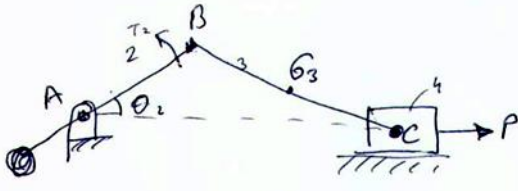


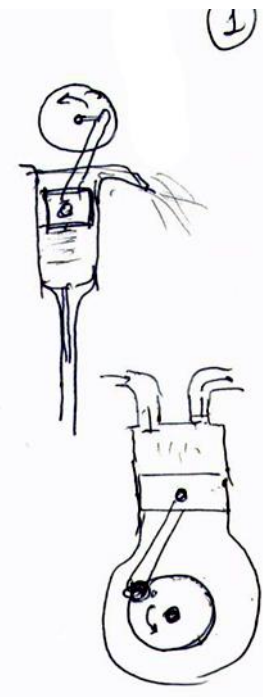
## MEKANİZMA TEKNİĞİ (4. Hafta)

### Mekanizmalarda Hız ve İvme Analizi

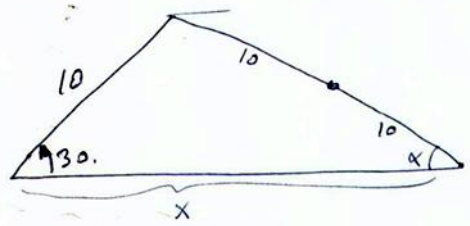
Örnek



$\theta_3 = 30^\circ$   
 $\omega_2 = 200 \text{ rdd/s}$   
 $AB = 10 \text{ cm}$   
 $BC = 20 \text{ cm}$   
 $BG_3 = 10 \text{ cm}$



① Önce Geometrik Bilgileri Bulalım.



$$20^2 = X^2 + 10^2 - 2 \cdot 10 \cdot X \cdot \cos 30$$

$$X^2 - 17,32X - 300 = 0$$

$$X_{1,2} = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} = \frac{-(-17,32) \pm \sqrt{(-17,32)^2 - 4 \cdot 1 \cdot (-300)}}{2 \cdot 1} = \frac{17,32 \pm 38,72}{2}$$

$X_1 = 28,0$

$X_2 = -21,4$

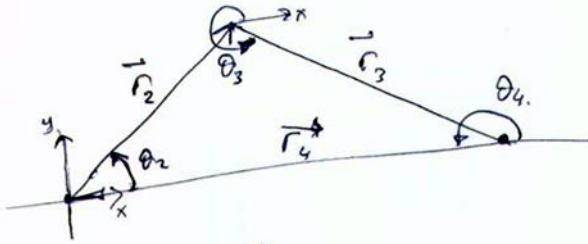
$$10^2 = 20^2 + 28^2 - 2 \cdot 20 \cdot 28 \cdot \cos \alpha$$

$$\alpha = 14,5^\circ$$



$\theta_2 = 30^\circ$   
 $\theta_3 = 360 - 14,5 = 345,5^\circ$

② Vektörel Konum Denklemini Oluşturalım, denklemleri bilimsizleri bulalım.



$$\vec{r}_2 + \vec{r}_3 + \vec{r}_4 = 0$$

$$\vec{r}_2 \cdot \vec{r}_3 / \sqrt{r_2 \cdot r_3} = \mu(\theta_2 - \theta_3)$$

$$r_2 \cdot \mu(\theta_2) \cdot \vec{v}(\theta_3) + r_3 \cdot \mu(\theta_3) \cdot \vec{v}(\theta_3) + r_4 \cdot \mu(\theta_4) \cdot \vec{v}(\theta_3) = 0$$

$$\sin(\theta_2 - \theta_3) \quad \sin(\theta_4 - \theta_3)$$

A)  $r_2 \sin(\theta_2 - \theta_3) + r_4 \sin(\theta_4 - \theta_3) = 0$

Prova)  $r_2 \cdot \mu(\theta_2) \cdot \vec{v}(\theta_4) + r_3 \cdot \mu(\theta_3) \cdot \vec{v}(\theta_4) + r_4 \cdot \mu(\theta_4) \cdot \vec{v}(\theta_4) = 0$

$$\sin(\theta_2 - \theta_4) \quad \sin(\theta_3 - \theta_4)$$

B)  $r_2 \sin(\theta_2 - \theta_4) + r_3 \sin(\theta_3 - \theta_4) = 0$

B den  $10 \cdot \sin(30 - 180) + 20 \cdot \sin(\theta_3 - 180) = 0$

$-5 + 20 (\sin \theta_3 \cdot \cos 180 - \cos \theta_3 \cdot \sin 180) = 0$

$-5 - 20 \cdot \sin \theta_3 = 0 \Rightarrow \theta_3 = -14.47^\circ$

A den  $10 \cdot \sin(30 - (-14.47)) + r_4 \cdot \sin(180 - (-14.47)) = 0$

$r_4 = -28$

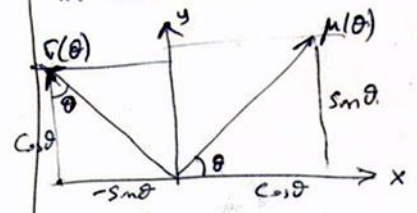
$\sin(a-b) = \sin a \cos b - \cos a \sin b$
$\cos(a-b) = \cos a \cos b + \sin a \sin b$
Dışlar farklı, içler aynı
Dışlar aynı, içler aynı
Dışlar farklı, içler farklı
Dışlar aynı, içler farklı

Vektörel Konum Denklemleri.

iki tane bilinmeyen var.  $\theta_3, r_4$  bulmaları bulalım.

Denklemleri hatırlayalım.

$\mu(\theta)$  ve  $\vec{v}(\theta)$  birbirine dik iki birim vektör



$\mu(\theta) = \cos \theta \cdot \vec{i} + \sin \theta \cdot \vec{j}$

$\vec{v}(\theta) = -\sin \theta \cdot \vec{i} + \cos \theta \cdot \vec{j}$

$\frac{d\mu(\theta)}{d\theta} = \dot{\theta}(-\sin \theta \cdot \vec{i} + \cos \theta \cdot \vec{j})$

$\frac{d\vec{v}(\theta)}{d\theta} = \dot{\theta}(\vec{v}(\theta))$

$\frac{d\vec{v}(\theta)}{d\theta} = \dot{\theta}(-\cos \theta \cdot \vec{i} - \sin \theta \cdot \vec{j})$

$\frac{d\mu(\theta)}{d\theta} = -\dot{\theta}(\mu(\theta))$

$\mu(\theta_k) \cdot \vec{v}(\theta_k) = 0$

$\mu(\theta_k) \cdot \mu(\theta_k) = 1$

$\vec{v}(\theta_k) \cdot \vec{v}(\theta_k) = 1$

$\mu(\theta_k) \cdot \vec{v}(\theta_n) = \sin(\theta_k - \theta_n)$

$\mu(\theta_k) \cdot \mu(\theta_n) = \cos(\theta_k - \theta_n)$

$\vec{v}(\theta_k) \cdot \vec{v}(\theta_n) = \cos(\theta_k - \theta_n)$

$\vec{v}(\theta_k) \cdot \mu(\theta_n) = -\cos(\theta_k - \theta_n)$

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3) Vektörel hız denklemini oluşturalım.

Bunun için konum denklemini 1 kez türev almamız gerekir. Türev alabilmek için ise değişkenleri neye aldığımızı bilmeliyiz.

Değişkenler:

$$r_2, r_3, r_4, \theta_2, \theta_3, \theta_4$$

$$\underbrace{r_2, r_3, \theta_4}_{\text{Sabit}}$$

$$\underbrace{\theta_2, \theta_3, r_4}_{\text{Değişken}}$$

$$\vec{r}(\theta_4) / \left[ \underbrace{r_2}_{\text{Sabit}} \cdot \underbrace{\dot{\theta}_2}_{\text{Değişken}} \cdot \underbrace{\vec{r}(\theta_2)}_{\text{Sabit}} + \underbrace{r_3}_{\text{Sabit}} \cdot \underbrace{\dot{\theta}_3}_{\text{Değişken}} \cdot \underbrace{\vec{r}(\theta_3)}_{\text{Sabit}} + \underbrace{\dot{r}_4}_{\text{Değişken}} \cdot \underbrace{\vec{\mu}(\theta_4)}_{\text{Sabit}} \right] = 0$$

$$r_2 \cdot \dot{\theta}_2 \cdot \vec{r}(\theta_2) \cdot \vec{r}(\theta_4) + r_3 \cdot \dot{\theta}_3 \cdot \vec{r}(\theta_3) \cdot \vec{r}(\theta_4) + \dot{r}_4 \cdot \vec{\mu}(\theta_4) \cdot \vec{r}(\theta_4) = 0$$

$\cos(\theta_2 - \theta_4)$                        $\cos(\theta_3 - \theta_4)$                       0

$$\dot{\theta}_3 = \frac{-r_2 \cdot \dot{\theta}_2 \cdot \cos(\theta_2 - \theta_4)}{r_3 \cdot \cos(\theta_3 - \theta_4)} = \frac{-10 \cdot 200 \cdot \cos(30 - 180)}{20 \cdot \cos(345,5 - 180)}$$

$$\omega_3 = \dot{\theta}_3 = -89,45 \text{ rad/s}$$

Azılar hep x eksenine göre saatim ters yönde pozitif alınıyor için negatif bu (-) negatif hız saatim yönünde olur.

$$\vec{\mu}(\theta_3) / \left[ r_2 \cdot \dot{\theta}_2 \cdot \vec{r}(\theta_2) \cdot \vec{\mu}(\theta_3) + r_3 \cdot \dot{\theta}_3 \cdot \vec{r}(\theta_3) \cdot \vec{\mu}(\theta_3) + \dot{r}_4 \cdot \vec{\mu}(\theta_4) \cdot \vec{\mu}(\theta_3) \right] = 0$$

$\sin(\theta_3 - \theta_2)$                       0                       $\cos(\theta_4 - \theta_3)$

$$\dot{r}_4 = v_4 = \frac{-r_2 \cdot \dot{\theta}_2 \cdot \sin(\theta_3 - \theta_2)}{\cos(\theta_4 - \theta_3)} = \frac{-10 \cdot 200 \cdot \sin(345,5 - 30)}{\cos(180 - 345,5)}$$

$$\dot{r}_4 = v_4 = -1447,93 \text{ cm/s} \quad (\leftarrow)$$

(14)

④ Vektörel ilme denklemini oluşturalım.

$$r_2 \cdot \ddot{\theta}_2 \cdot \vec{r}(\theta_2) + r_2 \cdot \dot{\theta}_2 \cdot (-\dot{\theta}_2) \cdot \vec{\mu}(\theta_2) + r_3 \cdot \ddot{\theta}_3 \cdot \vec{r}(\theta_3) + r_3 \cdot \dot{\theta}_3 \cdot (-\dot{\theta}_3) \cdot \vec{\mu}(\theta_3) + \ddot{r}_4 \cdot \vec{\mu}(\theta_4) = 0$$

$$r_2 \cdot \ddot{\theta}_2 \cdot \vec{r}(\theta_2) + r_2 \cdot \dot{\theta}_2^2 \cdot \vec{\mu}(\theta_2) + r_3 \cdot \ddot{\theta}_3 \cdot \vec{r}(\theta_3) - r_3 \cdot \dot{\theta}_3^2 \cdot \vec{\mu}(\theta_3) + \ddot{r}_4 \cdot \vec{\mu}(\theta_4) = 0$$

$$\vec{r}(\theta_4) / - r_2 \cdot \dot{\theta}_2^2 \cdot \vec{\mu}(\theta_2) + r_3 \cdot \ddot{\theta}_3 \cdot \vec{r}(\theta_3) - r_3 \cdot \dot{\theta}_3^2 \cdot \vec{\mu}(\theta_3) + \ddot{r}_4 \cdot \vec{\mu}(\theta_4) = 0$$

$$- r_2 \cdot \dot{\theta}_2^2 \cdot \vec{\mu}(\theta_2) \cdot \vec{r}(\theta_4) + r_3 \cdot \ddot{\theta}_3 \cdot \vec{r}(\theta_3) \cdot \vec{r}(\theta_4) - r_3 \cdot \dot{\theta}_3^2 \cdot \vec{\mu}(\theta_3) \cdot \vec{r}(\theta_4) + \ddot{r}_4 \cdot \vec{\mu}(\theta_4) \cdot \vec{r}(\theta_4) = 0$$

$\underbrace{\hspace{10em}}_{\sin(\theta_2 - \theta_4)} \quad \underbrace{\hspace{10em}}_{\cos(\theta_3 - \theta_4)} \quad \underbrace{\hspace{10em}}_{\sin(\theta_3 - \theta_4)} \quad \underbrace{\hspace{10em}}_0$

$$\ddot{\theta}_3 = \alpha_3 = \frac{+ r_2 \cdot \dot{\theta}_2^2 \cdot \sin(\theta_2 - \theta_4) + r_3 \cdot \dot{\theta}_3^2 \cdot \sin(\theta_3 - \theta_4)}{r_3 \cdot \cos(\theta_3 - \theta_4)}$$

$$\ddot{\theta}_3 = \alpha_3 = \frac{10 \cdot 200^2 \cdot \sin(30 - 180) + 20 \cdot (-89,45)^2 \cdot \sin(345,5 - 180)}{20 \cdot \cos(345,5 - 180)}$$

$$\boxed{\ddot{\theta}_3 = \alpha_3 = 8259 \text{ rad/s}^2} \quad (\uparrow)$$

$$\vec{\mu}(\theta_3) / - r_2 \cdot \dot{\theta}_2^2 \cdot \vec{\mu}(\theta_2) \cdot \vec{\mu}(\theta_3) + r_3 \cdot \ddot{\theta}_3 \cdot \vec{r}(\theta_3) \cdot \vec{\mu}(\theta_3) - r_3 \cdot \dot{\theta}_3^2 \cdot \vec{\mu}(\theta_3) \cdot \vec{\mu}(\theta_3) + \ddot{r}_4 \cdot \vec{\mu}(\theta_4) \cdot \vec{\mu}(\theta_3) = 0$$

$\underbrace{\hspace{10em}}_{\cos(\theta_2 - \theta_3)} \quad \underbrace{\hspace{10em}}_0 \quad \underbrace{\hspace{10em}}_{\cos(\theta_4 - \theta_3)} \quad \underbrace{\hspace{10em}}_{\cos(\theta_4 - \theta_3)}$

$$\ddot{r}_4 = a_4 = \frac{r_2 \cdot \dot{\theta}_2^2 \cdot \cos(\theta_2 - \theta_3) + r_3 \cdot \dot{\theta}_3^2}{\cos(\theta_4 - \theta_3)} = \frac{10 \cdot 200^2 \cdot \cos(30 - 345,5) + 20 \cdot (-89,45)^2}{\cos(180 - 345,5)}$$

$$\boxed{\ddot{r}_4 = a_4 = -459977,6 \text{ cm/s}^2 \approx -4600 \text{ m/s}^2} \quad (\leftarrow)$$