Note Title

Eample : 4-bar mechansim.

Assume : $d_1 = 0.9\,m$, $d_2 = 0.45\,m$, $d_3 = 1.1\,m$, $d_4 = 0.7$ and $\theta_1 = 0°$;

For $\theta_2 = 60°$, $W_2 = 1200\,RPm$, $\alpha_2 = 10000\,\frac{Rad}{s^2}$

Position Analysis:-

According to position analysis :-

$$\theta_{4_{1,2}} = 2\tan^{-1}(\phi_{1,2}) \; ; \; \phi_{1,2} = \frac{-b \pm \sqrt{b^2 - c^2 + a^2}}{c - a}$$

* $a = 2d_1 d_4 \cos(\theta_1) - 2d_2 d_4 \cos(\theta_2)$
  $= 2(0.9)(0.7)\cos(0) - 2(0.45)(0.7)\cos(60) = 0.945$.

* $b = 2d_1 d_4 \sin(\theta_1) - 2d_2 d_4 \sin(\theta_2)$
  $= 2(0.9)(0.7)\sin(0) - 2(0.45)(0.7)\sin(60) = -0.546$.

* $c = d_1^2 + d_2^2 + d_4^2 - d_3^2 - 2d_1 d_2 \cos(\theta_1 - \theta_2)$
  $= 0.9^2 + 0.45^2 + 0.7^2 - 1.1^2 - (2)(0.9)(0.45)\cos(-60) = -0.1125$

$$\Rightarrow \phi_{1,2} = \frac{+0.546 \pm \sqrt{(0.546)^2 - (0.1125^2) + (0.945)^2}}{-0.1125 - 0.945}$$

$$= -1.543 \;,\; 0.51$$

$\Rightarrow \theta_{4_{1,2}} = -114$ ✗ , $54.1°$ ✓ Becase we assume θ_4 +ve

$$\theta_3 = \tan^{-1}\left[\frac{d_1 \sin(\theta_1) + d_4 \sin(\theta_4) - d_2 \sin(\theta_2)}{d_1 \cos(\theta_1) + d_4 \cos(\theta_4) - d_2 \cos(\theta_4)}\right]$$

$\theta_4 = 54.1°$

$= 9.3°$

Note Title

Velocity Analysis:-

$$\omega_4 = \frac{d_2 \omega_2 \sin(\theta_3 - \theta_2)}{d_4 \sin(\theta_3 - \theta_4)} = \frac{(0.45)(1200) \sin(9.3 - 60)}{0.7 \sin(9.3 - 54.1)}$$

$$\Rightarrow \omega_4 = 847 \text{ RPM} = 88.7 \text{ Rad/S}$$

$$\omega_3 = -\frac{d_2 \omega_2 \sin(\theta_4 - \theta_2)}{d_3 \sin(\theta_4 - \theta_3)} = -\frac{0.45(1200) \sin(54.1 - 60)}{1.1 \sin(54.1 - 9.3)}$$

$$\Rightarrow \omega_3 = 72 \text{ RPM} = 7.5 \text{ Rad/s}$$

Acc. Analysis:-

$$\alpha_4 = \frac{1}{d_4 \sin(\theta_3 - \theta_4)} \left[d_2 \alpha_2 \sin(\theta_3 - \theta_2) - d_2 \omega_2^2 \cos(\theta_2 - \theta_3) - d_3 \omega_3^2 + d_4 \omega_4^2 \cos(\theta_4 - \theta_3) \right]$$

where:-

$\theta_2 = 60°$, $\theta_3 = 9.3°$, $\theta_4 = 54.1°$,

$\omega_2 = \frac{2\pi}{60} 1200 = 125.7$ Rad/s, $\omega_3 = 7.5$ Rad/s

$\omega_4 = 88.7$ Rad/s, $\alpha_2 = 10,000$ Rad/s^2

$$\alpha_4 = 8379 \frac{\text{Rad}}{s^2}$$

$$\alpha_3 = \frac{-d_2 \alpha_2 \sin(\theta_4 - \theta_2) + d_2 \omega_2^2 \cos(\theta_2 - \theta_4) + d_3 \omega_3^2 \cos(\theta_3 - \theta_4) - d_4 \omega_4^2}{d_3 \sin(\theta_4 - \theta_3)}$$

$$\Rightarrow \alpha_3 = 2663 \text{ Rad}/s^2$$

Note Title

Static Analysis:- Assume $T_2 = 200 N.m$ Find $T_4 = ?$ and Reactions

$R_{O2x} - F_{32} \cos(\theta_3) = 0$ --- (1)

$R_{O2y} - F_{32} \sin(\theta_3) = 0$ --- (2)

$T_2 = F_{32} d_2 \sin(\theta_3 - \theta_2)$ --- (3)

$R_{O4,x} + F_{32} \cos(\theta_3) = 0$ --- (4)

$R_{O4,y} + F_{32} \sin(\theta_3) = 0$ --- (5)

$T_4 = F_{32} d_4 \sin(\theta_3 - \theta_4) =$ --- (6)

Start with Eq (3) to Find F_{32}:-

$$F_{32} = \frac{T_2}{d_2 \sin(\theta_3 - \theta_2)} = \frac{200 N.m}{0.45 \sin(9.3 - 60)} = -574 N$$

Now, From Eqs (1) & (2):-

$R_{O2x} = -567 N$, $R_{O2y} = -92.8 N$.

From Eqs (4) & (5):-

$R_{O4,x} = 567 N$, $R_{O4,y} = 92.8 N$

Finally, From Eq (6):-

$T_4 = 283 N.M$

or $\frac{T_4}{T_2} = \frac{\omega_2}{\omega_4} \Rightarrow T_4 = T_2 \frac{\omega_2}{\omega_4} = 283 N.m$