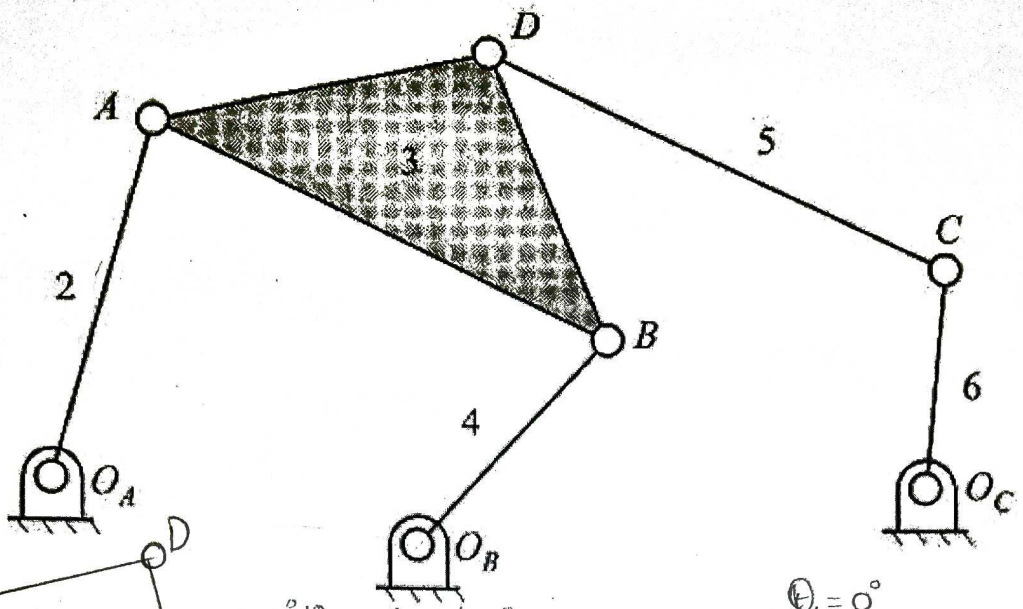
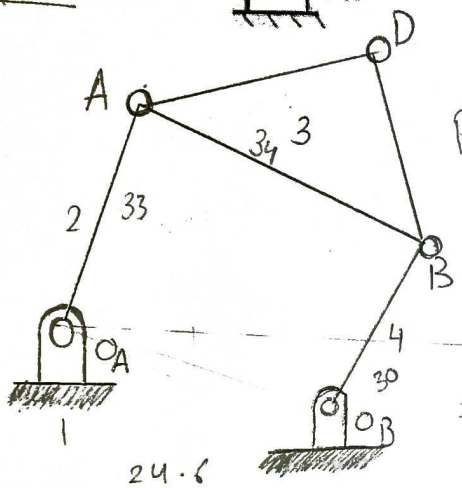


1st part



Position Analysis:

$\theta_1 = 0^\circ$

Grashof's rule

$S + l \leq p + q$

$24.6 + 34 \leq 33 + 30$

$58.6 \leq 63$

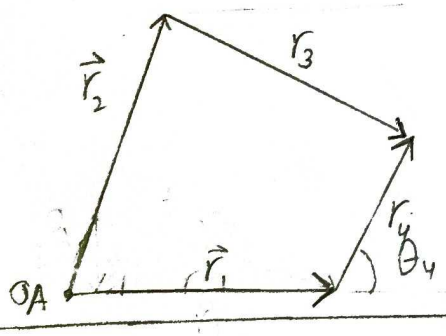
$\therefore$ Grashof Mechanism

$$\vec{r}_2 + \vec{r}_3 - \vec{r}_1 - \vec{r}_4 = 0$$

$$= r_2 e^{j\theta_2} + r_3 e^{j\theta_3} - r_1 e^{j\theta_1} - r_4 e^{j\theta_4} = 0$$

$$= -r_2 e^{j\theta_2} + r_3 e^{j\theta_3} - r_1 - r_4 e^{j\theta_4} = 0$$

$$= r_2(\cos\theta_2 + j\sin\theta_2) + r_3(\cos\theta_3 + j\sin\theta_3) - r_1 - r_4(\cos\theta_4 + j\sin\theta_4) = 0$$



Re: $r_2\cos\theta_2 + r_3\cos\theta_3 - r_1 - r_4\cos\theta_4 = 0 \longrightarrow (1)$

Im: $r_2\sin\theta_2 + r_3\sin\theta_3 - r_4\sin\theta_4 - b = 0 \longrightarrow (2)$

knowns:
$r_1, r_2, r_3, r_4, b, \omega_2, \theta_2, \theta_1$

unknowns:
θ_3, θ_4

$\omega_1 = 0 \quad \omega_b = 0$

$\dot{r}_1 = \dot{r}_2 = \dot{r}_3 = \dot{r}_4 = 0$

Velocity Analysis.

$$\rightarrow \dot{r}_2 e^{j\theta_2} + (\omega_2 r_2) j e^{j\theta_2} + \dot{r}_3 e^{j\theta_3} + (\omega_3 r_3) j e^{j\theta_3} + \dot{r}_1 e^{j\theta_1} + (\omega_1 r_1) j e^{j\theta_1} - \dot{r}_4 e^{j\theta_4} - (\omega_4 r_4) j e^{j\theta_4} = 0$$

$$= \omega_2 r_2 j e^{j\theta_2} + \omega_3 r_3 j e^{j\theta_3} - \omega_4 r_4 j e^{j\theta_4} = 0$$

Re: $-\omega_2 r_2 \sin\theta_2 - \omega_3 r_3 \sin\theta_3 + \omega_4 r_4 \sin\theta_4 = 0 \longrightarrow (3)$

Im: $\omega_2 r_2 \cos\theta_2 + \omega_3 r_3 \cos\theta_4 - \omega_4 r_4 \cos\theta_4 = 0 \longrightarrow (4)$

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

unknowns
ω_3, ω_4

Acceleration analysis

$$[\ddot{r}_2 - \omega_2^2 r_2]e^{j\theta_2} + [\alpha_2 r_2 + 2\omega_2 \dot{r}_2]je^{j\theta_2} + [\ddot{r}_3 - \omega_3^2 r_3]e^{j\theta_3} + [\alpha_3 r_3 + 2\omega_3 \dot{r}_3]je^{j\theta_3} - [\ddot{r}_4 - \omega_4^2 r_4]e^{j\theta_4} -$$

$$[\alpha_4 r_4 + 2\omega_4 \dot{r}_4]je^{j\theta_4} = 0$$

$$= -\omega^2 r_2 e^{j\theta_2} - \omega_3^2 r_3 e^{j\theta_3} + \alpha_3 r_3 j e^{j\theta_3} + \omega_4 r_4 e^{j\theta_4} - \alpha_4 r_4 j e^{j\theta_4} = 0$$

Re: $-\omega_2^2 r_2 \cos\theta_2 - \omega_3^2 r_3 \cos\theta_3 - \alpha_3 r_3 \sin\theta_3 + \omega_4 r_4 \cos\theta_4 + \alpha_4 r_4 \sin\theta_4 = 0 \rightarrow (5)$

Im: $-\omega^2 r_2 \sin\theta_2 - \omega_3^2 r_3 \sin\theta_3 + \alpha_3 r_3 \cos\theta_3 + \omega_4 r_4 \sin\theta_4 - \alpha_4 r_4 \cos\theta_4 = 0 \rightarrow (6)$

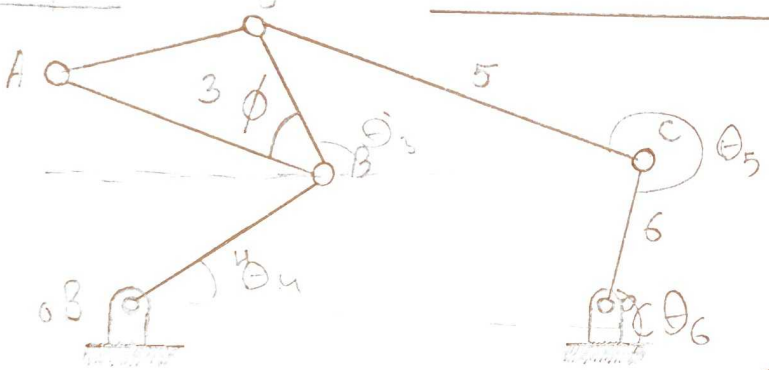
knowns

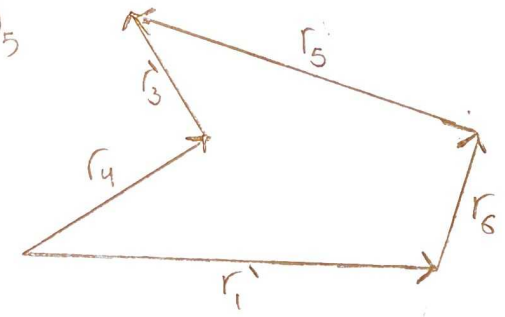
$\omega_2, r_2, r_3, r_4, \theta_2, \theta_3, \theta_4, \omega_3, \omega_4$

unknowns

α_3, α_4

2nd part





$$\vec{r}_4 + \vec{r}_3 - \vec{r}_1 - \vec{r}_6 - \vec{r}_5 = 0$$

$$r_4 e^{j\theta_4} + r_3 e^{j\theta_3} - r_1 e^{j\theta_1} - r_6 e^{j\theta_6} - r_5 e^{j\theta_5} = 0$$

$\theta_1 = 0^\circ$

$\theta_3 = 180^\circ - \theta_3 - \phi \rightarrow (9)$

where ϕ is $\angle ABD$

$$r_4(\cos\theta_4 + i\sin\theta_4) + r_3(\cos\theta_3 + i\sin\theta_3) - r_1 - r_6(\cos\theta_6 + i\sin\theta_6) - r_5(\cos\theta_5 + i\sin\theta_5) = 0$$

Re: $r_4\cos\theta_4 + r_3\cos\theta_3 - r_1 - r_6\cos\theta_6 - r_5\cos\theta_5 = 0 \rightarrow (7)$

Im: $r_4\sin\theta_4 + r_3\sin\theta_3 - r_6\sin\theta_5 - r_5\sin\theta_5 = 0 \rightarrow (8)$

knowns:

$r_5, r_4, r_3, r_1, r_6, \theta_4, \theta_3$

unknowns:

θ_5, θ_6

$\dot{r}_4 e^{j\theta_4} + (\omega_4 r_4) j e^{j\theta_4} + \dot{r}_3' e^{j\theta_3'} + (\omega_3 r_3') e^{j\theta_3'} - \dot{r}_1 e^{j\theta_1} - (\omega_1 r_1') j e^{j\theta_1} - \dot{r}_5 e^{j\theta_5} - (\omega_5 r_5) j e^{j\theta_5}$

$- \dot{r}_6 e^{j\theta_6} - (\omega_6 r_6) j e^{j\theta_6} = 0$

knowns:
$\omega_1, \omega_3, \theta_1, \theta_3', \theta_5, \theta_6, r_1, r_3', r_5, r_6$

unknowns
ω_5, ω_6

$(\omega_4 r_4) j e^{j\theta_4} + (\omega_3 r_3') e^{j\theta_3'} - (\omega_5 r_5) j e^{j\theta_5} - (\omega_6 r_6) j e^{j\theta_6} = 0$

Re: $-\omega_4 r_4 \sin\theta_4 - \omega_3 r_3' \sin\theta_3' + \omega_5 r_5 \sin\theta_5 + \omega_6 r_6 \sin\theta_6 = 0 \longrightarrow (b)$

Im: $\omega_4 r_4 \cos\theta_4 + \omega_3 r_3' \cos\theta_3' - \omega_5 r_5 \cos\theta_5 - \omega_6 r_6 \cos\theta_6 = 0 \longrightarrow (11)$

Acceleration Analysis

$[\ddot{r}_4 - \omega_4^2 r_4] e^{j\theta_4} + [\alpha_4 r_4 + 2\omega_4 \dot{r}_4] j e^{j\theta_4} + [\ddot{r}_3' - \omega_3^2 r_3'] e^{j\theta_3'} + [\alpha_3 r_3' + 2\omega_3 \dot{r}_3'] j e^{j\theta_3'} - [\ddot{r}_5 - \omega_5^2 r_5] e^{j\theta_5}$

$- [\alpha_5 r_5 + 2\omega_5 \dot{r}_5] j e^{j\theta_5} - [\ddot{r}_6 - \omega_6^2 r_6] e^{j\theta_6} - [\alpha_6 r_6 + 2\omega_6 \dot{r}_6] j e^{j\theta_6} = 0$

$= (-\omega_4^2 r_4) e^{j\theta_4} + (\alpha_4 r_4) j e^{j\theta_4} + (-\omega_3^2 r_3') e^{j\theta_3'} + (\alpha_3 r_3') j e^{j\theta_3'} - (-\omega_5^2 r_5) e^{j\theta_5} - (\alpha_5 r_5) j e^{j\theta_5} - (-\omega_6^2 r_6) e^{j\theta_6}$

$- (\alpha_6 r_6) j e^{j\theta_6} = 0$

Re: $-\omega_4^2 r_4 \cos\theta_4 - \alpha_4 r_4 \sin\theta_4 - \omega_3^2 r_3' \cos\theta_3' - \alpha_3 r_3' \sin\theta_3' + \omega_5^2 r_5 \cos\theta_5 + \alpha_5 r_5 \sin\theta_5 +$
$\omega_6^2 r_6 \cos\theta_6 + \alpha_6 r_6 \sin\theta_6 = 0 \longrightarrow (12)$

Im: $-\omega_4^2 r_4 \sin\theta_4 + \alpha_4 r_4 \cos\theta_4 - \omega_3^2 r_3' \sin\theta_3' + \alpha_3 r_3' \cos\theta_3' + \omega_5^2 r_5 \sin\theta_5 - \alpha_5 r_5 \cos\theta_5 +$
$\omega_6^2 r_6 \sin\theta_6 - \alpha_6 r_6 \cos\theta_6 = 0 \longrightarrow (13)$

knowns

$r_4, r_3', r_5, r_6, \theta_4, \theta_3', \theta_5, \theta_6$
$, \omega_4, \omega_3, \omega_5, \omega_6, \alpha_4, \alpha_3$

unknowns

α_5, α_6