IMPORTANT DATES

26th Oct : Lab II

2nd Nov : HW III Due

4th Nov : EXAM III [Chap 4, 5, 6]

9th Nov : ALL LAB II REPORTS ARE DUE
Two-Force and three force members

Two Force Members:

If the system of forces and moments acting on an object at different points, it is referred as a Two Force Member.

The following object is subjected to two set of concurrent forces whose lines of action intersect at A and B, where \( F^2 = \sum_{i=1}^{N} f_i \) and \( F' = \sum_{i=1}^{M} f_i' \)

\[ F = F_1 + F_2 + \ldots + F_N \quad \text{and} \quad F' = F_1' + F_2' + \ldots + F_M' \]

If the object is in equilibrium, \( F + F' = 0 \Rightarrow F = -F' \)

Forces \( F \) and \( -F' \) form a couple, so sum of the moments is not zero unless the line of action of the forces lie along the line of action of forces lie along the line through the points A & B.
Equilibrium is when two forces are equal in magnitude, are opposite in direction, and have the same line of action.

THREE-FORCE MEMBERS

Of the system of forces and moments acting on an object is equivalent to three forces acting at different points, it is called a three force member.

If a three force member is in equilibrium, the three forces are co-planar and are either parallel or concurrent.
The L-shaped bar has a pin support at A and is loaded by 6-kN force at B. Neglect the weight of the bar. Determine the angle $\alpha$ and the reaction at A.

Solution

\[
\tan \alpha = \frac{400}{700}
\]

\[
\Sigma F_x = A_x + 6 \cos \alpha = 0
\]

\[
\Sigma F_y = A_y + 6 \sin \alpha = 0
\]

\[
\Sigma M_A = (6 \sin \alpha)(0.7) - (6 \cos \alpha)(0.4) = 0
\]

8 equations, 3 unknowns
Consider $0 \leq \alpha \leq 360^\circ$

1. $\alpha = 29.7^\circ \Rightarrow A_x = -5.21 \, \text{KN}, \quad A_y = -2.98 \, \text{KN}$
2. $\alpha = 209.7^\circ \Rightarrow A_x = 5.21 \, \text{KN}, \quad A_y = 2.98 \, \text{KN}$

(iii) Treat the bar as a two-force member for equilibrium. Force at B should be balance by force at A.

Two possibilities:

\[ \tan \alpha = \tan^{-1} \left( \frac{4}{\ell} \right) \]

\[ \alpha = 29.7^\circ \]

$A_x = -6 \cos 29.7^\circ = -5.21 \, \text{KN}$

$A_y = -6 \sin 29.7^\circ = -2.98 \, \text{KN}$

(iv) $\alpha = 180 + 29.7^\circ = 209.7^\circ$

$A_x = 6 \cos 29.7^\circ = 5.21 \, \text{KN}$

$A_y = 6 \sin 29.7^\circ = 2.98 \, \text{KN}$
The 100 lb weight of rectangular plate acts at mid point. Determine reaction at B & C

**Solution**

**Forces:** weight + Reaction at B and C

i. 3 Force member.

ii. gt is in equilibrium, their line of action must intersect.

\[ \sum F_x = B \cos 45 - C \cos 45 = 0 \]
\[ \sum F_y = B \cos 45 + C \cos 45 - 100 = 0 \]

\[ B = C = 70.7 \text{ lb} \]
Chapter 6 - Structures in Equilibrium

A truss is a structure composed of slender members joined together at their end points. Example: A typical roof supporting truss or a bridge truss.

Simple Truss:

- Pin three bars together at their ends to form a triangle. Supports are added.
- A structure is obtained that will support load \( F \). Bars are members of the structure placed where bars are pinned are joints.
- Elaborate structures can be created by adding more triangles.
Forces exerted on these members at its joints is called axial force in the member. 

If forces are directed away from each other: Tension

If forces are directed towards each other: Compression

To analyze and compute these axial forces:

* Method of joints
* Method of section
Method of Joints

(3) Determine the force in each member of truss and indicate whether the members are in tension or compression.

Joint B

\[ \sum F_x = 0 \Rightarrow 500 = F_{BC} \sin 45^\circ \]
\[ \sum F_y = 0 \Rightarrow F_{BC} \cos 45^\circ - F_{BA} = 0 \]
\[ F_{BC} = 707.1 \text{ N (C)} \]
\[ F_{BA} = 500 \text{ N (T)} \]

Joint C

\[ \sum F_x = 0 \Rightarrow -F_{CA} + F_{BC} \cos 45^\circ = 0 \]
\[ \sum F_y = 0 \Rightarrow C_y - F_{BC} \sin 45^\circ = 0 \]
\[ F_{CA} = 500 \text{ N (C)} \]
\[ C_y = 500 \text{ N (T)} \]
**Joint A**

\[ F_{BA} = 500 \text{N} \]

\[ F_{CA} = 500 \text{N} \]

\[
\begin{align*}
\sum F_x &= 0 \\
\sum F_y &= 0 \\
F_{CA} - A_x &= 0 \\
F_{BA} - A_y &= 0
\end{align*}
\]

\[
\begin{align*}
A_x &= 500 \text{N} \\
A_y &= 500 \text{N}
\end{align*}
\]

\[ F_{CD} = 707.1 \text{N} \] (C)

\[ F_{CA} = 500 \text{N} \] (T)

\[ A_x = 500 \text{N} \]

\[ A_y = 500 \text{N} \]

\[ C_y = 500 \text{N} \]
Method of Sections: when forces in only a few members of truss is required.

Basic Idea:
- Cut or section the truss through the members where forces are determined.
- Make the free body diagram.
- Write the equilibrium equation and compute the unknown.

4) Determine the force in members GE, GC and BC of the truss. Indicate whether the members are in tension or compression.
FBD of entire truss:

\[ \Sigma F_x = 0 \Rightarrow 400 - A_x = 0 \]
\[ \Rightarrow A_x = 400 \text{ N} \]

\[ \Sigma M_A = 0 \]
\[ \Rightarrow (1200 \text{ N})(8 \text{ m}) - 400 \text{ N}(3 \text{ m}) + D_y(12 \text{ m}) = 0 \]
\[ \Rightarrow D_y = 900 \text{ N} \]

\[ \Sigma F_y = 0 \]
\[ \Rightarrow A_y - 1200 + 900 = 0 \]
\[ \Rightarrow A_y = 300 \text{ N} \]

\[ \Sigma M_G = 0 \Rightarrow (-300 \text{ N})(4 \text{ m}) - 450 \text{ N}(3 \text{ m}) + F_{BC}(3 \text{ m}) = 0 \]
\[ F_{BC} = 800 \text{ N} \]

\[ \Sigma M_C = 0 \Rightarrow -300(8 \text{ m}) + F_{GE}(3 \text{ m}) = 0 \]
\[ F_{GE} = 800 \text{ N \ (C)} \]

\[ \Sigma F_y = 0 \]
\[ \Rightarrow \frac{3}{5} \sin x = \frac{4}{5} \cos x \]
\[ \Rightarrow \sin x = \frac{4}{3} \cos x \]
\[ \Rightarrow \sin x = 0 \]
\[ \Rightarrow F_{y} = 0 \Rightarrow 300 - F_{GC} \sin x = 0 \]
300 N - \frac{3}{5} F_{GC} = 0

\begin{align*}
F_{GC} &= 500 N
\end{align*}