

AKADEMIA EDUKACYJNO - INŻYNIERSKA

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MATURA STUDIA PRAKTYKA STAŻ PRACA BIZNES PRZEMYSŁ STEAM

KOMPLEKSOWE WSPARCIE EDUKACYJNE **ON – LINE** NA KAŻDYM ETAPIE KSZTAŁCENIA INŻYNIERSKIEGO

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TEORIA MECHANIZMÓW I MANIPULATORÓW

"ANALIZA I SYNTEZA UKŁADÓW MECHANICZNYCH"

PROJEKT

Przeprowadź:

- analizę strukturalną, kinematyczną, dynamiczną
- syntezę geometryczną

dla układu mechanicznego manipulatora płaskiego w zadanym położeniu.

DANE:

$F_1, F_2, M_1, q = OK$

SZUKAM:

$R, M_R = ?$

D: $s_{10A} = 10\ [mm] = 0{,}01\ [m]$

$s_{5H} = 40\ [mm] = 0{,}04\ [m]$

$\varphi_{10A} = \varphi_{1AB} = 0\ [rad]$

$\varphi_{1BC} = \frac{\pi}{2}$

$\varphi_{2CD} = \frac{\pi}{18}$

$\varphi_{3DF} = \frac{\pi}{4}$

$\varphi_5 = \frac{3\pi}{2}$

$\varphi_{010} = \pi$

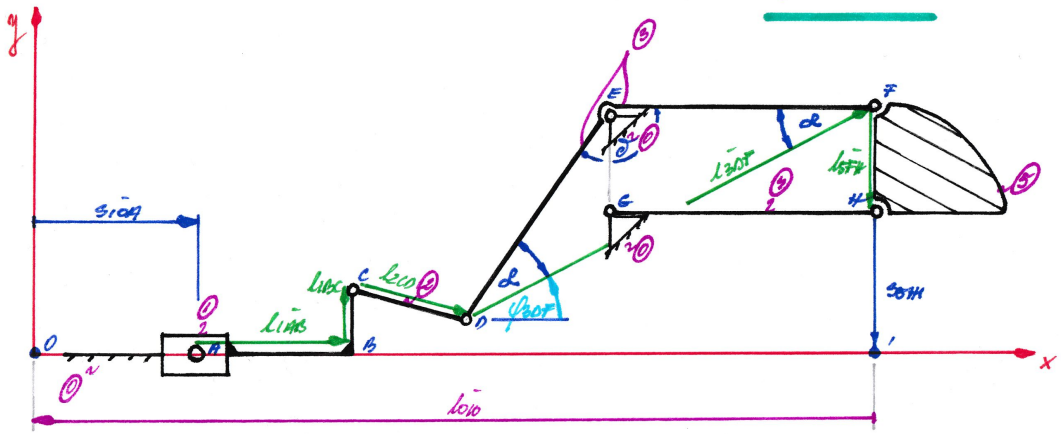
$l_{1AB} = 1{,}5\ [cm] = 0{,}015\ [m]$

$l_{1BC} = 1\ [cm] = 0{,}01\ [m]$

$l_{5FH} = 1\ [cm] = 0{,}01\ [m]$

$l_{010} = 12\ [cm] = 0{,}12\ [m]$

1) SKICA STRUKTURALNEGA MODELA.



2) SINTEZA GEOMETRIJSKA.

$$\bar{s}_{10A} + \bar{l}_{1AB} + \bar{l}_{1BC} + \bar{l}_{2CD} + \bar{l}_{3DF} + \bar{l}_{5FH} + \bar{s}_{5H} + \bar{l}_{010} = \bar{0}$$

$x:\ s_{10A}\cos\varphi_{10A} + l_{1AB}\cos\varphi_{1AB} + l_{1BC}\cos\varphi_{1BC} + l_{2CD}\cos\varphi_{2CD} + l_{3DF}\cos\varphi_{3DF} + l_{5FH}\cos\varphi_{5FH} + s_{5H}\cos\varphi_{5H} + l_{010}\cos\varphi_{010} = 0$

$y:\ s_{10A}\sin\varphi_{10A} + l_{1AB}\sin\varphi_{1AB} + l_{1BC}\sin\varphi_{1BC} + l_{2CD}\sin\varphi_{2CD} + l_{3DF}\sin\varphi_{3DF} + l_{5FH}\sin\varphi_{5FH} + s_{5H}\sin\varphi_{5H} + l_{010}\sin\varphi_{010} = 0$

$$x\ |\ 0{,}01 + 0{,}015 + l_{2D}\cos\frac{\pi}{18} + l_{3DF}\cos\frac{\pi}{4} - 0{,}12 = 0$$

$$y\ |\ 0{,}01 + l_{2D}\sin\frac{\pi}{18} + l_{3DF}\sin\frac{\pi}{4} - 0{,}01 - 0{,}04 = 0$$

$$x\ |\ 0{,}9848\, l_{2D} + 0{,}4041\, l_{3DF} = 0{,}096$$

$$y\ |\ 0{,}1436\, l_{2D} + 0{,}4041\, l_{3DF} = 0{,}04 \quad /\cdot(-1)$$

$$x\ |\ 0{,}9848\, l_{2D} + 0{,}4041\, l_{3DF} = 0{,}096$$

$$y\ |\ -0{,}1436\, l_{2D} - 0{,}4041\, l_{3DF} = -0{,}04$$

$$0{,}9848\, l_{2D} + 0{,}4041\, l_{3DF} - 0{,}1436\, l_{2D} - 0{,}4041\, l_{3DF} = 0{,}096 - 0{,}04$$

$$0{,}8112\, l_{2D} = 0{,}056 \quad /:0{,}8112$$

$$l_{2D} = 0{,}06480\ [m] = 6{,}48\ [cm]$$

$$y\ |\ 0{,}1436\, l_{2D} + 0{,}4041\, l_{3DF} = 0{,}04$$

$$l_{3DF} = \frac{0{,}04 - 0{,}1436\, l_{2D}}{0{,}4041}$$

$$\Rightarrow l_{3DF} = \frac{0{,}04 - 0{,}1436 \cdot 0{,}06480}{0{,}4041} = \frac{0{,}04 - 0{,}01144}{0{,}4041} = \frac{0{,}02823}{0{,}4041} = 0{,}03532\ [m] = 3{,}99\ [cm]$$

$$\Rightarrow \begin{cases} l_{2D} = 6{,}48\ [cm] \\ l_{3DF} = 3{,}99 \end{cases}$$

$$\frac{l_{3DF}}{\sin\vartheta} = \frac{l_{3DE}}{\sin\alpha} = \frac{l_{3ET}}{\sin\alpha}$$

$$\begin{cases} \vartheta = 120^\circ \\ \alpha = 30^\circ \end{cases}$$

$$\Rightarrow \frac{3{,}99}{\sin 120^\circ} = \frac{l_{3DE}}{\sin 30^\circ} = \frac{l_{3ET}}{\sin 30^\circ}$$

$$\Rightarrow l_{3DE} = \frac{\sin 30^\circ}{\sin 120^\circ} \cdot 3{,}99 = 2{,}34\ [cm]$$

$$\Rightarrow l_{3DE} = l_{3ET} = 2{,}34\ [cm]$$

3) ANALIZA KINEMATICKA - REALIZAREA I POS.

$s_{1OA} = 6 \text{ [mm]} = 0,6 \text{ [cm]}$

$l_{1AB} = 15 \text{ [mm]} = 1,5 \text{ [cm]}$

$l_{1BC} = 10 \text{ [mm]} = 1,0 \text{ [cm]}$

$l_{2CD} = 64,8 \text{ [mm]} = 6,48 \text{ [cm]}$

$l_{3DF} = 39,9 \text{ [mm]} = 3,99 \text{ [cm]}$

$l_{3DE} = l_{3EF} = 23,4 \text{ [mm]} = 2,34 \text{ [cm]}$

$l_{5FH} = 10 \text{ [mm]} = 1,0 \text{ [cm]}$

$l_{OD} = 120 \text{ [mm]} = 12 \text{ [cm]}$

$s_{5H1} = ?$; $l_{4GH} = l_{3EF} = 23,4 \text{ [mm]} = 2,34 \text{ [cm]}$

$\alpha = 30^\circ$

$\beta = 120^\circ$

$(s_{1OA}) = \frac{s_{1OA}}{H_L} = \frac{0,6}{1} = 0,6 \text{ [cm]}$

$(l_{1AB}) = 1,5 \text{ [cm]}$

$(l_{1BC}) = 1,0 \text{ [cm]}$

$(l_{2CD}) = 6,48 \text{ [cm]}$

$(l_{3DF}) = 3,99 \text{ [cm]}$

$(l_{3DE}) = (l_{3EF}) = 2,34 \text{ [cm]}$

$(l_{5FH}) = 1,0 \text{ [cm]}$

$(l_{OD}) = 12 \text{ [cm]}$

$(s_{5H1}) = ?$

$\alpha = 30^\circ$

$\beta = 120^\circ$; $(l_{4GH}) = (l_{3EF}) = 2,34 \text{ [cm]}$

H_L)

$$H_L = \frac{l_{OD}}{(l_{OD})}$$

$\Rightarrow (l_{OD}) = \frac{l_{OD}}{H_L} = \frac{12}{1} = 12 \text{ [cm]}$

$\Rightarrow H_L = 1$

$\Rightarrow (s_{5H1}) = 2,80 \text{ [cm]}$; $H_L = 1$

$\Rightarrow s_{5H1} = (s_{5H1}) \cdot H_L = 2,80 \cdot 1 = 2,80 \text{ [cm]}$

4) ANALIZA KINEMATYCZNA - GRAFICZNA:

v_E)

$$v_E = \frac{dx_{OA}}{dt} = \text{const.}$$

$$\Rightarrow v_E = \frac{1}{0{,}12} = 5{,}0 \ [\text{cm/s}]$$

v_A, v_B, v_C)

$$\bar{v}_E = \bar{v}_A = \bar{v}_B = \bar{v}_C$$

$$\Rightarrow v_E = v_A = v_B = v_C = 5{,}0 \ [\text{cm/s}]$$

ω_1)

$$\omega_1 = 0$$

H_v)

$$H_v = \frac{\bar{v}_A}{(\bar{v}_A)}$$

$$\Rightarrow (v_A) = \frac{v_A}{H_v} = \frac{5}{1} = 5 \ [\text{cm}]$$

$$\Rightarrow H_v = 1$$

v_B)

$$\begin{cases} \bar{v}_B = \bar{v}_C + \bar{v}_{BC} \\ \bar{v}_B = \bar{v}_E + \bar{v}_{BE} \end{cases}$$

$$\bar{v}_B = \bar{v}_C + \bar{v}_{BC} = \bar{v}_E + \bar{v}_{BE}$$

$v_C = 5{,}0 \ [\text{cm/s}]$

$v_{BC} = \omega_2 \cdot |BC| = ?$

$v_E = 0$

$v_{BE} = \omega_3 \cdot |BE| = ?$

$$\Rightarrow \begin{cases} (v_B) = 5{,}50 \ [\text{cm}] \\ (v_{BC}) = 2{,}10 \end{cases} ; \quad H_v = 1$$

$$\Rightarrow \begin{cases} v_B = (v_B) \cdot H_v = 5{,}50 \cdot 1 = 5{,}50 \ [\text{cm/s}] \\ v_{BC} = (v_{BC}) \cdot H_v = 2{,}10 \cdot 1 = 2{,}10 \end{cases}$$

ω_2)

$$\omega_2 = \frac{v_{BC}}{|BC|} \Rightarrow \omega_2 = \frac{2{,}10}{6{,}48} = 0{,}31 \ [\text{rad/s}]$$

ω_3)

$$\omega_3 = \frac{v_B}{|BE|} \Rightarrow \omega_3 = \frac{5{,}50}{2{,}34} = 2{,}35 \ [\text{rad/s}]$$

v_F)

$\begin{cases} \bar{v}_F = \bar{v}_E + \bar{v}_{FE} \\ \bar{v}_F = \bar{v}_D + \bar{v}_{FD} \end{cases}$ ⊕

$\bar{v}_F = \bar{v}_E + \bar{v}_{FE} - \bar{v}_D + \bar{v}_{FD}$

$v_E = 0$ [cm/s]

$v_{FE} = w_3 \cdot |TE| = ?$

$v_D = 5{,}80$

$v_{FD} = w_3 \cdot |TD| = ?$

$\Rightarrow \begin{cases} (v_{FE}) = 5{,}80 \text{ [cm]} \\ (v_{FD}) = 9{,}80 \end{cases}$; $H_v = 1$

$\Rightarrow \begin{cases} v_{FE} = (v_{FE}) \cdot H_v = 5{,}80 \cdot 1 = 5{,}80 \text{ [cm/s]} \\ v_{FD} = (v_{FD}) \cdot H_v = 9{,}80 \cdot 1 = 9{,}80 \end{cases}$

$\Rightarrow v_F = v_{FE} = 5{,}80$ [cm/s]

v_H)

$v_H = v_F$

$\Rightarrow v_H = v_F = 5{,}80$ [cm/s]

w_5)

$w_5 = \frac{v_{HF}}{|HF|}$ $\Rightarrow$ $w_5 = \frac{0}{1} = 0$ [rad/s]

w_4)

$w_4 = \frac{v_H}{|GH|}$ $\Rightarrow$ $w_4 = \frac{5{,}80}{2{,}34} = 2{,}35$ [rad/s]

5) ANALIZA KINEMATYCZNA - GRAFICZNA.

a)

$a_E = 0$

$\Rightarrow a_E = 0 \quad [cm/s^2]$

a_A, a_B, a_C

$\bar{a}_A = \bar{a}_B = \bar{a}_C - \bar{a}_C$

$\Rightarrow a_A = a_B = a_C = a_C = 0 \quad [cm/s^2]$

ε)

$\varepsilon_2 = 0$

$\Rightarrow \varepsilon_2 = 0 \quad [rad/s^2]$

a)

$$\left| \begin{array}{l} \bar{a}_B = \bar{a}_C + \bar{a}_{BC}^{\,n} + \bar{a}_{BC}^{\,\tau} \\ \bar{a}_B = \bar{a}_E^{\,0} + \bar{a}_{BE}^{\,n} + \bar{a}_{BE}^{\,\tau} \end{array} \right.$$

$$\bar{a}_B = \bar{a}_C + \bar{a}_{BC}^{\,n} + \bar{a}_{BC}^{\,\tau} = \bar{a}_E^{\,0} + \bar{a}_{BE}^{\,n} + \bar{a}_{BE}^{\,\tau}$$

$a_C = 0 \quad [cm/s^2]$

$a_{BC}^{\,n} = \omega_2^2 \cdot |BC| = (0{,}31)^2 \cdot 6{,}48 = 0{,}66$

$a_{BC}^{\,\tau} = \varepsilon_2 \cdot |BC| = ?$

$a_E = 0$

$a_{BE}^{\,n} = \omega_3^2 \cdot |BE| = (2{,}35)^2 \cdot 2{,}34 = 12{,}92$

$a_{BE}^{\,\tau} = \varepsilon_3 \cdot |BE| = ?$

Ha)

$$Ha = \frac{a_{BE}^{\,n}}{(a_{BE}^{\,n})}$$

$\Rightarrow (a_{BE}^{\,n}) = \frac{a_{BE}^{\,n}}{Ha} = \frac{12{,}92}{3} = 4{,}31 \quad [cm]$

$\Rightarrow Ha = 3$

$\Rightarrow (a_{BC}^{\,n}) = \frac{a_{BC}^{\,n}}{Ha} = \frac{0{,}65}{3} = 0{,}22 \quad [cm]$

$$\Rightarrow \begin{cases} (a_{Dc}^{\tau}) = 4,75 \ [cm] \\ (a_{DE}^{\tau}) = 2,0 \\ (a_D) = 4,80 \end{cases} ; \quad H_a = 3$$

$$\Rightarrow \begin{cases} a_{Dc}^{\tau} - (a_{Dc}^{\tau}) \cdot H_a = 4,75 \cdot 3 = 14,25 \ [cm/s^2] \\ a_{DE}^{\tau} - (a_{DE}^{\tau}) \cdot H_a = 2 \cdot 3 = 6,0 \\ a_D = (a_D) \cdot H_a = 4,80 \cdot 3 = 14,40 \end{cases}$$

ε_2)

$$\varepsilon_2 = \frac{a_{Dc}^{\tau}}{|DC|} \Rightarrow \varepsilon_2 = \frac{14,25}{6,48} = 2,10 \ [rad/s^2]$$

ε_3)

$$\varepsilon_3 = \frac{a_{DE}^{\tau}}{|DE|} \Rightarrow \varepsilon_3 = \frac{6,0}{2,34} = 2,56 \ [rad/s^2]$$

a_F)

$$\left| \begin{array}{l} \bar{a}_F = \bar{a}_E^{\,3^0} + \bar{a}_{FE}^{\,n} + \bar{a}_{FE}^{\,\tau} \\ \bar{a}_F = \bar{a}_D + \bar{a}_{FD}^{\,n} + \bar{a}_{FD}^{\,\tau} \end{array} \right. \oplus$$

$$\bar{a}_F = \bar{a}_E^{\,3^0} + \bar{a}_{FE}^{\,n} + \bar{a}_{FE}^{\,\tau} = \bar{a}_D + \bar{a}_{FD}^{\,n} + \bar{a}_{FD}^{\,\tau}$$

$a_E = 0 \ [cm/s^2]$

$a_{FE}^{n} = \omega_3^2 \cdot |FE| = (2,35)^2 \cdot 2,34 = 12,92$

$a_{FE}^{\tau} = \varepsilon_3 \cdot |FE| = ?$; $a_{FD}^{\tau} = \varepsilon_3 \cdot |FD| = ?$

$a_D = 14,40$

$a_{FD}^{n} = \omega_3^2 \cdot |FD| = (2,35)^2 \cdot 3,99 = 22,03$

$H_a = 3$

$$\Rightarrow (a_{FE}^{n}) = \frac{a_{FE}^{n}}{H_a} = \frac{12,92}{3} = 4,31 \ [cm]$$

$$(a_{FD}^{n}) = \frac{a_{FD}^{n}}{H_a} = \frac{22,03}{3} = 4,34$$

$$\Rightarrow \begin{cases} (a_{re}^{\tilde{i}}) = 2,30 \ [au] \\ (a_{rn}^{\tilde{i}}) = 3,65 \\ (a_F) = 4,95 \end{cases} ; \quad Ha = 3$$

$$\Rightarrow \begin{cases} a_{re}^{\tilde{i}} = (a_{re}^{\tilde{i}}) \cdot Ha = 2,30 \cdot 3 = 6,90 \ [au/s^2] \\ a_{rn}^{\tilde{i}} = (a_{rn}^{\tilde{i}}) \cdot Ha = 3,65 \cdot 3 = 10,95 \\ a_F = (a_F) \cdot Ha = 4,95 \cdot 3 = 14,85 \end{cases}$$

a_H)

$$a_H = a_F$$

$$\Rightarrow a_H = a_F = 14,85 \ [au/s^2]$$

ε_4)

$$\varepsilon_4 = \varepsilon_3$$

$$\Rightarrow \varepsilon_4 = \varepsilon_3 = 2,56 \ [rad/s^2]$$

ε_5)

$$\varepsilon_5 = 0$$

6) Analiza dinamicii - kinetostatica.

6)

$$G = m \cdot g$$

$$G_5 = m_5 \cdot g = 0{,}2 \cdot 9{,}81 = 1{,}96 = 2{,}0 \ [N]$$

$$G_6 = 10 \ [N]$$

$$h_6 = 10 \ [mm] = 1{,}0 \ [cm]$$

H_F)

$$H_F = \frac{G_6}{(G_6)}$$

$$(G_6) = \frac{G_6}{H_F} = \frac{10}{2} = 5{,}0 \ [cm]$$

$$(G_5) = \frac{G_5}{H_F} = \frac{2}{2} = 1{,}0$$

$$H_F = 2$$

5)

$$\sum T_{i5} = 0 \Rightarrow \bar{R}_{45} + \bar{G}_5 + \bar{G}_6 + \bar{R}_{35} = 0$$

$$\Rightarrow \begin{cases} (R_{45}) = 6{,}30 \ [cm] \\ (R_{35}) = 8{,}30 \end{cases} ; \quad H_F = 2$$

$$\Rightarrow \begin{cases} R_{45} = (R_{45}) \cdot H_F = 6{,}30 \cdot 2 = 12{,}60 \ [N] \\ R_{35} = (R_{35}) \cdot H_F = 8{,}30 \cdot 2 = 16{,}60 \end{cases}$$

$$\Rightarrow R_{40} = R_{45} = 12{,}60 \ [N]$$

3)

$$\sum T_{i3} = 0 \Rightarrow \bar{R}_{23} + \bar{R}_{43} + \bar{R}_{03} = 0$$

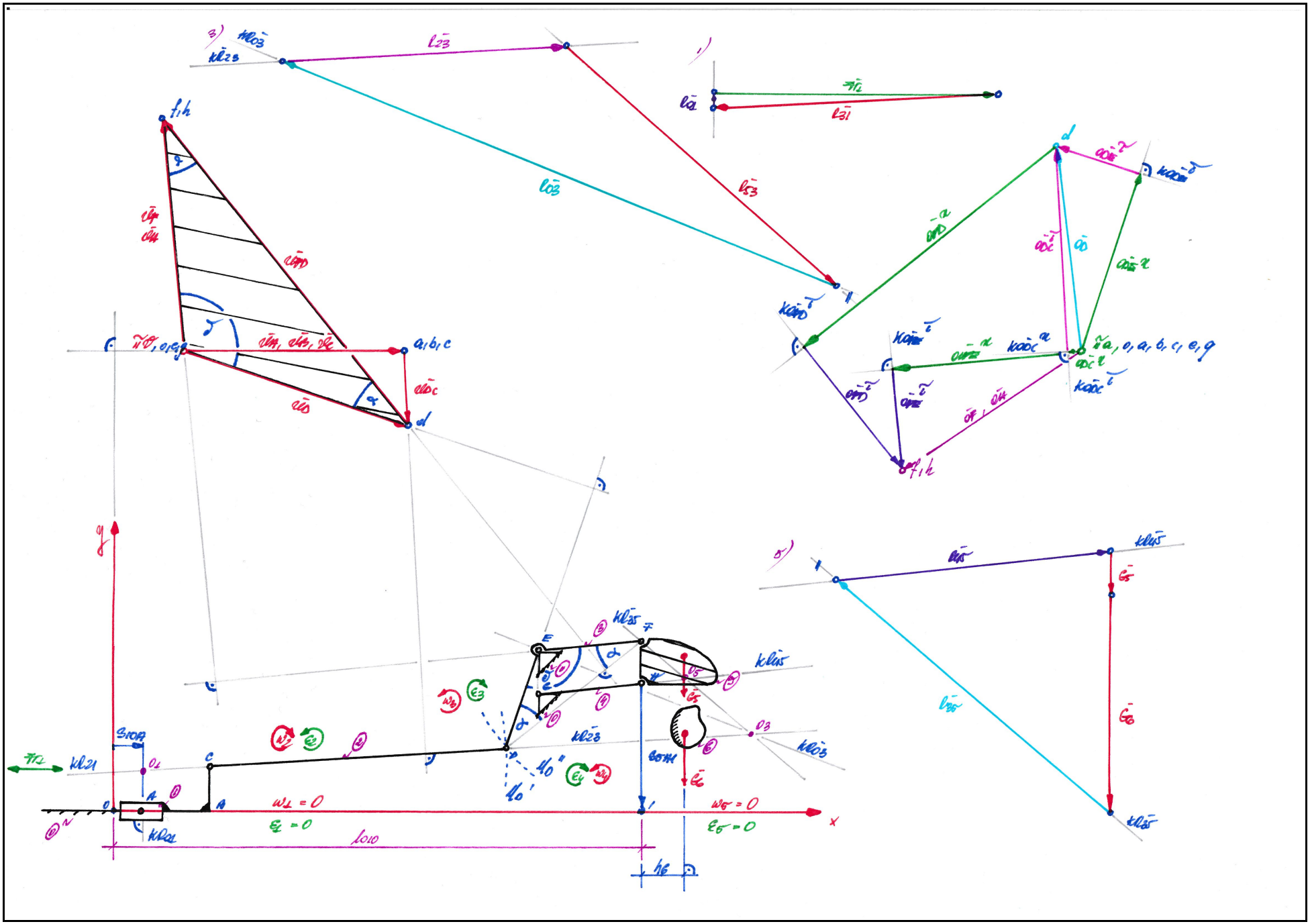
$$\Rightarrow \begin{cases} (R_{23}) = 6{,}50 \ [cm] \\ (R_{03}) = 13{,}40 \end{cases} ; \quad H_F = 2$$

$$\Rightarrow \begin{cases} R_{23} = (R_{23}) \cdot H_F = 6{,}50 \cdot 2 = 13{,}0 \ [N] \\ R_{03} = (R_{03}) \cdot H_F = 13{,}40 \cdot 2 = 24{,}40 \end{cases}$$

$\sum \bar{T}_{i1} = 0 \rightarrow \bar{T}_{r1} + \bar{R}_{a1} + \bar{R}_{a2} = 0$

$\rightarrow \begin{cases} (T_{r1}) = 6{,}45 \ [cm] \\ (R_{a1}) = 0{,}30 \quad ; \quad H_F = 2 \end{cases}$

$\rightarrow \begin{cases} T_{r1} = (T_{r1}) \cdot H_F = 6{,}45 \cdot 2 = 12{,}90 \ [N] \\ R_{a1} = (R_{a1}) \cdot H_F = 0{,}30 \cdot 2 = 0{,}60 \end{cases}$


x
y
$\omega_1 = 0$
$\varepsilon_1 = 0$
$\omega_6 = 0$
$\varepsilon_6 = 0$
l_{010}
h_6


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