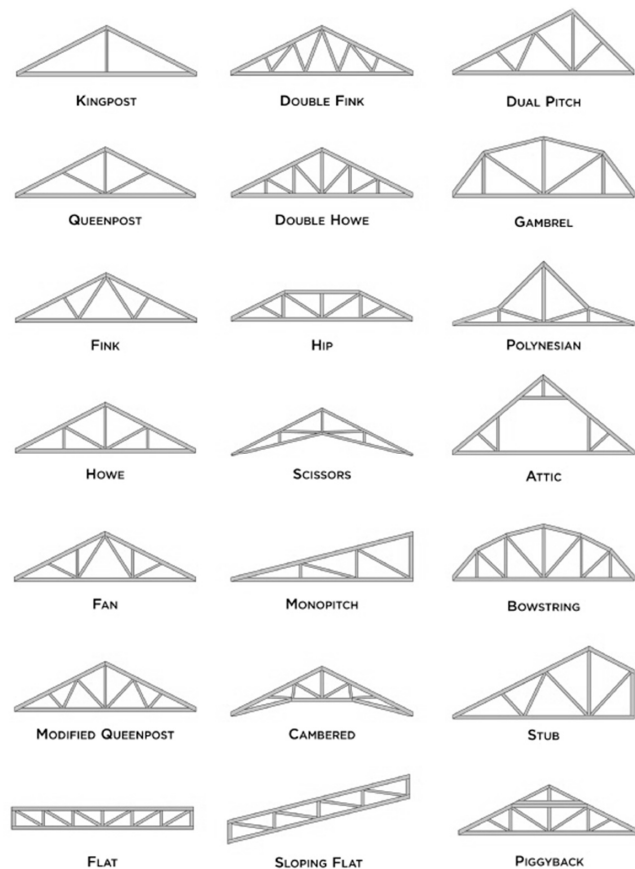


Trusses by Sections

Analysis by sections

Examples



Definitions and Assumptions of Truss Systems

2 Force Members ✓

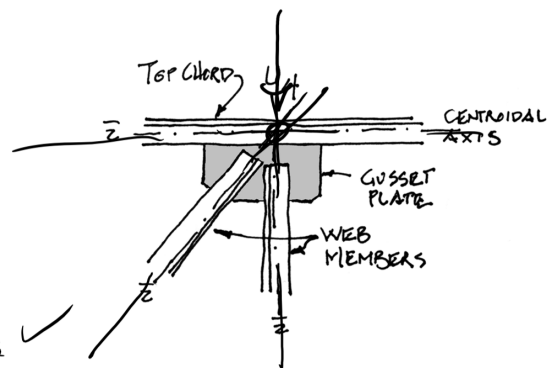
Pinned Joints ✓

Concurrent Member Centroids at Joints ✓

Joint Loaded ✓

Straight Members ✓

Small Deflections



Bullring Covering, Xàtiva, Spain
Kawaguchi and Engineers, 2007

Qualitative T or C

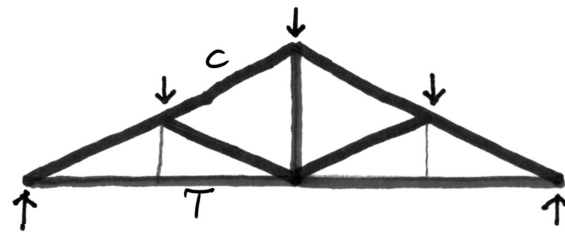
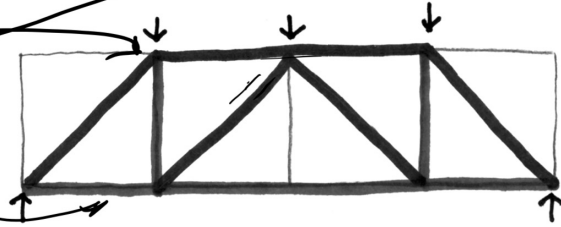
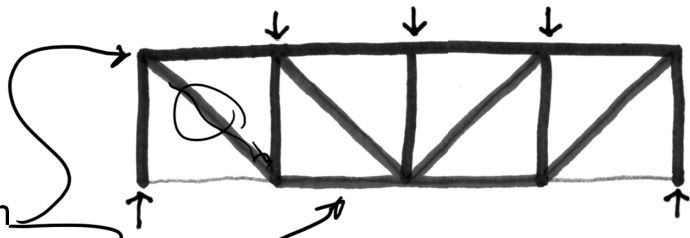
For typical gravity loading:
(tension=red compression=blue)

Top chords are in compression

Bottom chords are in tension

Diagonals down toward center
are in tension (usually)

Diagonals up toward center are
in compression (usually)

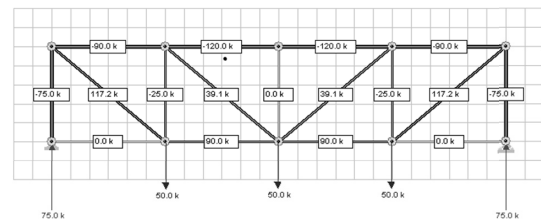
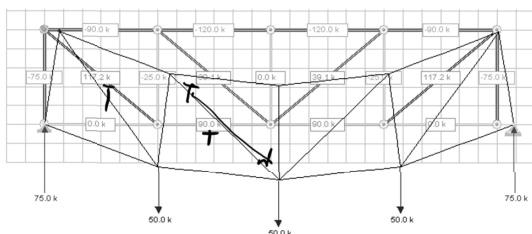
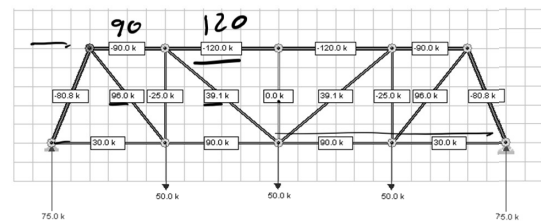
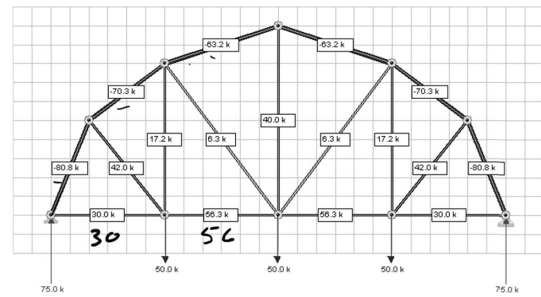


Qualitative Force

For spanning trusses with uniform
loading: (tension=blue compression=red)

Top and bottom chords greatest at
center when flat (at maximum
curvature or moment)

Diagonals greatest at ends (near
reactions, i.e. greatest shear)



Truss Analysis

Method of Joints ✓

Method of Sections ←

Graphic Methods

James Clerk Maxwell 1869

M. Williot 1877

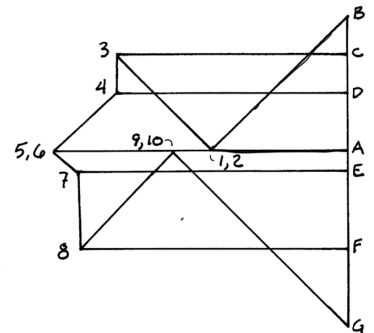
Otto Mohr 1887

Heinrich Müller-Breslau 1904

William Baker, SOM



James Clerk Maxwell

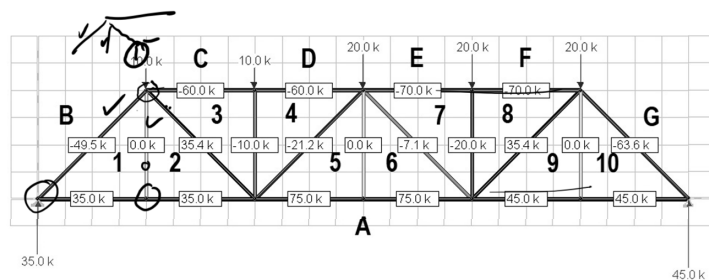


Computer Programs

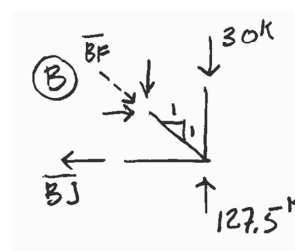
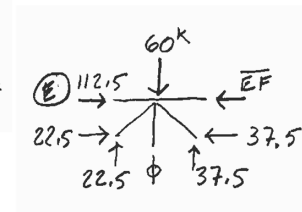
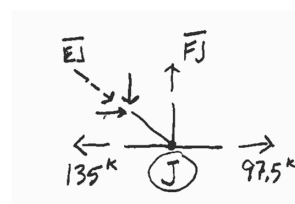
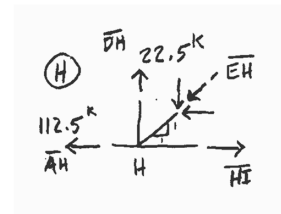
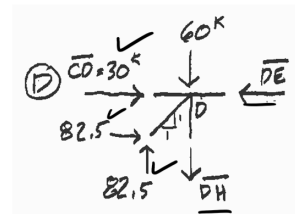
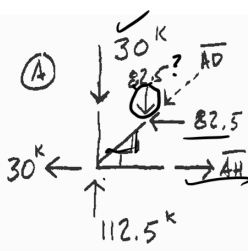
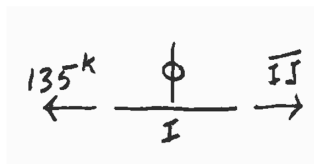
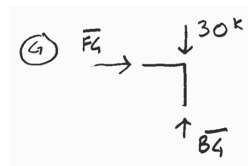
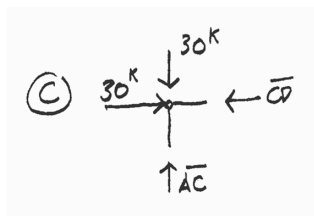
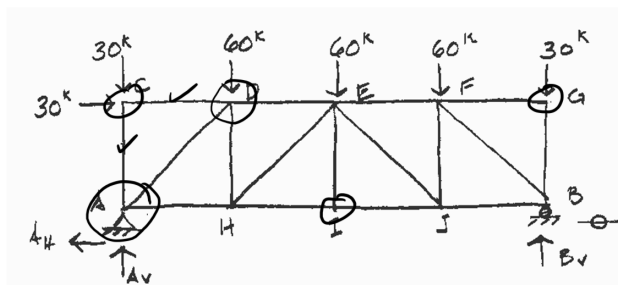
Dr. Frame (2D)

STAAD Pro (2D or 3D)

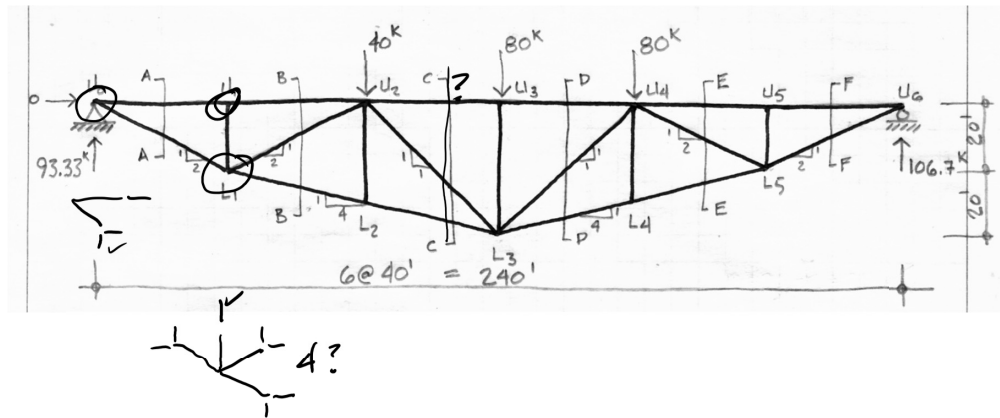
West Point Bridge Designer



Method of Joints – procedure

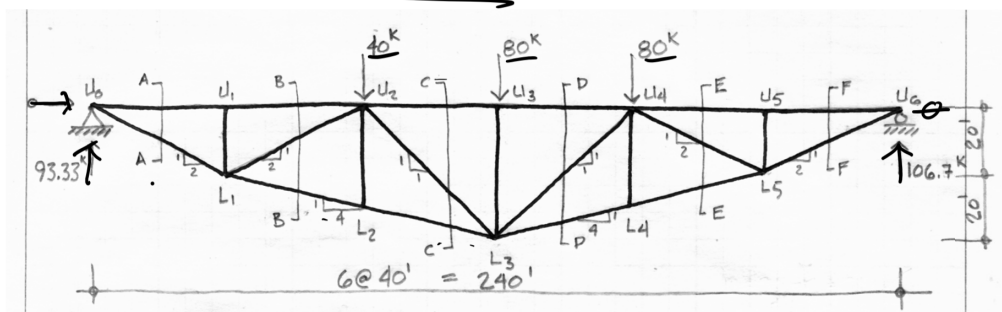


Method of Sections

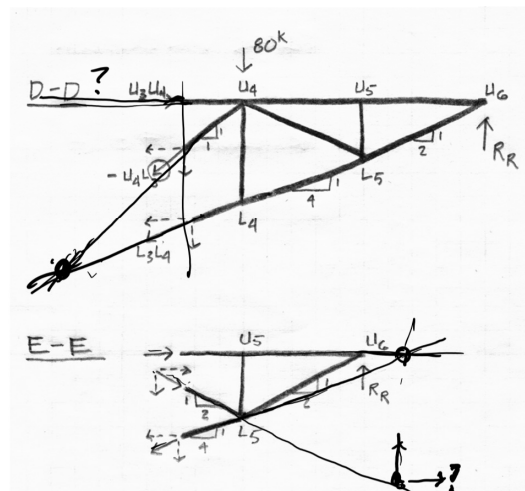


- Makes use of all 3 statics equations: $\sum F_x$, $\sum F_y$, $\sum M$
- Can solve some statically determinate trusses that cannot be solved by joints.
- Can solve for most members directly. ✓

Method of Sections - procedure



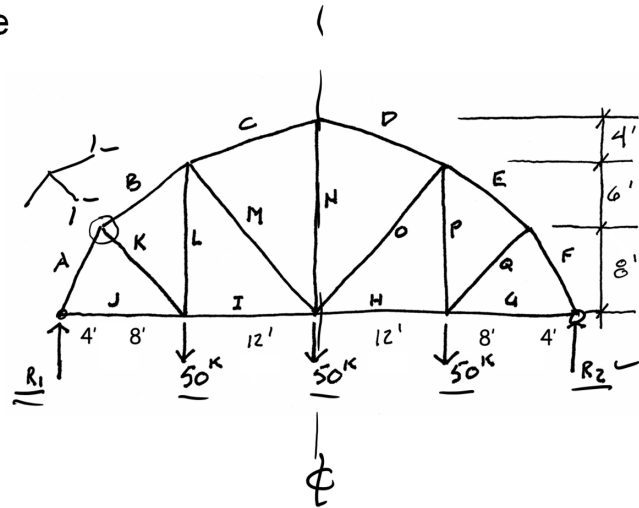
1. Solve Reactions ✓
2. Cut section through truss.
3. Choose point where all but one of the unknown forces cross and $\sum M$
4. Continue with $\sum F_H$ and $\sum F_V$



Method of Sections - example

1. Solve the external reactions for the whole truss.

Sum moments about each end. Or using symmetry, divide vertical forces evenly between reactions



REACTIONS :

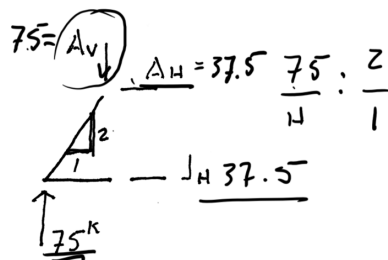
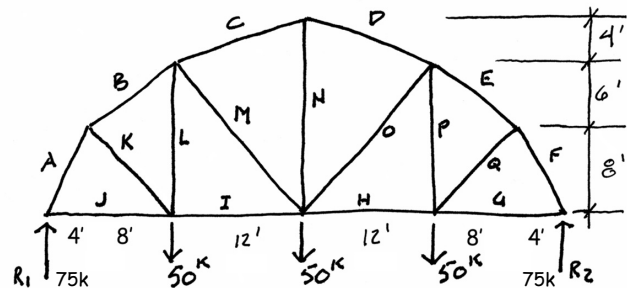
$$\begin{aligned}\sum M_{R1} &= 0 \\ &= 50(12') + 50(24') + 50(36') - R_2(48') \\ R_2(48') &= 3600 \text{ k-ft} \\ R_2 &= \underline{75 \text{ k}}\end{aligned}$$

$$\begin{aligned}\sum M_{R2} &= 0 \\ &= R_1(48') - 50(36') - 50(24') - 50(12') \\ R_1(48') &= 3600 \text{ k-ft} \\ R_1 &= \underline{75 \text{ k}}\end{aligned}$$

Method of Sections - example

2. Solution proceeds by cutting FBDs of either joints or sections of the truss.

Member forces are shown as horizontal and vertical force components at each cut section.



$$\begin{aligned}\sum F_v &= 0 = 75 - A_v \\ A_v &= \underline{75 \text{ k}} \downarrow \\ A_h &= \underline{37.5 \text{ k}} \leftarrow\end{aligned}$$

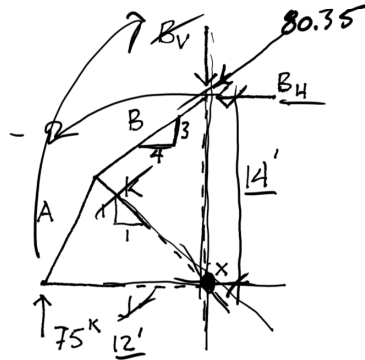
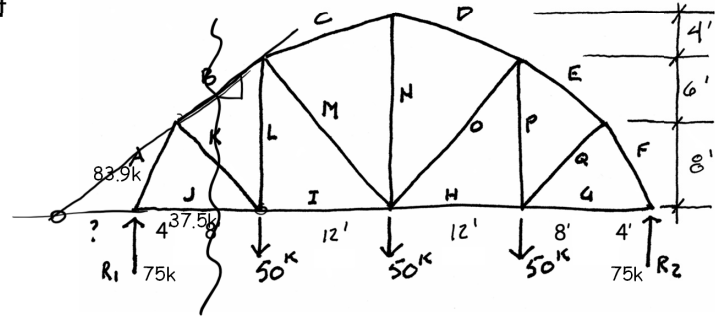
$$\begin{aligned}\sum F_h &= 0 = -37.5 + J_h \\ J_h &= \underline{37.5 \text{ k}} \rightarrow T\end{aligned}$$

Method of Sections - example

- Solution proceeds by cutting FBDs of either joints or sections of the truss.

Member forces are shown as horizontal and vertical force components at each cut section.

- Choose a point where all but one of the forces cross and sum moments.

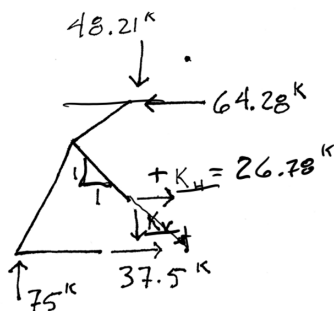
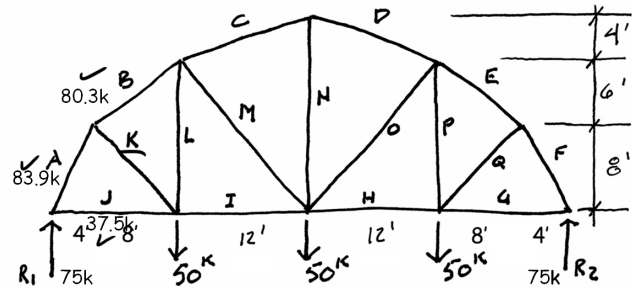


$$\begin{aligned}\sum M_x = 0 &= 75^k(12') - B_H(14') \\ B_H &= 64.28^k \leftarrow \\ \frac{3}{4} : \frac{B_V}{64.28^k} \\ B_V &= 48.21^k \downarrow \\ B &= 80.35^k \quad C\end{aligned}$$

Method of Sections - example

- Continue with $\sum F_H$ and $\sum F_V$

Member forces are shown as horizontal and vertical force components at each cut section.

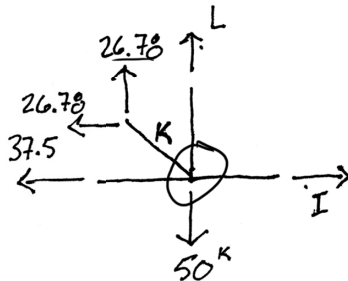
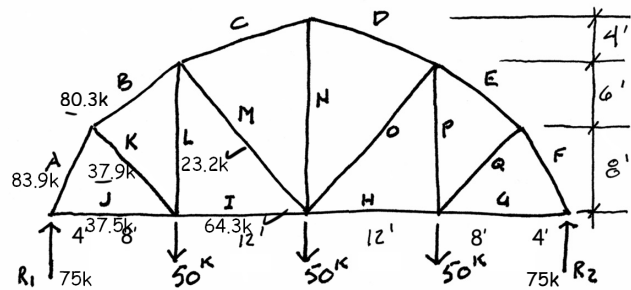


$$\begin{aligned}\sum F_H = 0 &= +37.5 - 64.28 + K_H \\ K_H &= 26.78^k \rightarrow \\ K_V &= 26.78^k \downarrow \\ K &= 37.87^k \quad T\end{aligned}$$

Method of Sections - example

4. Continue with ΣF_H and ΣF_V

Member forces are shown as horizontal and vertical force components at each cut section.



$$\Sigma F_V = 0 = 26.78^k - 50^k + L$$

$$L = 23.22^k \text{ T}$$

$$\Sigma F_H = 0 = -37.5 - 26.78 + I$$

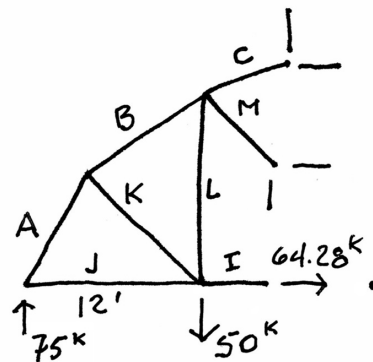
$$I = 64.28^k \text{ T}$$

Method of Sections - example

2. Solution proceeds by cutting FBDs of either joints or sections of the truss.

Member forces are shown as horizontal and vertical force components at each cut section.

3. Choose a point where all but one of the forces cross and sum moments.



$$\Sigma M_X = 0$$

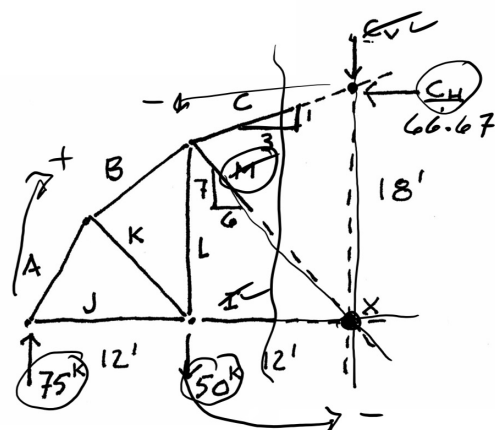
$$= 75^k(24') - 50^k(12') - C_H(18')$$

$$C_H(18) = 1200$$

$$C_H = 66.67^k \leftarrow$$

$$C_V = 22.22^k \downarrow$$

$$C = 70.27^k \checkmark$$



Method of Sections - example

4. Continue with ΣF_H and ΣF_V

Member forces are shown as horizontal and vertical force components at each cut section.

$$\Sigma F_V = 0 = 75 - 50 - 22.22 - M_V$$

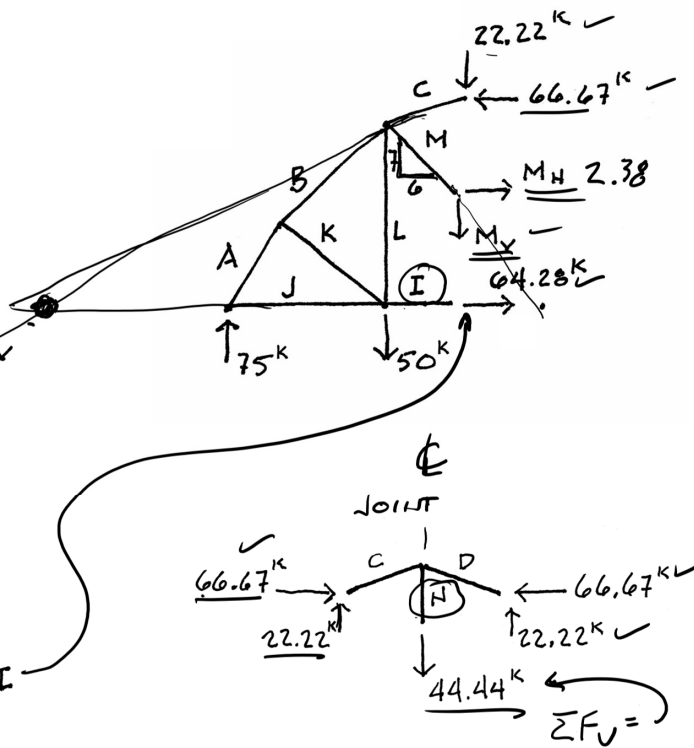
$$M_V = 2.78 \text{ K} \downarrow$$

$$M_H = 2.38 \text{ K} \rightarrow$$

$$M = 3.66 \text{ K T}$$

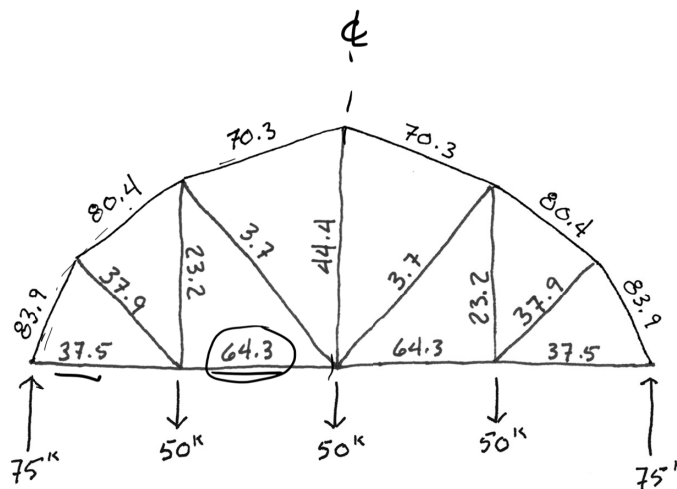
$$\Sigma F_H = 0 = -66.67 + 2.38 + I$$

$$I = 64.29 \text{ K T}$$



Method of Sections - example

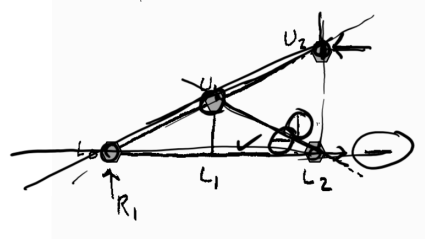
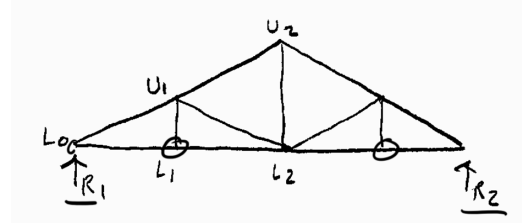
5. Make final qualitative check of solution.



Tips on Sections

Howe Truss

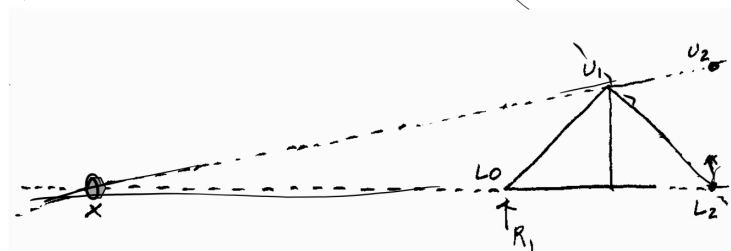
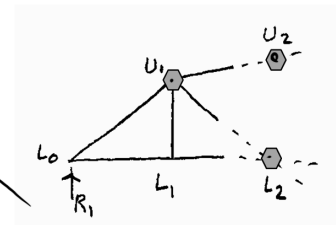
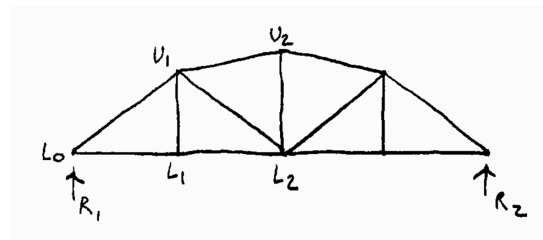
1. Cut a panel with diagonals
2. ΣM at $\underline{L_2}$ and resolve upper chord force at U_2 . This gives $\underline{U_1 U_2 H}$
3. ΣM at U_1 to find $L_1 L_2$
4. ΣM at $\underline{U_2}$ and resolve $U_1 L_2$ at L_2 to find $\underline{U_1 L_2 H}$
5. ΣM at L_0 and resolve $U_1 L_2$ at L_2 to find $\underline{U_1 L_2 V}$
6. $U_1 U_2 V$ can now be found by ΣF_v



Tips on Sections

Parker Truss

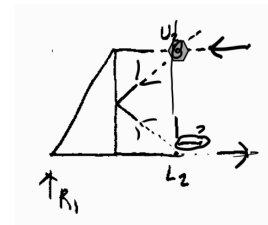
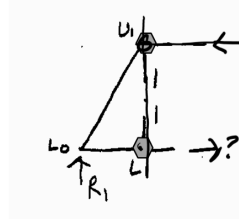
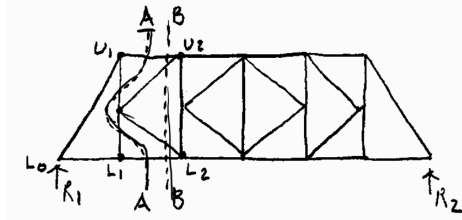
1. Cut a panel with diagonals and ΣM at L_2 to solve $U_1 U_2 H$ as before.
2. ΣM at U_1 to find $L_1 L_2$
3. ΣM at U_2 and resolve $U_1 L_2$ at L_2 to find $U_1 L_2 H$
4. Find point x in line with $U_1 U_2$. ΣM at x and resolve $U_1 L_2$ at L_2 to find $U_1 L_2 V$
5. $U_1 U_2 V$ can now be found by ΣF_v



Tips on Sections

K Truss

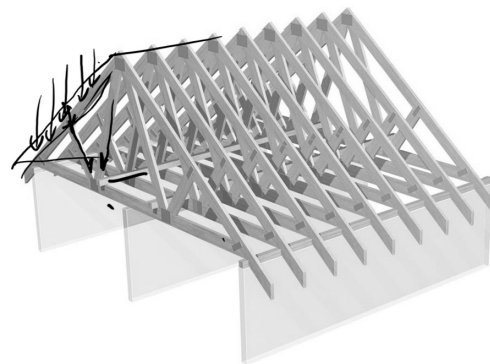
1. Make cut A-A to avoid the mid panel joint
2. ΣM at U_1 to get L_1L_2
3. ΣM at L_1 to get U_1U_2
4. The vertical web forces can be solved using joints
5. Cut B-B through the diagonals
6. ΣM at U_2 and resolve lower diagonal at L_2 to find its H component. The V component can be found by slope triangle. Top and bottom chords are known from steps 2. & 3.
7. Repeat step 6 by ΣM at L_2 to find other diagonal.



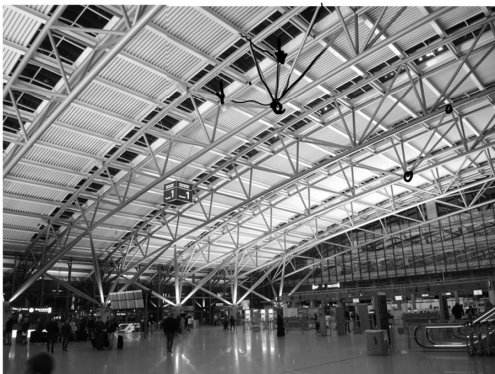
Examples of Trusses



Timber Frame



Light Frame – dimensioned lumber



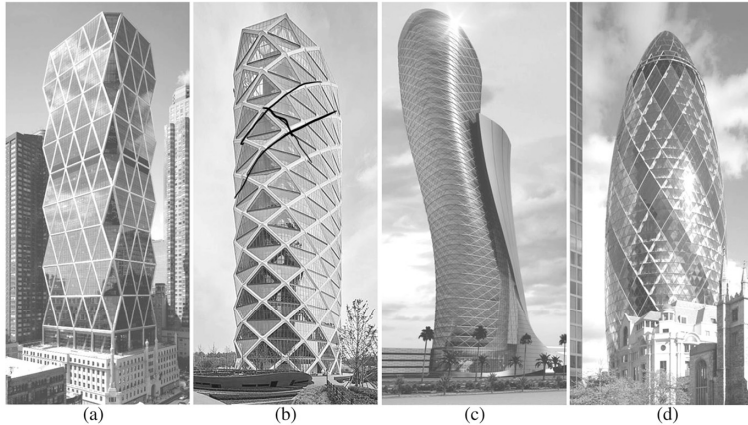
Hamburg Airport – steel tube truss



Concrete Truss – Kilburn Rd. Bridge, Calif.

Trussed Lateral Bracing

Diagrid Towers



(a) Hearst Tower in NY

(b) Poly International Plaza tower in Chaoyang Qu

(c) Capital Gate tower in Abu Dhabi

(d) 30 St. Mary Axe in London



John Hancock Tower - 1968
875 North Michigan Avenue, Chicago
Fazlur Kahn, SOM

Optimized Principal Stress Grid

Figure 1. (a) Original Michell's minimum frame [9], (b) structural design by Zalewski and Zabłocki [105], and (c) CITIC financial centre in Shenzhen by SOM [105]. William Baker

