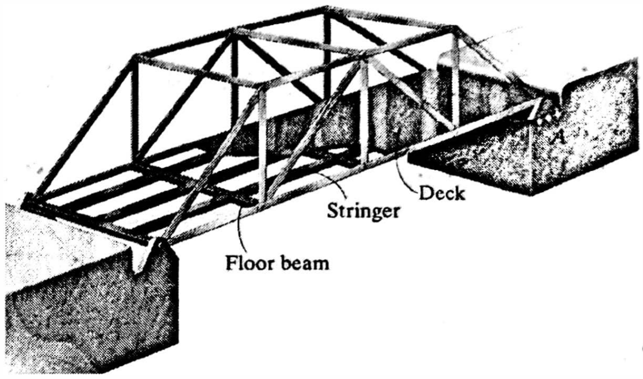
Name: ______________
Group members: ____________________ ____________________ ____________________

TAM 210/211 - Worksheet 8

Truss Analysis

A simple model of a bridge is an example of a truss: load transferred from the deck to stringers, and from stringers to floor beams, and the floor beams then connect to the joints in supporting side trusses.

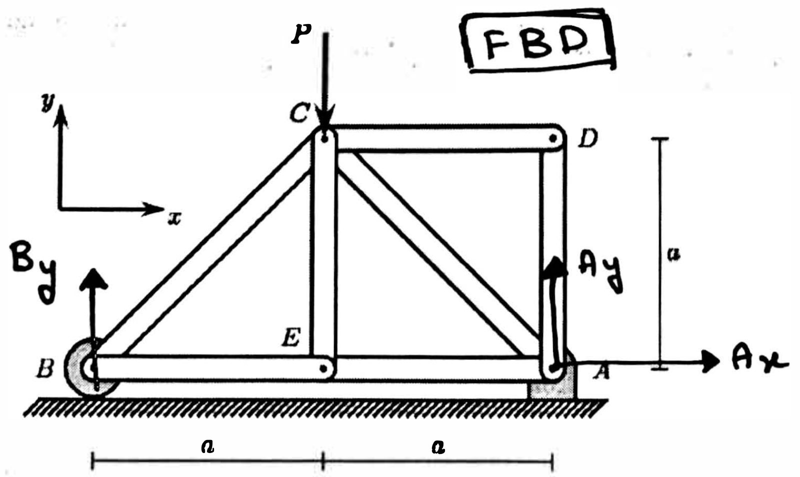


To analyze the design of a truss, we will work through a **free-body diagram** including **reaction forces**, followed by **equations for equilibrium**, and determine **reaction forces at the supports** and **internal forces** on the supporting side truss members. For everything ahead, we will simplify the problem by considering it in 2D.

Objectives:

- Identify whether truss members are in tension or compression.
- Identify zero-force members.

1) A truss experiences a load of magnitude P downward as shown in the figure below. The truss has a roller support at B and is pinned at A. Draw a free body diagram for the truss.



$A_x = 0$

2) Use the FBD from Question 1 to find the support reaction forces at A and B in terms of the load P and distance a.

$\Sigma F_x = 0 \Rightarrow A_x = 0$

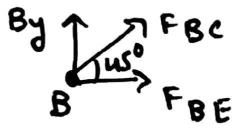
$\Sigma F_y = 0 \Rightarrow B_y + A_y - P = 0$

$\boxed{A_y = P/2}$

$\Sigma M_A = 0 \Rightarrow -B_y(2a) + P(a) = 0$

$\Rightarrow \boxed{B_y = P/2}$

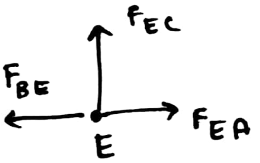
3) Use the method of joints for pin B to determine the forces in members BC and BE in terms of P and a, specify whether they are in tension or compression. Then repeat the process with pins E, C and A for members AC, AD, AE, CD and CE.



$\Sigma F_x = 0 \Rightarrow F_{BE} + \frac{F_{BC}}{\sqrt{2}} = 0$

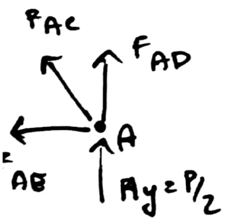
$\Sigma F_y = 0 \Rightarrow B_y + \frac{F_{BC}}{\sqrt{2}} = P/2 + \frac{F_{BC}}{\sqrt{2}} = 0$

$\Rightarrow \boxed{F_{BC} = -P/\sqrt{2}}$ compression $\boxed{F_{BE} = P/2}$ tension



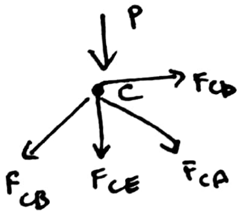
$\Sigma F_x = -F_{BE} + F_{EA} = -P/2 + F_{EA} = 0 \Rightarrow \boxed{F_{EA} = P/2}$ tension

$\Sigma F_y = \boxed{F_{EC} = 0}$ - zero force member



$\Sigma F_x = -F_{EA} - F_{AC}/\sqrt{2} = 0 \Rightarrow \boxed{F_{AC} = -P/\sqrt{2}}$ compression

$\Sigma F_y = F_{AD} + A_y + \frac{F_{AC}}{\sqrt{2}} = 0 \Rightarrow \boxed{F_{AD} = 0}$ zero force



$\Sigma F_x = -\frac{F_{CB}}{\sqrt{2}} + \frac{F_{CA}}{\sqrt{2}} + F_{CD} = 0 \Rightarrow \boxed{F_{CD} = 0}$ zero force member

4) Which members experience zero force? These are called zero-force members.

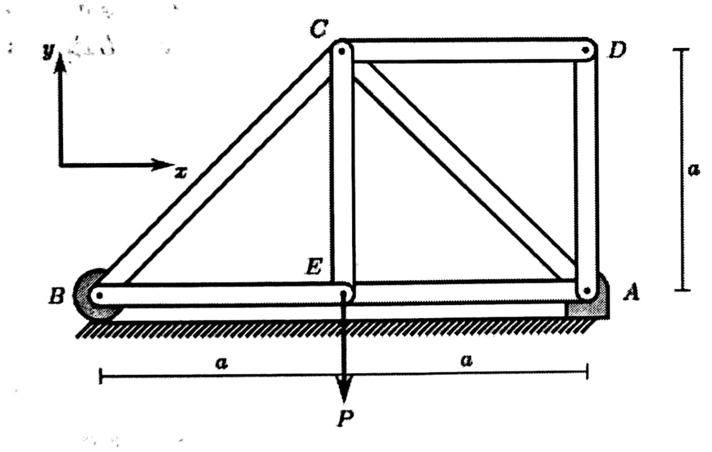
EC, AD, CD

5) Construct the truss from Question 1 with the given truss kit. Tension members are red and compression members are blue. Use the appropriate type of members according to your answer for Question 3, and use compression members for zero-force members. Use your finger to apply load P. Does your truss retain its shape after the loading is applied? If not, go over Question 3 again to make sure that all the members are correctly classified.

6) Remove zero-force members from the truss kit structure. What happens when load P is applied at C? Why?

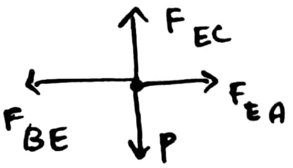
Nothing happens, as zero-force members donot support the truss. Their presence or absence makes no difference.

7) If the same load P is applied at E instead of C, will each truss member experience the same tensile/compressive force? Test it on your kit structure from Question 6. What changed?



No, as member EC is no longer a zero-force member.

8) Perform the method of joints analysis on pin E and reconstruct the new truss system with the kit again and show that correct tension and compression members are identified. Which members are now in tension? And zero-force members?

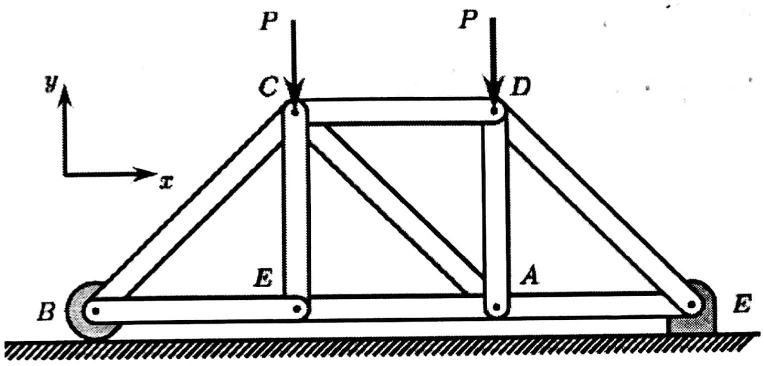


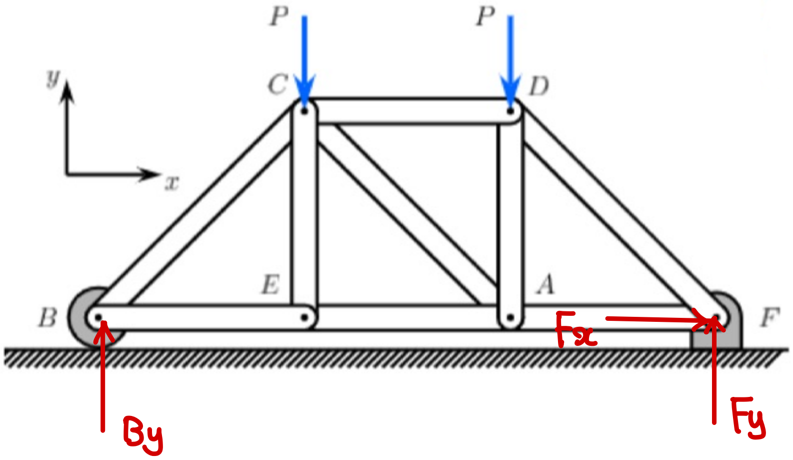
$$\Sigma F_x = -F_{BE} + F_{EA} = 0 \Rightarrow F_{BE} = F_{EA} = P/2 \text{ [tension]}$$

$$\Sigma F_y = F_{EC} - P = 0 \Rightarrow F_{EC} = P \text{ [tension]}$$

No zero-force members at pin E.

9) *Challenge.* Determine which members in the truss below are in tension and compression, and check your solution by constructing the truss and apply appropriate loadings.





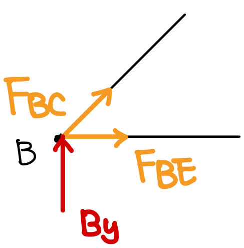
For the entire system) $\Sigma F_x = F_x = 0 \rightarrow F_x = 0$

$\Sigma F_y = B_y + F_y - 2P = 0$

$\Sigma M_F = a \times P + 2a \times P - 3a \times B_y = 0 \rightarrow B_y = P$

$\therefore F_y = -B_y + 2P = P$

For Joint B)



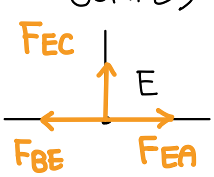
$\Sigma F_x = F_{BE} + F_{BC}\cos 45^\circ = 0$

$\Sigma F_y = B_y + F_{BC}\sin 45^\circ = 0$

$F_{BC} = -B_y \cdot \frac{1}{\sin 45^\circ} = -P \times \frac{2}{\sqrt{2}} = -\sqrt{2}P$ (comp.)

$F_{BE} = -F_{BC}\cos 45^\circ = \sqrt{2}P \times \frac{\sqrt{2}}{2} = P$ (ten.)

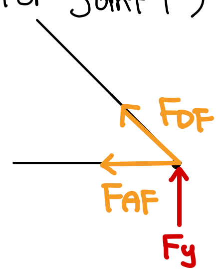
For Joint E)



$F_{EC} = 0$ (∵ zero force member rule)

$F_{EA} = F_{BE} = P$ (ten.)

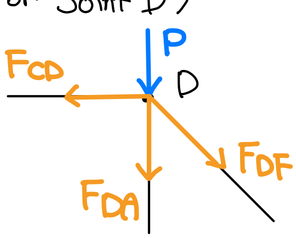
For Joint F)



$\Sigma F_x = -F_{AF} - F_{DF}\cos 45^\circ = 0 \rightarrow F_{DF} = -\frac{F_y}{\sin 45^\circ} = -\sqrt{2}P$ (comp.)

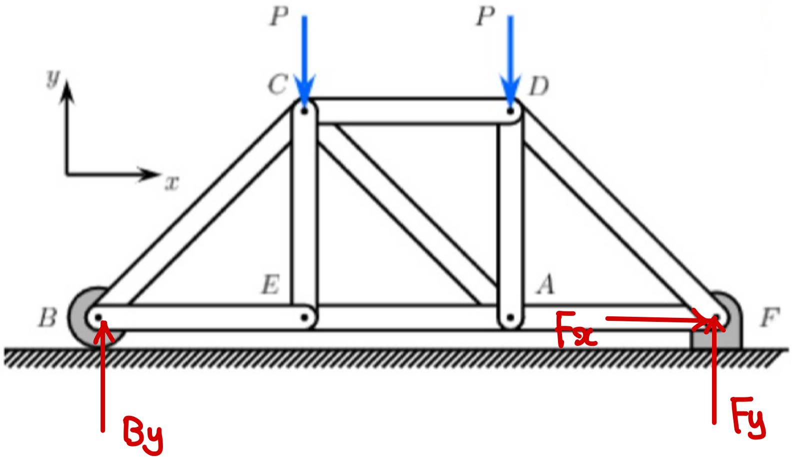
$\Sigma F_y = F_{DF}\sin 45^\circ + F_y = 0 \rightarrow F_{AF} = \sqrt{2}P \cdot \frac{\sqrt{2}}{2} = P$ (ten.)

For Joint D)

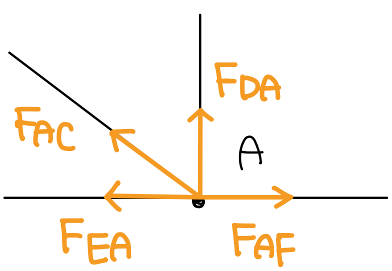


$\Sigma F_x = -F_{CD} + F_{DF}\sin 45^\circ = 0 \rightarrow F_{CD} = -\sqrt{2}P \times \frac{\sqrt{2}}{2} = -P$ (comp.)

$\Sigma F_y = -P - F_{DA} - F_{DF}\cos 45^\circ = 0 \rightarrow F_{DA} = -P + \sqrt{2}P \times \frac{\sqrt{2}}{2} = 0$



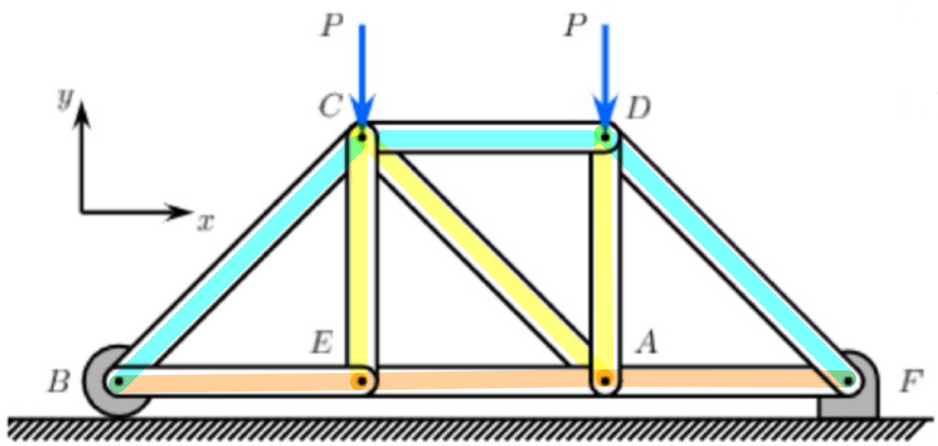
For Joint A)



$\Sigma F_x = F_{AF} - F_{EA} - F_{AC}\cos 45° = 0 \rightarrow P - P - F_{AC}\cos 45° = 0$

$\Sigma F_y = \underbrace{\cancel{F_{DA}}}_{0} + F_{AC}\sin 45° = 0$

$\rightarrow F_{AC}\sin 45° = 0 \rightarrow F_{AC} = 0$



: zero force member

: compression

: tension