2D EQUILIBRIUM WEEK

FBD OF 2D SYSTEMS (CHAPTER 5.1-5.2)

5.1 EQUILIBRIUM OF A RIGID BODY

\[ \sum F = 0 \]
\[ \sum M = 0 \]

All acting forces & moments sum up to zero.

5.2 FREE BODY DIAGRAMS

Always start with a FBD!

I. DRAW OUR UNIQUED SHAPE isolate/cut/freeze

II. SHOW ALL FORCES & MOMENTS identify all external forces from:
   1) applied loading
   2) reactions @ support or contact points
   3) weight of the body

III. IDENTIFY LOADING & GIVE DIMENSIONS

Label all loads & dimensions!
SUPPORT REACTIONS = IMPORTANT!

**General Rules:**
- If a support prevents **translation**, a **Force** develops in that direction.
- If a support prevents **rotation**, a **Moment** develops.

**Example:** Support of a beam

1) **Roller (Cylinder)**
   - No motion in vertical direction.
   - Vertical force.

2) **Pin**
   - No motion in horizontal & vertical directions.
   - Horizontal & Vertical forces.

3) **Fixed**
   - No motion & no rotation.
   - Horizontal & Vertical forces and moment.

**Table 5-1: Memorize!**

*Images on page 211.* Discuss!

Familiarize yourself w/symbols & forces.
EXAMPLE #1: STEEL BEAM

Assumptions:
- Steel is "rigid" → small deformation
- Bolted connection @ A  vs pin
- No resistance to horizontal loading @ B
- Weight << loading 1x can be neglected

MODEL

PROBLEM:
- Given F, a, b, c, d
- 3 unknowns Ax, Ay, B
- 3 equations: \( \Sigma F_x = 0; \Sigma F_y = 0; \Sigma M = 0 \)

EXAMPLE #2: LIFT BOOM

Assumptions:
- Pin support @ A
- Boom has weight W @ center of gravity
- Hydraulic cylinder BC, face along link
- Loaded by force P (vertical)
**MODEL**

**PROBLEM:**
- given $l$, $\alpha$, $B$, $G$, $P$
- unknowns $A_x$, $A_y$, $F_{bc}$
- equations
  \[ \Sigma F_x = 0, \Sigma F_y = 0, \Sigma M = 0 \]
**Problem F4-41**

Determine resultant force & specify where it acts on the beam measured from point A.

\[
\begin{align*}
6 \text{ kN/m} & \\
& \downarrow \downarrow \downarrow \downarrow \downarrow \downarrow \downarrow \downarrow \downarrow \\
& \longrightarrow 4.5 \text{ m} \quad \longrightarrow 1.5 \text{ m} \\
\hline
& \hline
2 \text{ kN/m} & \\
\end{align*}
\]

**1D Force** \( F_r \)

\[
\uparrow F_r = \sum F_y = -3 \text{ kN/m} \cdot 6 \text{ m} - \frac{1}{2} \cdot 3 \text{ kN/m} \cdot 4.5 \text{ m}
\]

**1D Moment** \( M_{MA} \)

\[
\sum M_{MA} = -3 \text{ kN/m} \cdot 6 \text{ m} \cdot \frac{1}{2} \cdot 6 \text{ m} - \frac{1}{2} \cdot 3 \text{ kN/m} \cdot 4.5 \text{ m} \cdot \frac{1}{3} \cdot 4.5 \text{ m}
\]

\[
= -18 \text{ kN} \cdot 3 \text{ m} - 6.75 \text{ kN} \cdot 1.5 \text{ m} = 64.125 \text{ kN m}
\]

\[
F_r \cdot d = -64.125 \text{ kN m}
\]

\[
d = -\frac{64.125 \text{ kN m}}{-24.75 \text{ kN}} = 2.59 \text{ m}
\]