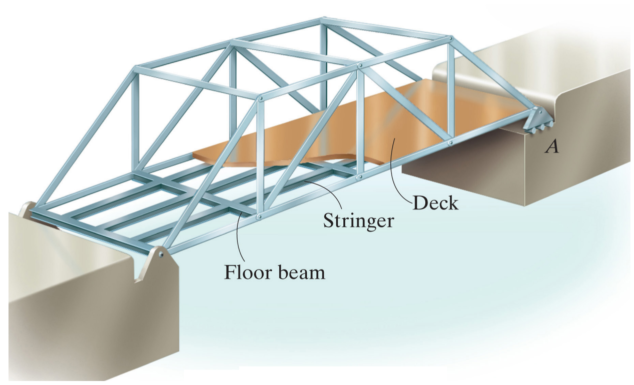
Name: _______________
Group members: ____________________ ____________________ ____________________

TAM 210/211 - Worksheet 8

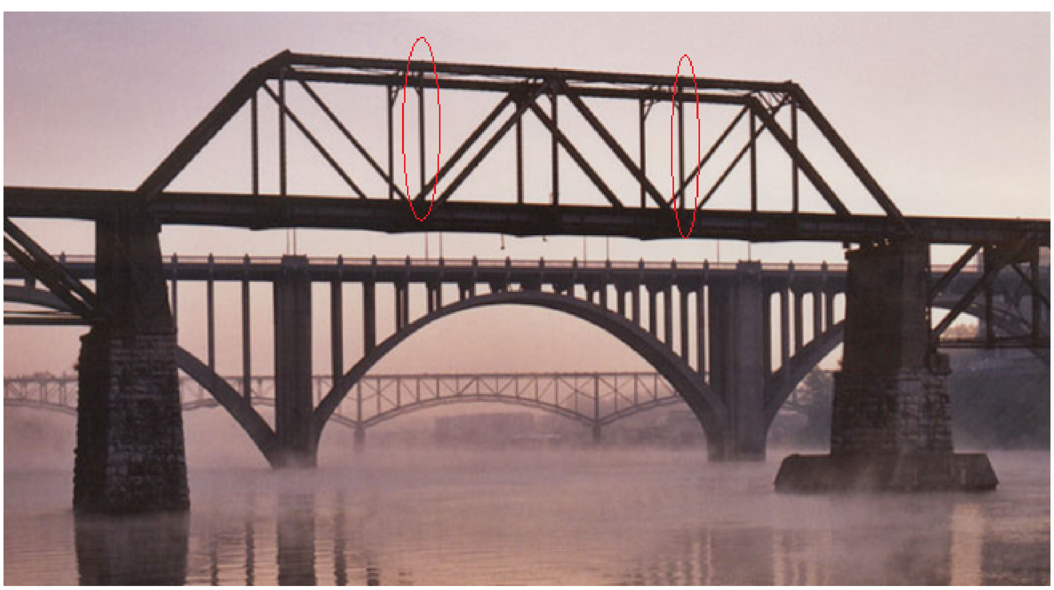
Today we will analyze loads on members in bridge, and identify how compressive vs. tensile loading takes place in a bridge.

Bridge Structure and trusses

We saw a simple model of a bridge: 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.

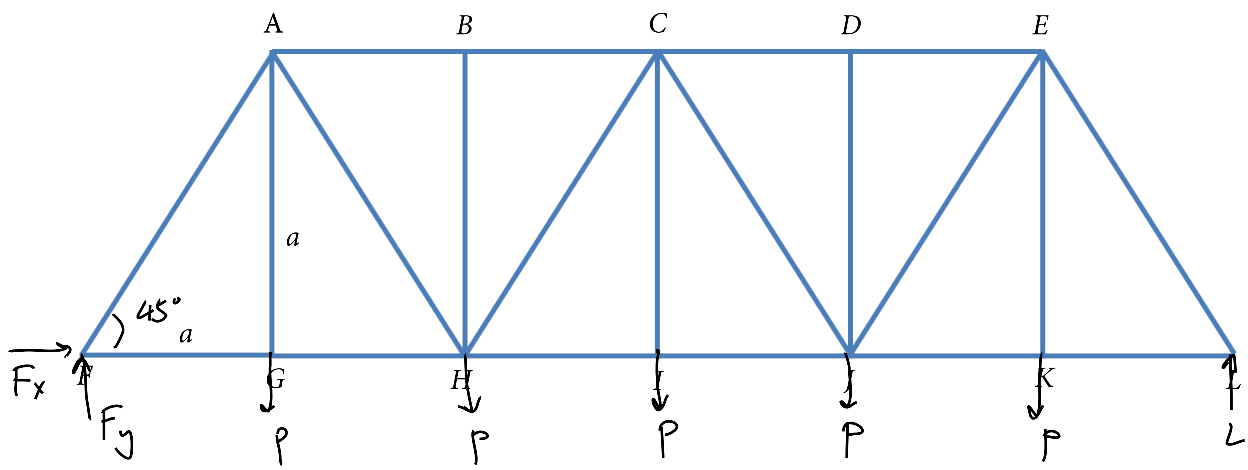


To analyze the bridge, we will work through a **free-body diagram** including **reaction forces**, followed by **equations for equilibrium**, and determine **reaction forces at the pylons** (supports) and **internal forces** on the supporting side truss members. For everything ahead, we will simplify the problem by considering it in 2D. Take the bridge below, where all vertical and horizontal members have a fixed length a, with a vertical load P at each of the joints in the support along the deck and at the pylons. This load P corresponds to the load from the deck.



1) Use the figure below to construct the free-body diagram for the supporting side truss of the bridge. Model one pylon at F as a pin and the other one at L as a roller. The same vertical load from the deck is applied at joints G, H, I, J and K.

FBD



2) Obtain expressions for the reaction forces as a function of P and a.

$$\Sigma F_x = F_x = 0$$

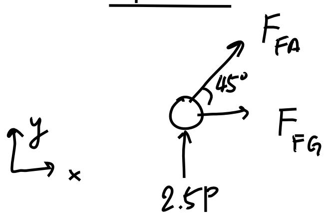
$$\Sigma F_y = F_y - 5P + L = 0$$

$$\Sigma M_F = -aP - 2aP - 3aP - 4aP - 5aP + 6aL = 0$$

- at pin support F: $F_x = 0$, $F_y = 2.5P$
- at roller support L: $L = 2.5P$

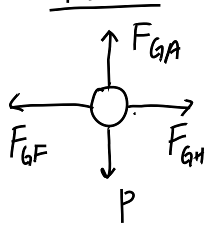
3) Use the method of joint to find the internal forces in truss members AF, (and GH) AG, AB, FG and BH as functions of P and a, indicate if it is compressive or tensile.

Pin F



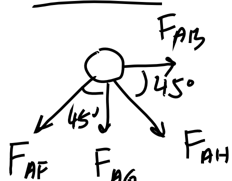
$$\Sigma F_x = F_{FA}\cos 45^\circ + F_{FG} = 0$$
$$\Sigma F_y = 2.5P + F_{FA}\sin 45^\circ = 0$$
$$\rightarrow \quad F_{FA} = -2.5\sqrt{2}P \quad (C)$$
$$F_{FG} = +2.5P \quad (T)$$

Pin G



$$\Sigma F_x = -F_{GF} + F_{GH} = 0$$
$$\Sigma F_y = F_{GA} - P = 0$$
$$\rightarrow \quad F_{GH} = F_{GF} = 2.5P \quad (T)$$
$$F_{GA} = P \quad (T)$$

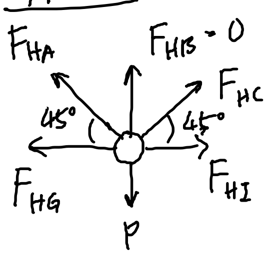
Pin A



$$\Sigma F_x = -F_{AF}\sin 45^\circ + F_{AB} + F_{AH}\cos 45^\circ = 0$$
$$\Sigma F_y = -F_{AF}\cos 45^\circ - F_{AG} - F_{AH}\sin 45^\circ$$
$$\longrightarrow \quad F_{AB} = -4P \quad (C)$$
$$F_{AH} = 1.5\sqrt{2}P \quad (T)$$

Zero-force member : BH

Pin H



$$\Sigma F_x = -F_{HG} - F_{HA}\cos 45^\circ + F_{HC}\cos 45^\circ + F_{HI} = 0$$
$$\Sigma F_y = F_{HA}\sin 45^\circ + F_{HB} + F_{HC}\sin 45^\circ - P = 0$$
$$\rightarrow \quad F_{HC} = -0.5\sqrt{2}P \quad (C)$$
$$F_{HI} = 4.5P \quad (T)$$

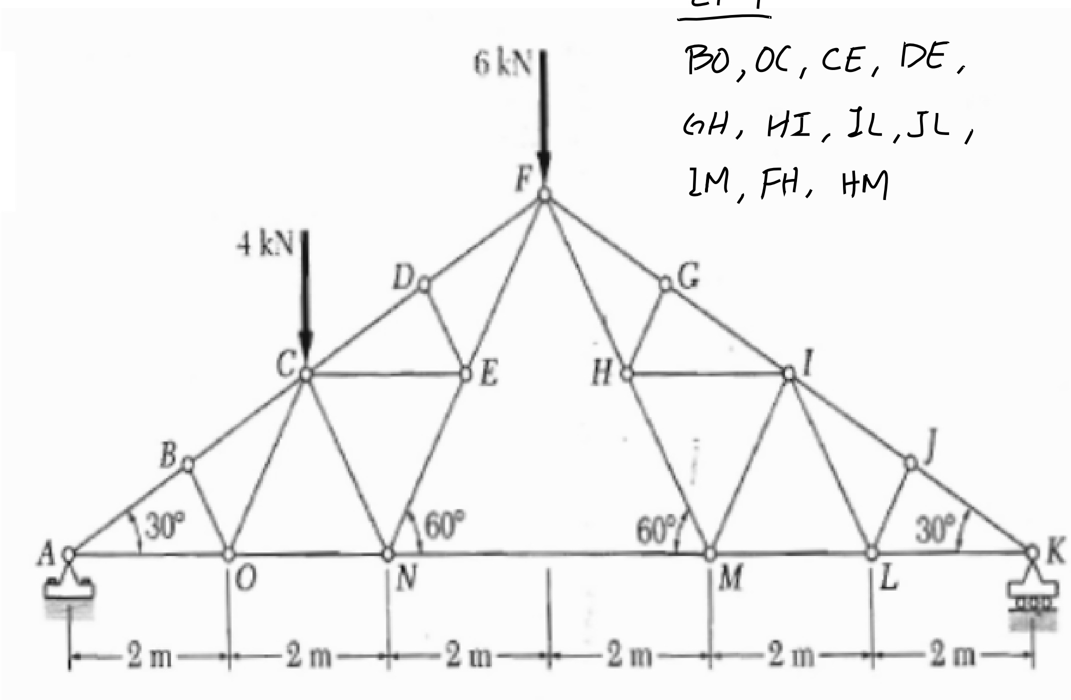
4) Take a look again at the bridge picture on page 1. Do you see anything different when comparing tensile vs. compressive members? Are all members the same size? Explain your findings.

The top chord (upper horizontal members) are in compression and the bottom chord (lower horizontal members) are in tension. Compressive members are thicker because these truss members have weaker compressive strength than tensile strength.

5) What would happen if you remove the two circled truss members (e.g. BH) from the bridge? Why?

Nothing would change because they are zero-force members.

6) Identify all the zero-force members in the truss below.

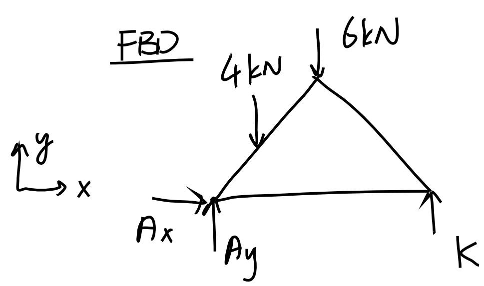


ZFM

BO, OC, CE, DE,
GH, HI, IL, JL,
IM, FH, HM

7) Draw a free-body diagram to determine the reaction forces at the supports A and K.

FBD



EoE

$\Sigma F_x = A_x = 0$

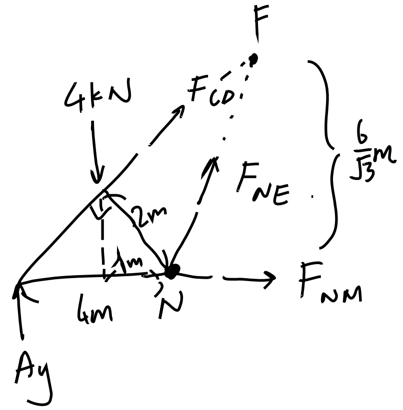
$\Sigma F_y = A_y - 4kN - 6kN + K = 0$

$\Sigma M_A = -(3m)(4kN) - (6m)(6kN) + (12m)K = 0$

$K = 4kN, \quad A_y = 6kN$

8) Use the method of sections to determine the internal forces in members CD and MN.

FBD



$\Sigma M_N = (1m)(4kN) - (4m)A_y - (2m)F_{CD} = 0$

$\rightarrow F_{CD} = -10$ kN (C)

$\Sigma M_F = \left(\frac{6}{\sqrt{3}}m\right)F_{MN} + (3m)(4kN) - (6m)A_y = 0$

$\rightarrow F_{MN} = 4\sqrt{3}$ kN (T)