E14- STATICS IX Wed 04/27/11

2D EQUILIBRIUM WEEK

WHAT'S FORCE & MOMENT EQUILIBRIUM IN 2D?

5.3 EQS OF EQUILIBRIUM (CHAPTER 5.3-5.4)

- equilibrium in 2d

$$\boxed{\Sigma F_x = 0 \qquad \Sigma F_y = 0 \qquad \Sigma M_z = 0}$$

- alternative set of equations

$$\boxed{\Sigma F_x = 0 \qquad \Sigma M_A = 0 \qquad \Sigma M_B = 0}$$

such that $r_{AB} \not\perp x$ (A & B may not be perp. to x)

- or, alternatively

$$\boxed{\Sigma M_A = 0 \qquad \Sigma M_B = 0 \qquad \Sigma M_C = 0}$$

such that A, B, C do not lie on the same line

remarks: I use one of the eqns you have not used before as a control!

II apply $\Sigma M_O = 0$ first, select point O such that two lines of action pass through it ⇝ direct solution of one force!

III you may orient the x-y-system along your members!

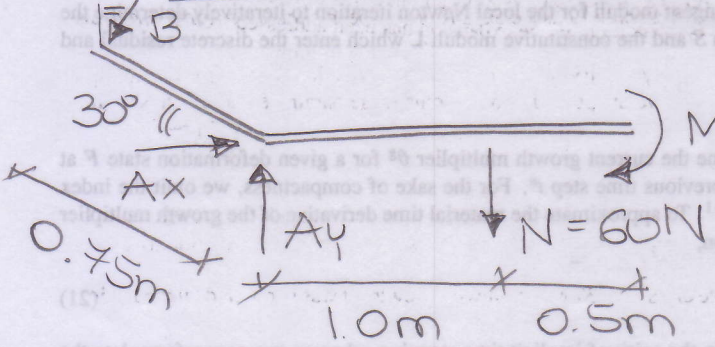
IV if the solution for a force is negative, this implies that it acts opposite to the direction you have assumed!

be smart!

EXAMPLE 5.5

I image ▷ project

II free body diagram (everybody try them = solve)



▷ project

III Solution

which equ do we start with? why?

$$\circlearrowleft \sum M_A \overset{!}{=} 0 \qquad +B \cdot 0.75m - N \cdot 1.0m - M \overset{!}{=} 0$$

$$\rightsquigarrow B = [N \cdot 1.0m + M]/0.75m$$

$$= [60Nm + 90Nm]/0.75m = \underline{\underline{200N}}$$

(sin or cos?)

$$\overset{+}{\rightarrow} \sum F_x \overset{!}{=} 0 \qquad Ax - B \cdot \sin 30° \overset{!}{=} 0$$

(CHECK IN FIGURE!)

$$\rightsquigarrow Ax = B \cdot \sin 30° = 200N \cdot 0.5 = \underline{\underline{100N}}$$

$$\overset{+}{\uparrow} \sum F_y \overset{!}{=} 0 \qquad Ay - N - B \cdot \cos 30° \overset{!}{=} 0$$

$$\rightsquigarrow Ay = N + B \cdot \cos 30°$$

$$= 60N + 200N \cdot \tfrac{1}{2}\sqrt{3} = \underline{\underline{233N}}$$

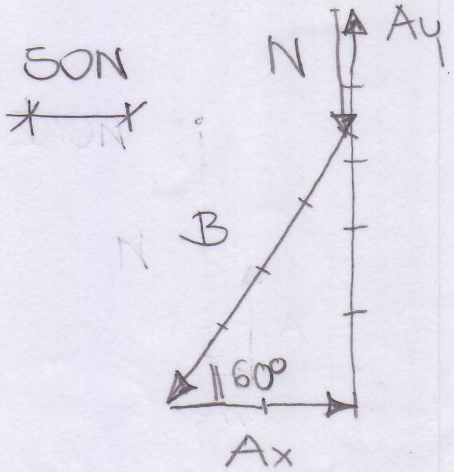
$$\circlearrowleft \sum M_B \overset{!}{=} 0 \qquad -M - N[1.0_m + 0.75_m \cos 30°]$$

$$+ Ax \cdot 0.75_m \sin 30° + Ay \cdot 0.75_m \cos 30°$$

$$= \underline{\underline{0Nm}}$$

▷ project!

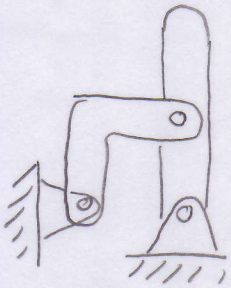
graphic control using vector addition



$$\boxed{\mathbb{A}_x + \mathbb{A}_y + \mathbb{B} + \mathbb{N} = \mathbb{0}}$$

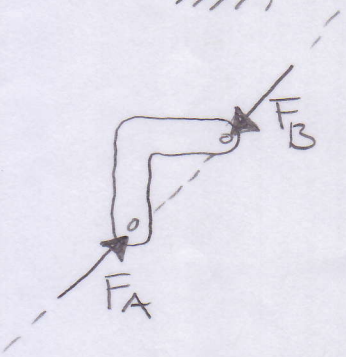
establish a length scale!

5.4 TWO- & THREE-FORCE MEMBERS



TWO FORCE MEMBERS

- pin-connected @ both ends
- weightless
- no extra forces acting on it



$\Sigma F_x = 0$ & $\Sigma F_y = 0$

$F_A = F_B$ F_A & F_B are equal & opposite

$\Sigma M = 0$

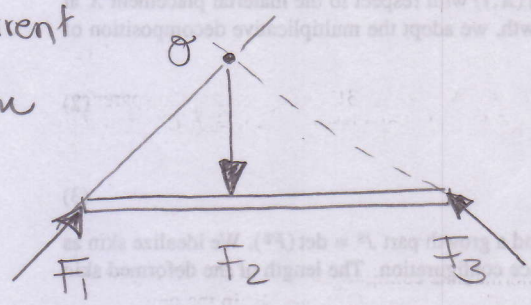
F_A & F_B lie on the same line of action (& do not produce a couple moment)

identifying two-force members is essential or you will not have enough equations to solve for the unknowns!

EXAMPLE 5.13!

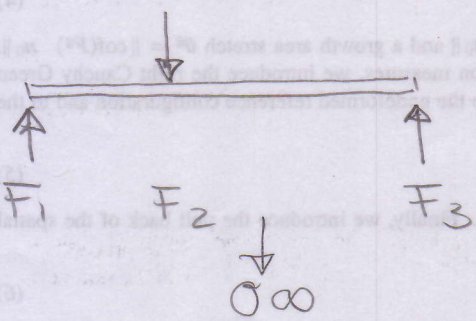
THREE FORCE MEMBER

concurrent force system



$\Sigma M = 0$ requires that the three forces form a concurrent (meeting in O) or parallel force system

parallel force system

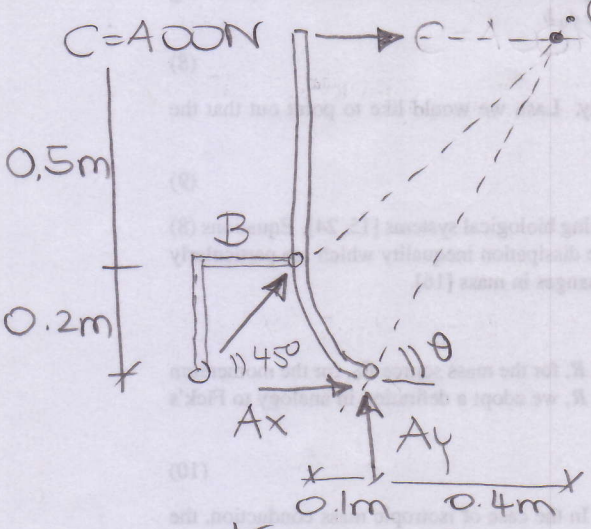


special case of parallel force system: lines of action intersect @ "infinity"

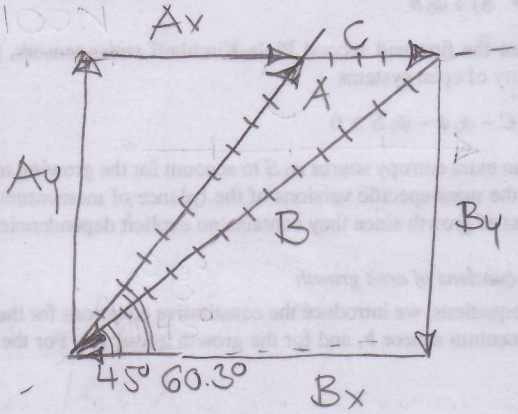
EXAMPLE 5.13

I image to project

II free body diagram



graphic solution



C=400N

B≈1300N

A≈1000N

Kinematics:

$\theta = ?$ $\quad \tan\theta = \dfrac{0.5m + 0.2m}{0.4m} \rightsquigarrow \underline{\underline{\theta = 60.3^\circ}}$

this replaces $\Sigma M = 0$ equation, then use $\Sigma F_x = 0$ & $\Sigma F_y = 0$ to det. A & B