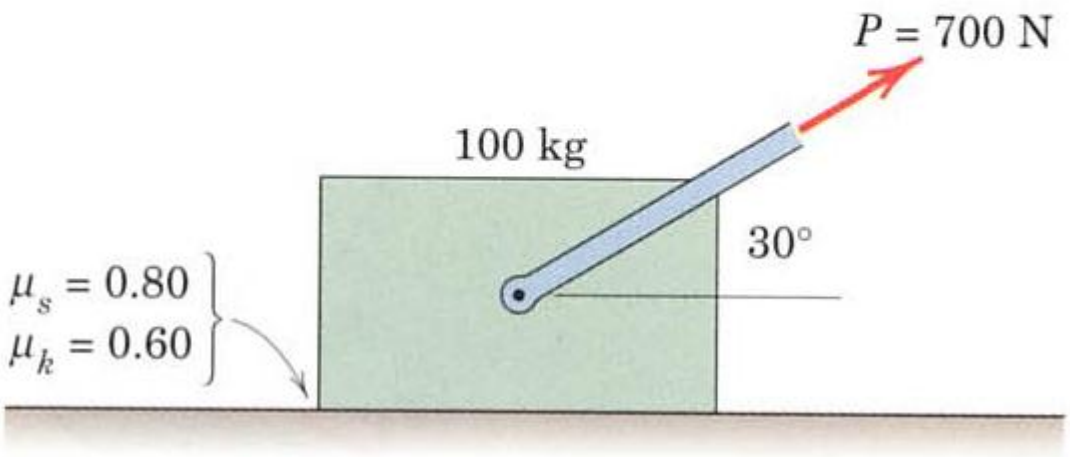
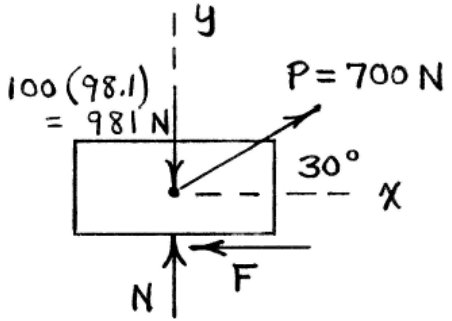
Classroom Tutorial Question

The 700-N force is applied to the 100-kg block, which is stationary before the force is applied. Determine the magnitude and direction of the friction force F exerted by the horizontal surface on the block.



Problem 1

Classroom Tutorial Question



Assume equilibrium.

$\Sigma F_x = 0: \quad 700 \cos 30° - F = 0, \quad F = 606 \text{ N}$

$\Sigma F_y = 0: \quad N - 981 + 700 \sin 30° = 0, \quad N = 631 \text{ N}$

$F_{max} = \mu_s N = 0.8(631) = 505 \text{ N} < F = 606 \text{ N}$

Assumption invalid, motion occurs.

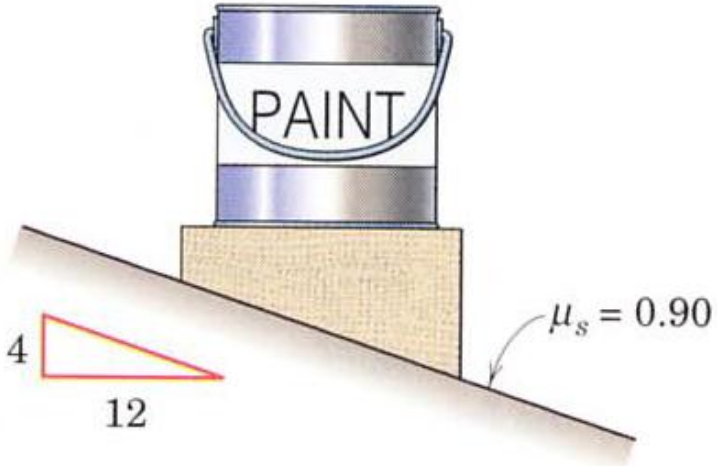
$F = \mu_k N = 0.6(631) = \underline{379 \text{ N}}$

Problem 1

Classroom Tutorial Question

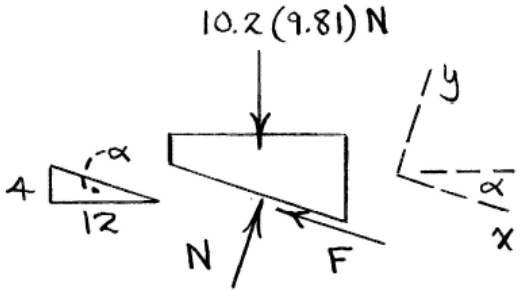
The 1.2-kg wooden block is used for level support of the 9-kg can of paint. Determine the magnitude and direction of (*a*) the friction force exerted by the roof surface on the wooden block and (*b*) the total force exerted by the roof surface on the wooden block.

Ans. (*a*) $F = 31.6$ N, (*b*) $P = 100.1$ N up



Problem 2

Classroom Tutorial Question



Assume equilibrium.

$\alpha = \tan^{-1}\frac{4}{12} = 18.43°$

$\Sigma F_x = 0: \; -F + 10.2(9.81)\sin\alpha = 0, \quad F = 31.6 \text{ N}$

$\Sigma F_y = 0: \; N - 10.2(9.81)\cos\alpha = 0, \quad N = 94.9 \text{ N}$

$F_{max} = \mu_s N = 0.9(94.9) = 85.4 \text{ N} > F = 31.6 \text{ N}$

Assumption valid; $\underline{F = 31.6 \text{ N}}$ ←

Total force $P = 10.2(9.81) = \underline{100.1 \text{ N}}$ ↑

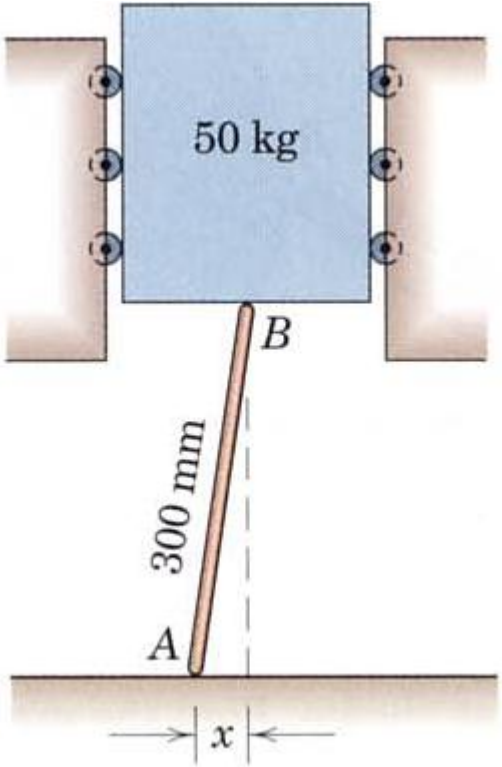
Problem 2

Classroom Tutorial Question

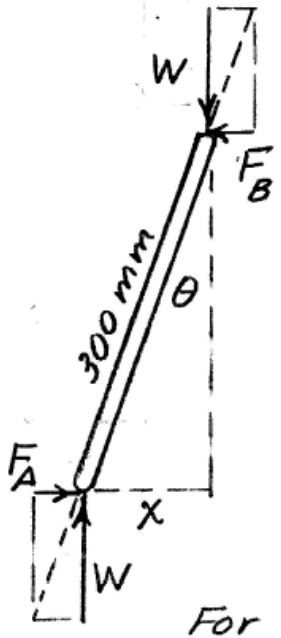
Problem 3

The light bar is used to support the 50-kg block in its vertical guides. If the coefficient of static friction is 0.30 at the upper end of the bar and 0.40 at the lower end of the bar, find the friction force acting at each end for $x = 75$ mm. Also find the maximum value of x for which the bar will not slip.

Ans. $F_A = F_B = 126.6$ N, $x_{max} = 86.2$ mm



Classroom Tutorial Question



For $x = 75$ mm, $\theta = \sin^{-1}\frac{75}{300} = 14.5°$

Friction angle $\phi = \tan^{-1}\mu_s$

for A is $\phi_A = \tan^{-1}0.40 = 21.8°$

" B " $\phi_B = \tan^{-1}0.30 = 16.7°$

Since $\theta < \phi_A$ & ϕ_B, bar does not slip & $F_A = F_B = W\tan\theta$

$= 50(9.81)\tan 14.5°$

$= \underline{126.6\ N}$

For increased x bar slips first at B with $\theta = \phi_B = 16.7°$. Thus $x_{max} = 300\sin 16.7°$

$= \underline{86.2\ mm}$

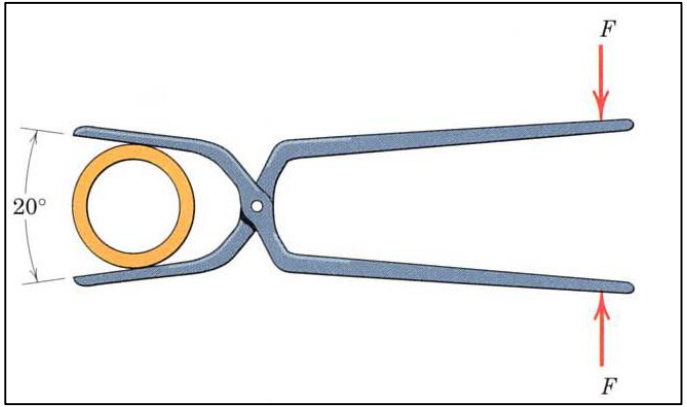
Problem 3

Classroom Tutorial Question

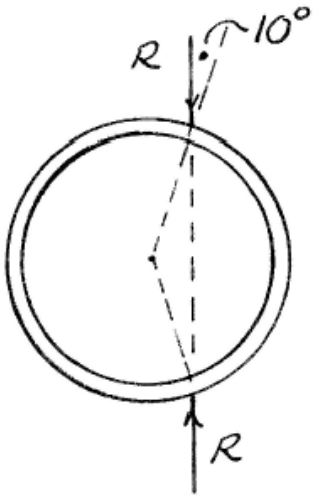
The tongs are designed to handle hot steel tubes which are being heat-treated in an oil bath. For a 20° jaw opening, what is the minimum coefficient of static friction between the jaws and the tube which will enable the tongs to grip the tube without slipping?

Ans. $\mu_{s_{\min}} = 0.176$

Problem 4



Classroom Tutorial Question



$$\mu_{s\,min} = \tan\phi = \tan 10^\circ$$

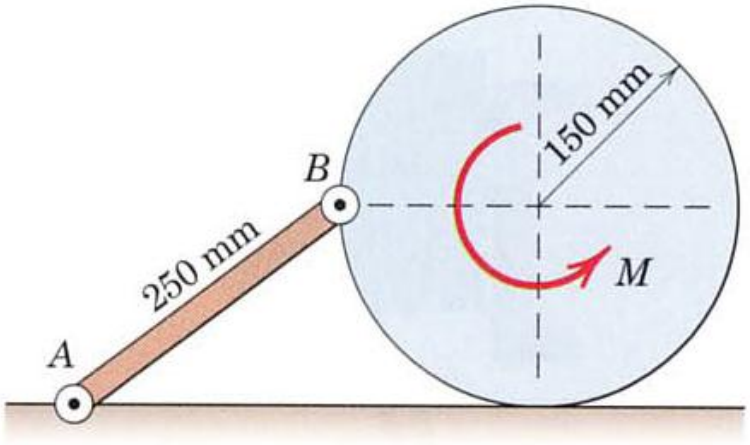
$$= 0.176$$

Problem 4

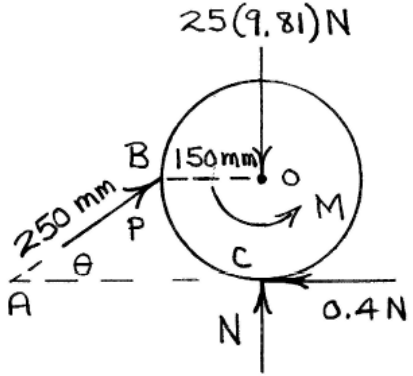
Classroom Tutorial Question

Problem 5

The strut AB of negligible mass is hinged to the horizontal surface at A and to the uniform 25-kg wheel at B. Determine the minimum couple M applied to the wheel which will cause it to slip if the coefficient of static friction between the wheel and the surface is 0.40.



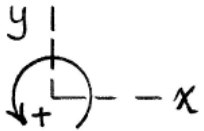
Classroom Tutorial Question



$$\sin\theta = \frac{150}{250} = 0.6$$

$$\cos\theta = 0.8$$

$$\overline{AC} = 0.8(0.25) + 0.15 = 0.35\,\text{m}$$



$$\begin{cases} \Sigma F_x = 0: & 0.8P - 0.4N = 0 \\ \Sigma F_y = 0: & N + 0.6P - 25(9.81) = 0 \\ \Sigma M_A = 0: & M + (N - 25(9.81))(0.35) = 0 \end{cases}$$

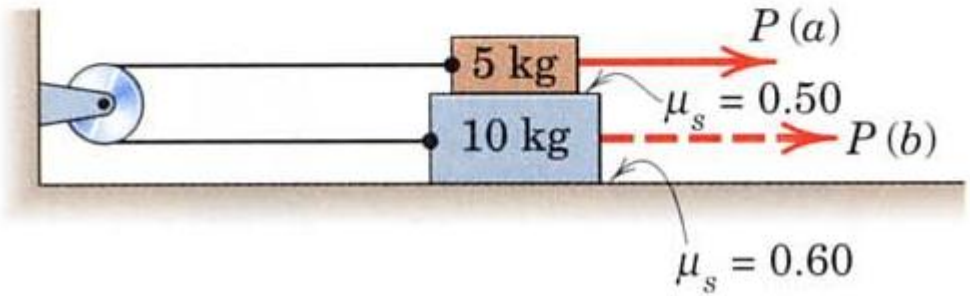
Solution: $N = 188.7\,\text{N}$, $P = 94.3\,\text{N}$, $\underline{M = 19.81\ \text{N}\cdot\text{m}}$

Problem 5

Classroom Tutorial Question

The system of two blocks, cable, and fixed pulley is initially at rest. Determine the horizontal force P necessary to cause motion when (*a*) P is applied to the 5-kg block and (*b*) P is applied to the 10-kg block. Determine the corresponding tension T in the cable for each case.

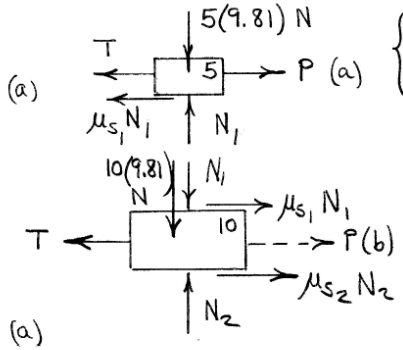
Ans. (*a*) $P = 137.3$ N, $T = 112.8$ N
(*b*) $P = 137.3$ N, $T = 24.5$ N



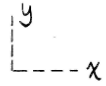
Problem 6

Classroom Tutorial Question

Problem 6



$$\begin{cases} \mu_{s_1} = 0.50 \\ \mu_{s_2} = 0.60 \end{cases}$$



From $\Sigma F_y = 0$,

$$\begin{cases} N_1 = 49.0 \text{ N} \\ N_2 = 147.2 \text{ N} \end{cases}$$

$$\Sigma F_x = 0: \begin{cases} P - T - 0.50(49.0) = 0 \\ -T + 0.50(49.0) + 0.60(147.2) = 0 \end{cases}$$

$\underline{T = 112.8 \text{ N}}$, $\underline{P = 137.3 \text{ N}}$

(b) Now P is applied to 10-kg block & we reverse all friction forces above:

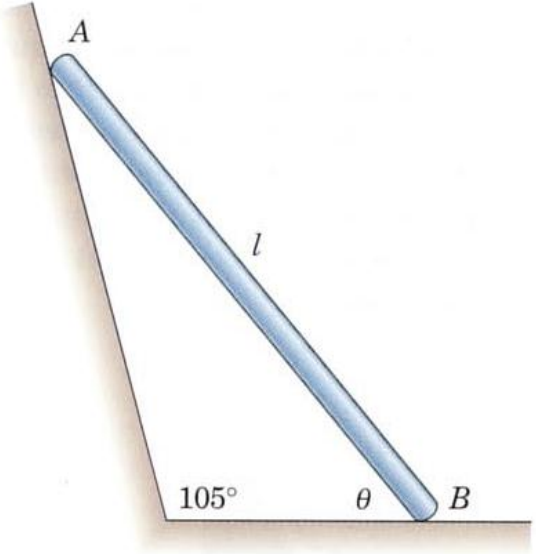
$$\Sigma F_x = 0: \begin{cases} -T + 0.50(49.0) = 0 \\ -T - 0.50(49.0) - 0.60(147.2) + P = 0 \end{cases}$$

$\underline{T = 24.5 \text{ N}}$, $\underline{P = 137.3 \text{ N}}$

Classroom Tutorial Question

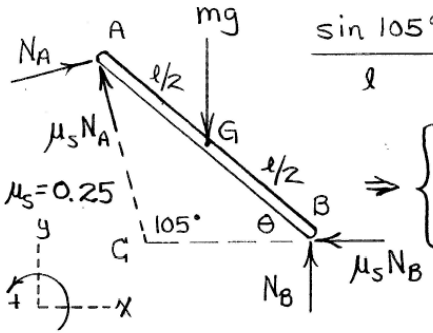
The uniform pole of length l and mass m is placed against the supporting surfaces shown. If the coefficient of static friction is $\mu_s = 0.25$ at both A and B, determine the maximum angle θ at which the pole can be placed before it begins to slip.

Ans. $\theta = 59.9°$



Problem 7

Classroom Tutorial Question



From law of sines:

$$\frac{\sin 105^\circ}{\ell} = \frac{\sin\theta}{\overline{AC}} = \frac{\sin(75^\circ-\theta)}{\overline{BC}}$$

$$\Rightarrow \begin{cases} \overline{AC} = \dfrac{\ell \sin\theta}{\sin 105^\circ} \\ \overline{BC} = \dfrac{\ell \sin(75^\circ-\theta)}{\sin 105^\circ} \end{cases}$$

$$\Sigma F_x = 0: \quad N_A \cos 15^\circ - 0.25 N_A \sin 15^\circ - 0.25 N_B = 0$$

$$\Sigma F_y = 0: \quad N_A \sin 15^\circ + 0.25 N_A \cos 15^\circ + N_B - mg = 0$$

$$\Sigma M_C = 0: \quad -N_A\left(\frac{\ell \sin\theta}{\sin 105^\circ}\right) + N_B\left(\frac{\ell \sin(75^\circ-\theta)}{\sin 105^\circ}\right) - mg\left[\frac{\ell \sin(75^\circ-\theta)}{\sin 105^\circ} - \frac{\ell}{2}\cos\theta\right] = 0$$

Solution:

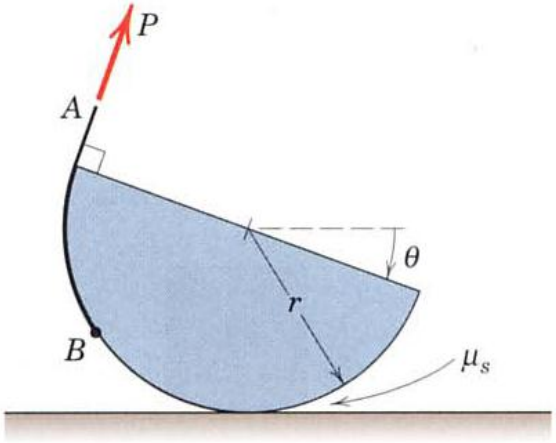
$$\begin{cases} N_A = 0.244\,mg \\ N_B = 0.878\,mg \\ \theta = 59.9^\circ \end{cases}$$

Problem 7

Classroom Tutorial Question

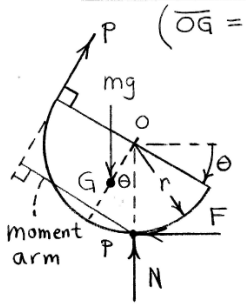
The homogeneous semicylinder rests on a horizontal surface and is subjected to the force P applied to a cord firmly attached to its periphery. The force P is slowly increased and kept normal to the flat surface of the semicylinder. If slipping is observed just as θ reaches 40°, determine the coefficient of static friction μ_s and the value of P when slipping occurs.

Ans. $\mu_s = 0.122$, $P = 0.1661mg$

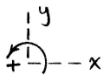


Problem 8

Classroom Tutorial Question



$$\left(\overline{OG} = \bar{r} = \frac{4r}{3\pi}\right)$$



$$\Sigma F_x = 0: \quad P\sin\theta - F = 0 \qquad (1)$$

$$\Sigma F_y = 0: \quad N - mg + P\cos\theta = 0 \qquad (2)$$

$$\Sigma M_P = 0: \quad mg\,\frac{4r}{3\pi}\sin\theta - P(r + r\sin\theta) = 0 \qquad (3)$$

When slipping impends, $F = \mu_s N$ (4)

(4) → (1): $P\sin\theta - \mu_s N = 0$ (5)

(2): $N = mg - P\cos\theta$ (6)

(6) → (5): $P\sin\theta - \mu_s(mg - P\cos\theta) = 0$

$$\Rightarrow P = \frac{\mu_s mg}{\sin\theta + \mu_s\cos\theta} \qquad (7)$$

(7) → (3) & simplification yields

$$\mu_s = \frac{4\sin^2\theta}{3\pi(1+\sin\theta) - 4\sin\theta\cos\theta}$$

For $\theta = 40°$, $\underline{\mu_s = 0.1223}$

(7) then gives $\underline{P = 0.1661\,mg}$

Problem 8

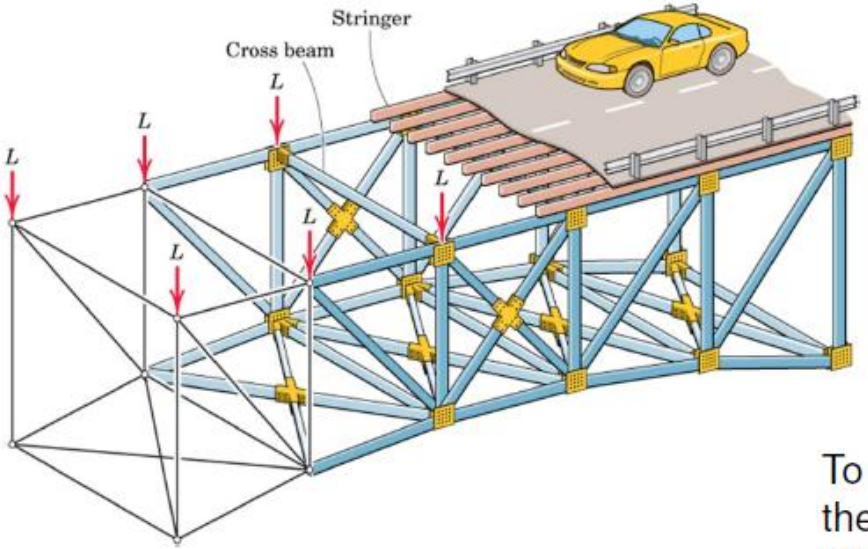
Lecture 8 & 9

Structural Analysis

Engineering Structure

An engineering structure is any connected system of members built to support or transfer forces and to safely withstand the loads applied to it.

Structural Analysis



Statically Determinate Structures

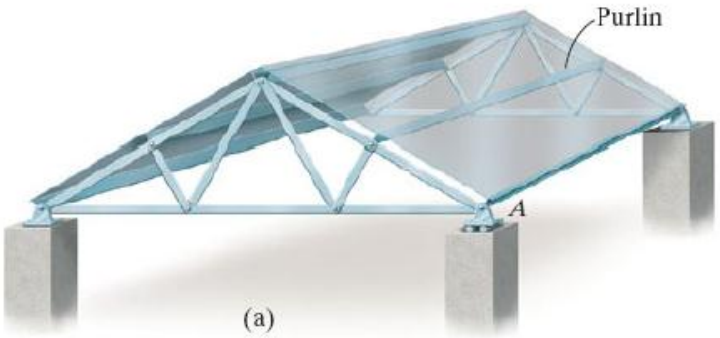
To determine the internal forces in the structure, dismember the structure and analyze separate free body diagrams of individual members or combination of members.

Structural Analysis: Trusses

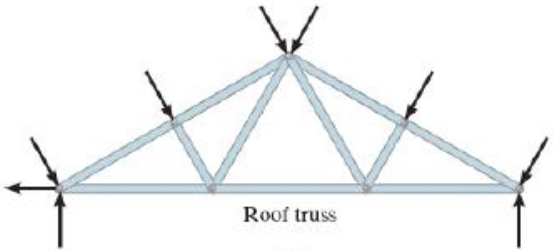
Truss: A framework composed of members joined at their ends to form a rigid structure

Joints (Connections): Welded, Riveted, Bolted, Pinned

Plane Truss: Members lie in a single plane



(a)

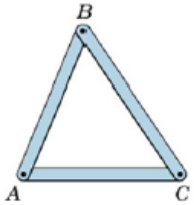


(b)

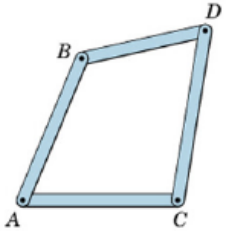
Structural Analysis: Trusses

Simple Trusses

Basic Element of a Plane Truss is the Triangle

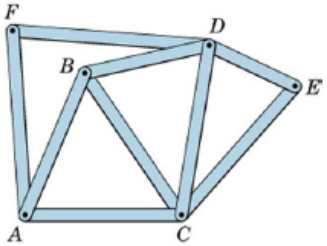


- Three bars joined by pins at their ends → Rigid Frame
  - Non-collapsible and deformation of members due to induced internal strains is negligible

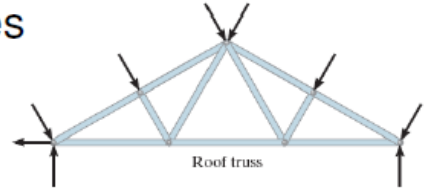


- Four or more bars polygon → Non-Rigid Frame
  How to make it rigid or stable?

  by forming more triangles!

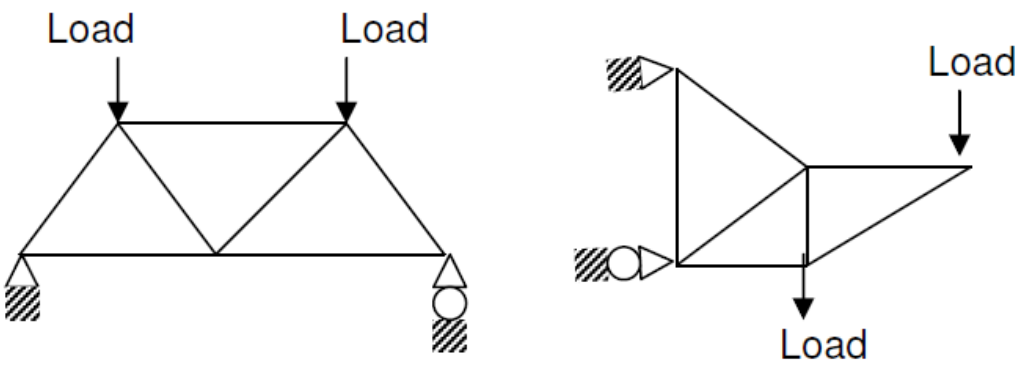


Structures built from basic triangles
→Simple Trusses

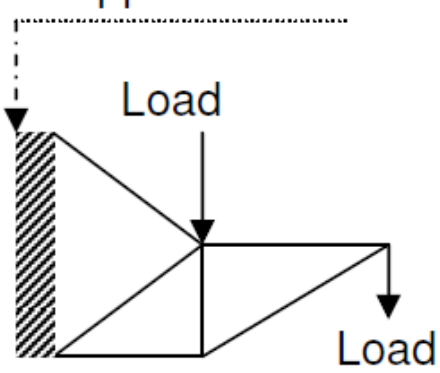


Structural Analysis: Trusses

Types of Trusses



Simply Supported Trusses

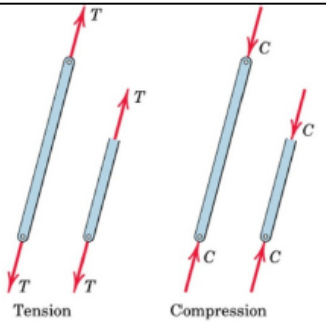


Cantilever Truss

Structural Analysis: Trusses

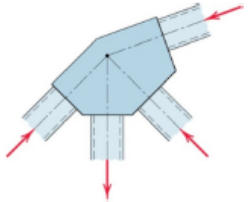
Basic Assumptions in Truss Analysis

- All members are two-force members.
- Weight of the members is small compared with the force it supports (weight may be considered at joints)
- No effect of bending on members even if weight is considered



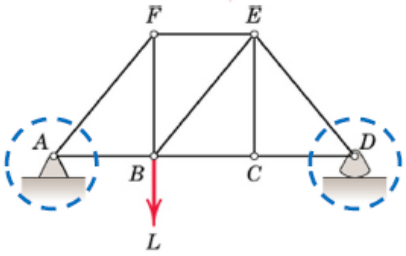
Two-Force Members

- External forces are applied at the pin connections
- Welded or riveted connections
- Pin Joint if the member centerlines are concurrent at the joint



Common Practice in Large Trusses

- Roller/Rocker at one end. Why?
  - to accommodate deformations due to temperature changes and applied loads.
  - otherwise it will be a statically indeterminate truss



Structural Analysis: Trusses

Truss Analysis: Method of Joints

- Finding forces in members

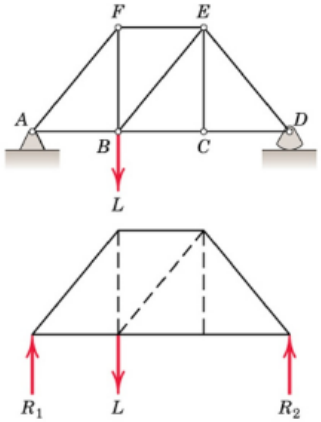
Method of Joints: Conditions of equilibrium are satisfied for the forces at each joint

– Equilibrium of concurrent forces at each joint

– only two independent equilibrium equations are involved

Steps of Analysis

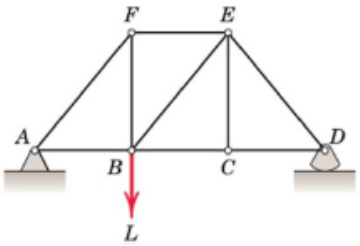
1. Draw Free Body Diagram of Truss
2. Determine external reactions by applying equilibrium equations to the whole truss
3. Perform the force analysis of the remainder of the truss by Method of Joints

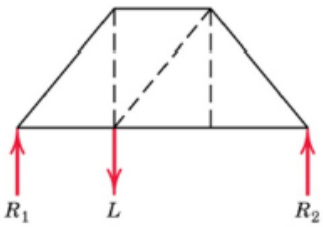


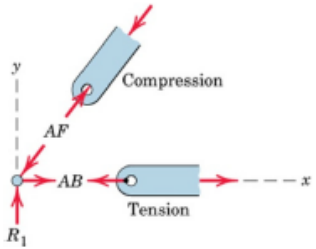
Structural Analysis: Trusses

Method of Joints

- Start with any joint where at least one known load exists and where not more than two unknown forces are present.







FBD of Joint A and members AB and AF: Magnitude of forces denoted as *AB* & *AF*

- Tension indicated by an arrow away from the pin
- Compression indicated by an arrow toward the pin

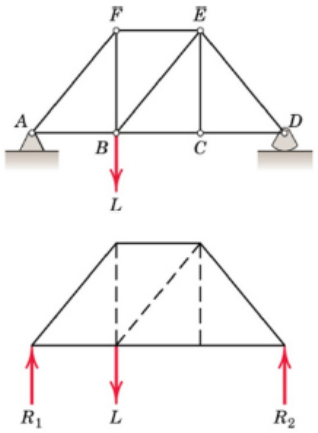
Magnitude of AF from $\sum F_y = 0$

Magnitude of AB from $\sum F_x = 0$

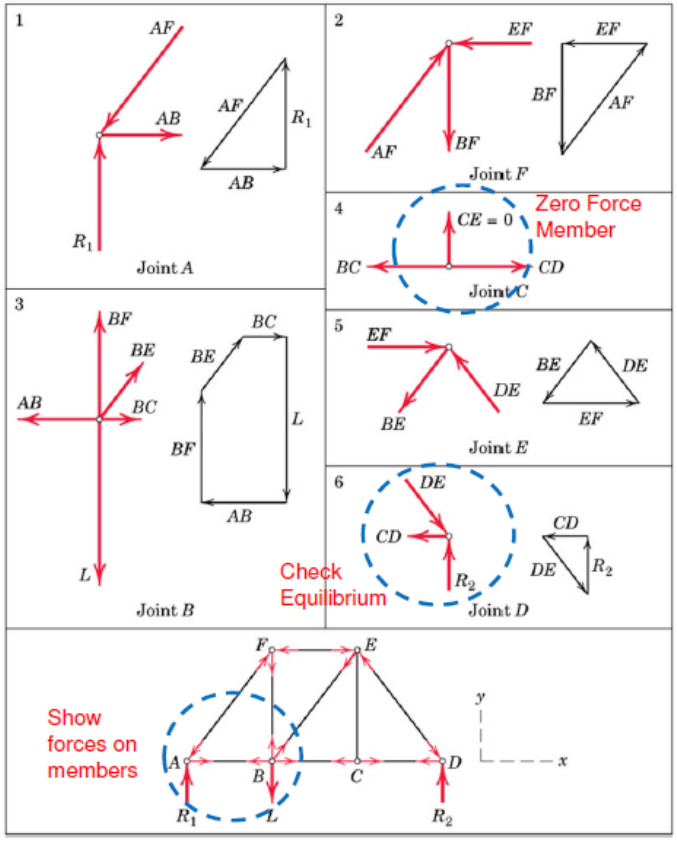
Analyze joints F, B, C, E, & D in that order to complete the analysis

Structural Analysis: Trusses

Method of Joints

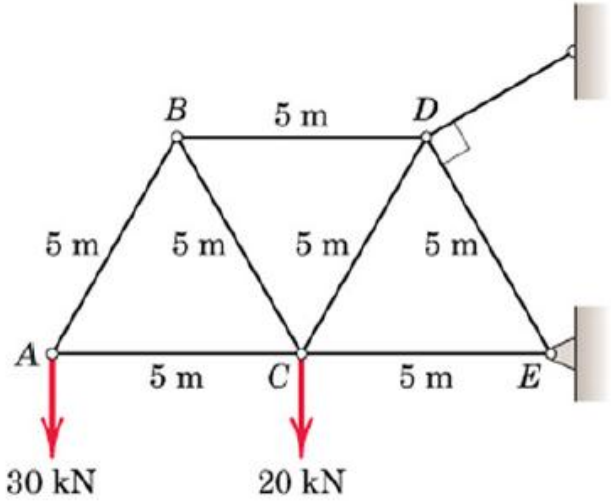


- Negative force if assumed sense is incorrect

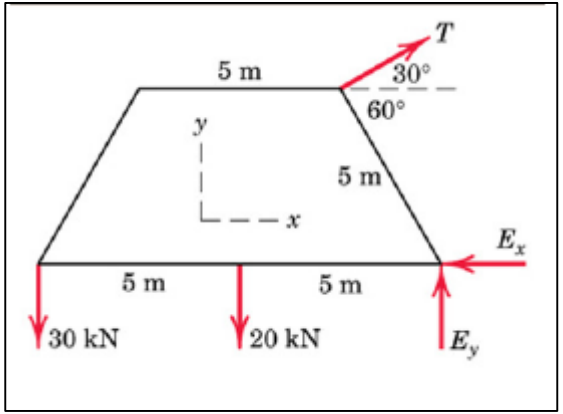


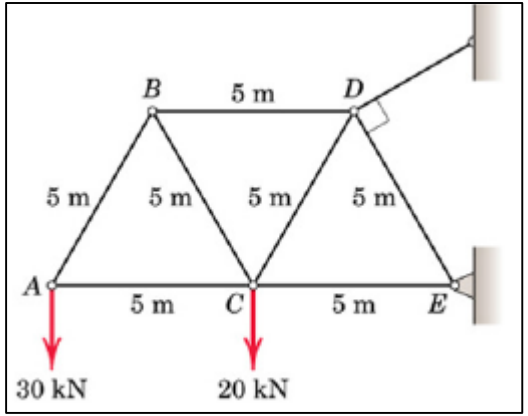
Trusses: Example Method of Joint

Determine the force in each member of the loaded truss by Method of Joints



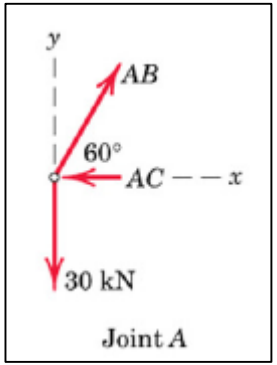
Trusses: Example Method of Joint





$[\Sigma M_E = 0]$	$5T - 20(5) - 30(10) = 0$	$T = 80$ kN
$[\Sigma F_x = 0]$	$80 \cos 30° - E_x = 0$	$E_x = 69.3$ kN
$[\Sigma F_y = 0]$	$80 \sin 30° + E_y - 20 - 30 = 0$	$E_y = 10$ kN

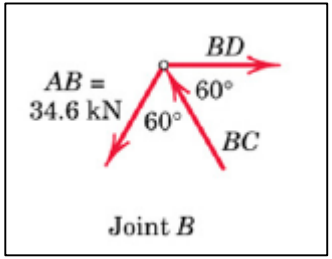
Trusses: Example Method of Joint



Joint A:

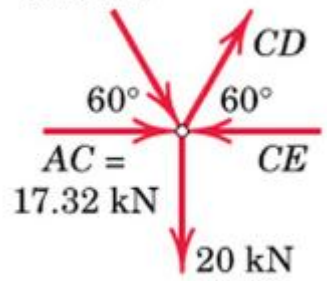
$[\Sigma F_y = 0]$	$0.866AB - 30 = 0$	$AB = 34.6 \text{ kN } T$
$[\Sigma F_x = 0]$	$AC - 0.5(34.6) = 0$	$AC = 17.32 \text{ kN } C$

Joint B:



$[\Sigma F_y = 0]$	$0.866BC - 0.866(34.6) = 0$	$BC = 34.6 \text{ kN } C$
$[\Sigma F_x = 0]$	$BD - 2(0.5)(34.6) = 0$	$BD = 34.6 \text{ kN } T$

Trusses: Example Method of Joint



Joint C

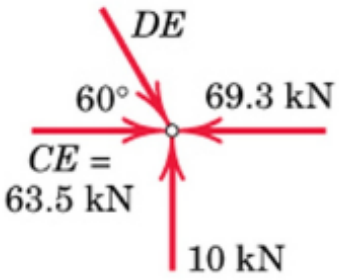
Joint C:

$[\Sigma F_y = 0]$ $\quad 0.866CD - 0.866(34.6) - 20 = 0$

$CD = 57.7 \text{ kN } T$

$[\Sigma F_x = 0]$ $\quad CE - 17.32 - 0.5(34.6) - 0.5(57.7) = 0$

$CE = 63.5 \text{ kN } C$



Joint E

Joint E:

$[\Sigma F_y = 0]$ $\quad 0.866DE = 10 \quad DE = 11.55 \text{ kN } C$

and the equation $\Sigma F_x = 0$ checks.

Trusses

When more number of members/supports are present than are needed to prevent collapse/stability

→ Statically Indeterminate Truss

- cannot be analyzed using equations of equilibrium alone!
- additional members or supports which are not necessary for maintaining the equilibrium configuration → Redundant

Internal and External Redundancy

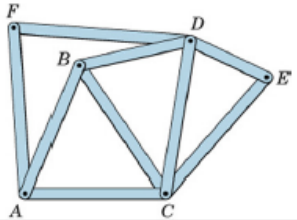
Extra Supports than required → External Redundancy

– Degree of indeterminacy from available equilibrium equations

Extra Members than required → Internal Redundancy

(truss must be removed from the supports to calculate internal redundancy)

– Is this truss statically determinate internally?



Truss is statically determinate internally if $m + 3 = 2j$

$m = 2j - 3$ m is number of members, and j is number of joints in truss

Trusses

Internal Redundancy or
Degree of Internal Static Indeterminacy

Extra Members than required → Internal Redundancy

Equilibrium of each joint can be specified by two scalar force equations → 2j equations for a truss with "j" number of joints

→ Known Quantities

For a truss with "m" number of two force members, and maximum 3 unknown support reactions → Total Unknowns = m + 3
("m" member forces and 3 reactions for externally determinate truss)

Therefore:

$m + 3 = 2j$ → Statically Determinate Internally

$m + 3 > 2j$ → Statically Indeterminate Internally

$m + 3 < 2j$ → Unstable Truss

A necessary condition for Stability but not a sufficient condition since one or more members can be arranged in such a way as not to contribute to stable configuration of the entire truss

Trusses

Why to Provide Redundant Members?

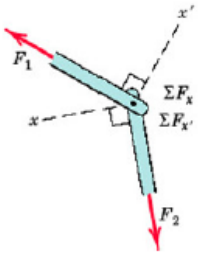
- To maintain alignment of two members during construction
- To increase stability during construction
- To maintain stability during loading (Ex: to prevent buckling of compression members)
- To provide support if the applied loading is changed
- To act as backup members in case some members fail or require strengthening
- Analysis is difficult but possible

Trusses

Zero Force Members: Conditions

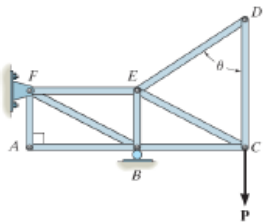
If only two non-collinear members form a truss joint and no external load or support reaction is applied to the joint, the two members must be zero force members

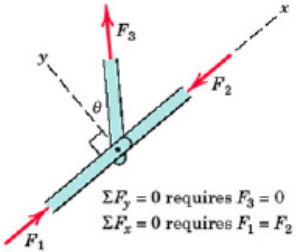
If three members form a truss joint for which two of the members are collinear, the third member is a zero-force member provided no external force or support reaction is applied to the joint



$\Sigma F_x = 0$ requires $F_1 = 0$

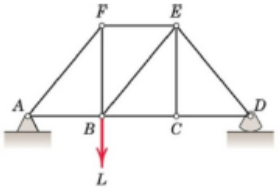
$\Sigma F_{x'} = 0$ requires $F_2 = 0$

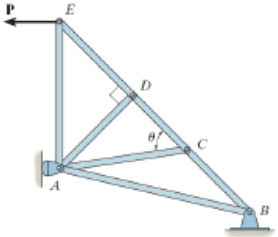




$\Sigma F_y = 0$ requires $F_3 = 0$

$\Sigma F_x = 0$ requires $F_1 = F_2$

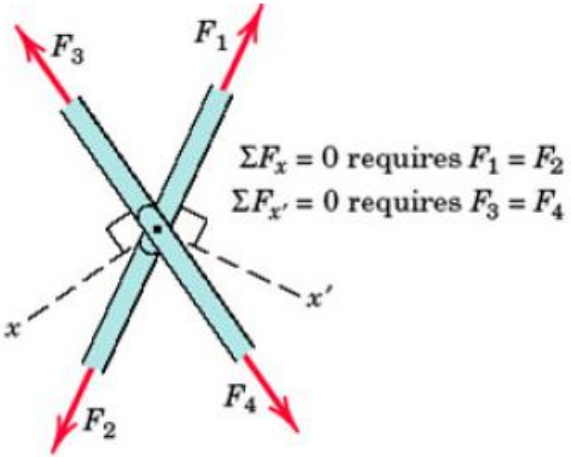




Trusses

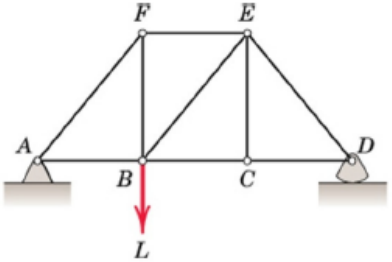
Special Condition

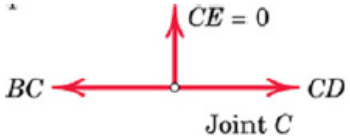
When two pairs of collinear members are joined as shown in figure, the forces in each pair must be equal and opposite.

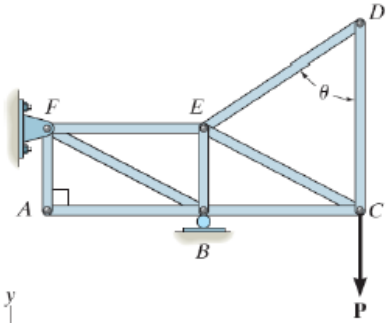


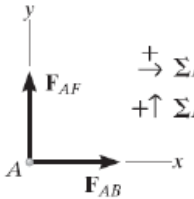
Trusses

Zero Force Members



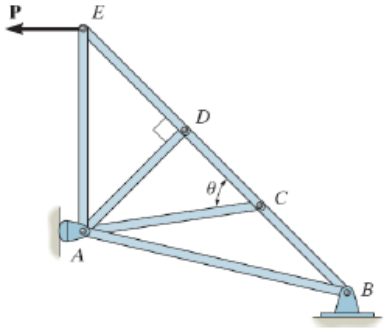


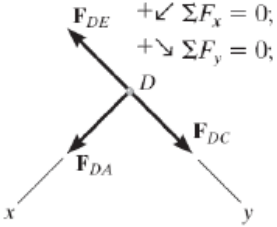




$\overset{+}{\rightarrow} \Sigma F_x = 0;\ \boxed{F_{AB} = 0}$

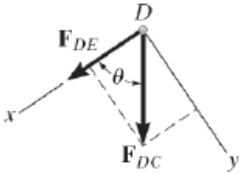
$+\uparrow \Sigma F_y = 0;\ \boxed{F_{AF} = 0}$





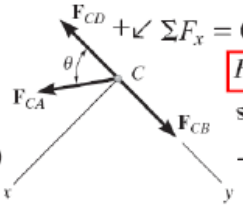
$+\swarrow \Sigma F_x = 0;\ \boxed{F_{DA} = 0}$

$+\searrow \Sigma F_y = 0;\ F_{DC} = F_{DE}$



$+\searrow \Sigma F_y = 0;\ F_{DC} \sin\theta = 0;\ \boxed{F_{DC} = 0}$ since $\sin\theta \neq 0$

$+\swarrow \Sigma F_x = 0;\ F_{DE} + 0 = 0;\ \boxed{F_{DE} = 0}$



$+\swarrow \Sigma F_x = 0;\ F_{CA} \sin\theta = 0$

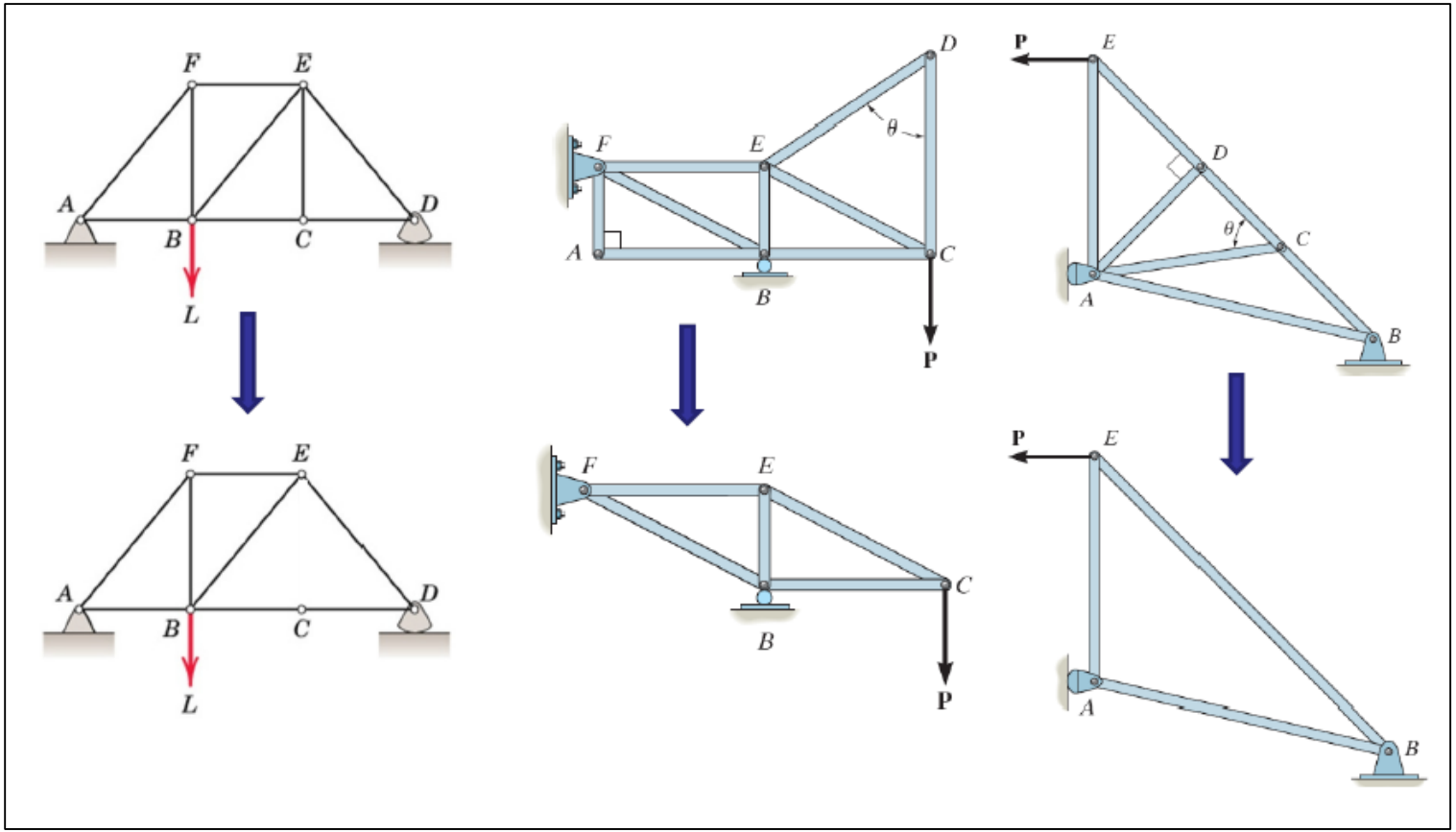
$\boxed{F_{CA} = 0}$

since $\sin\theta \neq 0$

$+\searrow \Sigma F_y = 0;$

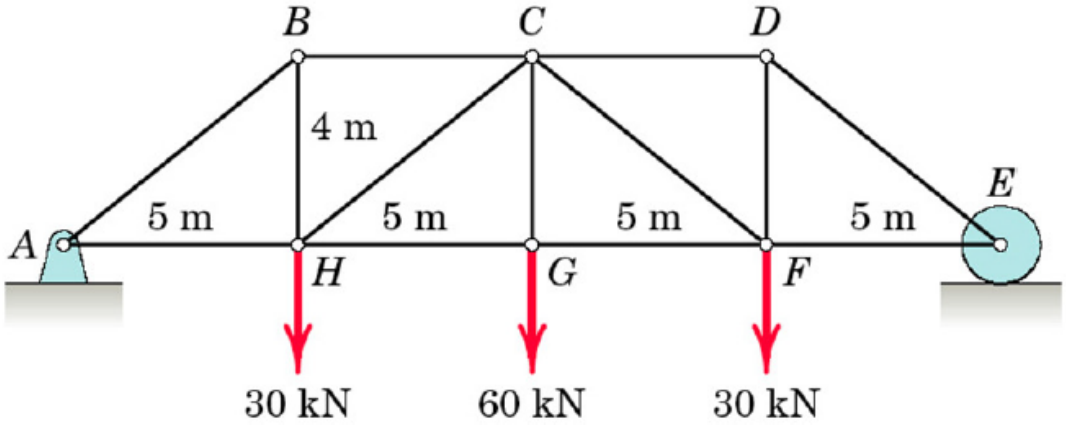
$F_{CB} = F_{CD}$

Trusses



Trusses: Example Method of Joint

Determine the force in each member of the loaded truss by Method of Joints.

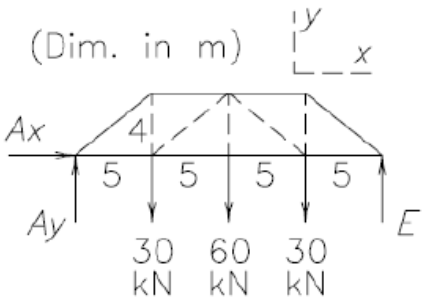


Is the truss statically determinant externally? Yes

Is the truss statically determinant internally? Yes

Are there any Zero Force Members in the truss? No

Trusses: Example Method of Joint

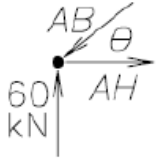


As a whole: $\Sigma F_x = 0 \Rightarrow A_x = 0$

$A_y = E = 60$ kN by

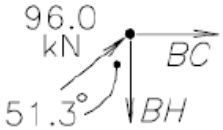
$\Sigma F_y = 0$ and symmetry.

Joint A: $\left(\theta = \tan^{-1}(4/5) = 38.7°\right)$



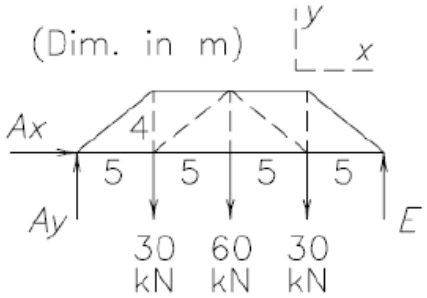
$$\begin{cases} \Sigma F_y = 0: 60 - AB\sin\theta = 0, \ \underline{AB = 96.0 \text{ kN } C} \\ \Sigma F_x = 0: AH - 96.0\cos\theta, \ \underline{AH = 75 \text{ kN } T} \end{cases}$$

Joint B:

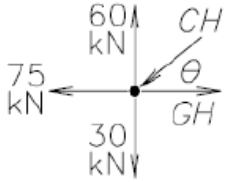


$$\begin{cases} \Sigma F_x = 0: BC + 96.0\sin 51.3° = 0, \ \underline{BC = -75 \text{ kN } (C)} \\ \Sigma F_y = 0: -BH + 96.0\cos 51.3° = 0, \ \underline{BH = 60 \text{ kN } T} \end{cases}$$

Trusses: Example Method of Joint

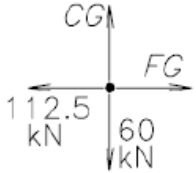


Joint H:



$$\begin{cases} \Sigma F_y = 0: -CH\sin\theta + 30 = 0,\ \underline{CH = 48.0 \text{ kN } C} \\ \Sigma F_x = 0: 48.0\cos\theta + GH - 75 = 0,\ \underline{GH = 112.5 \text{ kN } T} \end{cases}$$

Joint G:



$$\Sigma F_y = 0 \Rightarrow CG = 60 \text{ kN } T$$

By symmetry:

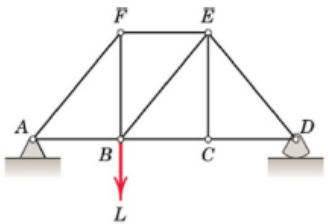
$FG = 112.5$ kN T, $CF = 48.0$ kN C

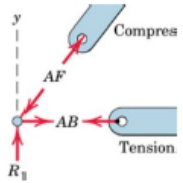
$CD = 75$ kN C, $DF = 60$ kN T

$\underline{EF = 75 \text{ kN } T,\ DE = 96.0 \text{ kN } C}$

Trusses: Method of Section

Method of Joints: only two of three equilibrium equations were applied at each joint because the procedures involve concurrent forces at each joint



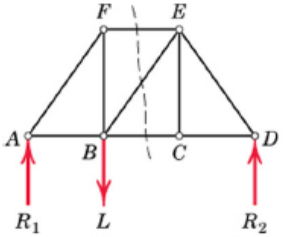


→Calculations from joint to joint

→More time and effort required

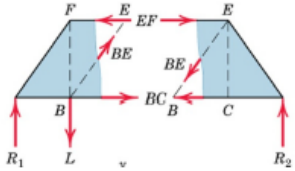
Method of Sections

Take advantage of the 3rd or moment equation of equilibrium by selecting an entire section of truss



→Equilibrium under non-concurrent force system

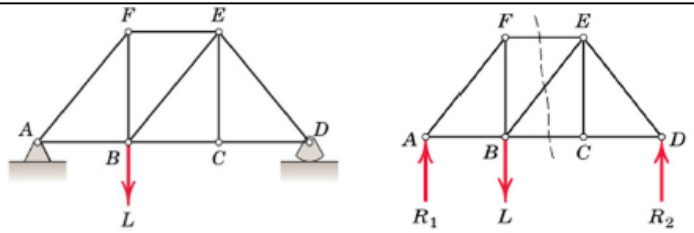
→Not more than 3 members whose forces are unknown should be cut in a single section since we have only 3 independent equilibrium equations



Trusses: Method of Section

Method of Sections

Find out the reactions from equilibrium of whole truss

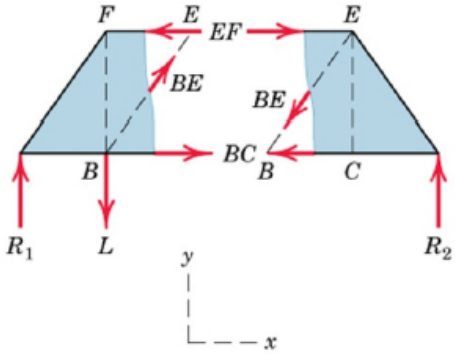


To find force in member BE
Cut an imaginary section (dotted line)
Each side of the truss section should remain in equilibrium

For calculating force on member EF, take moment about B

Take moment about E, for calculating force BC

Now apply $\sum F_y = 0$ to obtain forces on the members BE



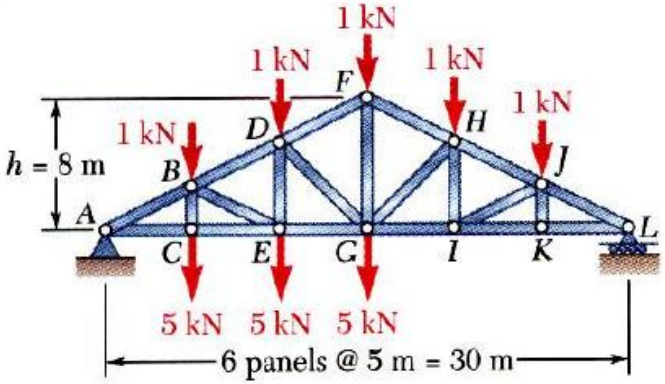
Trusses

Method of Sections

- Principle: If a body is in equilibrium, then any part of the body is also in equilibrium.
- Forces in few particular member can be directly found out quickly without solving each joint of the truss sequentially
- Method of Sections and Method of Joints can be conveniently combined
- A section need not be straight.
- More than one section can be used to solve a given problem

Trusses

Method of Sections: Example



Find out the internal forces in members FH, GH, and GI

Find out the reactions

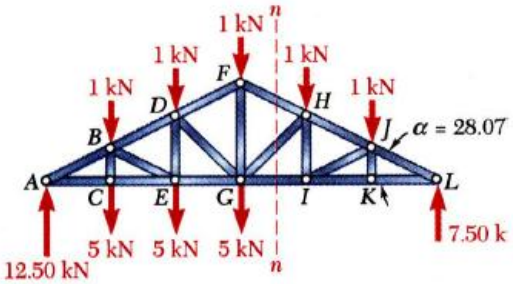
$$\sum M_A = 0 = -(5\text{ m})(6\text{ kN}) - (10\text{ m})(6\text{ kN}) - (15\text{ m})(6\text{ kN}) - (20\text{ m})(1\text{ kN}) - (25\text{ m})(1\text{ kN}) + (30\text{ m})L$$

$$L = 7.5\text{ kN} \uparrow$$

$$\sum F_y = 0 = -20\text{ kN} + L + A$$

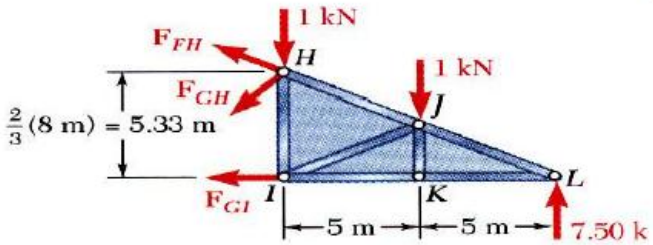
$$A = 12.5\text{ kN} \uparrow$$

Trusses



- Pass a section through members FH, GH, and GI and take the right-hand section as a free body.

$$\tan\alpha = \frac{FG}{GL} = \frac{8\text{ m}}{15\text{ m}} = 0.5333 \qquad \alpha = 28.07°$$



- Apply the conditions for static equilibrium to determine the desired member forces.

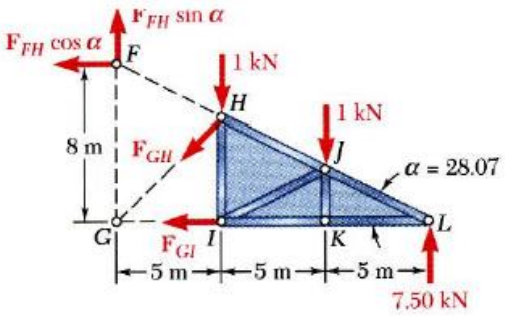
$$\sum M_H = 0$$

$$(7.50\text{ kN})(10\text{ m}) - (1\text{ kN})(5\text{ m}) - F_{GI}(5.33\text{ m}) = 0$$

$$F_{GI} = +13.13\text{ kN}$$

$$\boxed{F_{GI} = 13.13\text{ kN} \quad T}$$

Trusses:

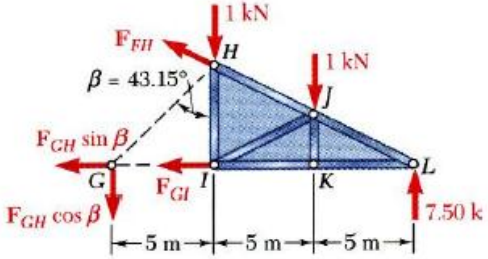


$$\sum M_G = 0$$

$$(7.5\text{ kN})(15\text{ m}) - (1\text{ kN})(10\text{ m}) - (1\text{ kN})(5\text{ m}) + (F_{FH}\cos\alpha)(8\text{ m}) = 0$$

$$F_{FH} = -13.82\text{ kN}$$

$$\boxed{F_{FH} = 13.82\text{ kN } C}$$



$$\tan\beta = \frac{GI}{HI} = \frac{5\text{ m}}{\frac{2}{3}(8\text{ m})} = 0.9375 \qquad \beta = 43.15°$$

$$\sum M_L = 0$$

$$(1\text{ kN})(10\text{ m}) + (1\text{ kN})(5\text{ m}) + (F_{GH}\cos\beta)(15\text{ m}) = 0$$

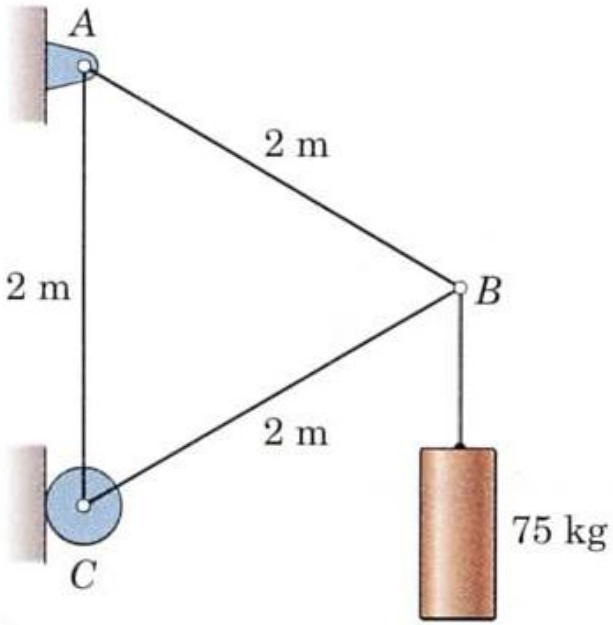
$$F_{GH} = -1.371\text{ kN}$$

$$\boxed{F_{GH} = 1.371\text{ kN } C}$$

Classroom Tutorial Question

Determine the force in each member of the simple equilateral truss.

Ans. $AB = 736$ N T, $AC = 368$ N T, $BC = 736$ N C

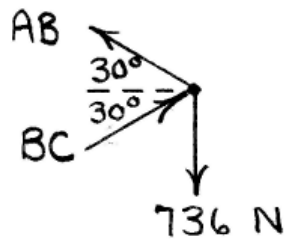


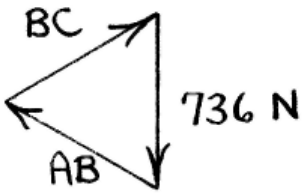
Problem 1

Classroom Tutorial Question

Load = 75(9.81) = 736 N

Joint B:

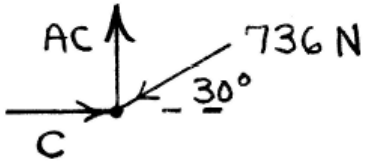


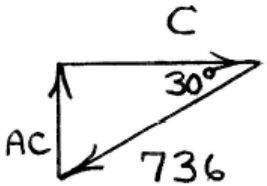


AB = 736 N T

BC = 736 N C

Joint C:





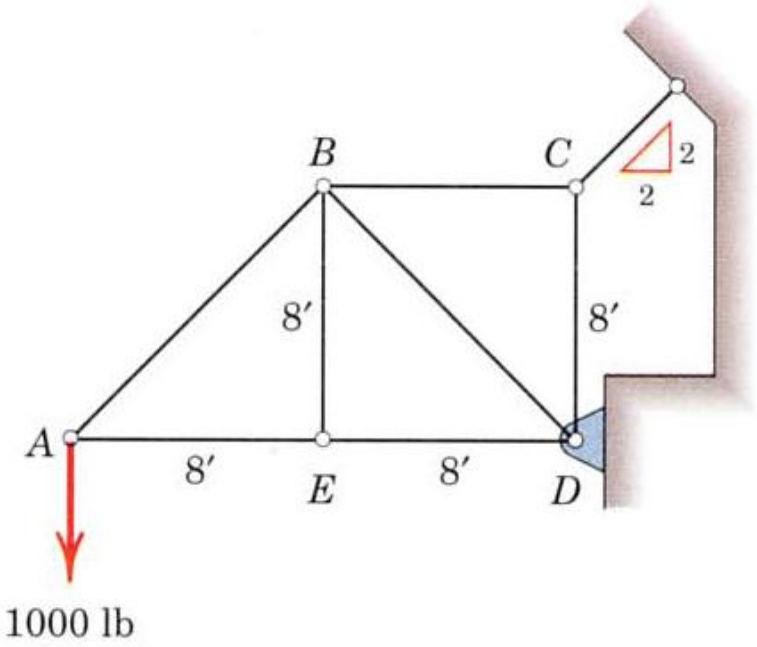
$AC = 736\left(\frac{1}{2}\right)$

$= 368$ N T

Problem 1

Classroom Tutorial Question

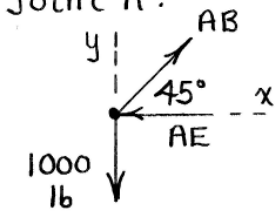
Calculate the forces in members BE and BD of the loaded truss.



Problem 2

Classroom Tutorial Question

Joint A:



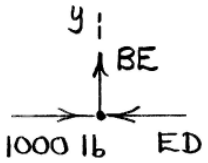
$\Sigma F_y = 0: \; AB \sin 45° - 1000 = 0$

$AB = 1414 \text{ lb} \quad T$

$\Sigma F_x = 0: \; 1414 \cos 45° - AE = 0$

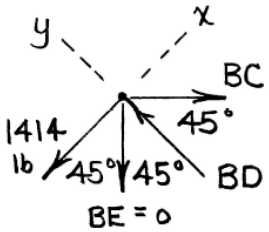
$AE = 1000 \text{ lb} \quad C$

Joint E:



$\Sigma F_y = 0: \; \underline{BE = 0}$

Joint B:



$\Sigma F_x = 0: \; BC \cos 45° - 1414 = 0$

$BC = 2000 \text{ lb} \quad T$

$\Sigma F_y = 0: \; BD - 2000 \cos 45° = 0$

$\underline{BD = 1414 \text{ lb} \quad C}$

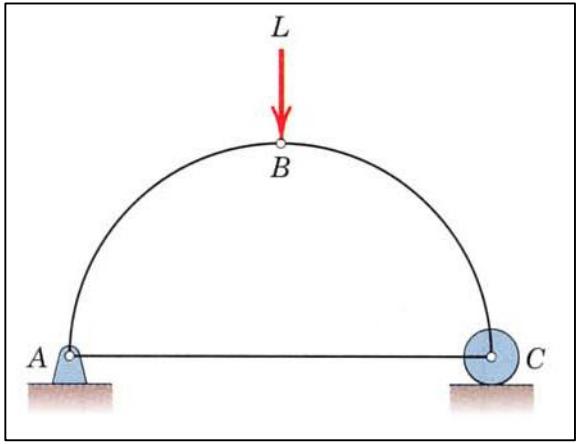
Problem 2

Classroom Tutorial Question

Problem 3

Determine the force in member AC of the loaded truss. The two quarter-circular members act as two-force members.

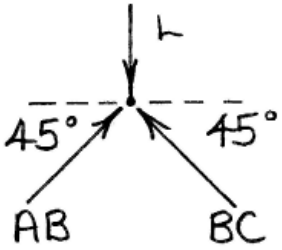
$$Ans.\ AC = \frac{L}{2}T$$



Classroom Tutorial Question

From $\Sigma F_x = 0$, $AB = BC$

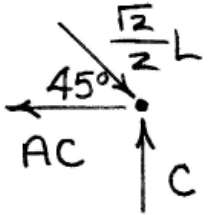
Joint B :



$$\Sigma F_y = 0: \quad 2AB\frac{\sqrt{2}}{2} - L = 0$$

$$AB = \frac{\sqrt{2}}{2}L = BC$$

Joint C :



$$\Sigma F_x = 0: \quad \frac{\sqrt{2}}{2}L\left(\frac{\sqrt{2}}{2}\right) - AC = 0$$

$$\underline{AC = \frac{L}{2} \quad T}$$

Problem 3

Classroom Tutorial Question

Determine the force in each member of the loaded truss. Make use of the symmetry of the truss and of the loading.

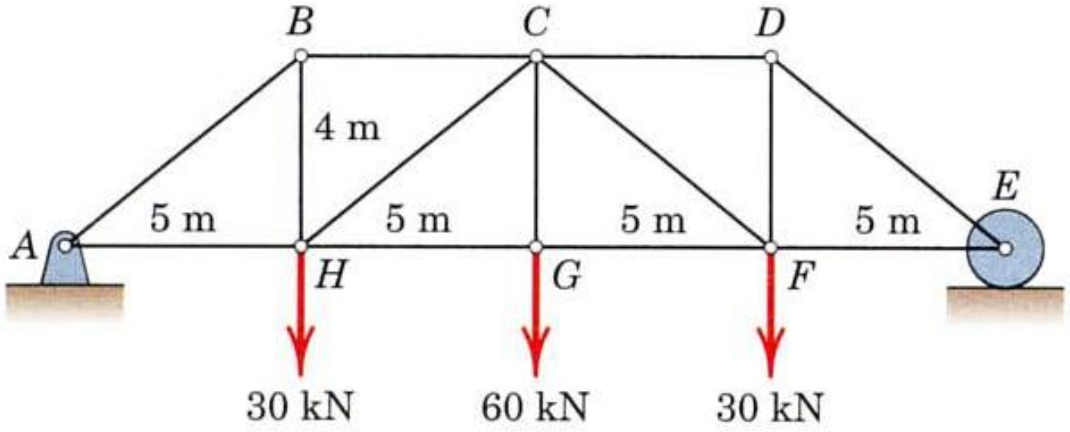
Ans. $AB = DE = 96.0$ kN C

$AH = EF = 75$ kN T, $BC = CD = 75$ kN C

$BH = CG = DF = 60$ kN T

$CH = CF = 48.0$ kN C, $GH = FG = 112.5$ kN T

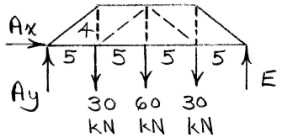
Problem 4



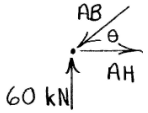
Classroom Tutorial Question

As a whole: $\Sigma F_x = 0 \Rightarrow A_x = 0$

(Dim. in m) $\uparrow y$, $\rightarrow x$ $A_y = E = 60$ kN by $\Sigma F_y = 0$ and symmetry.



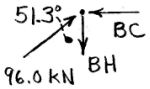
Joint A: $\left(\theta = \tan^{-1}\left(\frac{4}{5}\right) = 38.7°\right)$



$\Sigma F_y = 0$: $60 - AB \sin\theta = 0$, $\underline{AB = 96.0 \text{ kN C}}$

$\Sigma F_x = 0$: $AH - 96.0 \cos\theta = 0$, $\underline{AH = 75 \text{ kN T}}$

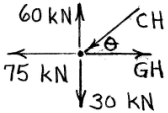
Joint B:



$\Sigma F_x = 0$: $-BC + 96.0 \sin 51.3° = 0$, $\underline{BC = 75 \text{ kN C}}$

$\Sigma F_y = 0$: $-BH + 96.0 \cos 51.3° = 0$, $\underline{BH = 60 \text{ kN T}}$

Joint H:



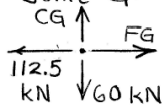
$\Sigma F_y = 0$: $-CH \sin\theta + 30 = 0$, $\underline{CH = 48.0 \text{ kN C}}$

$\Sigma F_x = 0$: $-48.0 \cos\theta + GH - 75 = 0$

$\underline{GH = 112.5 \text{ kN T}}$

$\Sigma F_y = 0 \Rightarrow \underline{CG = 60 \text{ kN T}}$

Joint G:



By symmetry:

FG = 112.5 kN T, CF = 48.0 kN C

CD = 75 kN C, DF = 60 kN T

EF = 75 kN T, DE = 96.0 kN C

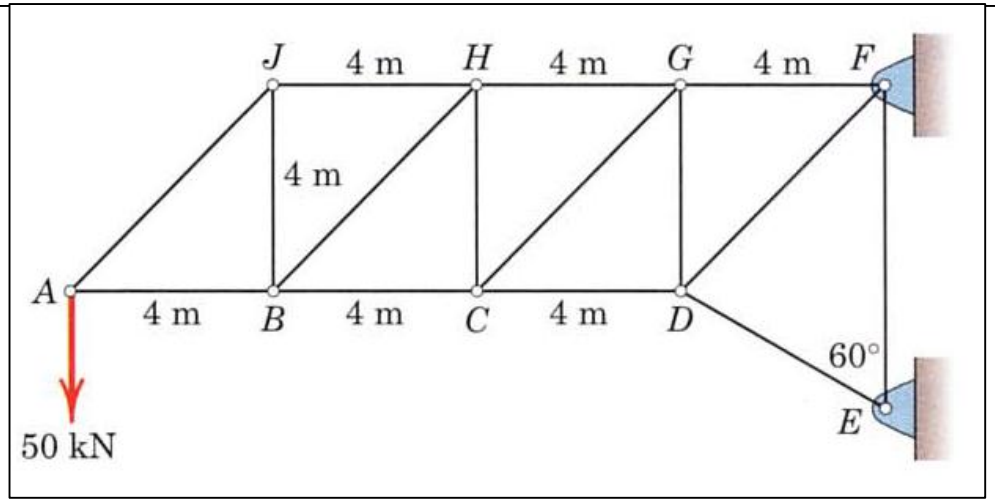
Problem 4

Classroom Tutorial Question

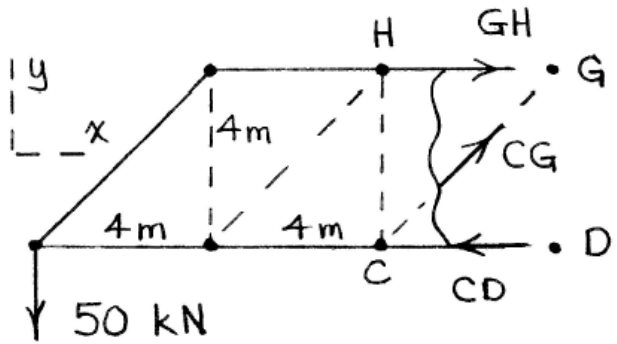
Determine the forces in members GH and CG for the truss loaded and supported as shown. Does the statical indeterminacy of the supports affect your calculation?

Ans. $CG = 70.7$ kN T, $GH = 100$ kN T, No

Problem 5



Classroom Tutorial Question



$\Sigma F_y = 0$: $CG \sin 45° - 50 = 0$, $\underline{CG = 70.7 \text{ kN T}}$

$\Sigma M_c = 0$: $GH(4) - 50(8) = 0$, $\underline{GH = 100 \text{ kN T}}$

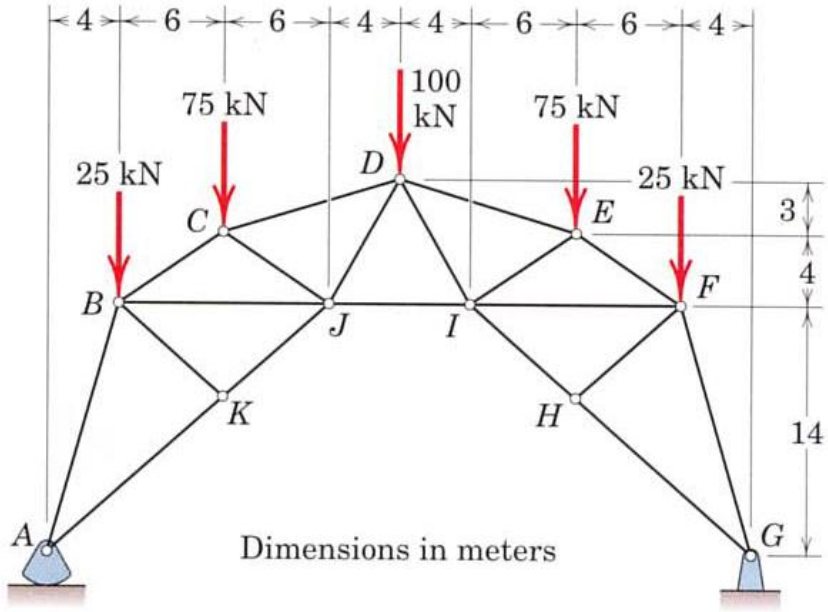
All members except EF are statically determinate, so above solution is unaffected by the redundant support.

Problem 5

Classroom Tutorial Question

Determine the forces in members DE, EI, FI, and HI of the arched roof truss.

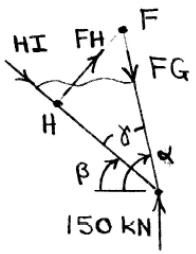
Ans. $DE = 297$ kN C, $EI = 26.4$ kN T
$FI = 205$ kN T, $HI = 75.9$ kN T



Problem 6

Classroom Tutorial Question

By symmetry, $A = G = 150$ kN



$\circlearrowleft \Sigma M_F = 0: \; 150(4) + HI\,(7.902) = 0$

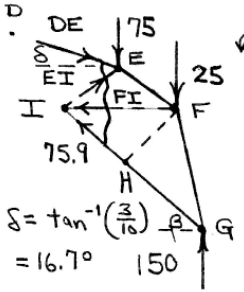
$\underline{HI = -75.9 \text{ kN T}}$

(Note: $\alpha = \tan^{-1}\left(\frac{14}{4}\right) = 74.1°$

$\beta = \tan^{-1}\left(\frac{14}{16}\right) = 41.2°$

$\gamma = \alpha - \beta = 32.9°$

Then $d_\perp = FG \sin\gamma = \sqrt{14^2+4^2}\,\sin\gamma = 7.902$ m)



$\delta = \tan^{-1}\left(\frac{3}{10}\right) = 16.7°$

$\circlearrowleft + \; \Sigma M_E = 0: -25(6) + 150(10)$

$-FI\,(4) - (75.9 \sin\beta)(6) - (75.9\cos\beta)(4)$

$= 0, \quad \underline{FI = 205 \text{ kN T}}$

$\Sigma M_I = 0: -75(6) - 25(12) + 150(16)$

$-(DE\cos\delta)(4) - (DE\sin\delta)(6) = 0$

$\underline{DE = 297 \text{ kN C}}$

$\Sigma F_y = 0: -75 - 25 + 150 - 297\sin\delta + 75.9\sin\beta$

$+ EI\,\frac{4}{\sqrt{52}} = 0, \quad \underline{EI = -26.4 \text{ kN T}}$

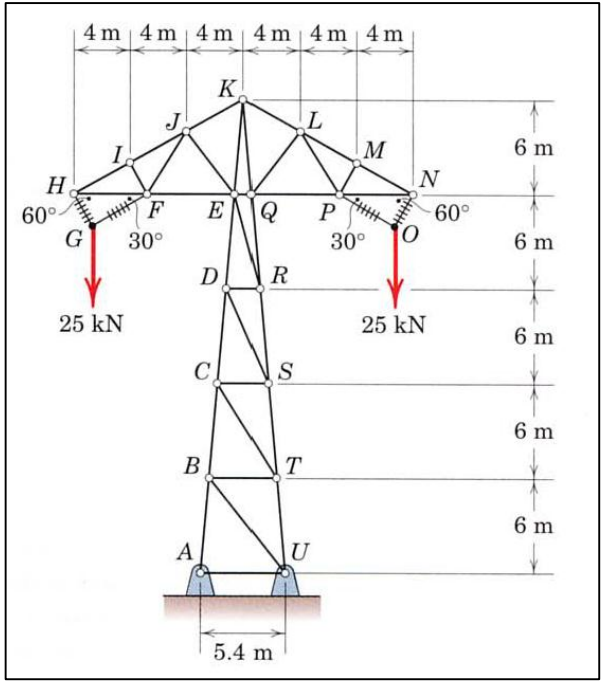
Problem 6

Classroom Tutorial Question

Problem 7

A design model for a transmission-line tower is shown in the figure. Members GH, FG, OP, and NO are insulated cables; all other members are steel bars. For the loading shown, compute the forces in members FI, FJ, EJ, EK, and ER. Use a combination of methods if desired.

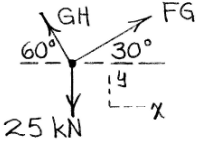
Ans. $FI = ER = 0$, $FJ = 7.81$ kN T
$EJ = 3.61$ kN C, $EK = 22.4$ kN C



Classroom Tutorial Question

$FI = 0$, by inspection of joint I.

Joint G:



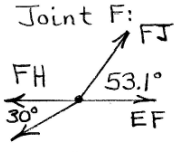
$$\begin{cases} \sum F_x = 0: -GH\left(\frac{1}{2}\right) + FG\left(\frac{\sqrt{3}}{2}\right) = 0 \\ \sum F_y = 0: GH\left(\frac{\sqrt{3}}{2}\right) + FG\left(\frac{1}{2}\right) - 25 = 0 \end{cases}$$

1st eq.: $GH = \sqrt{3}\, FG$

2nd eq.: $\sqrt{3}\, FG\left(\frac{\sqrt{3}}{2}\right) + \frac{1}{2} FG = 25$

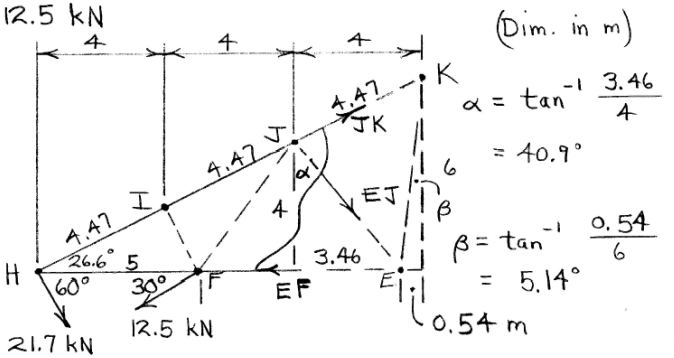
$\Rightarrow FG = 12.5$ kN T, $GH = 21.7$ kN T

Joint F:



$\sum F_y = 0: FJ(\sin 53.1°) - 12.5 \sin 30° = 0$

$FJ = 7.81$ kN T



(Dim. in m)

$\alpha = \tan^{-1} \frac{3.46}{4}$

$= 40.9°$

$\beta = \tan^{-1} \frac{0.54}{6}$

$= 5.14°$

Problem 7

UNIT - 1
Completed
Thanks