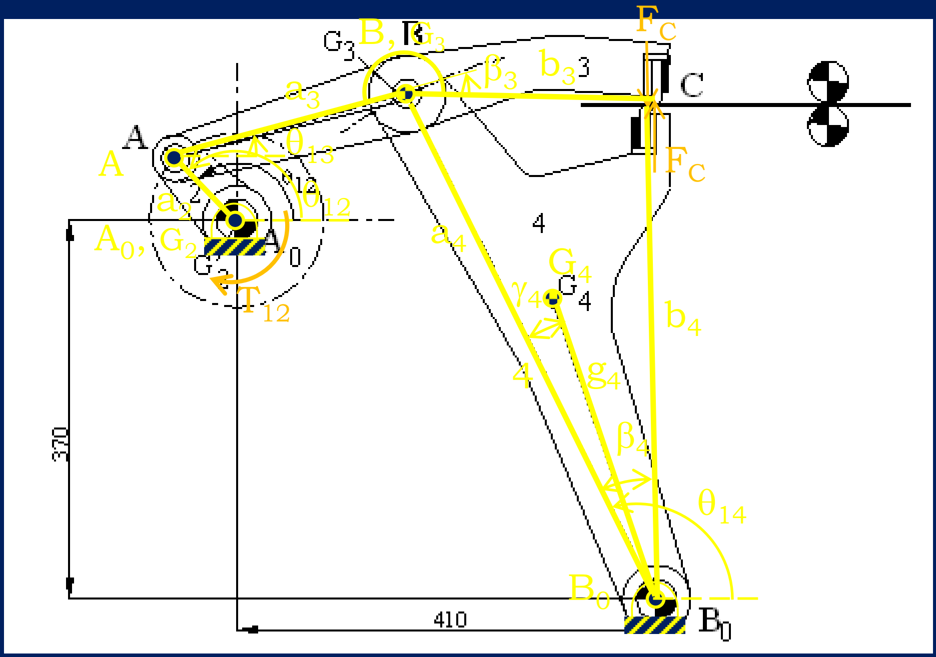
Dynamic Force Analysis

Example:

This is a shear cutter that cuts the strip while it is running through the cutting edges C on links 3 and 4. It is driven at the crank A_0 by a torque T_{12}. The known cutting force at the cutting edges are F_C. Determine the driving torque T_{12} for a given crank speed $\dot{\theta}_{12}$. The machine works in the vertical plane.



Example 5.9 of the textbook
https://ocw.metu.edu.tr/pluginfile.php/6467/mod_resource/content/6/ch6/6-5.htm

Dynamic Force Analysis

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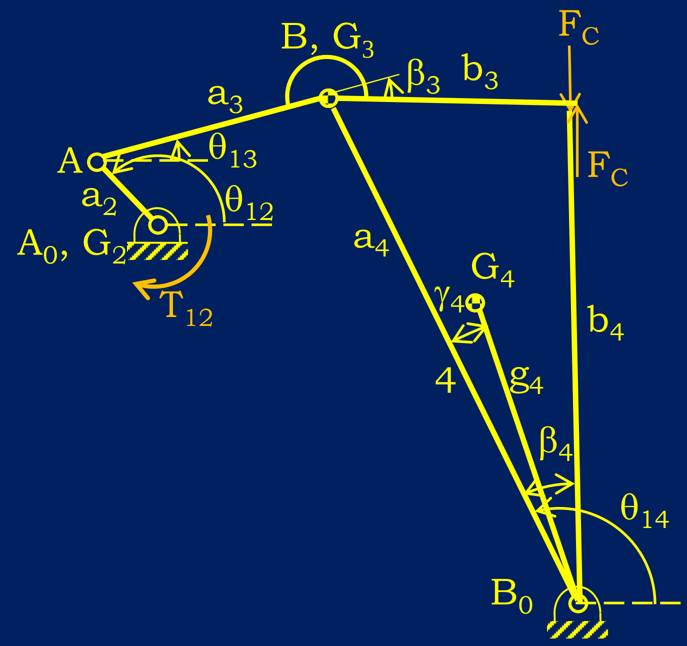
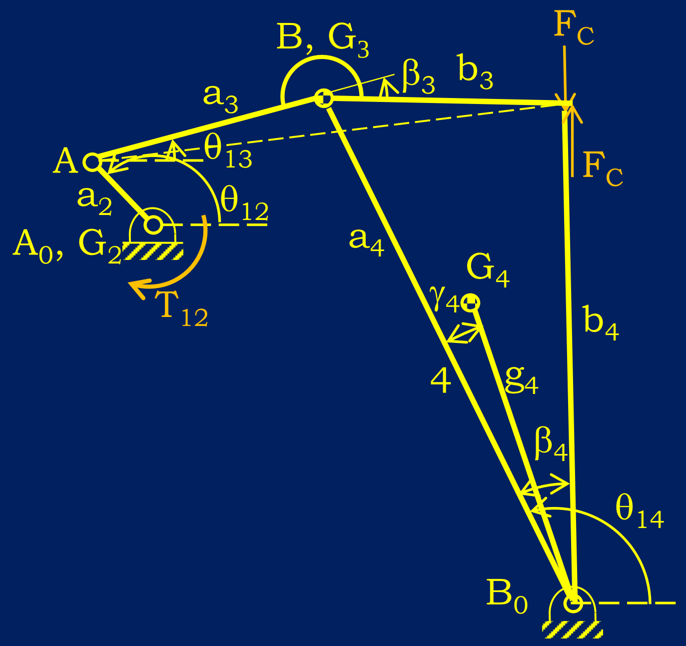


Solution Procedure:

- Perform kinematic analysis.
- Draw free body diagrams with inertia forces and write the dynamic equations of equilibrium.
- Solve the equations for unknown force.

Dynamic Force Analysis

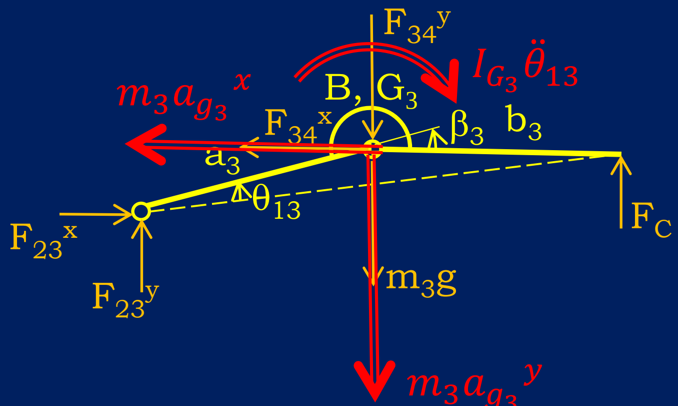
- Perform kinematic analysis.

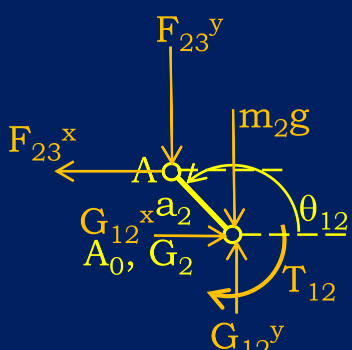


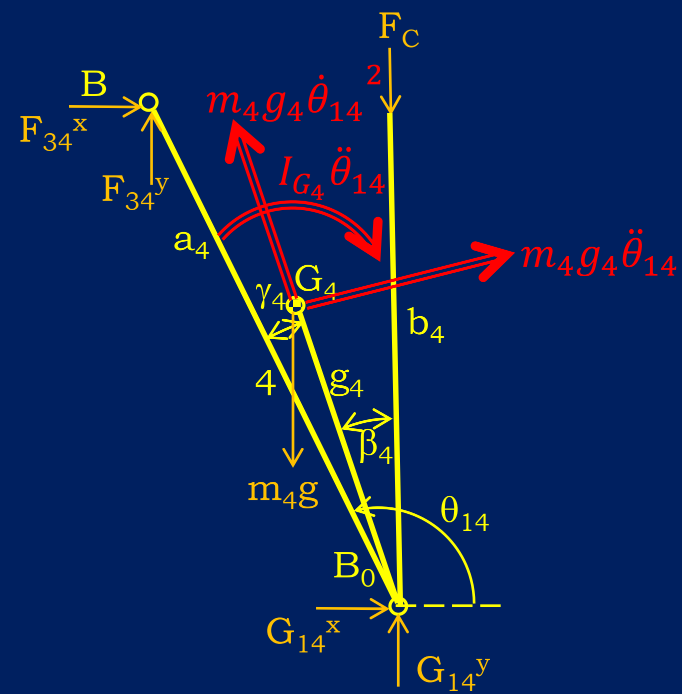
Dynamic Force Analysis

Example:

- Draw free body diagrams with inertia forces and write the equations of equilibrium.





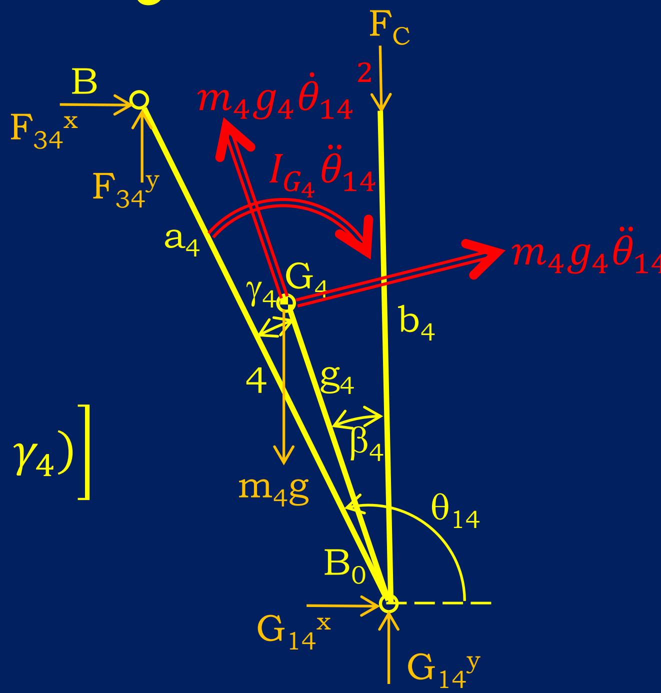


Dynamic Force Analysis

Example:

Link 4:

$$\sum M_{B_0} = 0$$



$$a_4 F_{34}{}^{x} sin(0-\theta_{14}) + a_4 F_{34}{}^{y} sin\left(\frac{\pi}{2}-\theta_{14}\right)$$
$$+ b_4 F_C sin\left[\frac{3\pi}{2}-(\theta_{14}-\gamma_4-\beta_4)\right] + g_4 m_4 g sin\left[\frac{3\pi}{2}-(\theta_{14}-\gamma_4)\right]$$
$$- g_4 m_4 g_4 \ddot{\theta}_{14} - I_{G_4}\ddot{\theta}_{14} = 0 \rightarrow F_{34}{}^{x}, F_{34}{}^{y}\ ??$$

$$\sum F_x = 0$$

$$G_{14}{}^{x} + F_{34}{}^{x} + m_4 g_4 \ddot{\theta}_{14} cos\left(\theta_{14}-\gamma_4-\beta_4-\frac{\pi}{2}\right)$$
$$+ m_4 g_4 \dot{\theta}_{14}{}^{2} cos(\theta_{14}-\gamma_4) = 0 \rightarrow G_{14}{}^{x}??$$

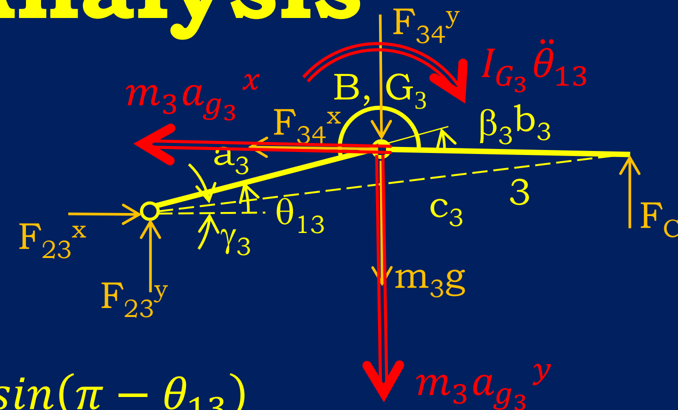
$$\sum F_y = 0$$

$$G_{14}{}^{y} + F_{34}{}^{y} + m_4 g_4 \ddot{\theta}_{14} sin\left(\theta_{14}-\gamma_4-\frac{\pi}{2}\right)$$
$$+ m_4 g_4 \dot{\theta}_{14}{}^{2} sin(\theta_{14}-\gamma_4-\beta_4) - F_C - m_4 g = 0 \rightarrow G_{14}{}^{y}??$$

Dynamic Force Analysis

Example:

Link 3:



$$\sum M_A = 0$$

$$a_3 F_{34}{}^x \sin(\pi - \theta_{13}) + a_3 F_{34}{}^y \sin\left(\frac{3\pi}{2} - \theta_{13}\right) + a_3 m_3 a_{g_3}{}^x \sin(\pi - \theta_{13})$$

$$+ a_3 m_3 a_{g_3}{}^y \sin\left(\frac{3\pi}{2} - \theta_{13}\right) + a_3 \mathrm{m_3 g} \sin\left(\frac{3\pi}{2} - \theta_{13}\right) + c_3 F_C \sin\left[\frac{\pi}{2} - (\theta_{13} - \gamma_3)\right]$$

$$- I_{G_3} \ddot{\theta}_{13} = 0 \rightarrow +\sum M_{B_0} = 0 \rightarrow F_{34}{}^x, F_{34}{}^y$$

$$\sum F_x = 0$$

$$F_{23}{}^x - F_{34}{}^x - m_3 a_{g_3}{}^x = 0 \rightarrow F_{23}{}^x$$

$$\sum F_y = 0$$

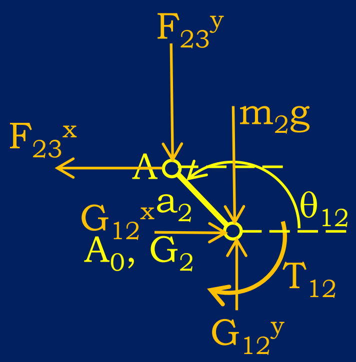
$$F_{23}{}^y - F_{34}{}^y - m_3 a_{g_3}{}^y - \mathrm{m_3 g} + F_C = 0 \rightarrow F_{23}{}^y$$

Dynamic Force Analysis

Example:

Link 2:

$$\sum M_{A_0} = 0$$



$$a_2 {F_{23}}^x sin(\pi - \theta_{12}) + a_2 {F_{23}}^y sin\left(\frac{3\pi}{2} - \theta_{12}\right) - T_{12} = 0 \rightarrow T_{12}$$

$$\sum F_x = 0$$

$${G_{12}}^x - {F_{23}}^x = 0 \rightarrow {G_{12}}^x$$

$$\sum F_y = 0$$

$${G_{12}}^y - {F_{23}}^y - m_2 g = 0 \rightarrow {G_{12}}^y$$