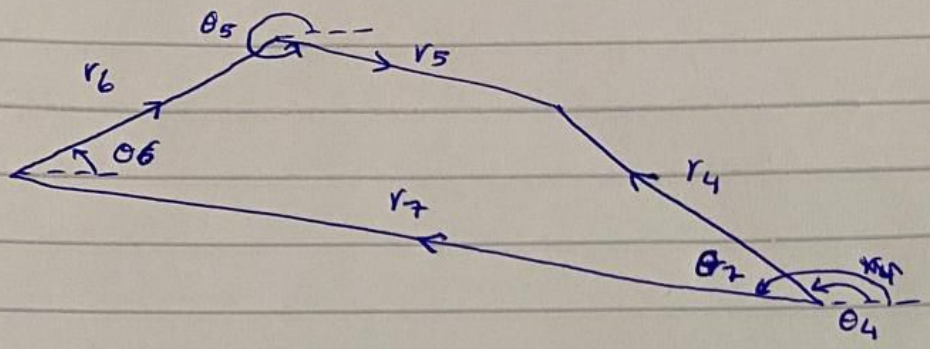
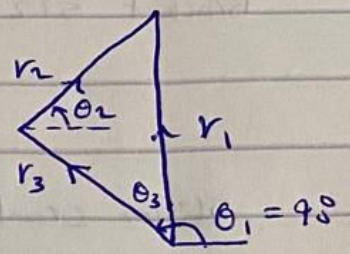
Position Analysis





$r_1 = 67mm$, $r_2 = 20mm$, $r_4 = 90mm$

$r_5 = 70mm$, $r_6 = 120mm$, $r_7 = 163mm$

$\theta_7 = 155.75$

$\theta_3 = \theta_4$

$$\vec{r_1} = \vec{r_2} + \vec{r_3}$$

RE: $0 = r_2 \cos\theta_2 + r_3 \cos\theta_3$

IM: $r_1 = r_2 \sin\theta_2 + r_3 \sin\theta_3$

$$\vec{r_4} = \vec{r_5} + \vec{r_6} + \vec{r_7}$$

RE: $r_4 \cos\theta_3 = r_5 \cos\theta_5 + r_6 \cos\theta_6 + r_7 \cos\theta_7$

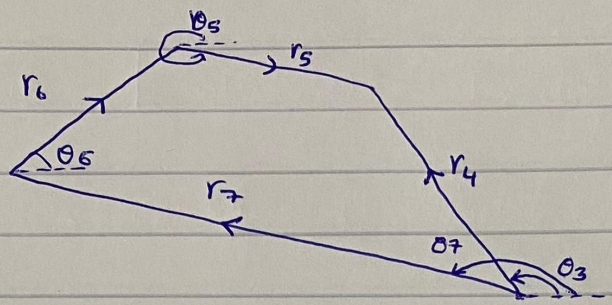
IM: $r_4 \sin\theta_3 = r_5 \sin\theta_5 + r_6 \sin\theta_6 + r_7 \sin\theta_7$

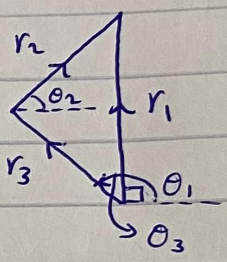
input : r_2

outputs : r_3 , θ_3 , θ_5 , θ_6

$r_1 = 67\text{ cm}$, $r_2 = 20\text{ cm}$, $r_4 = 90\text{ cm}$, $r_5 = 70\text{ cm}$, $r_6 = 120\text{ cm}$, $r_7 = 163\text{ cm}$, $\theta_7 = 155.7^\circ$

$\omega_2 = 20\text{ rad/s}$





Velocity Analysis

$\vec{r}_1 = \vec{r}_2 + \vec{r}_3$

$\dot{r}_1 = \dot{r}_2 = \dot{r}_4 = \dot{r}_5 = \dot{r}_6 = \dot{r}_7 = \omega_1 = \omega_7 = 0$

$\omega_3 = \omega_4$

RE: $0 = -\omega_2 r_2 \sin\theta_2 + \dot{r}_3 \cos\theta_3 - \omega_3 r_3 \sin\theta_3$

IM: $0 = \omega_2 r_2 \cos\theta_2 + \dot{r}_3 \sin\theta_3 + \omega_3 r_3 \cos\theta_3$

$\vec{r}_4 = \vec{r}_5 + \vec{r}_6 + \vec{r}_7 \to 0$

outputs: $\dot{r}_3$, ω_3, ω_5, ω_6

RE: $-\omega_3 r_4 \sin\theta_3 = -\omega_5 r_5 \sin\theta_5 - \omega_6 r_6 \sin\theta_6$

IM: $\omega_3 r_4 \cos\theta_3 = \omega_5 r_5 \cos\theta_5 + \omega_6 r_6 \cos\theta_6$

Acceleration Analysis

$\ddot{r}_1 = \ddot{r}_2 = \ddot{r}_4 = \ddot{r}_5 = \ddot{r}_6 = \ddot{r}_7 = \alpha_1 = \alpha_2 = \alpha_7 = 0$

RE: $0 = -\omega_2^2 r_2 \cos\theta_2 + (\ddot{r}_3 - \omega_3^2 r_3)\cos\theta_3 - (\alpha_3 r_3 + 2\omega_3 \dot{r}_3)\sin\theta_3$

IM: $0 = -\omega_2^2 r_2 \sin\theta_2 + (\ddot{r}_3 - \omega_3^2 r_3)\sin\theta_3 + (\alpha_3 r_3 + 2\omega_3 \dot{r}_3)\cos\theta_3$

RE: $-\omega_3^2 r_4 \cos\theta_3 - \alpha_3 r_4 \sin\theta_3 = -\omega_5^2 r_5 \cos\theta_5 - \alpha_5 r_5 \sin\theta_5 - \omega_6^2 r_6 \cos\theta_6 - \alpha_6 r_6 \sin\theta_6$

$\alpha_3 = \alpha_4$

IM: $-\omega_3^2 r_4 \sin\theta_3 + \alpha_3 r_4 \cos\theta_3 = -\omega_5^2 r_5 \sin\theta_5 + \alpha_5 r_5 \cos\theta_5 - \omega_6^2 r_6 \sin\theta_6 + \alpha_6 r_6 \cos\theta_6$

outputs: $\ddot{r}_3$, α_3, α_5, α_6

Velocity Analysis @ $\theta_2 = 66.5°$

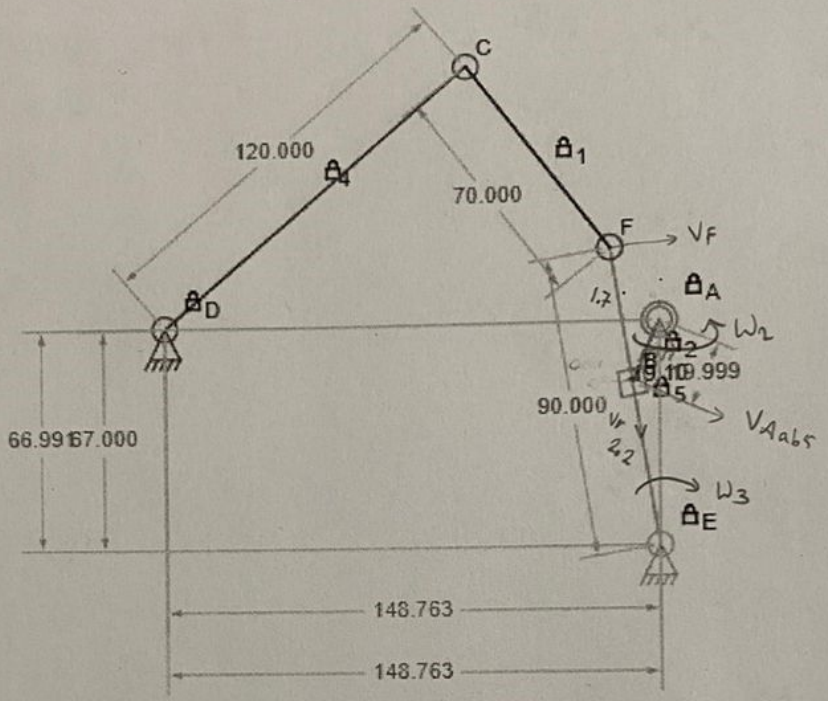
$\omega_2 = 2$ rad/s CCW

$\vec{V}_C = \vec{V}_F + \vec{V}_{C/F}$

$V_{A_{abs}} = \omega_2 r_2 = 2 \times 20 = 40$ mm/s $= 4$ cm/s, $\mu_V = 1$

$\vec{V}_{A_{abs}} = \vec{V}_{A_{base}} + \vec{V}_{A_{relative}}$

3.3 cm → 2.2
5.85 cm → 3.9



$V_F = 5.8$ cm/s

$\omega_3 = \frac{5.8}{9\text{cm}} = 0.644$ rad/s CW

$\omega_3 = -0.644$ rad/s

$\omega_{3\ \text{actual}} = -0.6816$ rad/s

$V_{C/F} = 5$ cm/s

$\omega_5 = \frac{5}{7\text{cm}} = 0.714$ rad/s CCW

$\omega_5 = 0.714$ rad/s

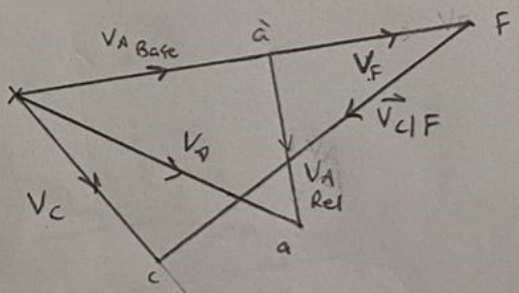
$\omega_{5\ \text{actual}} = 0.753$ rad/s

$V_C = 2.8$ cm

$\omega_6 = \frac{2.8}{12\text{cm}} = 0.233$ rad/s CW

$\omega_6 = -0.233$ rad/s

$\omega_{6\ \text{actual}} = -0.241$ rad/s



$V_{A_{relative}} = -2.2$ cm/s $= -22$ mm/s

$\dot{r}_3 = -22$ mm/s

$\dot{r}_{3\ \text{actual}} = 21.67$ mm/s

Acceleration Analysis @ $\theta_2 = 66.5°$

$\alpha_2 = 0$

$$\underset{abs}{a_A} = a_A^n + a_A^t \to 0$$

a_A^n : $\omega_2^2 r_2$, a_A^t : $\alpha_2 r_2$

$$\underset{abs}{a_A} = 2^2 * 2cm = 8 cm^2/s \quad , m_a = 2$$

↳ 4cm

$$\vec{a}_F = a_f^n + a_f^t$$

a_f^n : $\omega_3^2 r_4$, a_f^t : $\alpha_3 r_4$

$$a_f^n = 0.644^2 \times 9 = 3.73 \, cm^2/s$$

↳ 1.85cm

$$a_{cor} = 2 \omega_3 V_r$$

$$a_{cor} = 2 \times 0.644 \times 2.2$$

$$a_{cor} = 2.83 \, cm^2/s$$

↳ 1.4 cm

a_f^n

1.85 → 3.9cm

1 → 2.2cm

↳ $a_{A\,base}^n$

$$a_f^t = 6.6 * 2 = \alpha_3 \times 9cm$$

$$\alpha_3 = 1.467 \, rad^2/s \quad \underline{CW}$$

$\alpha_3 = -1.467 \, rad^2/s$

$\alpha_3 = -1.478 \, rad^2/s$ actual

$$a_{c/F}^t = 4.9 * 2 = \alpha_5 * 7cm$$

$$\alpha_5 = 1.4 \, rad^2/s \quad \underline{CCW}$$

$\alpha_5 = 1.4 \, rad^2/s$

$\alpha_5 = 1.398 \, rad^2/s$ actual

$$a_c^t = 6.5 * 2 = \alpha_6 * 12cm$$

$$\alpha_6 = 1.083 \, rad^2/s \quad \underline{CW}$$

$\alpha_6 = -1.083 \, rad^2/s$

$\alpha_6 = -1.159 \, rad^2/s$ actual

From F

$$a_c = a_F + a_{c/F}$$

a_c : a_c^n ($\omega_6^2 r_6$) , a_c^t ($\alpha_6 r_6$)

a_F ↙

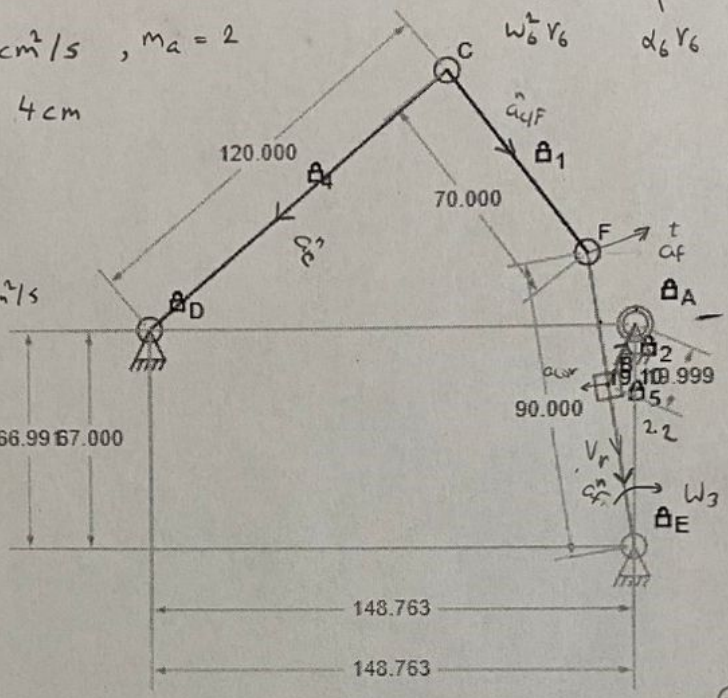
$a_{c/F}$: $a_{c/F}^n$ ($\omega_5^2 r_5$) , $a_{c/F}^t$ ($\alpha_5 r_5$)

$$a_c^n = 0.233^2 * 12cm = 0.651 \, cm^2/s$$

↳ 0.33cm

$$a_{c/F}^n = 0.714^2 * 7cm = 3.57 \, cm^2/s$$

↳ 1.8cm



$$a_{A\,relative} = 44mm * 2 = 88 \, mm^2/s$$

$\ddot{r}_3 = 88 \, mm^2/s$

$\ddot{r}_3$ actual $= 90.157 \, mm^2/s$