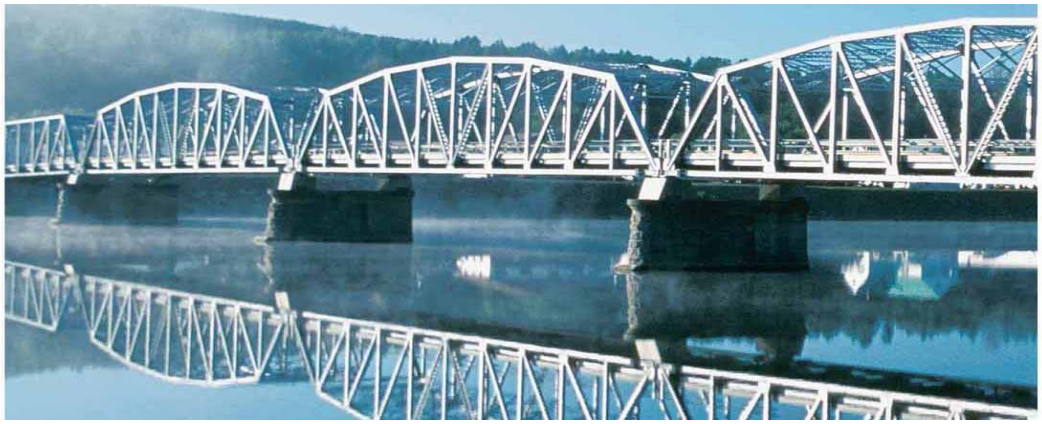
Structural Analysis (Ch 6)

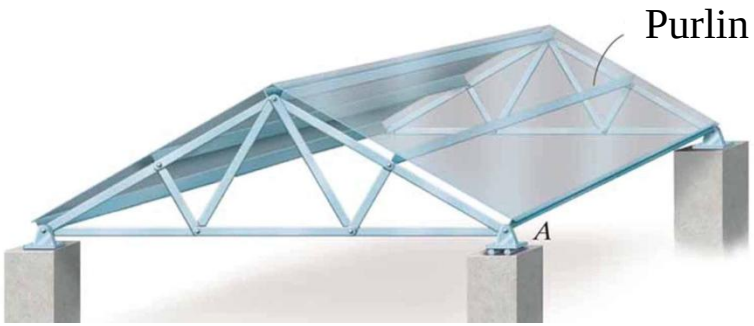


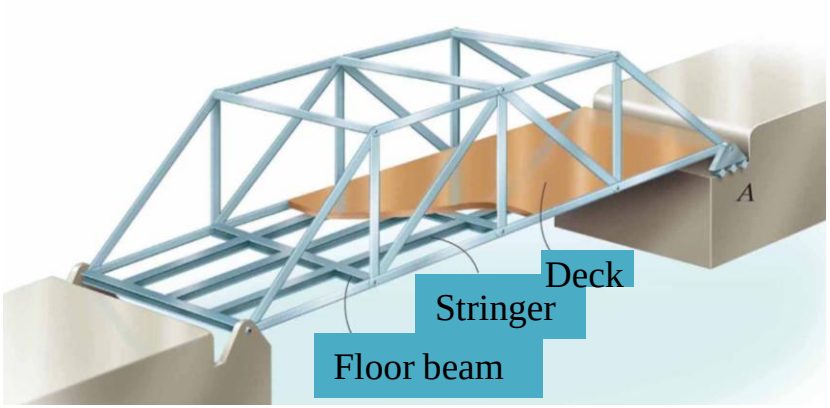
- Overview of Trusses
- Method of Joints
- Zero-Force Members
- Method of Sections
- Frames and Machines

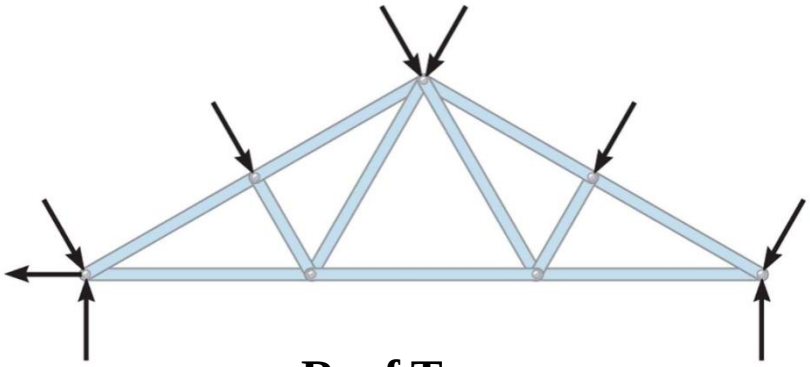
Overview of Trusses

TRUSS — a structure consisting of members that are

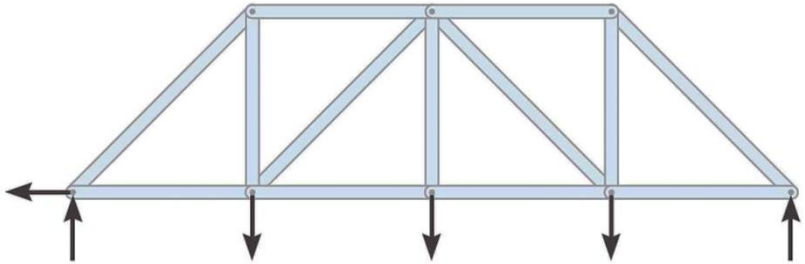
- straight
- slender (often assumed to have negligible weight)
- pin-connected at their ends (or approximated so)
- loaded only at joints







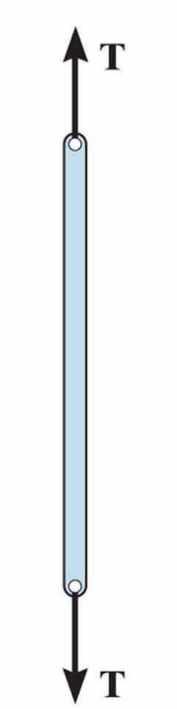
Roof Truss



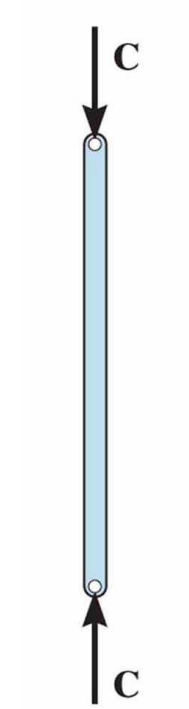
Bridge Truss

Joint Loading in Truss

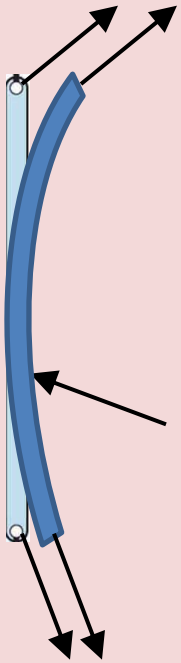
- All members are **two-force bodies**.
- Force in a member is along the axis of the member
- **Tension** or **Compression** (….Not **Bending**)



Very Strong

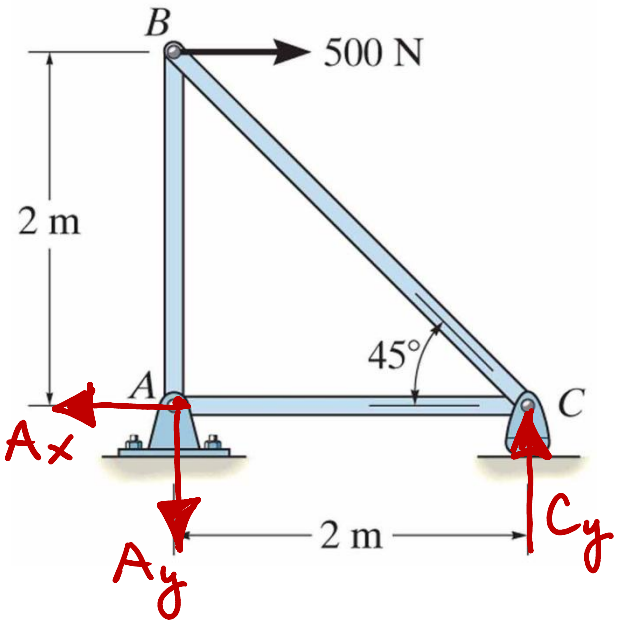


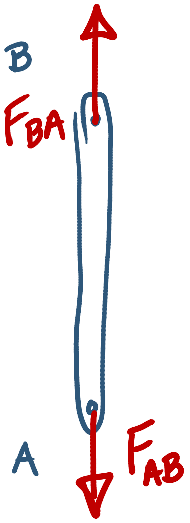
Strong

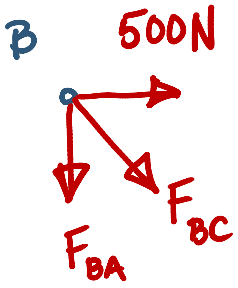


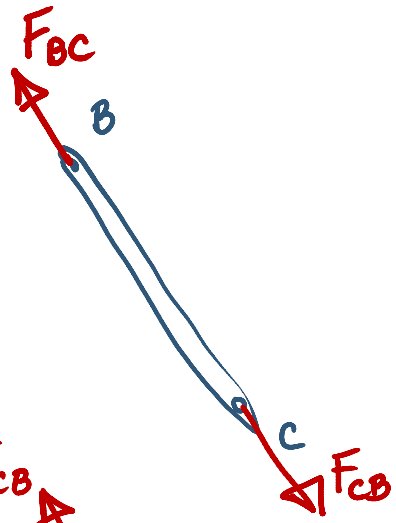
Weak

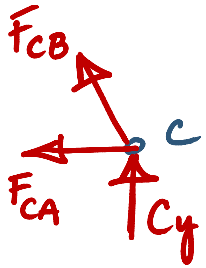
FBDs for Joints and Members

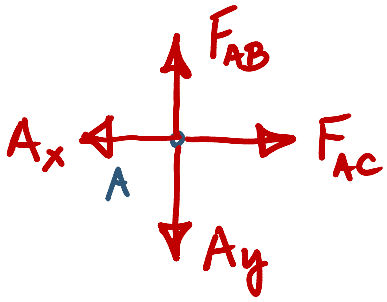


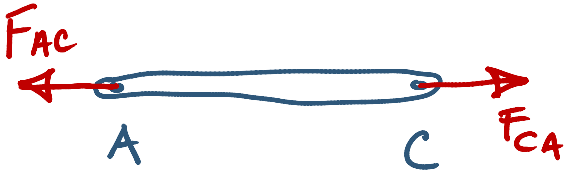


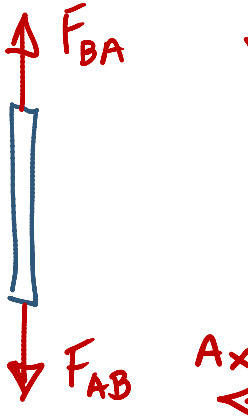


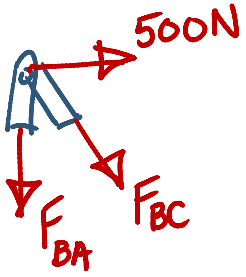


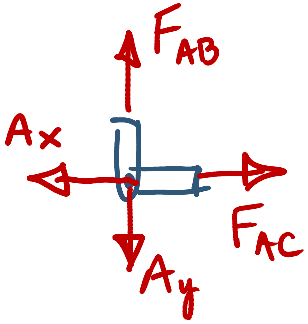










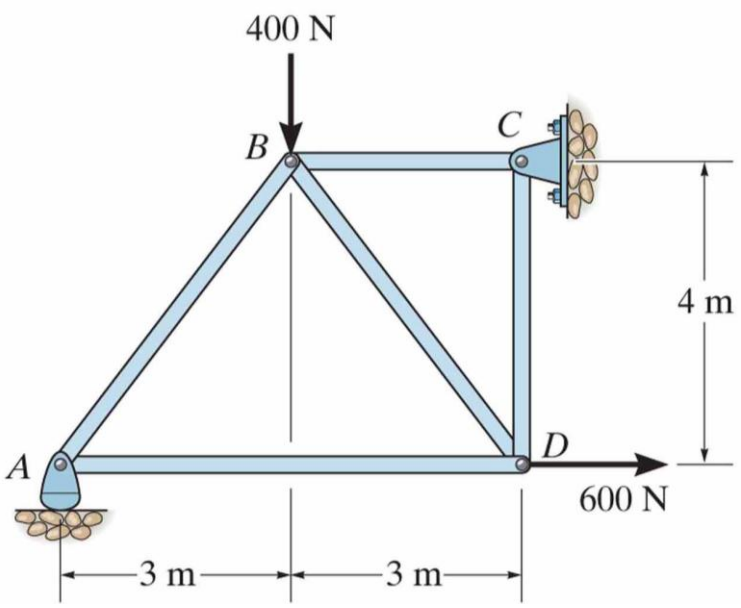


\+ **Tension (away from FB)**

– **Compression (towards FB)**

Method of Joints

- Involves looking at successive FBD's of joints.
- Each joint is a "particle" (concurrent force system)

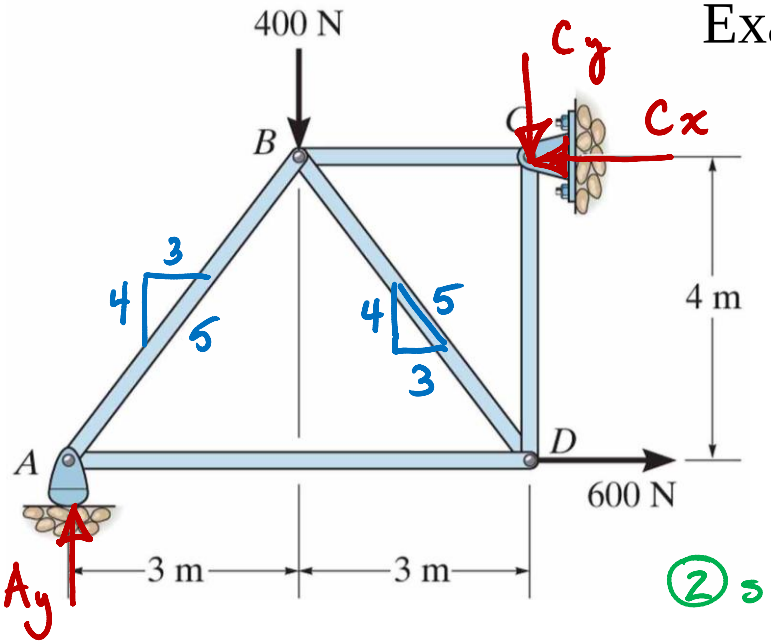


Steps:

1. Find reactions at supports.
2. FBD's of successive joints.
   - Concurrent force system → 2 equilibrium equations
   - "Happy Joint" – only 2 unknowns.

$\Sigma F_x = 0 \quad \Sigma F_y = 0$

Example 1. Find the force in each member.



① Reactions at supports

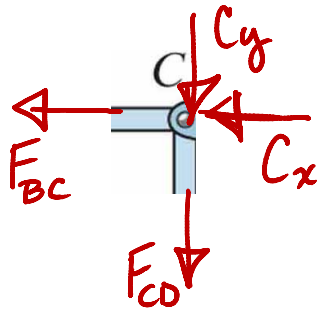
$\Sigma F_x = 0 = 600N - C_x \Rightarrow C_x = 600N$

$\Sigma F_y = 0 = A_y - C_y - 400N \Rightarrow C_y = +200N$

$\Sigma M_c = 0 = 400N(3m) + 600N(4m) - A_y(6m)$

$\Rightarrow A_y = 600N$

② solve for member Fs

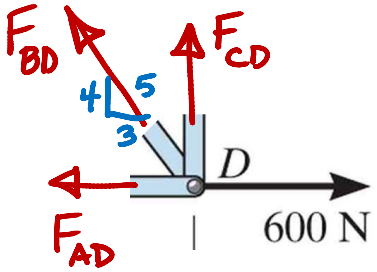


$\Sigma F_x \Rightarrow F_{BC} = -C_x$

$F_{BC} = -600N\,(c)$

$\Sigma F_y \Rightarrow F_{CD} = -C_y$

$F_{CD} = -200N\,(c)$



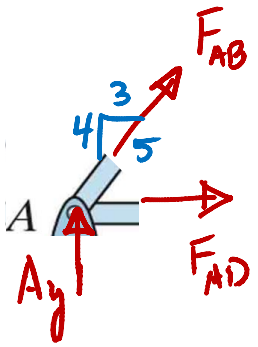
$\Sigma F_x = 0 = 600N - F_{AD} - \frac{3}{5}F_{BD}$

$\Sigma F_y = 0 = F_{CD} + \frac{4}{5}F_{BD}$

$\Rightarrow F_{BD} = -\frac{5}{4}(-200N)$

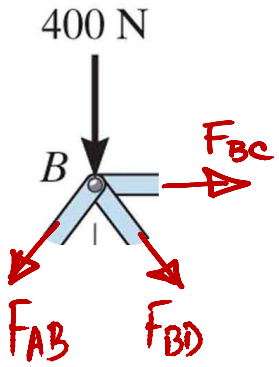
$F_{BD} = 250N\,(T)$

$F_{AD} = 450N\,(T)$



$\Sigma F_y = 0 = A_y + \frac{4}{5}F_{AB}$

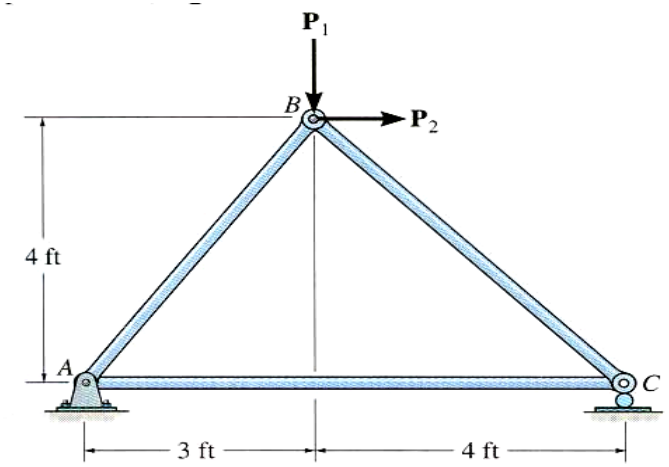
$\Rightarrow F_{AB} = -750N\,(c)$



$\Sigma F_x = F_{BC} + \frac{3}{5}F_{BD} - \frac{3}{5}F_{AB}$ ✓

$\Sigma F_y = -400 - \frac{4}{5}F_{AB} - \frac{4}{5}F_{BD}$ ✓

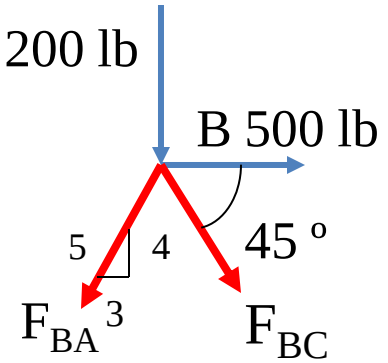
EXAMPLE assuming all Tension forces



Given: $P_1 = 200$ lb, $P_2 = 500$ lb

Find: The forces in each member of the truss.

Plan: First analyze pin B and then pin C

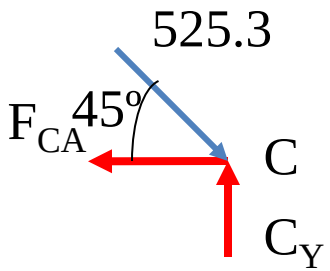


FBD of pin B

$$+ \rightarrow \sum F_X = 500 + F_{BC} \cos 45° - (3/5) F_{BA} = 0$$

$$+ \uparrow \sum F_Y = -200 - F_{BC} \sin 45° - (4/5) F_{BA} = 0$$

$F_{BA} = 214$ lb (T) and $F_{BC} = -525.3$ lb (C)



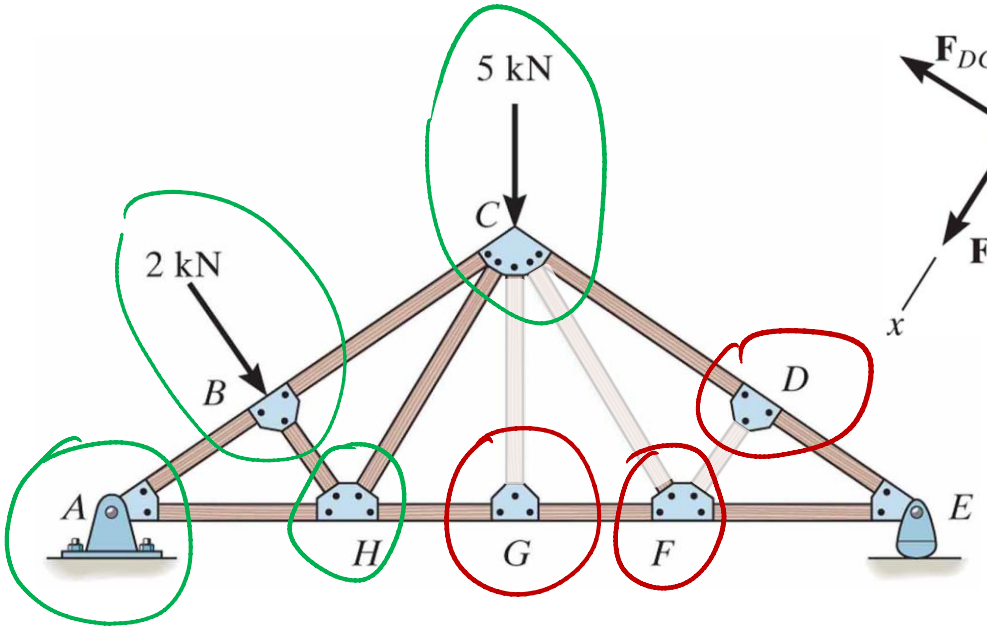
FBD of pin C

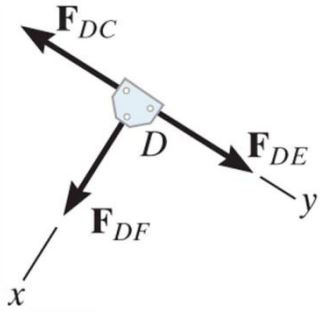
$$+ \rightarrow \sum F_X = - F_{CA} + 525.3 \cos 45° = 0$$

$F_{CA} = 371$ (T)

Zero-Force Members

- Inspection can determine that F = 0 for some members.
- Look for collinear members with no applied loads.

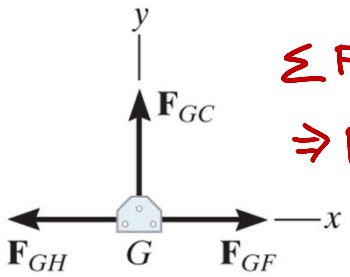




$\Sigma F_x = 0 \Rightarrow F_{DF} = 0$

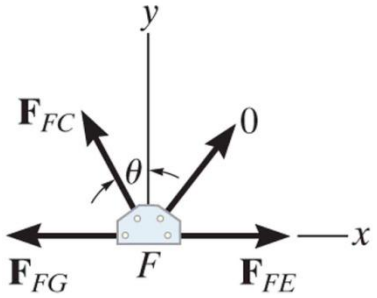
$\Sigma F_y = 0 \Rightarrow F_{DE} = F_{DC}$

$\Sigma F_y = 0 \Rightarrow F_{FC} = 0$



$\Sigma F_y = 0$

$\Rightarrow F_{GC} = 0$

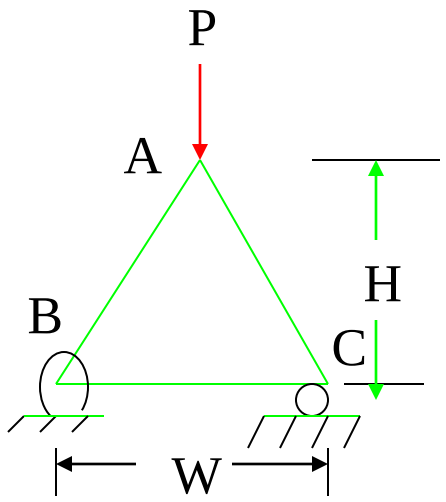


$\Sigma F_x = 0 \Rightarrow$

$F_{GH} = F_{FG} = F_{FE}$

CONCEPT QUIZ

1. Truss ABC is changed by decreasing its height from H to 0.9 H. Width W and load P are kept the same. Which one of the following statements is true for the revised truss as compared to the original truss?



A) Force in all its members have decreased.

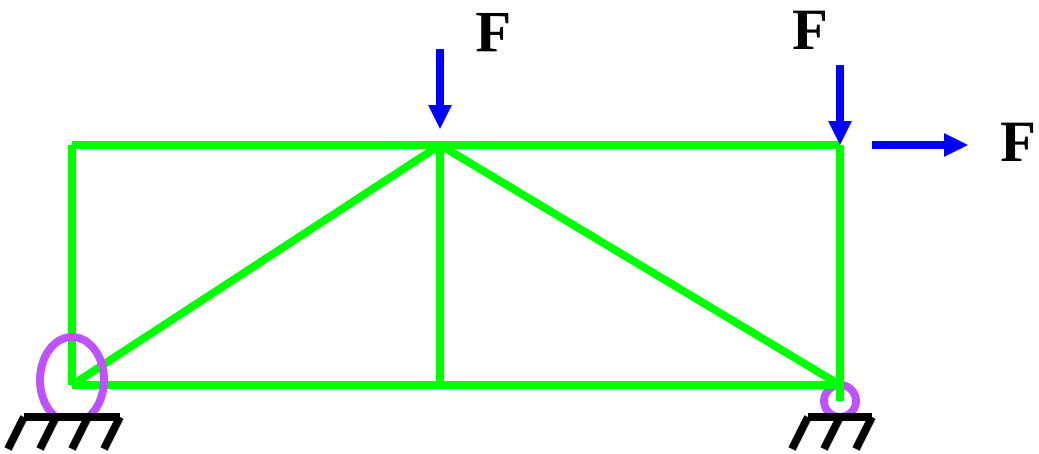
B) Force in all its members have increased.

C) Force in all its members have remained the same.

D) None of the above.

CONCEPT QUIZ

(continued)

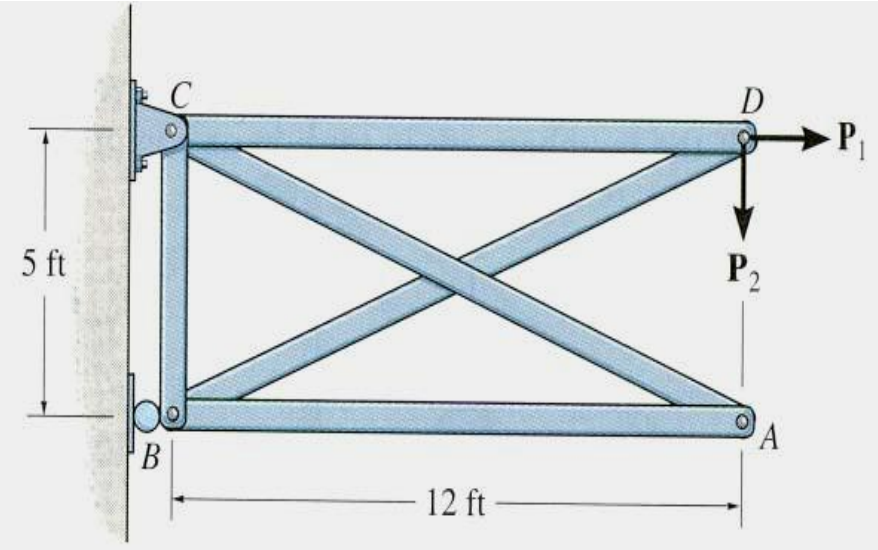


2. For this truss, determine the number of zero-force members.

1) 0 2) 1 3) 2

4) 3 5) 4

GROUP PROBLEM SOLVING



Given: P_1 = 240 lb and

P_2 = 100 lb

Find: Determine the force in all the truss members (do not forget to mention whether they are in T or C).

Plan:

a) Check if there are any zero-force members.

b) Draw FBDs of pins D and B, and then apply EE at those pins to solve for the unknowns.

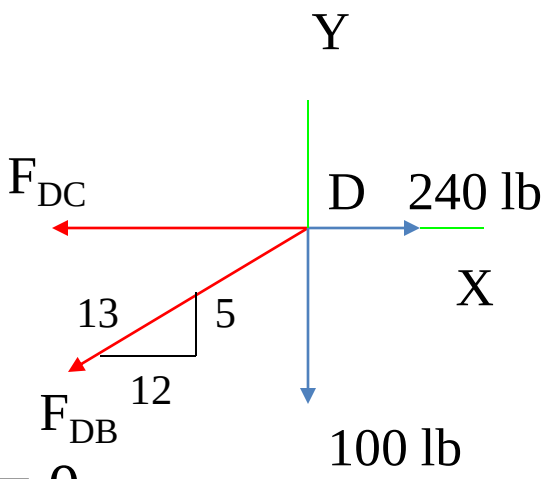
Solution:

Members AB and AC are zero-force members.

GROUP PROBLEM SOLVING

(continued)

FBD of pin D



Analyzing pin D:

$\uparrow + \sum F_Y = -100 - (5/13)\, F_{DB} = 0$

$F_{DB} = -260$ lb (C)

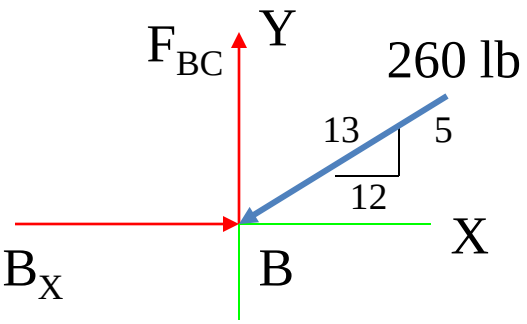
$\rightarrow + \sum F_X = 240 - F_{DC} - (12/13)(-260) = 0$

$F_{DC} = 480$ lb (T)

Analyzing pin B:

$\uparrow + \sum F_Y = F_{BC} - (5/13)\, 260 = 0$

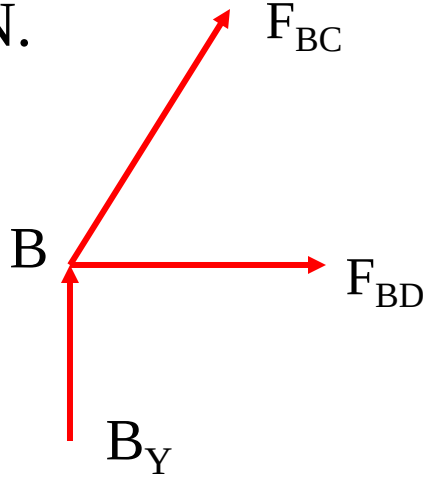
$F_{BC} = 100$ lb (T)



FBD of pin B

ATTENTION QUIZ

1. Using this FBD, you find that $F_{BC} = -500$ N. Member BC must be in _____.



   A) tension

   B) compression

   C) cannot be determined

2. For the same magnitude of force to be carried, truss members in compression are generally made _____ as compared to members in tension.

   A) thicker

   B) thinner

   C) the same size

End of the Lecture

Let Learning Continue