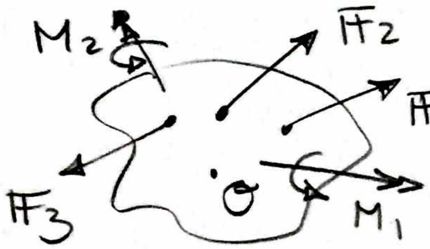
ENGR 14 - STATICS - VIII - TUE 02/02/16

2D EQUILIBRIUM WEEK

FBD OF 2D SYSTEMS (CHAPTERS 5.1-5.2)

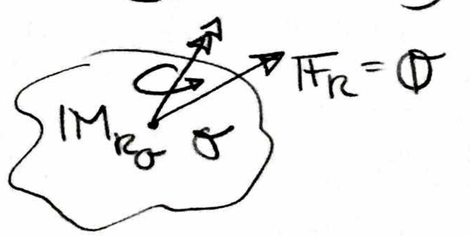
5.1 EQUILIBRIUM OF A RIGID BODY



$$\sum_i F_R = \sum_i F \stackrel{!}{=} 0$$

$$\sum_i M_{R_O} = \sum_i M_O \stackrel{!}{=} 0$$

all acting forces & moments sum up to zero



remark this holds for <u>any</u> point O!

5.2 FREE BODY DIAGRAMS

>> always start with a FBD!

I. <u>DRAW OUTLINED SHAPE</u> isolate /cut/free

II. <u>SHOW ALL FORCES & MOMENTS</u>

identify all external forces from

1) applied loading
2) reactions @ supports or contact points
3) weight of the body

III. <u>IDENTIFY LOADING & GIVE DIMENSIONS</u>

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

more restrictive ~> more support

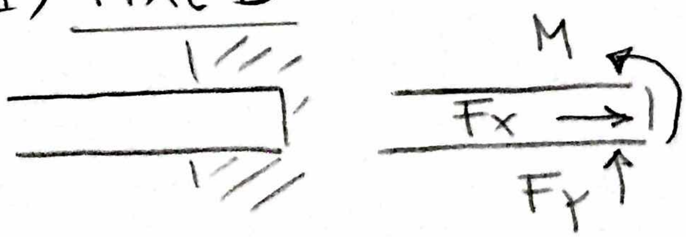
I) ROLLER (CYLINDER)

no motion in vertical direction ~> vertical force

II) PIN

no motion in horizontal & vertical directions ~> horizontal & vertical forces

III) FIXED



no motion & no rotation ~> horizontal & vertical forces and moment

>> TABLE 5-1 - MEMORIZE!

IMAGES ON PAGE 211 >> DISCUSS!

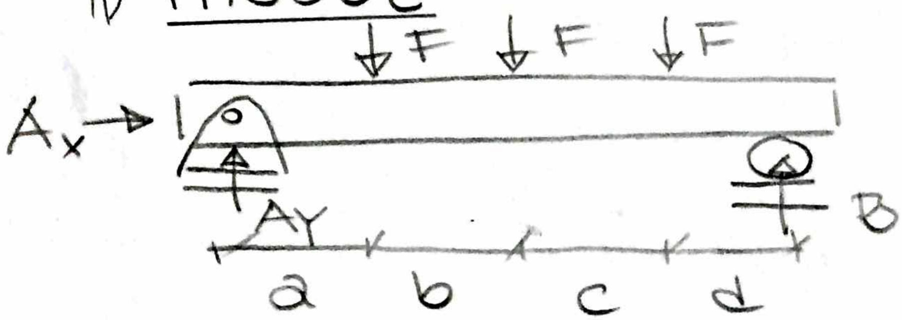
FAMILIARIZE YOURSELF W/ SYMBOLS & FORCES

EXAMPLE #1 : STEEL BEAM

assumptions:

- steel is "rigid" ▷ small deformation
- bolted connection @ A ▷ pin
- no resistance to horizontal loading @ B ▷ roller
- weight ≪ loading ▷ can be neglected

▷ MODEL



▷ PROBLEM:

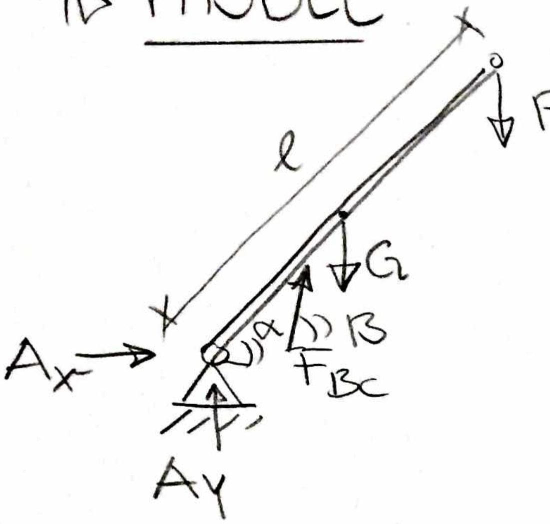
- given F, a, b, c, d
- 3 unknowns A_x, A_y, B
- 3 equations $\Sigma F_x = 0; \Sigma F_y = 0; \Sigma M = 0$

EXAMPLE #2: LIFT BOOM

assumptions:

- pin support @ A
- boom has weight W @ center of gravity
- hydraulic cylinder BC, force along link
- loaded by force P (vertical)

1) MODEL

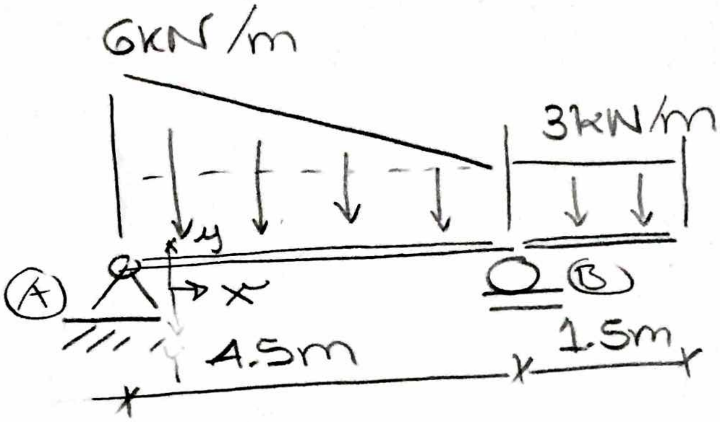


1) PROBLEM:

- given l, α, β, G, P
- unknowns A_x, A_y, F_{BC}
- equations
  $\Sigma F_x \overset{!}{=} 0$, $\Sigma F_y \overset{!}{=} 0$, $\Sigma M \overset{!}{=} 0$

PROBLEM F4-41

DETERMINE RESULTANT FORCE & SPECIFY WHERE IT ACTS ON THE BEAM MEASURED FROM POINT A.



1) FORCE F_R

$+\uparrow F_R = \sum F_y = -3\,kN/m \cdot 6m - \frac{1}{2} \cdot 3kN/m \cdot 4.5m$

$= -[18 + 6.75]\,kN = -24.75\,kN$ (pointing down)

1) MOMENT M_{RA}

$\circlearrowleft + M_{R(A)} = \sum M_{(A)} = -3kN/m \cdot 6m \cdot \frac{1}{2} \cdot 6m - \frac{1}{2} \cdot 3kN/m \cdot 4.5m \cdot \frac{1}{3} \cdot 4.5m$

$= -18kN \cdot 3m - 6.75kN \cdot 1.5m = -64.125kNm$

$F_R \cdot d = -64.125kNm$

$d = -64.125\,kNm / -24.75kN$

$d = 2.59m$