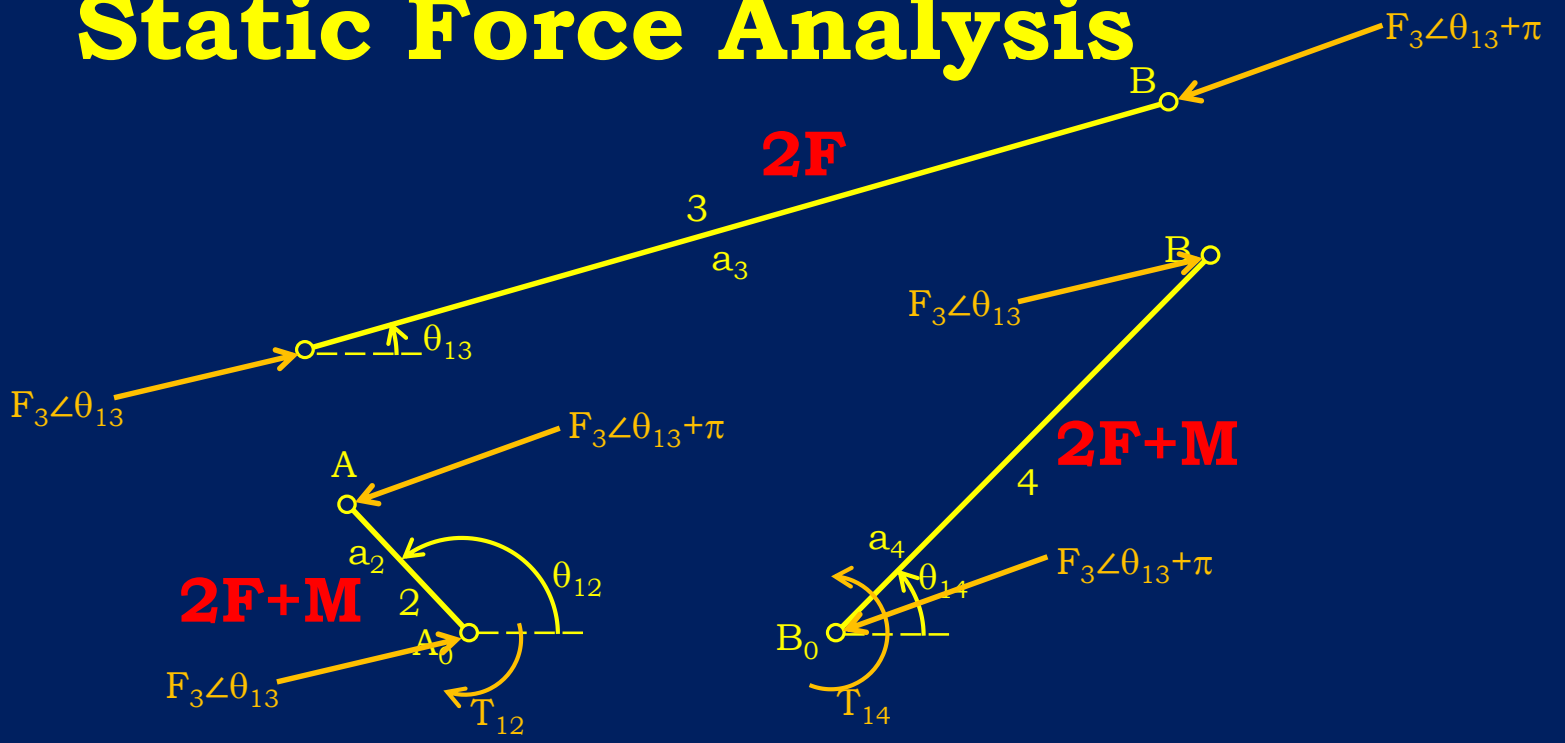
Static Force Analysis



Link 4

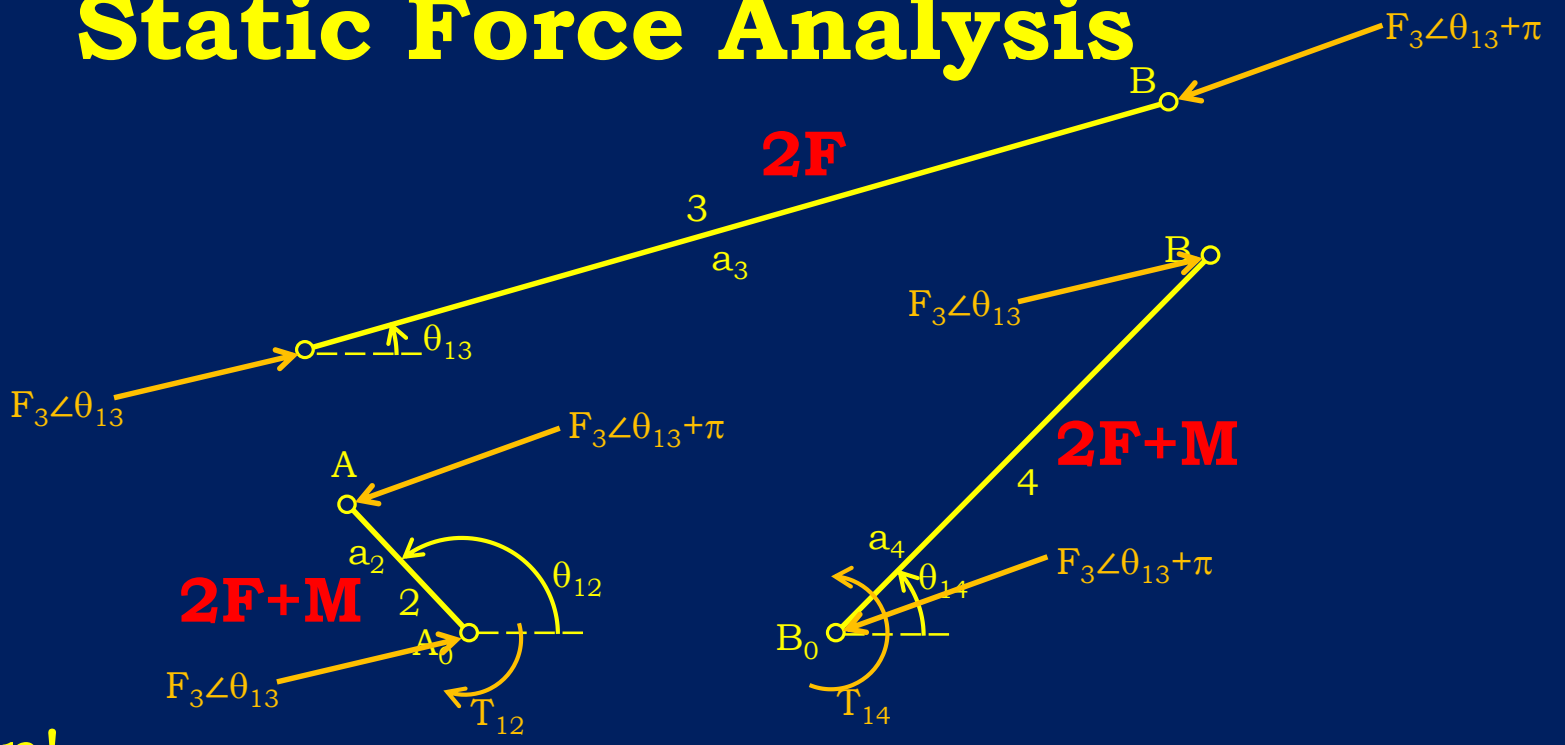
$$\sum M_{B_0} = 0 \rightarrow T_{14} + a_4 cos\theta_{14} F_3 sin\theta_{13} - a_4 sin\theta_{14} F_3 cos\theta_{13} = 0$$

$$T_{14} + a_4 F_3 sin(\theta_{13} - \theta_{14}) = 0$$

$$\boxed{M = a_i F_j sin\left(\theta_{F_j} - \theta_{a_i}\right)}$$

$$F_3 = \frac{T_{14}}{a_4 sin(\theta_{14} - \theta_{13})}$$

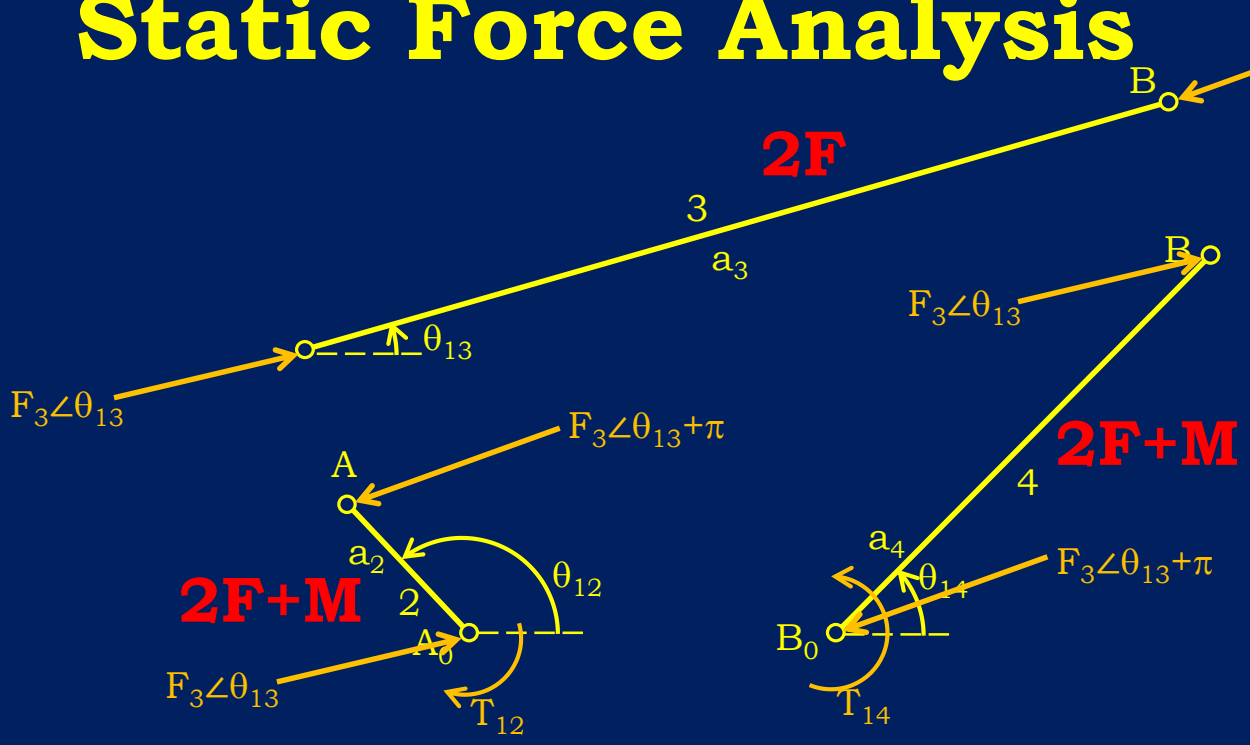
Static Force Analysis



Link 3

No equation!

Static Force Analysis



Link 2

$$\sum M_{A_0} = T_{12} + a_2 F_3 sin[(\theta_{13} + \pi) - \theta_{12}] = 0$$

$$-T_{12} + a_2 F_3 sin[(\theta_{13} + \pi)\theta_{12}] = 0$$

$$T_{12} = -a_2 F_3 sin[(\theta_{13} + \pi)\theta_{12}]$$

*Only **two** equations of equilibrium!*

Static Force Analysis

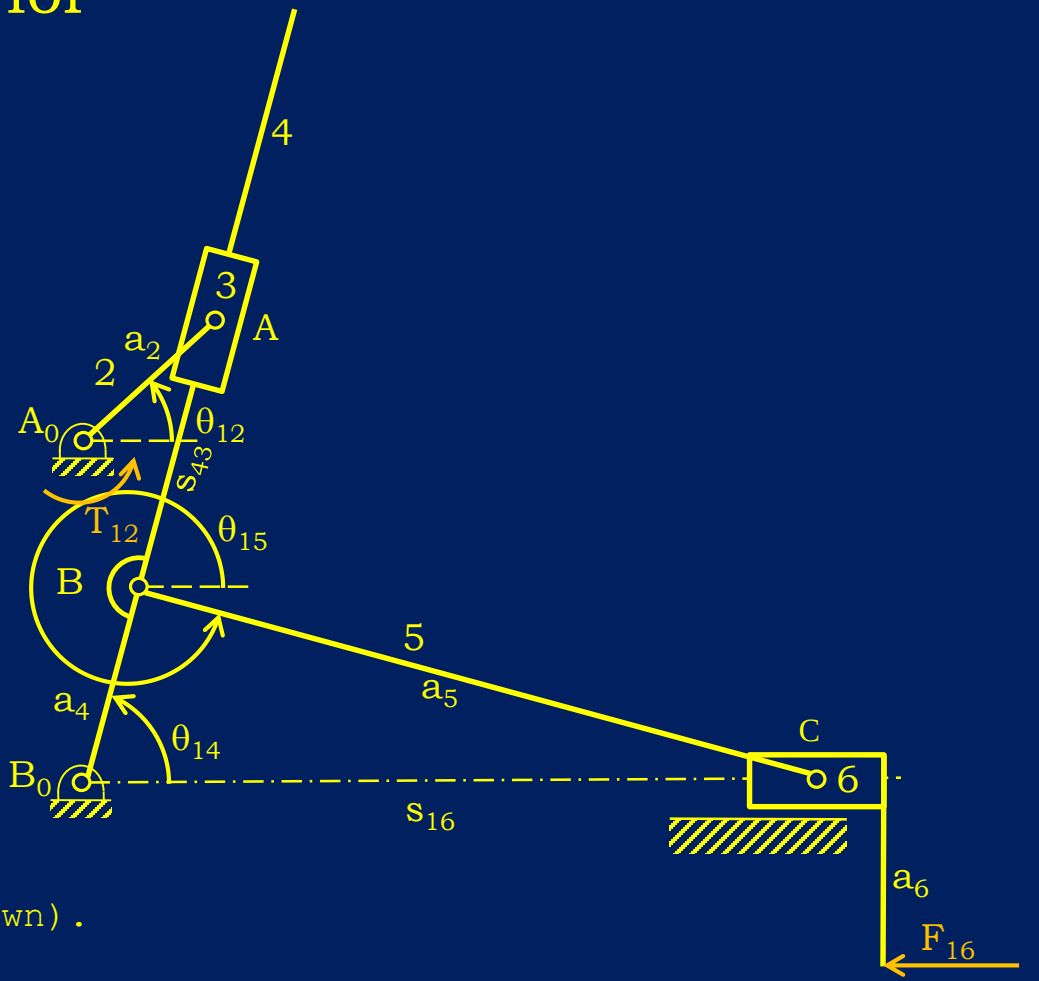
Quick Return Mechanism:

Known F_{16} determine T_{12} for *every* position.

Link 5 is 2F

Link 2 is 2F+M

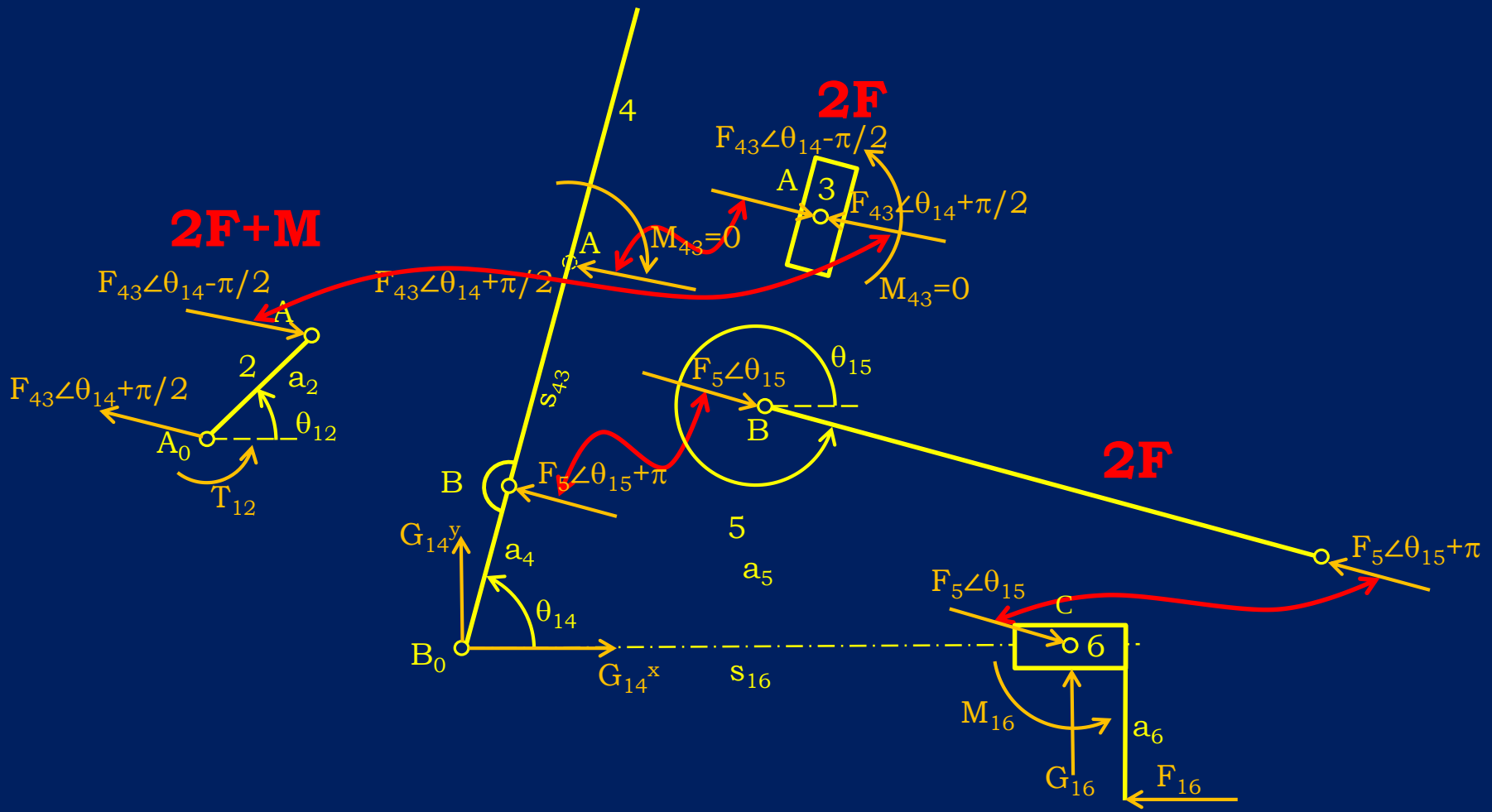
Link 3 is 2F



See also Example 6.1 (Please scroll down).

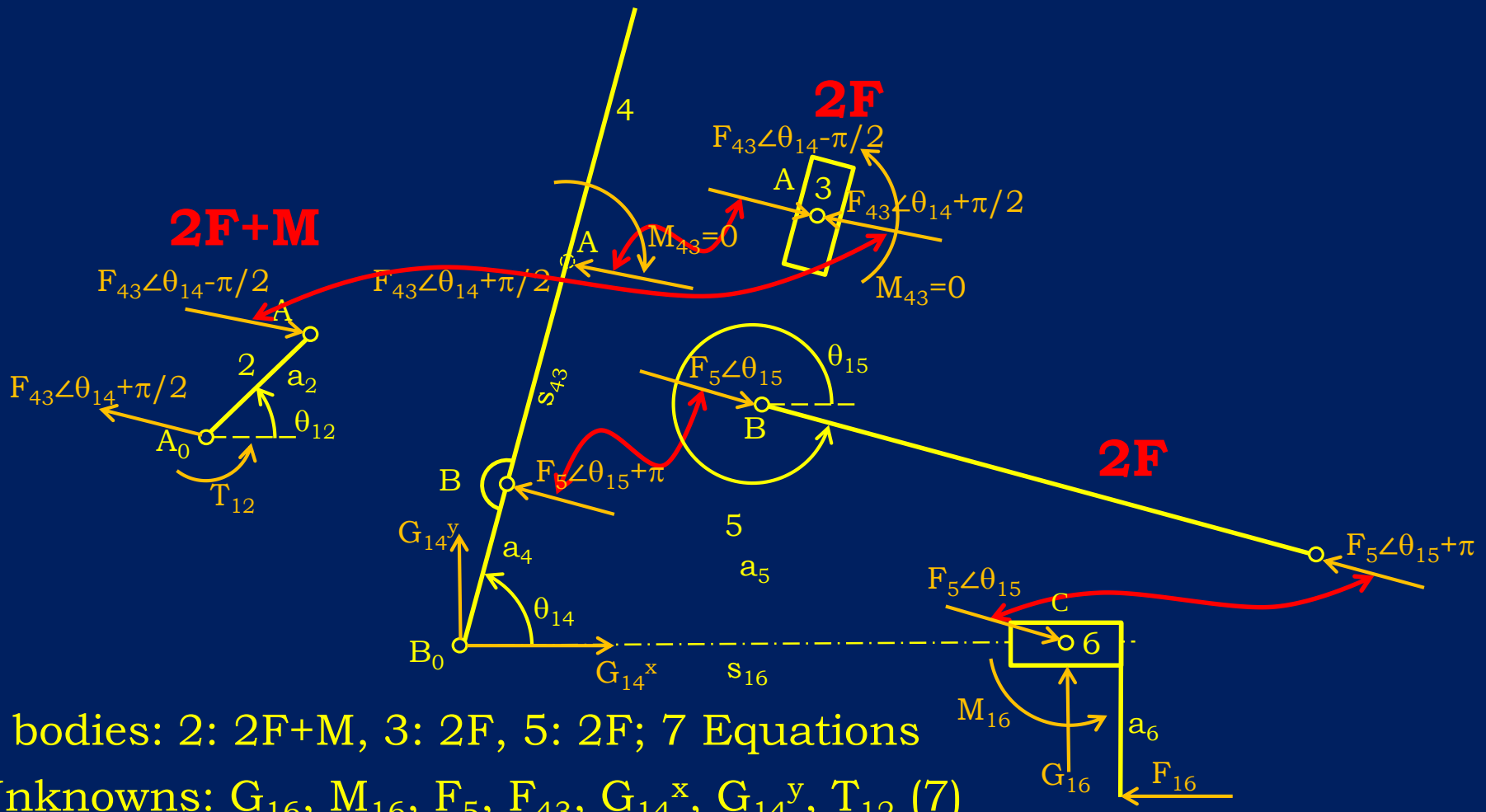
Static Force Analysis

Quick Return Mechanism:



Static Force Analysis

Quick Return Mechanism:



5 bodies: 2: 2F+M, 3: 2F, 5: 2F; 7 Equations

Unknowns: G_{16}, M_{16}, F_5, F_{43}, $G_{14}{}^x$, $G_{14}{}^y$, T_{12} (7)

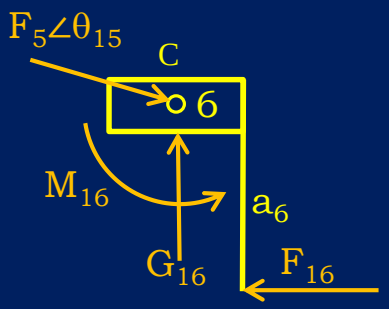
Static Force Analysis

Link 6:

$$\sum F_x = 0 \rightarrow -F_{16} + F_5 cos\theta_{15} = 0 \rightarrow F_5$$

$$\sum F_y = 0 \rightarrow G_{16} + F_5 sin\theta_{15} = 0 \rightarrow G_{16}$$

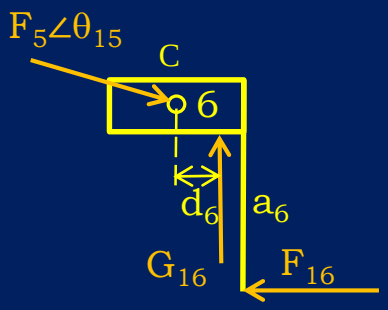
$$\sum M_C = 0 \rightarrow M_{16} - a_6 F_{16} = 0 \rightarrow M_{16}$$



Alternatively

$$\sum M_C = 0 \rightarrow d_6 G_{16} - a_6 F_{16} = 0 \rightarrow d_6$$

$$(M_{16} = d_6 G_{16})$$



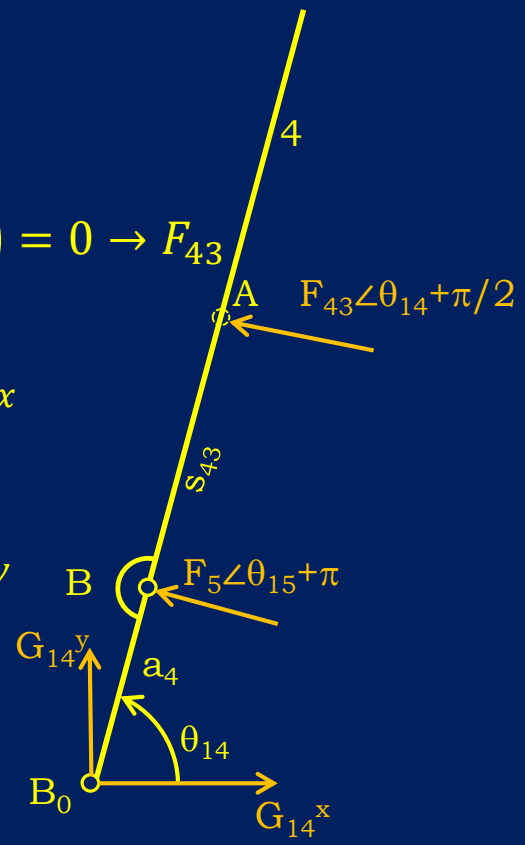
Static Force Analysis

Link 4:

$$\sum M_{B_0} = 0 \rightarrow a_4 F_5 sin(\theta_{15} + \pi - \theta_{14}) + s_{43} F_{43} sin\left(\theta_{14} + \frac{\pi}{2} - \theta_{14}\right) = 0 \rightarrow F_{43}$$

$$\sum F_x = 0 \rightarrow {G_{14}}^x + F_5 cos(\theta_{15} + \pi) + F_{43} cos\left(\theta_{14} + \frac{\pi}{2}\right) = 0 \rightarrow {G_{14}}^x$$

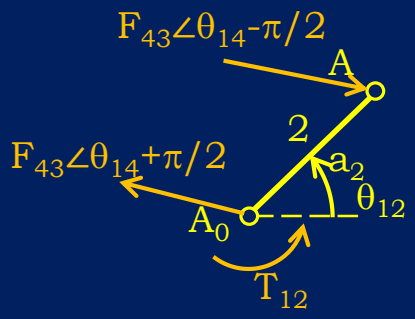
$$\sum F_y = 0 \rightarrow {G_{14}}^y + F_5 sin(\theta_{15} + \pi) + F_{43} sin\left(\theta_{14} + \frac{\pi}{2}\right) = 0 \rightarrow {G_{14}}^y$$



Static Force Analysis

Link 2 (2F+M):

$$\sum M_{A_0} = 0 \rightarrow T_{12} + a_2 F_{43} sin\left(\theta_{14} - \frac{\pi}{2} - \theta_{12}\right) = 0 \rightarrow T_{12}$$



Static Force Analysis

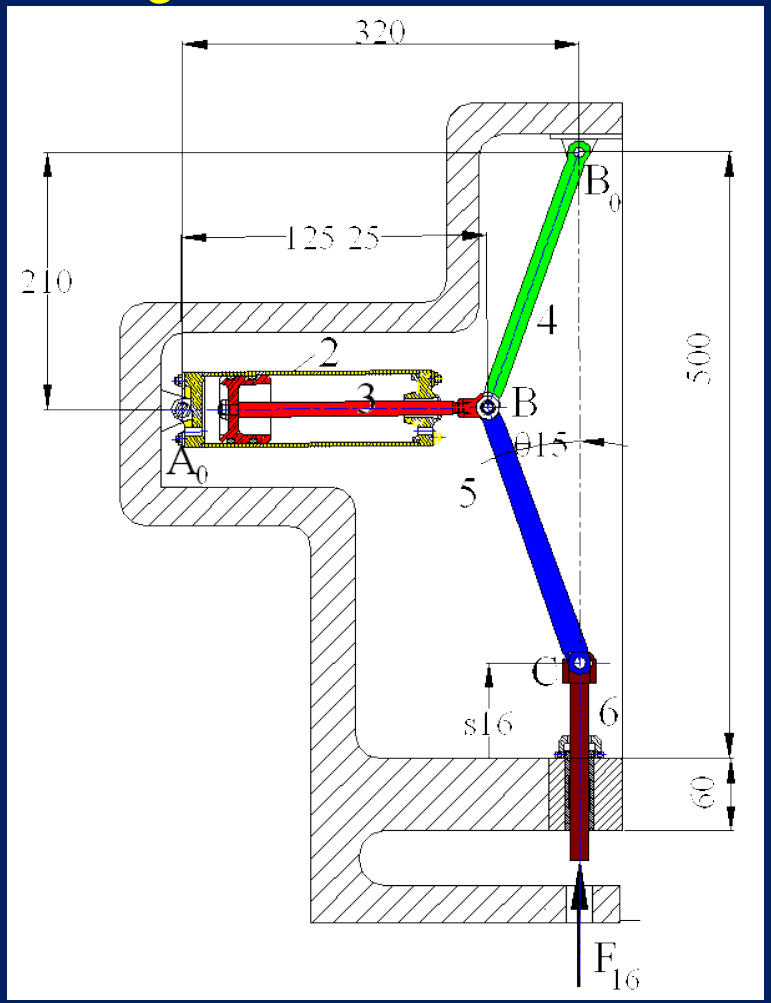
Pneumatic Press (Textbook Example 5.2):

Known F_{16} determine the pressure force, P, of the piston for *every* position (i.e. $s_{23_{min}} \leq s_{23} \leq s_{23_{max}}$).

Links 2 and 3 together form 2F

Link 4 is 2F

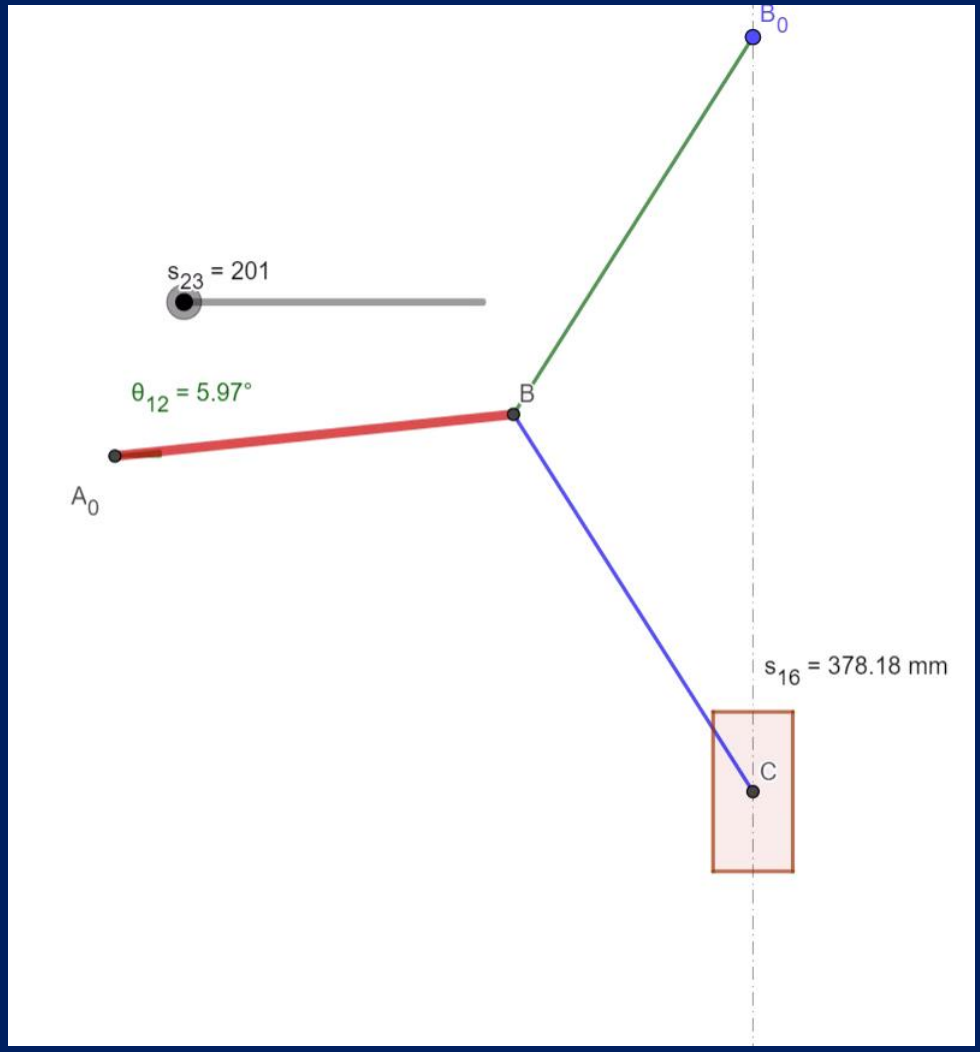
Link 5 is 2F



See also Example 6.2 (Please scroll down).
Figure from the same source.

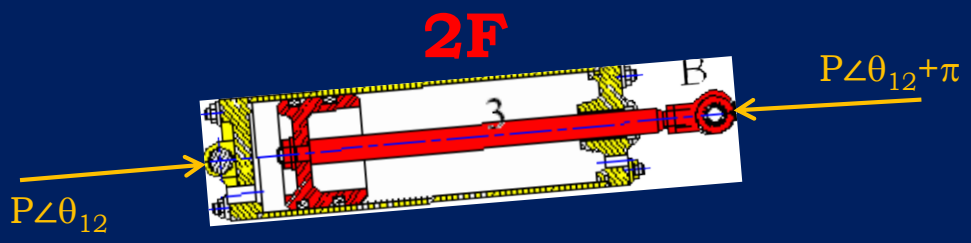
Static Force Analysis

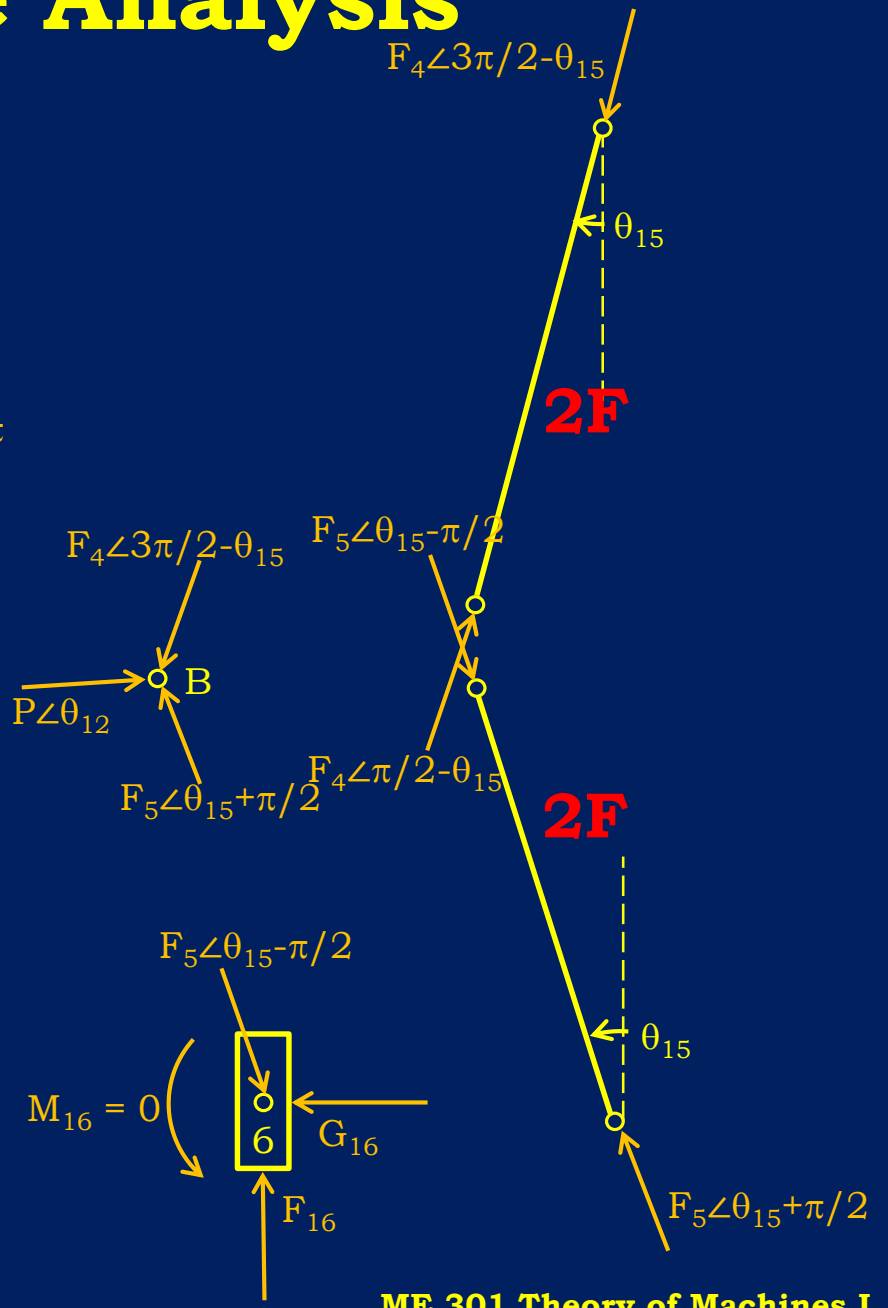
Pneumatic Press (Textbook Example 5.2)**:**



Static Force Analysis

Pneumatic Press (Textbook Example 5.2):





θ_{15} defined in an awkward way!

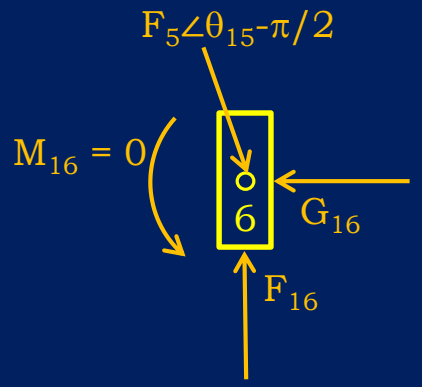
Static Force Analysis

Link 6:

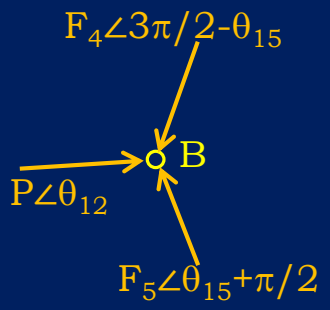
$$\sum F_y = 0 \rightarrow F_{16} + F_5 sin\left(\theta_{15} - \frac{\pi}{2}\right) = 0 \rightarrow F_5$$

$$\sum F_x = 0 \rightarrow -G_{16} + F_5 cos\left(\theta_{15} - \frac{\pi}{2}\right) = 0 \rightarrow G_{16}$$

$$\sum M_C = 0 \rightarrow M_{16} = 0$$



Static Force Analysis



Pin at B:

$$\left.\begin{aligned}\sum F_x = 0 \rightarrow P\cos\theta_{12} + F_4\cos\left(\frac{3\pi}{2} - \theta_{14}\right) + F_5\cos\left(\theta_{15} - \frac{\pi}{2}\right) = 0 \\ \sum F_y = 0 \rightarrow P\sin\theta_{12} + F_4\sin\left(\frac{3\pi}{2} - \theta_{14}\right) + F_5\sin\left(\theta_{15} - \frac{\pi}{2}\right) = 0\end{aligned}\right\} \rightarrow P, F_4$$

Static Force Analysis

Principle of Superposition:

The effect of forces is the sum (vector sum whenever applicable) of effect of each individual force considered separately.

- Load torque increase by a factor increases the driving torque by the same factor.
- Change in weight of the members during design stage may be considered separately.
- Influence factors, considering unit loads may be calculated once and used under changing conditions.