Analysis of Truss Structures

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Overview

1. Analysis of Truss Structure
   - Modeling Assumptions
2. Method of Joints
   - Procedure and Examples
3. Method of Sections
   - Procedure and Examples

Part 1

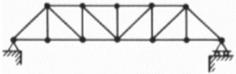
4. Zero-Force Members
   - Identification and Examples
5. Summary

Types of Truss Structure

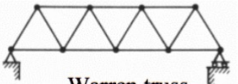
(Please download handouts on class web page)

Types of Truss Structure

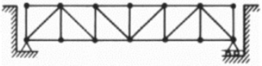
Many types of truss structure (see handout on class web page):



trough Pratt truss

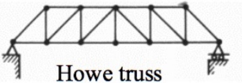


Warren truss

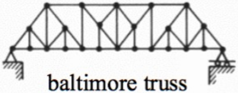


deck Pratt truss

parker truss
(pratt truss with curved chord)



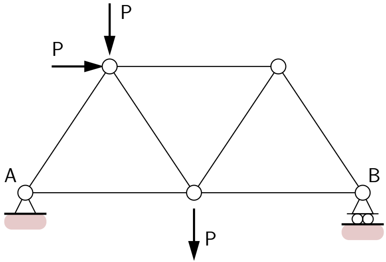
Howe truss



baltimore truss

Analysis of Truss Structure

Modeling Assumptions

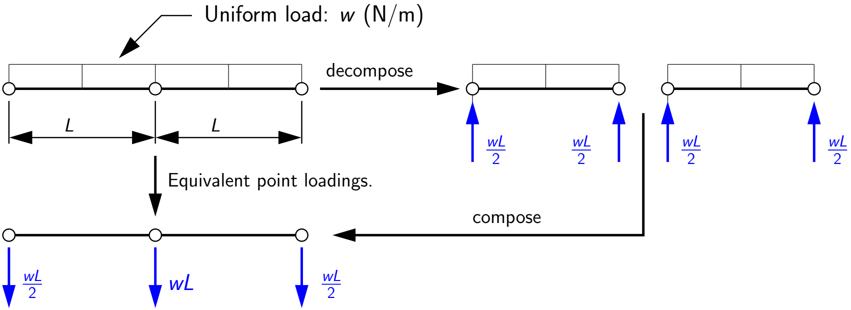


- Pins offer no resistance to moment (i.e., frictionless).
- Truss elements are straight.
- Truss elements can only carry axial forces: tension (T), compression (C).
- Loads are only applied at the joints.

Modeling Assumptions

Treatment of Uniform Loads

Uniform loads need to be converted into equivalent point loads.

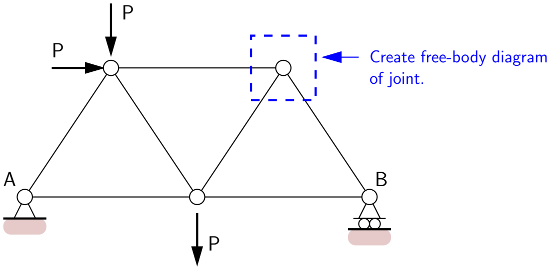


Method of Joints

Method of Joints

Procedure and Assumptions

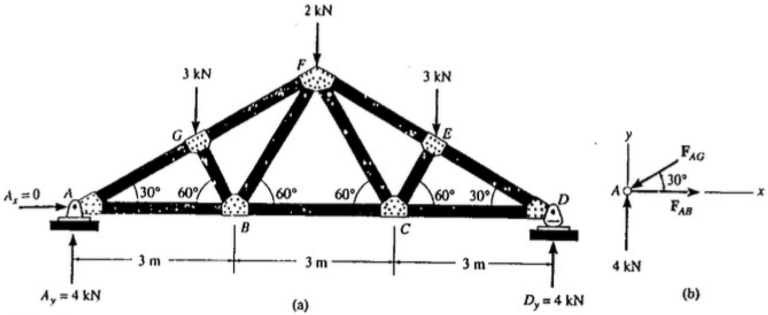
- Create free-body diagram for each joint and consider equilibrium of forces. Two equations of equilibrium per joint.



- Bar forces are aligned with the corresponding bars.
- All forces pass through center of joint.

Method of Joints

Example 1.



Note. Geometry and loading pattern are symmetric about point F.

Solution Strategy. Compute member forces at points B and G. Use symmetry → member forces on right-hand side of structure. Verify equilibrium at point F.

Method of Joints

Solution

Only the forces in half the members have to be determined, since the truss is symmetric with respect to *both* loading and geometry.

Joint A, Fig. 3–20b. We can start the analysis at joint A. Why? The free-body diagram is shown in Fig. 3–20b.

$+\uparrow\Sigma F_y = 0;\quad 4 - F_{AG}\sin 30^\circ = 0 \qquad F_{AG} = 8\text{ kN (C)}$ ***Ans.***

$\overset{+}{\rightarrow}\Sigma F_x = 0;\quad F_{AB} - 8\cos 30^\circ = 0 \qquad F_{AB} = 6.93\text{ kN (T)}$ ***Ans.***

Joint G, Fig. 3–20c. In this case note how the orientation of the x, y axes avoids simultaneous solution of equations.

$+\nwarrow\Sigma F_y = 0;\quad F_{GB} - 3\cos 30^\circ = 0 \qquad F_{GB} = 2.60\text{ kN (C)}$ ***Ans.***

$+\nearrow\Sigma F_x = 0;\quad 8 - 3\sin 30^\circ - F_{GF} = 0 \qquad F_{GF} = 6.50\text{ kN (C)}$ ***Ans.***

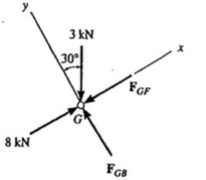
Joint B, Fig. 3–20d

$+\uparrow\Sigma F_y = 0;\quad F_{BF}\sin 60^\circ - 2.60\sin 60^\circ = 0$

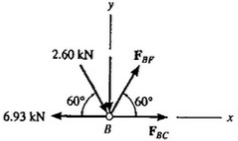
$F_{BF} = 2.60\text{ kN (T)}$ ***Ans.***

$\overset{+}{\rightarrow}\Sigma F_x = 0;\quad F_{BC} + 2.60\cos 60^\circ + 2.60\cos 60^\circ - 6.93 = 0$

$F_{BC} = 4.33\text{ kN (T)}$ ***Ans.***



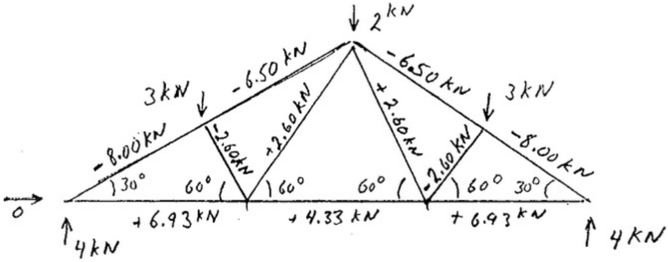
(c)



(d)

Fig. 3–20

Method of Joints



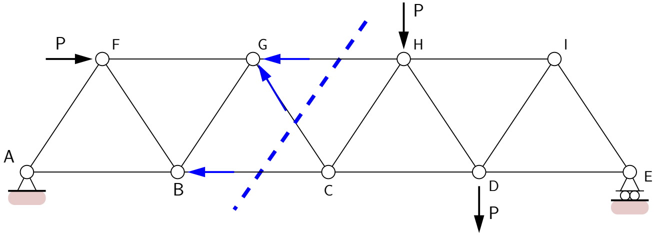
Results are symmetric.
(Structure & Loads are symmetric)

Method of Sections

Method of Sections

Procedure and Assumptions

- Provides a short cut for solution of forces in a few specified bars.

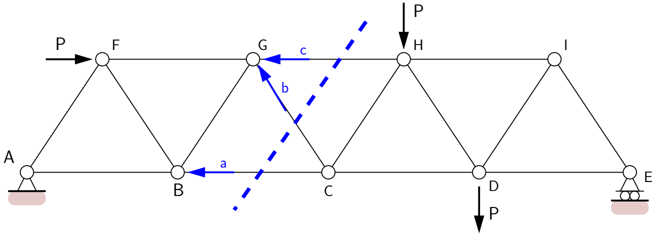


- Divide truss into free bodies by cutting a section through the truss.
- Use statics to solve for individual bar forces.

Method of Sections

Procedure and Assumptions

Carefully select locations for evaluation of equations of equilibrium.

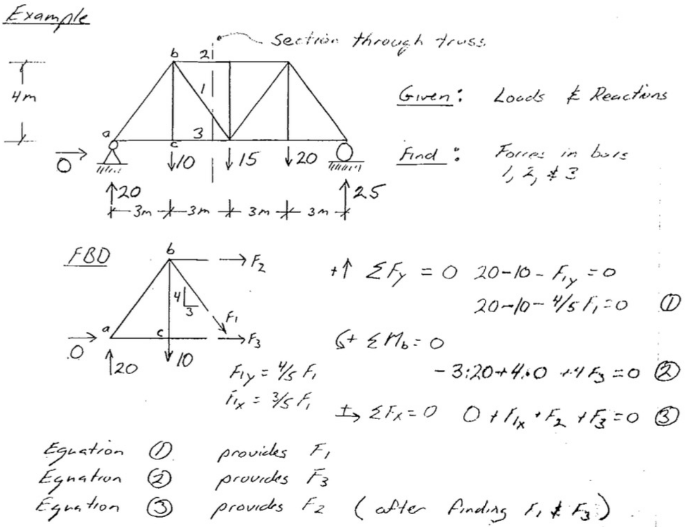


For this example:

- Member forces a and b pass through point C, hence, take moments about point C to determine member force c.
- Member forces b and c pass through point G, hence, take moments about point G to determine member force a.

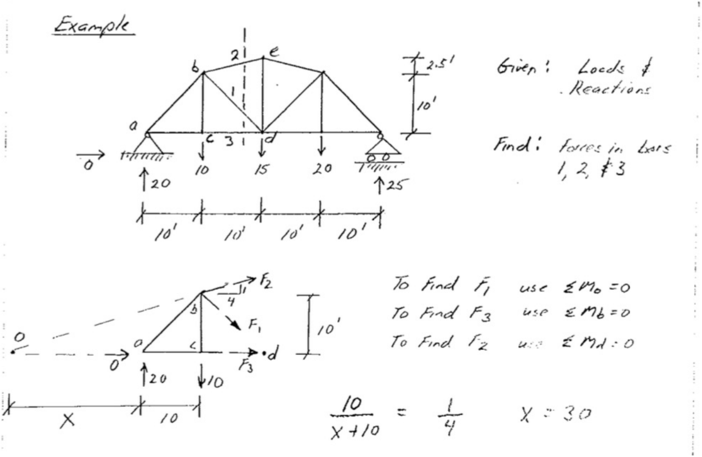
Method of Sections

Example 1.



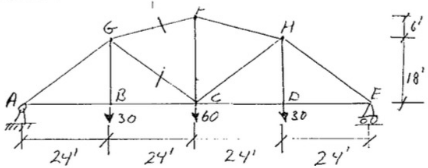
Method of Sections

Example 2.



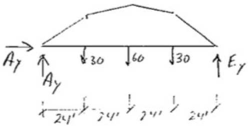
Method of Sections

Example



Determine forces in bars GF & GC

1. Reactions



$\rightarrow \Sigma F_x = 0 \qquad A_x = 0$

$\circlearrowleft \Sigma M_a = 0 \qquad 96' E_y - 24'(30)^k - 48'(60)^k - 72'(30)^k = 0$

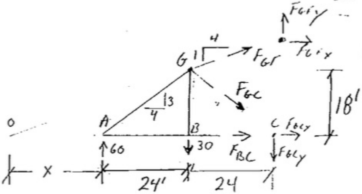
$E_y = 60^k$

$\Sigma F_y = 0 \qquad E_y + A_y - 30^k - 60^k - 30^k = 0$

$A_y = 60^k$

Method of Sections

2. Cut Section



F_{GC}

$\circlearrowleft + \Sigma M_o = 0$ (Translate F_{GC} to pt. C)

$48' \cdot 60^k - 72' \cdot 30^k - 96' F_{GCy} = 0$

$F_{GCy} = 7.5^k$

$F_{GC} = \frac{5}{3} F_{GCy} = 12.5^k$

$F_{GCx} = \frac{4}{3} F_{GCy} = 10^k$

$\circlearrowleft + \Sigma M_o = 0$ (Translate F_{GC} to pt. G)

$48' \cdot 60^k - 72' \cdot 30^k - 72' F_{GCy} - 18' F_{GCx} = 0$

$48' \cdot 60^k - 72' \cdot 30^k - 72 (3/5 F_{GC}) - 18 (4/5 F_{GC}) = 0$

$F_{GC} = 12.5^k$

$$\frac{18}{x+24} = \frac{1}{4}$$

$x = 48$

F_{GF}

$\Sigma F_y = 0 \quad 60 - 30 - F_{GCy} + F_{GFy} = 0$ (7.5)

$F_{GFy} = 22.5$

$F_{GF} = \frac{\sqrt{17}}{1} \cdot F_{GFy} = 92.8$

OR

Summary

Summary

Method of Joints vs Method of Sections

- Use method of joints when you need to know element forces throughout the structure. Two equations of equilibrium per joint.
- Method of sections provides a short cut for solution of forces in a few specified bars.

Simplifications

- You can reduce computational effort by taking advantage of symmetries (when they exist) and removing zero-force members.