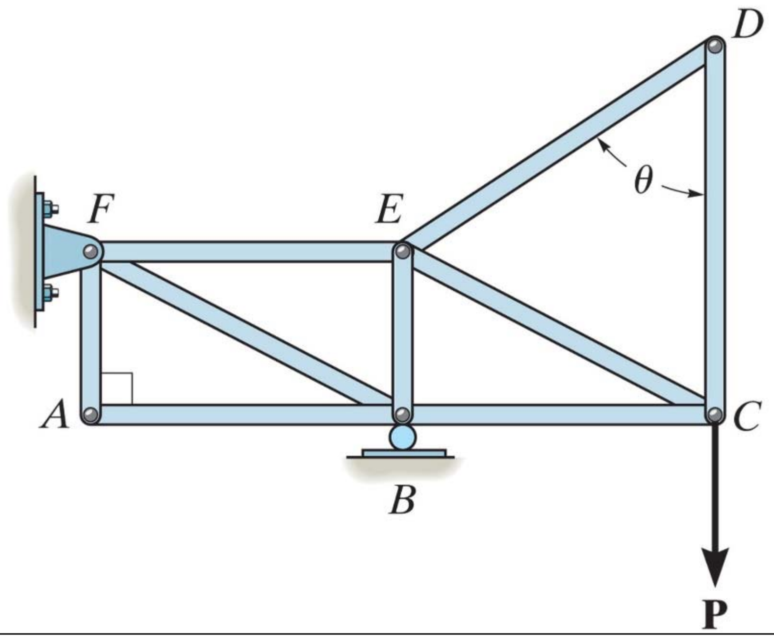
https://www.youtube.com/watch?v=67fSwIjYJ-E
https://www.youtube.com/watch?v=Gb9eemosZF8

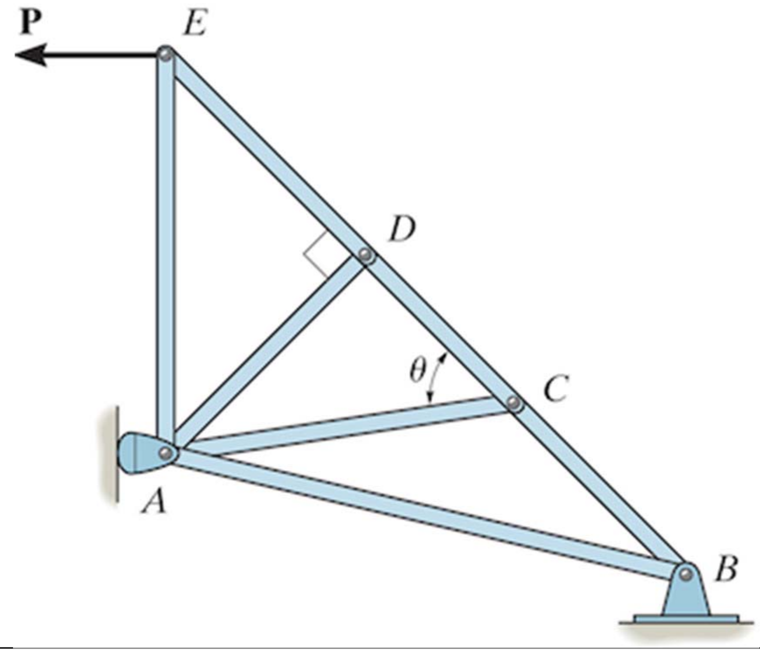
Zero-force members

- Particular members in a structure may experience no force for certain loads.
- Zero-force members are used to increase stability
- Identifying members with zero-force can expedite analysis.

Two situations:

- Joint with two non-collinear members, no external or support reaction applied to the joint → **Both members are zero-force members**.
- Joint with two collinear member, plus third non-collinear, no external or support reaction applied to non-collinear member → **Non-collinear member is a zero-force member**.





Zero-force members

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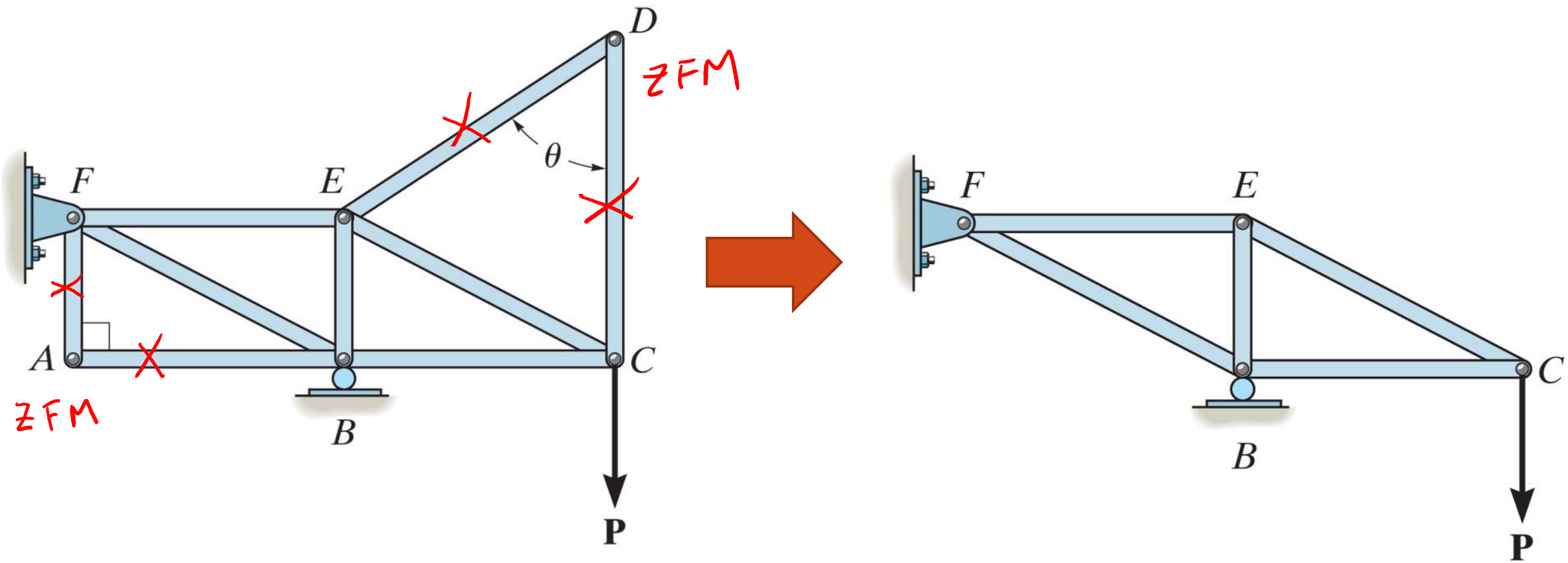

Zero-force members

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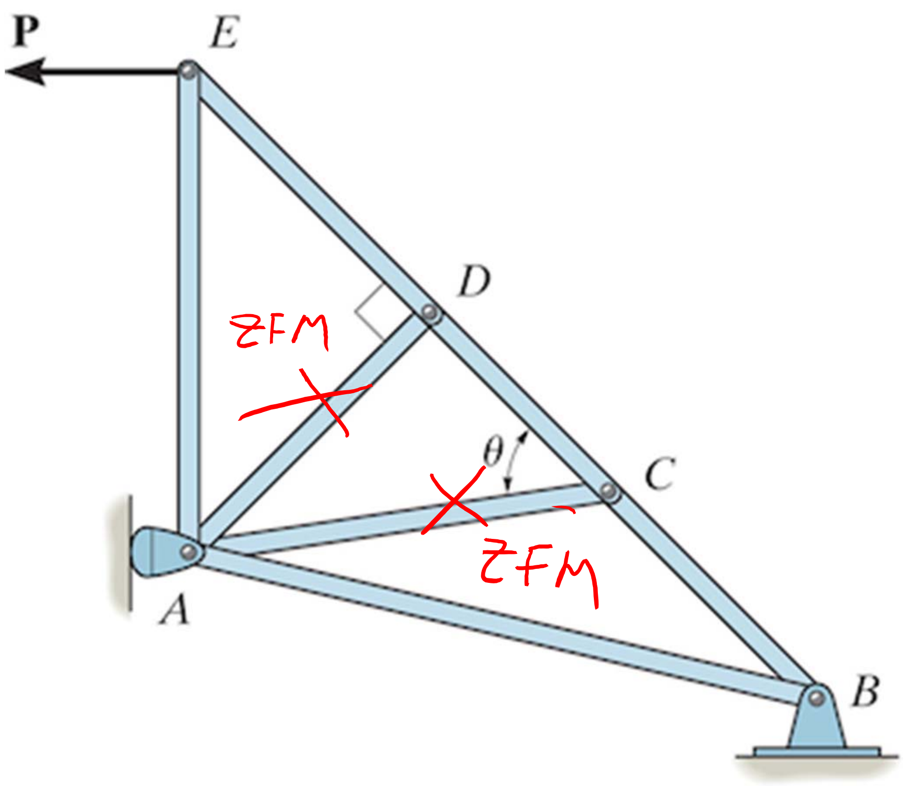
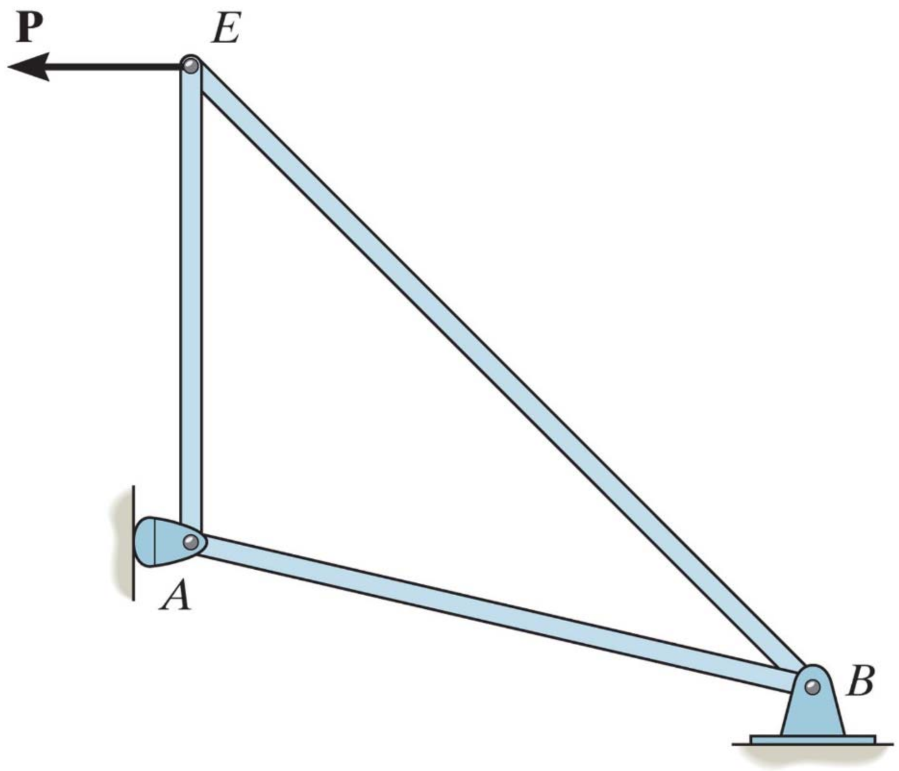
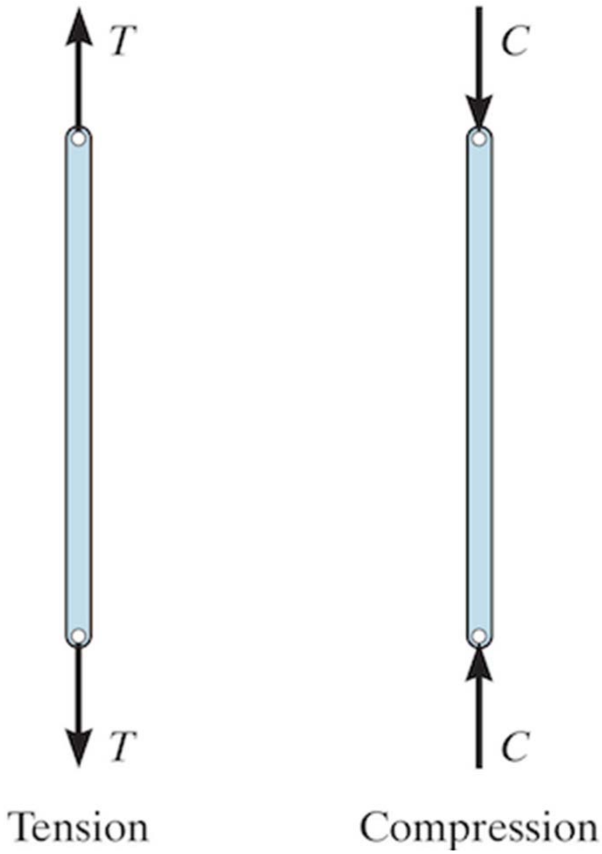




Method of joints: Method to determine forces in members

- Entire truss is in equilibrium if and only if all individual pieces (truss members and connecting pins) are in equilibrium.
- Truss members are two-force members: equilibrium satisfied by equal, opposite, collinear forces.
  - Tension: member has forces elongating.
  - Compression: member has forces shortening.
- Pins in equilibrium: $\sum F_x = 0$ and $\sum F_y = 0$
- Compare to finding forces on a single particle.

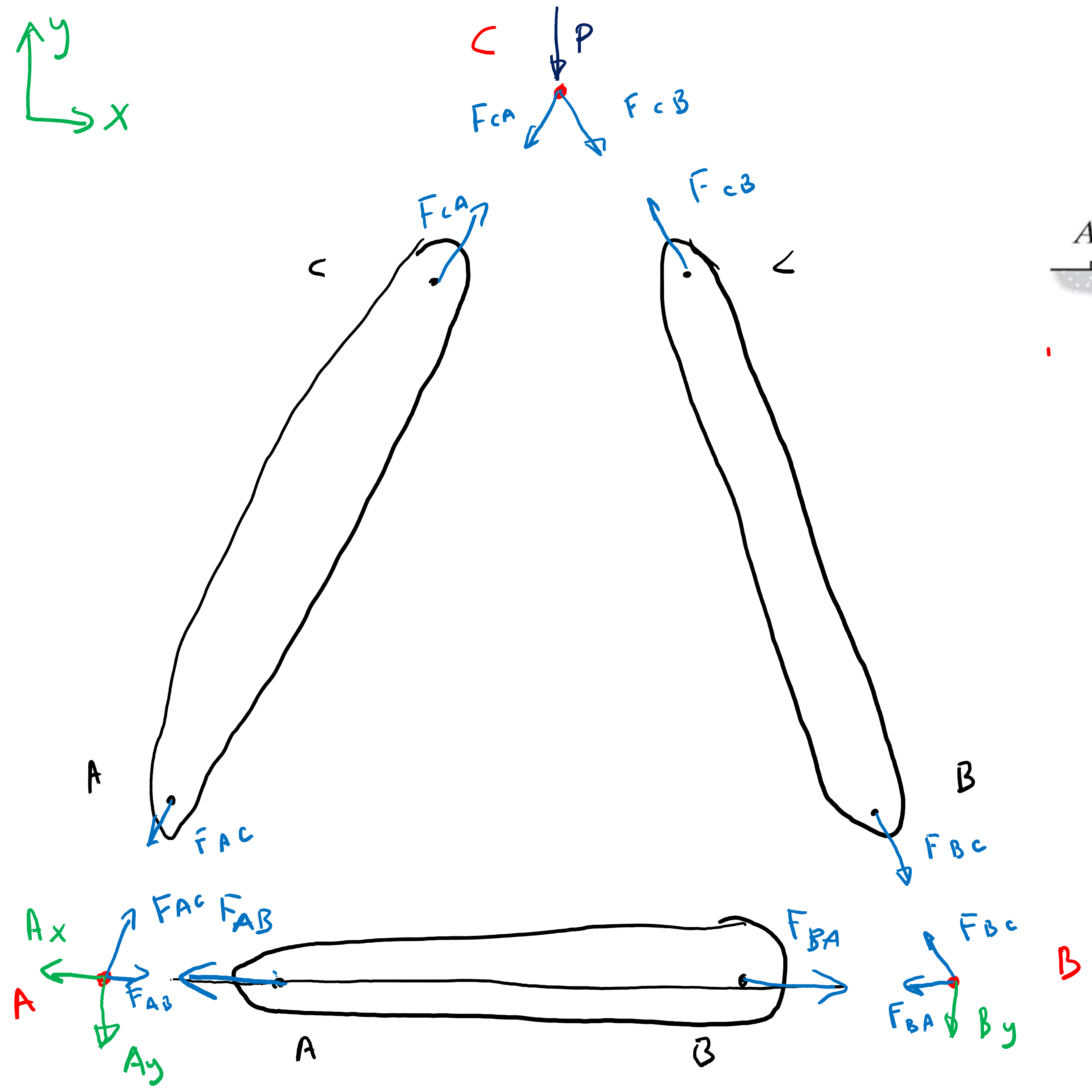


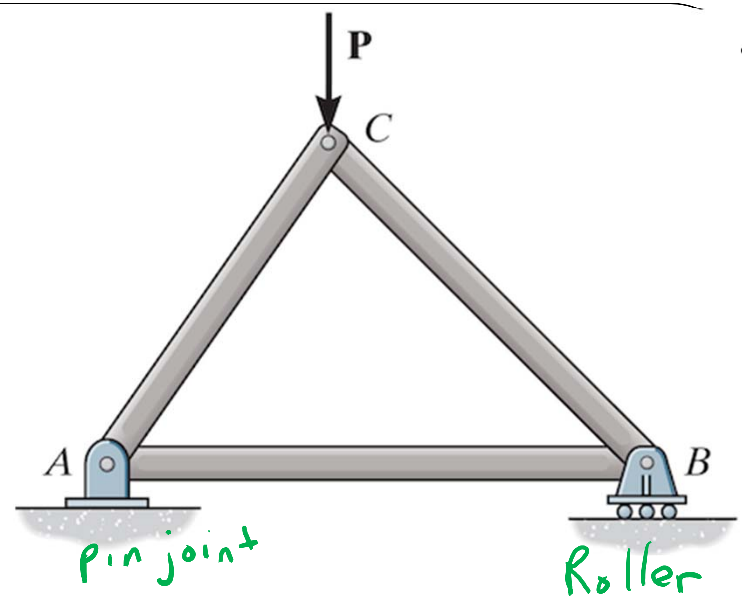
Procedure for analysis:

- Free-body diagram for each joint
- Start with joints with at least 1 known force and 1-2 unknown forces.
- Generates two equations, 1-2 unknowns for each joint.
- Assume the unknown force members to be in *tension; i.e. the forces "pull" on the pin*. Numerical solutions will yield positive scalars for members in tension and negative scalar for members in compression.

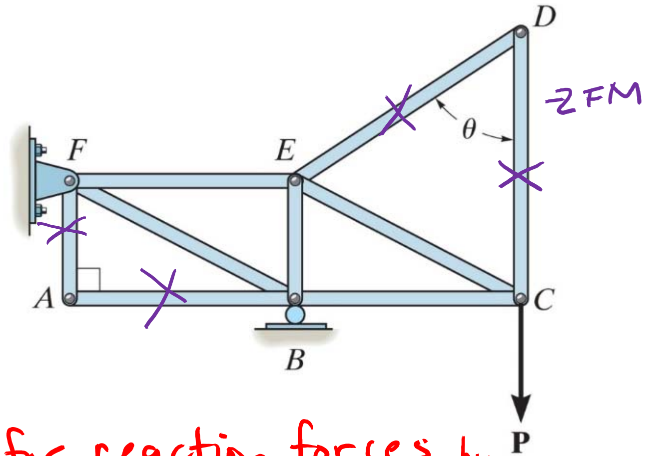
Create FBDs for each joint and each member.

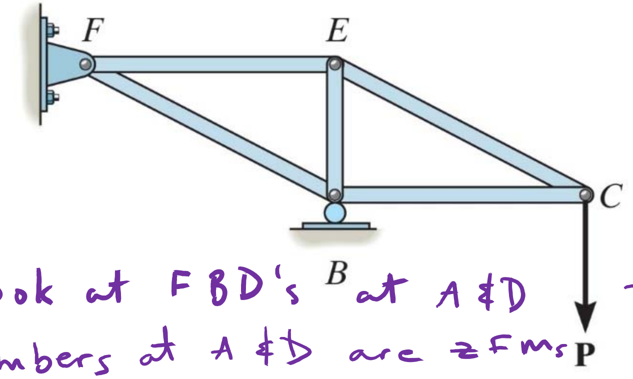
Assume unknown force members to be in *tension*



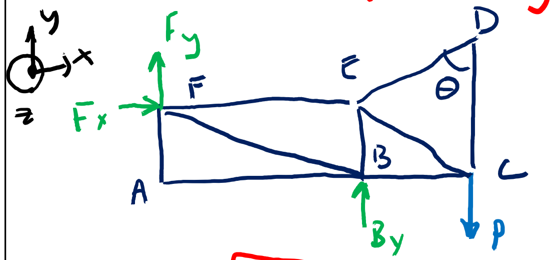


Use Method of joints to prove that members attached to A and D should be FZM:





① Solve for reaction forces by considering the entire structure as one single rigid body.



$\Sigma F_x = 0$: $\boxed{F_x = 0}$

$\Sigma F_y = 0$: $F_y + B_y - P = 0$

$\Sigma M_F = 0$: $(r_{FE})B_y - (r_{AC})P = 0$

+↺

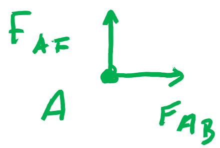
$$\boxed{B_y = \left(\frac{r_{AC}}{r_{FE}}\right)P}$$

$$\boxed{F_y = \left(1 - \frac{r_{AC}}{r_{FE}}\right)P}$$

② Let's look at FBD's at A & D to prove that members at A & D are ZFMs

Assume that there are forces pointing in tension and aligned in direction of truss link members. Label forces as F_{ij} where i is tail and j is arrow head

@ Jt A:

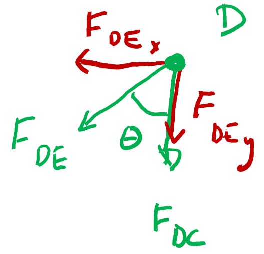


$\Sigma F_x = 0$: $F_{AB} = 0$

$\Sigma F_y = 0$: $F_{AF} = 0$

✓ ZFMs

@ Jt D:



$\Sigma F_x = 0$: $F_{DE_x} = 0$

$\Sigma F_y = 0$: $F_{DE_y} + F_{DC} = 0$

Note: $F_{DE_x} = F_{DE} \sin\theta = 0$

since $\theta \neq 0$, ∴ $F_{DE} = 0$ ✓ ZFM

⇒ $F_{DE_y} + F_{DC} = F_{DE}\cos\theta + F_{DC} = 0$

∴ $F_{DC} = 0$ ✓ ZFM