

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 DYNAMICZNA – RÓWNANIA WEKTOROWE"

PROJEKT

Przeprowadź:

- analizę strukturalną
- analizę dynamiczną

dla układu mechanicznego jarzmowego w zadanym położeniu.

DANE:

$F_1, F_2, M_1, q = OK$

SZUKAM:

$R, M_R = ?$

100

DANE

$|\bar{AB}_1| = 0{,}2\ [m] = 20\ [cm]$

$|\bar{AC}| = 0{,}5\ [m] = 50\ [cm]$

$|\bar{CD}| = 0{,}8\ [m] = 80\ [cm]$

$|\bar{DS}_3| = 0{,}3\ [m] = 30\ [cm]$

$m_1 = 2\ [kg]$

$m_3 = 2{,}5\ [kg]$

$I_3 = 0{,}002\ [kgm^2]$

$\omega_1 = 6\ [\frac{rad}{s}]$; $\varphi_1 = 100°$

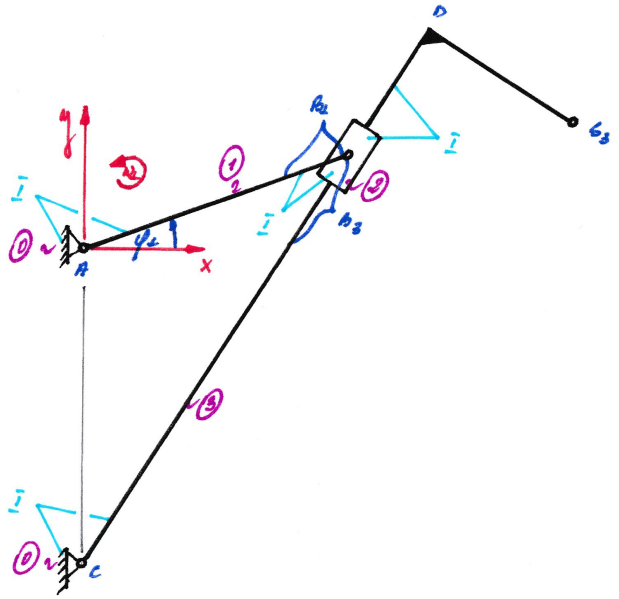
SZUKAM

$\bar{v}, \bar{a} = ?$

$\bar{\omega}, \bar{\varepsilon} = ?$

$\bar{R}, \bar{M} = ?$

1) SCHEMAT STRUKTURALNY UKŁADU.



2) RUCHLIWOŚĆ MECHANIZMU.

$W_R = W_T - W_L + W_B$

$W_T = 3k - 2p_1 - p_2$

$k = 3$

$p_1 = 4$

$p_2 = 0$

$\Rightarrow \quad W_T = 3 \cdot 3 - 2 \cdot 4 = 9 - 8 = \underline{1}$

$W_L = 0$

$W_B = 0$

$\Rightarrow \quad W_R = W_T = \underline{1}$

3) PODZIAŁKA (WEKTORA)

$$\mathcal{H}_L = \frac{\bar{l}}{(\bar{l})}$$

$$\mathcal{H}_v = \frac{\bar{v}}{(\bar{v})}$$

$$\mathcal{H}_a = \frac{\bar{a}}{(\bar{a})}$$

$$\mathcal{H}_L = \frac{|\bar{OS}|}{(|\bar{OS}|)} \Rightarrow (|\bar{OS}|) = \frac{|\bar{OS}|}{\mathcal{H}_L} = \frac{80}{\mathcal{H}_L} = \boxed{\mathcal{H}_L = 10} =$$

$$= \frac{80}{10} = 8 \Rightarrow (|\bar{OS}|) = \underline{8{,}0} \ [cm]$$

4) ANALIZA PRZEMIESZCZENIA - POŁOŻENIE I TRAJEKTORIA

$$(|\bar{AB}_2|) = \frac{|\bar{AB}_2|}{\mathcal{H}_L} = \frac{20}{10} = 2{,}0 \ [cm]$$

$$(|\bar{AC}|) = \frac{|\bar{AC}|}{\mathcal{H}_L} = \frac{80}{10} = 5{,}0 \ [cm]$$

$$(|\bar{OS}|) = \frac{|\bar{OS}|}{\mathcal{H}_L} = \frac{80}{10} = 8{,}0 \ [cm]$$

$$(|\bar{DS}_3|) = \frac{|\bar{DS}_3|}{\mathcal{H}_L} = \frac{30}{10} = \underline{3{,}0} \ [cm]$$

$\varphi_L = 100°$; $\omega_L = 6 \left[\frac{rad}{s}\right]$

4) ANALIZA KINEMATYCZNA - PRĘDKOŚCI

v_{B2}:

$$\bar{v}_{B2} = \bar{v}_A + \bar{v}_{B_2A}$$

$\bar{v}_A = 0 \quad [cm/s]$

$v_{B_2A} = \omega_2 \cdot |B_2A| = 6 \cdot 20 = 120 \quad [cm/s]$

$\bar{v}_{B2} = \bar{v}_{B_2A} = 120 \quad [cm/s]$

$$H_v = \frac{\bar{v}_{B2}}{(\bar{v}_{B2})}$$

$H_v = \frac{\bar{v}_{B2}}{(\bar{v}_{B2})} \Rightarrow (\bar{v}_{B2}) = \frac{\bar{v}_{B2}}{H_v} = \frac{120}{H_v} =$ $\boxed{H_v = 20}$ $=$

$= \frac{120}{20} = 6 \Rightarrow (\bar{v}_{B2}) = 6,0 \quad [cm]$

v_{B3}:

$$\begin{cases} \bar{v}_{B3} = \bar{v}_{B2} + \bar{v}_{B_3B_2} \\ \bar{v}_{B3} = \bar{v}_C + \bar{v}_{B_3C} \end{cases} \oplus$$

$$\bar{v}_{B3} = \bar{v}_{B2} + \bar{v}_{B_3B_2} = \bar{v}_C + \bar{v}_{B_3C}$$

$\bar{v}_{B2} = 120 \quad [cm/s]$

$v_{B_3B_2} = ? \; ; \; k \parallel 3$

$\bar{v}_C = 0 \quad [cm/s]$

$v_{B_3C} = \omega_3 \cdot |B_3C| = ? \; ; \; \omega_3 = ?$

$\bar{v}_{B3} = \bar{v}_{B_3C} = k \perp 3$

v_v:

$$\begin{cases} (v_{B_3B_2}) = 0,80 \quad [cm] \\ (v_{B3}) = 5,90 \end{cases} ; \quad \boxed{H_v = 20}$$

$$\Rightarrow \begin{cases} v_{B_3B_2} = (v_{B_3B_2}) \cdot H_v = 0,80 \cdot 20 = 16 \quad [cm/s] \\ v_{B3} = (v_{B3}) \cdot H_v = 5,90 \cdot 20 = 118 \end{cases}$$

v_D :

$$\begin{cases} \bar{v}_D = \bar{v}_E + \bar{v}_{DE} \\ \bar{v}_D = \bar{v}_{B_3} + \bar{v}_{DB_3} \end{cases} \oplus$$

$$\bar{v}_D = \bar{v}_E^{\,\nearrow^0} + \bar{v}_{DE} = \bar{v}_{B_3} + \bar{v}_{DB_3}$$

$\bar{v}_E = 0 \quad [cm/s]$

$v_{DE} = \omega_3 \cdot |\bar{DE}| = ? \quad ; \quad \omega_3 = ?$

$v_{B_3} = 118 \quad [cm/s]$

$v_{DB_3} = \omega_3 \cdot |\bar{DB}_3| = ? \quad ; \quad \omega_3 = ?$

$\bar{v}_{DE}, \bar{v}_{DB_3} = k \perp 3$

$$\frac{|\bar{ad}|}{|\bar{DE}|} = \frac{|\bar{cb}_3|}{|\bar{CB}_3|}$$

$$\Rightarrow |\bar{ad}| = \frac{|\bar{cb}_3| \cdot |\bar{DE}|}{|\bar{CB}_3|} = \frac{5{,}90 \cdot 80}{70} = \frac{472}{70} = 6{,}74 \ [cm]$$

v_D :

$(\bar{v}_D) = 6{,}74 \ [cm] \quad ; \quad H_v = 20$

$\Rightarrow \bar{v}_D = (\bar{v}_D) \cdot H_v = 6{,}74 \cdot 20 = 134{,}80 \ [cm/s]$

v_{B_3} :

$$\begin{cases} \bar{v}_{B_3} = \bar{v}_E + \bar{v}_{B_3E} \\ \bar{v}_{B_3} = \bar{v}_{B_3} + \bar{v}_{B_3B_3} \end{cases} \oplus$$

$$\bar{v}_{B_3} = \bar{v}_E^{\,\nearrow^0} + \bar{v}_{B_3E} = \bar{v}_{B_3} + \bar{v}_{B_3B_3}$$

$\bar{v}_E = 0 \quad [cm/s]$

$v_{B_3E} = \omega_3 \cdot |\bar{B_3E}| = ? \quad ; \quad \omega_3 = ?$

$v_{B_3} = 118 \quad [cm/s]$

$v_{B_3B_3} = \omega_3 \cdot |\bar{B_3B_3}| = ? \quad ; \quad \omega_3 = ?$

H_v :

$$\begin{cases} (\bar{v}_{B_3E}) = 7{,}20 \ [cm] \\ (\bar{v}_{B_3B_3}) = 2{,}10 \end{cases} ; \quad H_v = 20$$

$$\Rightarrow \begin{cases} \bar{v}_{B_3E} = (\bar{v}_{B_3E}) \cdot H_v = 7{,}20 \cdot 20 = 144 \ [cm/s] \\ \bar{v}_{B_3B_3} = (\bar{v}_{B_3B_3}) \cdot H_v = 2{,}10 \cdot 20 = 42 \end{cases}$$

v_{S1}:

$$\bar{v}_{S1} = \bar{v}_A + \bar{v}_{S1A}$$

$\bar{v}_A = 0 \quad [\text{cm/s}]$

$v_{S1A} = \omega_1 \cdot |\bar{S_1 A}| = 6 \cdot 10 = 60 \quad [\text{cm/s}]$

$\underline{v_{S1}} = v_{S1A} = \underline{60} \quad [\text{cm/s}]$

$|H_v = 20|$

$\Rightarrow (\underline{v_{S1}}) = \frac{v_{S1}}{H_v} = \frac{60}{20} = \underline{3,0} \quad [\text{cm}]$

ω_1:

$\omega_1 = 6 \quad [\frac{\text{rad}}{\text{s}}]$

ω_2:

$\omega_2 = \omega_3 = 1,68 \quad [\frac{\text{rad}}{\text{s}}]$

ω_3:

$\underline{\omega_3} = \frac{v_{B3}}{|\bar{CB_3}|} = \frac{118}{70} = \underline{1,68} \quad [\frac{\text{rad}}{\text{s}}]$

6) Analiza mecanismului - metoda grafică.

O_{B1}:

$$\bar{a}_{B1} = \bar{a}_{B}^{0} + \bar{a}_{B1B}^{n} + \bar{a}_{B1B}^{\tau}$$

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

$a_{B1B}^{n} = \omega_1^2 \cdot |\bar{B_1A}| = 6^2 \cdot 20 = 720 \quad [cm/s^2]$

$a_{B1A}^{\tau} = \varepsilon_1 \cdot |\bar{B_1A}| = 0 \cdot 20 = 0 \quad [cm/s^2]$

$a_{B1} = a_{B1A}^{n} = 720 \quad [cm/s^2]$

$$H_a = \frac{a_{B1}}{(a_{B1})}$$

$H_a = \frac{a_{B1}}{(a_{B1})} \Rightarrow (a_{B1}) = \frac{a_{B1}}{H_a} = \frac{720}{H_a} = \boxed{H_a = 100} =$

$= \frac{720}{100} = 7,2 \Rightarrow (a_{B1}) = 7,20 \quad [cm]$

O_{B3}:

$$\begin{cases} \bar{a}_{B3} = \bar{a}_{B1} + a_{B3B1}^{n} + a_{B3B1}^{\tau} + a_{B3B1}^{c} \\ \bar{a}_{B3} = \bar{a}_{C} + a_{B3C}^{n} + a_{B3C}^{\tau} \end{cases} \quad (+)$$

$$\bar{a}_{B3} = \bar{a}_{B1} + a_{B3B1}^{n} + a_{B3B1}^{\tau} + a_{B3B1}^{c} = \bar{a}_{C}^{0} + a_{B3C}^{n} + a_{B3C}^{\tau}$$

$a_{B1} = 720 \quad [cm/s^2]$

$a_{B3B1}^{n} = \frac{v_{B3B1}^2}{\rho \to \infty} = 0$; $k a_{B3B1}^{n} \perp 3$

$a_{B3B1}^{\tau} = ?$; $k a_{B3B1}^{\tau} \parallel 3$

$a_{B3B1}^{c} = 2\,\bar{\omega}_3 \times v_{B3B1} = 2 \cdot \omega_3 \cdot v_{B3B1} \cdot \sin(\bar{\omega}_3 ; v_{B3B1}) = 2 \cdot 1,68 \cdot 16 \cdot \sin 90^\circ =$

$= 53,76 \quad [cm/s^2]$

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

$a_{B3C}^{n} = \omega_3^2 \cdot |\bar{B_3C}| = (1,68)^2 \cdot 70 = 197,06 \quad [cm/s^2]$

$a_{B3C}^{\tau} = \varepsilon_3 \cdot |\bar{B_3C}| = ? \quad ; \quad \varepsilon_3 = ?$

$\boxed{H_a = 100}$

$(\bar{a}_{B_1}) = \frac{\bar{a}_{B_1}}{H_a} = \frac{720}{100} = 7,20 \quad [cm]$

$(\bar{a}_{B_1C}^{e}) = \frac{\bar{a}_{B_1C}^{e}}{H_a} = \frac{53,46}{100} = 0,53$

$(\bar{a}_{BC}^{n}) = \frac{\bar{a}_{BC}^{n}}{H_a} = \frac{187,66}{100} = 1,97$

Va:

$$\begin{cases} (\bar{a}_{B_3B_1}^{\tau}) = 5,30 \quad [cm] \\ (\bar{a}_{B_3C}^{\tau}) = 0,30 \\ (\bar{a}_{B_3}) = 2,0 \end{cases} ; \qquad H_a = 100$$

$$\rightsquigarrow \begin{cases} \bar{a}_{B_3B_1}^{\tau} = (\bar{a}_{B_3B_1}^{\tau}) \cdot H_a = 5,30 \cdot 100 = 530 \quad [cm/s^2] \\ \bar{a}_{B_3C}^{\tau} = (\bar{a}_{B_3C}^{\tau}) \cdot H_a = 0,30 \cdot 100 = 30 \\ \bar{a}_{B_3} = (\bar{a}_{B_3}) \cdot H_a = 2 \cdot 100 = 200 \end{cases}$$

Da:

$$\begin{cases} \bar{a}_D = \bar{a}_C + \bar{a}_{DC}^{n} + \bar{a}_{DC}^{\tau} \\ \bar{a}_D = \bar{a}_{B_3} + \bar{a}_{DB_3}^{n} + \bar{a}_{DB_3}^{\tau} \end{cases} \quad (+)$$

$$\bar{a}_D = \bar{a}_C + \bar{a}_{DC}^{n} + \bar{a}_{DC}^{\tau} = \bar{a}_{B_3} + \bar{a}_{DB_3}^{n} + \bar{a}_{DB_3}^{\tau}$$

$\bar{a}_C = 0 \quad [cm/s^2]$

$a_{DC}^{n} = \omega_3^2 \cdot |\bar{DC}| = (1,68)^2 \cdot 80 = 226,79 \quad [cm/s^2]$

$\bar{a}_{DC}^{\tau} = \varepsilon_3 \cdot |\bar{DC}| = ? \quad ; \quad \varepsilon_3 = ?$

$\bar{a}_{B_3} = 200 \quad [cm/s^2]$

$a_{DB_3}^{n} = \omega_3^2 \cdot |\bar{DB_3}| = (1,68)^2 \cdot 10 = 28,22 \quad [cm/s^2]$

$\bar{a}_{DB_3}^{\tau} = \varepsilon_3 \cdot |\bar{DB_3}| = ? \quad ; \quad \varepsilon_3 = ?$

$$\frac{|\bar{dc}|}{|\bar{DC}|} = \frac{|\bar{cb_3}|}{|\bar{CB_3}|}$$

$$\rightsquigarrow |\bar{dc}| = \frac{|\bar{cb_3}| \cdot |\bar{DC}|}{|\bar{CB_3}|} = \frac{2 \cdot 80}{70} = \frac{160}{70} = 2,28 \quad [cm]$$

Va:

$(\bar{a}_D) = 2,28 \quad [cm] \quad ; \qquad H_a = 100$

$\rightsquigarrow \bar{a}_D = (\bar{a}_D) \cdot H_a = 2,28 \cdot 100 = 228 \quad [cm/s^2]$

a_{S3}:

$$\begin{cases} \bar{a}_{S3} = \bar{a}_C + \bar{a}_{S3C}^{\,n} + \bar{a}_{S3C}^{\,t} \\ \bar{a}_{S3} = \bar{a}_{P3} + \bar{a}_{S3P3}^{\,n} + \bar{a}_{S3P3}^{\,t} \end{cases} \quad \oplus$$

$$\bar{a}_{S3} = \bar{a}_C^{\,=0} + \bar{a}_{S3C}^{\,n} + \bar{a}_{S3C}^{\,t} = \bar{a}_{P3} + \bar{a}_{S3P3}^{\,n} + \bar{a}_{S3P3}^{\,t}$$

$$\frac{|s_3\bar{a}|}{|s_3\bar{D}|} = \frac{|\bar{c}a|}{|\bar{C}\bar{D}|}$$

$$\Rightarrow |s_3\bar{a}| = \frac{|\bar{c}a| \cdot |s_3\bar{D}|}{|\bar{C}\bar{D}|} = \frac{2{,}28 \cdot 30}{80} = \frac{68{,}4}{80} = 0{,}85 \text{ [cm]}$$

γ_a:

$$(\bar{a}_{S3}) = 2{,}80 \text{ [cm]} \quad ; \quad \boxed{\mu_a = 100}$$

$$\Rightarrow a_{S3} = (a_{S3}) \cdot \mu_a = 2{,}80 \cdot 100 = 280 \text{ [cm/s}^2\text{]}$$

a_{S1}:

$$\bar{a}_{S1} = \bar{a}_{P1}^{\,=0} + \bar{a}_{S1P1}^{\,n} + \bar{a}_{S1P1}^{\,t}$$

$$\bar{a}_{P1} = 0 \text{ [cm/s}^2\text{]}$$

$$a_{S1P1}^{\,n} = \omega_1^2 \cdot |s_1\bar{P}| = 6^2 \cdot 10 = 360 \text{ [cm/s}^2\text{]}$$

$$a_{S1P1}^{\,t} = \varepsilon_1 \cdot |s_1\bar{P}| = 0 \cdot 10 = 0 \text{ [cm/s}^2\text{]}$$

$$a_{S1} = a_{S1P1}^{\,n} = 360 \text{ [cm/s}^2\text{]}$$

$$\boxed{\mu_a = 100}$$

$$\Rightarrow (a_{S1}) = \frac{a_{S1}}{\mu_a} = \frac{360}{100} = 3{,}60 \text{ [cm]}$$

ε_1: $\varepsilon_1 = 0 \left[\frac{\text{rad}}{\text{s}^2}\right]$

ε_2: $\varepsilon_2 - \varepsilon_3 = 0{,}43 \left[\frac{\text{rad}}{\text{s}^2}\right]$

ε_3: $\varepsilon_3 = \frac{a_{S3C}^{\,t}}{|P_3\bar{C}|} = \frac{30}{70} = 0{,}43 \left[\frac{\text{rad}}{\text{s}^2}\right]$

-8-

4) ANALIZA DYNAMICZNA - siły i momenty bezwładności.

$$\begin{cases} \bar{G} = m \cdot \bar{g} \\ \bar{B} = -m \cdot \bar{a} \\ \bar{M_B} = -\underline{I} \cdot \bar{\varepsilon} \end{cases}$$

1)

$G_1 = m_1 \cdot g = 2 \cdot 9,81 = 19,62 \ [N]$

$B_1 = m_1 \cdot a_1 = 2 \cdot 3,6 = 7,20 \ [N]$

$M_{B1} = I_1 \cdot \varepsilon_1 = \underline{0} \quad ; \quad \underline{\varepsilon_1 = 0}$

2)

—

3)

$G_3 = m_3 \cdot g = 2,5 \cdot 9,81 = 24,53 \ [N]$

$B_3 = m_3 \cdot a_3 = 2,5 \cdot 2,5 = 6,25 \ [N]$

$M_{B3} = I_3 \cdot \varepsilon_3 = 0,002 \cdot 0,43 = 0,00086 \ [Nm]$

$$\begin{cases} \sum Fiy = 0 \\ \sum Miy = 0 \end{cases}$$

$$\begin{cases} G_1 = 19,62 \ [N] \\ B_1 = 7,20 \\ G_3 = 24,53 \\ B_3 = 6,25 \end{cases}$$

$$H_F = \frac{\bar{F}}{(\bar{F})}$$

$H_F = \frac{\bar{G_3}}{(\bar{G_3})} = \frac{24,53}{(\bar{G_3})} \Rightarrow (\bar{G_3}) = \frac{24,53}{H_F} = \begin{cases} H_F = 6 \\ = \end{cases}$

$= \frac{24,53}{6} = 4,08 \Rightarrow (\bar{G_3}) = 4,08 \ [cm]$

$(\bar{G_1}) = \frac{\bar{G_1}}{H_F} = \frac{19,62}{6} = 3,27 \ [cm]$

$(\bar{B_1}) = \frac{\bar{B_1}}{H_F} = \frac{7,20}{6} = 1,20$

$(\bar{G_3}) = \frac{\bar{G_3}}{H_F} = \frac{24,53}{6} = 4,08$

$(\bar{B_3}) = \frac{\bar{B_3}}{H_F} = \frac{6,25}{6} = 1,04$

3:)

$$\sum F_{i3} = 0 \Rightarrow \bar{R}_{23} + \bar{G}_3 + \bar{B}_3 + \bar{R}_{03} = 0$$

$$\underline{\bar{R}}_{23} + \underline{\bar{G}}_3 + \underline{\bar{B}}_3 + \underline{\bar{R}}_{03}^{\bar{\imath}} + \underline{\bar{R}}_{03}^{u} = 0$$

$$\sum M_{i3}^{(C)} = 0 \Rightarrow -R_{23} \cdot h_{e23} + G_3 \cdot h_{G3} + B_3 \cdot h_{B3} + M_{B3} = 0$$

$$\underline{\bar{R}}_{23} = \frac{G_3 \cdot h_{G3} + B_3 \cdot h_{B3} + M_{B3}}{h_{e23}} = \frac{24,53 \cdot 0,25 + 6,25 \cdot 0,14 + 0,00086}{0,40} =$$

$$= \frac{6,13 + 0,875 + 0,00086}{0,40} = \frac{7,00586}{0,40} = \underline{10} \ [N]$$

$H_F = 6$

$$(\underline{\bar{R}}_{23}) = \frac{\bar{R}_{23}}{H_F} = \frac{10}{6} = \underline{1,66} \ [cm]$$

$$\underline{\bar{R}}_{03}^{u} + \underline{\bar{R}}_{23} + \underline{\bar{G}}_3 + \underline{\bar{B}}_3 + \underline{\bar{R}}_{03}^{\bar{v}} = 0$$

Z:)

$$\begin{cases} (\bar{R}_{03}^{u}) = 3,15 \ [cm] \\ (\bar{R}_{03}^{\bar{v}}) = 1,40 \\ (\underline{\bar{R}}_{03}) = 3,50 \end{cases}$$

;

$H_F = 6$

$$\Rightarrow \begin{cases} R_{03}^{u} = (\bar{R}_{03}^{u}) \cdot H_F = 3,15 \cdot 6 = 18,90 \ [N] \\ \bar{R}_{03}^{\bar{\imath}} = (\bar{R}_{03}^{\bar{\imath}}) \cdot H_F = 1,40 \cdot 6 = 8,40 \\ \underline{\bar{R}}_{03} = (\underline{\bar{R}}_{03}) \cdot H_F = 3,50 \cdot 6 = \underline{21} \end{cases}$$

1:)

$$\sum F_{i1} = 0 \Rightarrow \bar{R}_{31} + \bar{G}_1 + \bar{B}_1 + \bar{R}_{01} = 0$$

$$\underline{\bar{R}}_{31} + \underline{\bar{G}}_1 + \underline{\bar{B}}_1 + \underline{\bar{R}}_{01}^{\bar{\imath}} + \underline{\bar{R}}_{01}^{u} = 0$$

$$\bar{R}_{01}^{u} + \bar{R}_{01} + \bar{G}_1 + \bar{B}_1 + \bar{R}_{01}^{\bar{v}} = 0$$

Z:)

$$\begin{cases} (\bar{R}_{01}^{u}) = 1,80 \ [cm] \\ (\bar{R}_{01}^{\bar{v}}) = 2,25 \\ (\underline{\bar{R}}_{01}) = 2,55 \end{cases}$$

;

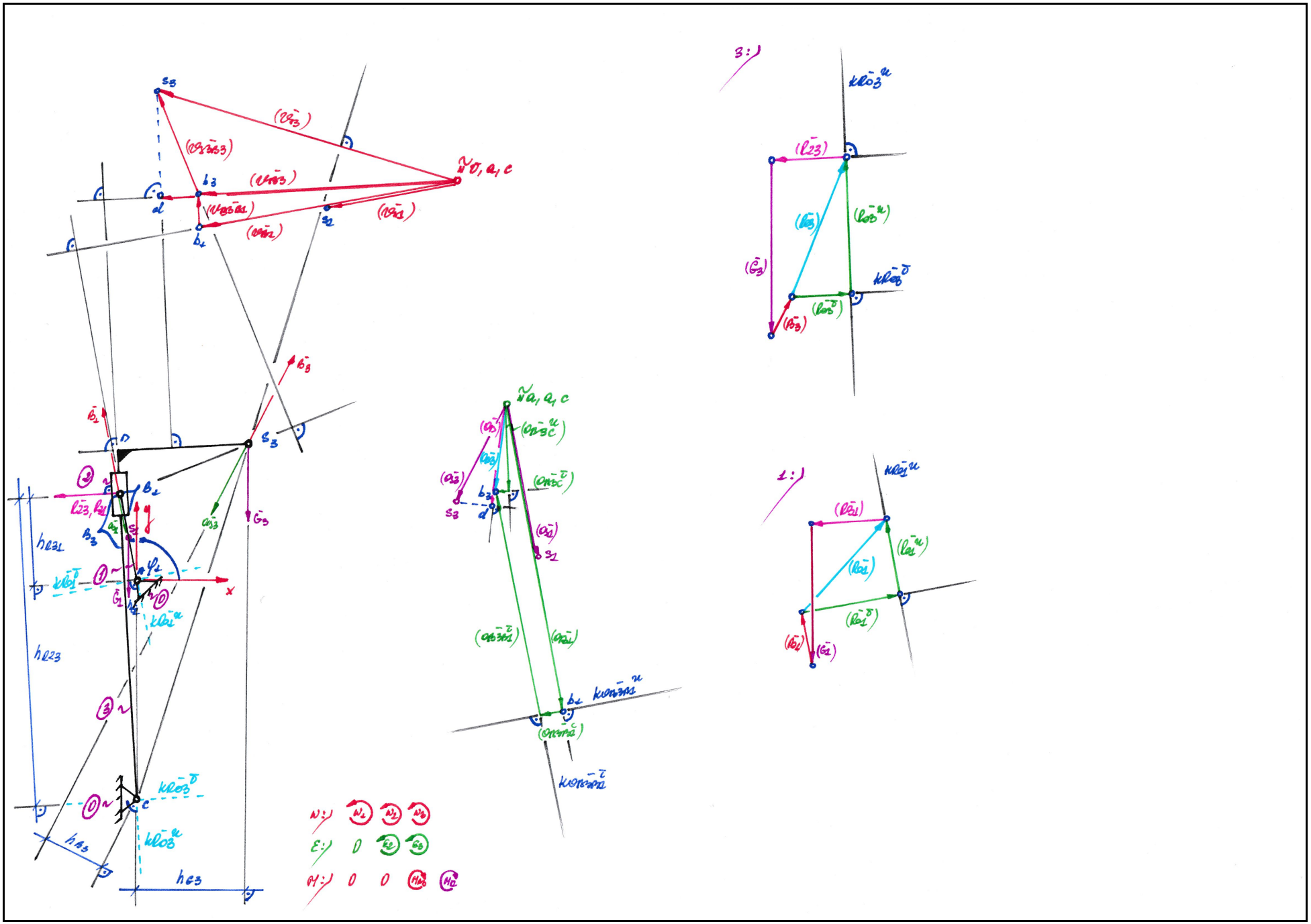
$H_F = 6$

$$\Rightarrow \begin{cases} \bar{R}_{01}^{u} = (\bar{R}_{01}^{u}) \cdot H_F = 1,80 \cdot 6 = 10,80 \ [N] \\ \bar{R}_{01}^{\bar{\imath}} = (\bar{R}_{01}^{\bar{\imath}}) \cdot H_F = 2,25 \cdot 6 = 13,50 \\ \underline{\bar{R}}_{01} = (\underline{\bar{R}}_{01}) \cdot H_F = 2,55 \cdot 6 = 14,40 \end{cases}$$

$$\sum M_{i1}^{(A)} = 0 \Rightarrow M_{r1} - G_1 \cdot h_{G1} - R_{31} \cdot h_{e31} = 0$$

$$\underline{M_{r1}} = G_1 \cdot h_{G1} + R_{31} \cdot h_{e31} = 19,62 \cdot 0,02 +$$

$$+ 10 \cdot 0,2 = 0,39 + 2 = \underline{2,39} \ [Nm]$$



230)

DANE

$|OB| = 0,25\ [m] = 25\ [cm]$

$|AC| = 0,80\ [m] = 80\ [cm]$

$|AO| = 0,40\ [m] = 40\ [cm]$

$\varphi_1 = 90°$

$\omega_1 = 2\ [\frac{rad}{s}]$

$\varepsilon_1 = 4\ [\frac{rad}{s^2}]$

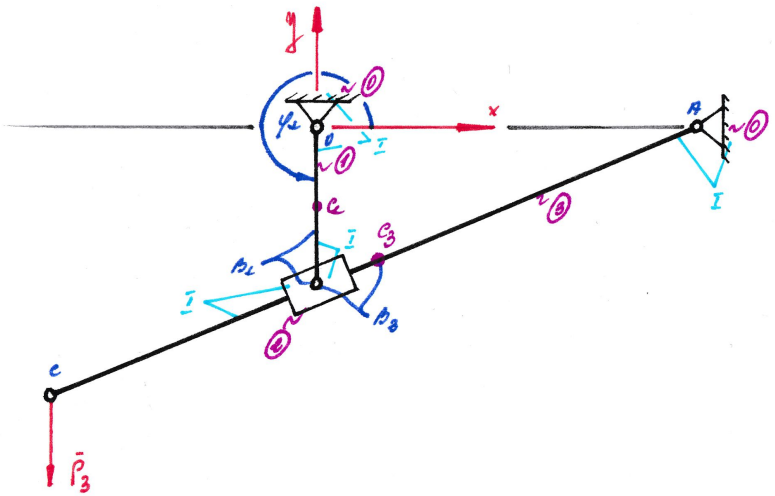
$P_3 = 100\ [N]$

$m_1 = m_3 = 10\ [kg/m]$

$\mu_p = 0,10$; $\mu_T = 0,08$

SZUKAM

1) SCHEMAT STRUKTURALNY UKŁADU.



2) ANALIZA STRUKTURALNA - RUCHLIWOŚĆ MECHANIZMU.

$W_R = W_T - W_L + W_B$

$W_T = 3k - 2p_1 - p_2$

$k = 3$

$p_1 = 4$

$p_2 = 0$

$W_T = 3 \cdot 3 - 2 \cdot 4 = 9 - 8 = \underline{1}$

$W_L = 0$

$W_B = 0$

$W_R = W_T = \underline{1}$

3) PODZIAŁKA (SKALA).

$$\mu_L = \frac{\bar{l}}{(\bar{l})}$$

$$\mu_v = \frac{\bar{v}}{(\bar{v})}$$

$$\mu_a = \frac{\bar{a}}{(\bar{a})}$$

$$\mu_L = \frac{|A\bar{C}|}{(|A\bar{C}|)} = \frac{80}{(|A\bar{C}|)} \rightsquigarrow (|A\bar{C}|) = \frac{80}{\mu_L} = \mu_L = 10 \frac{1}{+} =$$

$$= \frac{80}{10} = 8 \rightsquigarrow (|A\bar{C}|) = 8{,}0 \ [cm]$$

4) ANALIZA GRAFICZNA - RODZAJE I TRAJEKTORIE.

$$(|\bar{OB}|) = \frac{|\bar{OB}|}{\mu_L} = \frac{25}{10} = 2{,}50 \ [cm]$$

$$(|A\bar{C}|) = \frac{|A\bar{C}|}{\mu_L} = \frac{80}{10} = 8{,}0 \ [cm]$$

$$(|A\bar{O}|) = \frac{|A\bar{O}|}{\mu_L} = \frac{40}{10} = 4{,}0 \ [cm]$$

$$(|O\bar{C}_1|) = \frac{|O\bar{C}_1|}{\mu_L} = \frac{12{,}5}{10} = 1{,}25 \ [cm]$$

$$(|A\bar{C}_3|) = \frac{|A\bar{C}_3|}{\mu_L} = \frac{40}{10} = 4{,}0 \ [cm]$$

$\varphi_1 = 90°$; $\omega_1 = 2 \left[\frac{rad}{s}\right]$; $\varepsilon_1 = 4 \left[\frac{rad}{s^2}\right]$

5) Analiza mehanizma - aneloidi:

v_{A1}:

$$\bar{v}_{A1} = \bar{v}_0 + \bar{v}_{A10}$$

$v_0 = 0 \quad [cm/s]$

$v_{A10} = \omega_1 \cdot |\bar{r}_{A0}| = 2 \cdot 25 = 50 \quad [cm/s]$

$v_{A1} = v_{A10} = 50 \quad [cm/s]$

$$H_v = \frac{v_{A1}}{(v_{A1})}$$

$$H_v = \frac{v_{A1}}{(v_{A1})} = \frac{50}{(v_{A1})} \rightsquigarrow (v_{A1}) = \frac{50}{H_v} = \overset{+}{H_v} = \overset{+}{10} =$$

$$= \frac{50}{10} = 5 \rightsquigarrow (v_{A1}) = 5{,}0 \quad [cm]$$

v_{A3}:

$$\bar{v}_{A3} = \bar{v}_{A1} + \bar{v}_{A1A3}$$

$v_{A1} = 50 \quad [cm/s]$

$v_{A1A3} = K \perp 3$

$v_{A3} = K \parallel 3$

v_v:

$$\begin{cases} (v_{A3}) = 2{,}70 \quad [cm] \\ (v_{A1A3}) = 4{,}30 \end{cases} ; \quad \overset{+}{H_v} = \overset{+}{10}$$

$$\rightsquigarrow \begin{cases} v_{A3} = (v_{A3}) \cdot H_v = 2{,}70 \cdot 10 = 27 \quad [cm/s] \\ v_{A1A3} = (v_{A1A3}) \cdot H_v = 4{,}30 \cdot 10 = 43 \end{cases}$$

v_C:

$$\left.\begin{array}{l} \bar{v}_C = \bar{v}_{B_3} + \bar{v}_{C B_3} \\ \bar{v}_C = \bar{v}_A + \bar{v}_{C A} \end{array}\right| \quad (+)$$

$$\bar{v}_C = \bar{v}_{B_3} + \bar{v}_{C B_3} = \bar{v}_A + \bar{v}_{C A}$$

$v_{B_3} = 27 \ [cm/s]$

$v_{B_3} = \omega_3 \cdot |\bar{CB_3}| = ? \quad ; \quad \omega_3 = ?$

$v_A = 0 \ [cm/s]$

$v_{CA} = \omega_3 \cdot |\bar{CA}| = ? \quad ; \quad \omega_3 = ?$

$v_{B_3}, v_{CA} = K_{b3}$

$$\frac{|\bar{CB_3}|}{|\bar{AB_3}|} = \frac{|\bar{AC}|}{|\bar{AC}|}$$

$$\rightsquigarrow |\bar{AC}| = \frac{|\bar{CB_3}| \cdot |\bar{AC}|}{|\bar{AB_3}|} = \frac{2{,}40 \cdot 80}{47} = \frac{216}{47} = 4{,}585 \ [cm]$$

v_C:

$(\bar{v}_C) = 4{,}585 \ [cm] \quad ; \quad H_v = 10$

$\rightsquigarrow \bar{v}_C = (\bar{v}_C) \cdot H_v = 4{,}585 \cdot 10 = 45{,}85 \ [cm/s]$

ω_2:

$\omega_2 = 2 \ [\frac{rad}{s}]$

ω_2:

$\omega_2 = \omega_3 = 0{,}57 \ [\frac{rad}{s}]$

ω_3:

$\omega_3 = \frac{v_C}{|AC|} = \frac{45{,}85}{80} = 0{,}57 \ [\frac{rad}{s}]$

v_{C_1}:

$\bar{v}_{C_1} = \bar{v}_O + \bar{v}_{C_1 O}$

$v_O = 0 \ [cm/s]$

$v_{C_1 O} = \omega_2 \cdot |\bar{CO}| = 2 \cdot 12{,}5 = 25 \ [cm/s]$

$v_{C_1} = v_{C_1 O} = 25 \ [cm/s] \quad ; \quad H_v = 10$

$\rightsquigarrow (\bar{v}_{C_1}) = \frac{v_{C_1}}{H_v} = \frac{25}{10} = 2{,}50 \ [cm]$

v_{C_3}:

$\bar{v}_{C_3} = \bar{v}_A + \bar{v}_{C_3 A}$

$v_A = 0 \ [cm/s]$

$v_{C_3 A} = \omega_3 \cdot |\bar{CA}| = 0{,}54 \cdot 40 = 22{,}80 \ [cm/s]$

$v_{C_3} = v_{C_3 A} = 22{,}80 \ [cm/s] \quad ; \quad H_v = 10$

$\rightsquigarrow (\bar{v}_{C_3}) = \frac{\bar{v}_{C_3}}{H_v} = \frac{22{,}80}{10} = 2{,}28 \ [cm]$

6) ANALIZA KINEMATICZNA - PRZYSPIESZENIA.

a_{B1}:

$$\bar{a}_{B1} = \bar{a}_0^{\,0} + \bar{a}_{B1B0}^{\,u} + \bar{a}_{B1B0}^{\,t}$$

$a_0 = 0 \quad [cm/s^2]$

$a_{B1B0}^{\,u} = \omega_1^2 \cdot |\bar{r}_{B0}| = 2^2 \cdot 25 = 100 \quad [cm/s^2]$

$a_{B1B0}^{\,t} = \varepsilon_1 \cdot |\bar{r}_{B0}| = 4 \cdot 25 = 100 \quad [cm/s^2]$

$$H_a = \frac{a_{B1B0}^{\,u}}{(a_{B1B0}^{\,u})}$$

$$H_a = \frac{a_{B1B0}^{\,u}}{(a_{B1B0}^{\,u})} = \frac{100}{(a_{B1B0}^{\,u})} \rightarrow (a_{B1B0}^{\,u}) = \frac{100}{H_a} = \boxed{H_a = 20}$$

$$= \frac{100}{20} = 5 \rightarrow (a_{B1B0}^{\,u}) = 5{,}0 \quad [cm]$$

$$(a_{B1B0}^{\,t}) = \frac{a_{B1B0}^{\,t}}{H_a} = \frac{100}{20} = 5 \rightarrow (a_{B1B0}^{\,t}) = 5{,}0 \quad [cm]$$

H_a:

$(a_{B1}) = 7{,}10 \quad [cm]$; $\boxed{H_a = 20}$

$\rightarrow a_{B1} = (a_{B1}) \cdot H_a = 7{,}10 \cdot 20 = 142 \quad [cm/s^2]$

a_{B3}:

$$\left| \begin{array}{l} \bar{a}_{B3} = \bar{a}_{B1} + \bar{a}_{B3B1}^{\,u} + \bar{a}_{B3B1}^{\,t} + \bar{a}_{B3B1}^{\,c} \\ \bar{a}_{B3} = \bar{a}_{B4}^{\,0} + \bar{a}_{B3B4}^{\,u} + \bar{a}_{B3B4}^{\,t} \end{array} \right. \quad (+)$$

$$\bar{a}_{B3} = \bar{a}_{B1} + \bar{a}_{B3B1}^{\,u} + \bar{a}_{B3B1}^{\,t} + \bar{a}_{B3B1}^{\,c} = \bar{a}_{B4} + \bar{a}_{B3B4}^{\,u} + \bar{a}_{B3B4}^{\,t}$$

$a_{B1} = 142 \quad [cm/s^2]$

$a_{B3B1}^{\,u} = \frac{v_{B3B1}^2}{R} = \frac{43^2}{\infty} = 0 \quad [cm/s^2]$; $K \in 3$

$a_{B3B1}^{\,t} = K \parallel 3$

$a_{B3B1}^{\,c} = 2 \cdot \omega_3 \cdot v_{B3B1} \cdot \sin[\omega_3 ; v_{B3B1}] =$

$= 2 \cdot 0{,}64 \cdot 43 \cdot \sin 90^\circ = 49{,}02 \quad [cm/s^2]$

$a_{B4} = 0 \quad [cm/s^2]$

$a_{B3B4}^{\,u} = \omega_3 \cdot |\bar{r}_{B3A}| = 0{,}64 \cdot 41 = 26{,}48 \quad [cm/s^2]$

$a_{B3B4}^{\,t} = \varepsilon_3 \cdot |\bar{r}_{B3A}| = ?$; $\varepsilon_3 = ?$; $K \in 3$

$\boxed{H_a = 20}$

$(o\bar{s}_2) = \frac{o\bar{s}_1}{H_a} = \frac{142}{20} = 7,10 \quad \rightsquigarrow \quad (o\bar{s}_2) = 7,10 \ [cm]$

$(o\bar{s}_{2A}^{\ i}) = \frac{o\bar{s}_{2A}^{\ i}}{H_a} = \frac{49,02}{20} = 2,45 \quad \rightsquigarrow \quad (o\bar{s}_{2A}^{\ i}) = 2,45 \ [cm]$

$(o\bar{s}_{3A}^{\ u}) = \frac{o\bar{s}_{3A}^{\ u}}{H_a} = \frac{26,45}{20} = 1,33 \quad \rightsquigarrow \quad (o\bar{s}_{3A}^{\ u}) = 1,33 \ [cm]$

Ha:)

$$\begin{cases} (o\bar{s}_{2A}^{\ \bar{i}}) = 2,80 \ [cm] \\ (o\bar{s}_{3A}^{\ \bar{i}}) = 4,60 \\ (o\bar{s}_3) = 4,40 \end{cases} ; \quad \boxed{H_a = 20}$$

$$\rightsquigarrow \begin{cases} o\bar{s}_{2A}^{\ \bar{i}} = (o\bar{s}_{2A}^{\ \bar{i}}) \cdot H_a = 2,80 \cdot 20 = 56 \ [cm/s^2] \\ o\bar{s}_{3A}^{\ \bar{i}} = (o\bar{s}_{3A}^{\ \bar{i}}) \cdot H_a = 4,60 \cdot 20 = 92 \\ o\bar{s}_3 = (o\bar{s}_3) \cdot H_a = 4,40 \cdot 20 = 94 \end{cases}$$

a_c:)

$$\frac{|o\bar{s}_3|}{|A\bar{s}_3|} = \frac{|a\bar{c}|}{|A\bar{c}|}$$

$$\rightsquigarrow |a\bar{c}| = \frac{|o\bar{s}_3| \cdot |A\bar{c}|}{|A\bar{s}_3|} = \frac{4,40 \cdot 80}{44} = \frac{376}{44} = 8,0 \ [cm]$$

Ha:)

$(a\bar{c}) = 8,0 \ [cm]$; $\boxed{H_a = 20}$

$\rightsquigarrow a\bar{c} = (a\bar{c}) \cdot H_a = 8 \cdot 20 = 160 \ [cm/s^2]$

ε:)

ε_1:) $\varepsilon_1 = 4 \ [\frac{rad}{s^2}]$

ε_2:) $\varepsilon_2 = \varepsilon_3 = 1,95 \ [\frac{rad}{s^2}]$

ε_3:) $\varepsilon_3 = \frac{o\bar{s}_{3A}^{\ \bar{i}}}{|B_3A|} = \frac{92}{47} = 1,95 \ [\frac{rad}{s^2}]$

a_{s_1}:)

$$\frac{|o\bar{b}_1|}{|o\bar{s}_1|} = \frac{|\bar{oc}_1|}{|\bar{oc}_1|}$$

$$\rightsquigarrow |\bar{oc}_1| = \frac{|o\bar{b}_1| \cdot |\bar{oc}_1|}{|o\bar{b}_1|} = \frac{4,10 \cdot 12,5}{25} = \frac{88,45}{25} = 3,55 \ [cm]$$

Ha:)

$(a\bar{c}_1) = 3,55 \ [cm]$; $\boxed{H_a = 20}$

$\rightsquigarrow a\bar{c}_1 = (a\bar{c}_1) \cdot H_a = 3,55 \cdot 20 = 71 \ [cm/s^2]$

a_{c_3}:)

$$\frac{|a\bar{c}|}{|A\bar{c}|} = \frac{|a\bar{c}_3|}{|A\bar{c}_3|}$$

$$\rightsquigarrow |a\bar{c}_3| = \frac{|a\bar{c}| \cdot |A\bar{c}_3|}{|A\bar{c}|} = \frac{8 \cdot 40}{80} = \frac{320}{80} = 4,0 \ [cm]$$

Ha:)

$(a\bar{c}_3) = 4,0 \ [cm]$; $\boxed{H_a = 20}$

$\rightsquigarrow a\bar{c}_3 = (a\bar{c}_3) \cdot H_a = 4 \cdot 20 = 80 \ [cm/s^2]$

4) ANALIZA DINAMICZNA - SIŁY I MOMENTY BEZWŁADNOŚCI:

$$\begin{cases} \bar{G} = m \cdot \bar{g} \\ \bar{P}_B = -m \cdot \bar{a} \\ \bar{M}_B = -\underline{I} \cdot \bar{\varepsilon} \end{cases}$$

1)

$G_1 = m_1 \cdot g = 0{,}25 \cdot 10 \cdot 9{,}81 = 24{,}52 \ [N]$

$P_{B1} = m_1 \cdot a_{C1} = 0{,}25 \cdot 10 \cdot 0{,}41 = 1{,}44 \ [N]$

$\underline{M_{B1}} = G_1 \cdot \underline{I_1} = 0{,}25 \cdot 10 \cdot (0{,}125)^2 \cdot 4 = \underline{0{,}15} \ [Nm]$

2)

---

3)

$G_3 = m_3 \cdot g = 0{,}8 \cdot 10 \cdot 9{,}81 = 78{,}48 \ [N]$

$P_{B3} = m_3 \cdot a_{C3} = 0{,}8 \cdot 10 \cdot 0{,}8 = 6{,}40 \ [N]$

$M_{B3} = I_3 \cdot \varepsilon_3 = 0{,}8 \cdot 10 \cdot (0{,}4)^2 \cdot 1{,}85 = 2{,}48 \ [Nm]$

$\underline{P_B} = \underline{100} \ [N]$

$$\begin{cases} \sum Fix = 0 \\ \sum Miz = 0 \end{cases}$$

$$\begin{cases} G_1 = 24{,}52 \ [N] \\ G_3 = 78{,}48 \\ \underline{P_B} = \underline{100} \end{cases}$$

$$\underline{H_F = \frac{\bar{F}}{(\bar{F})}}$$

$$H_F = \frac{\bar{P}_B}{(\bar{P}_B)} = \frac{100}{(\bar{P}_B)} \Rightarrow (\bar{P}_B) = \frac{100}{H_F} \cdot \begin{vmatrix} H_F = 20 \\ + \end{vmatrix} =$$

$$= \frac{100}{20} = 5 \Rightarrow (\underline{\bar{P}_B}) = \underline{5{,}0} \ [cm]$$

$$(\bar{G}_1) = \frac{\bar{G}_1}{H_F} = \frac{24{,}52}{20} = 1{,}22 \ [cm]$$

$$(\underline{\bar{G}_3}) = \frac{\bar{G}_3}{H_F} = \frac{78{,}48}{20} = \underline{3{,}92} \ [cm]$$

$$\Rightarrow \begin{cases} (\bar{G}_1) = 1{,}22 \ [cm] \\ (\bar{G}_3) = 3{,}92 \\ (\underline{\bar{P}_B}) = \underline{5{,}0} \end{cases}$$

3:)

$$\sum \bar{T}_{i3} = 0 \rightsquigarrow \bar{l}_{23} + \bar{P}_3 + \bar{G}_3 + \bar{l}_{03} = 0$$

$$\bar{l}_{23} + \bar{P}_3 + \bar{G}_3 + \bar{l}_{03}^{\bar{T}} + \bar{l}_{03}^{\bar{N}} = 0$$

$$\sum M_{i3}^{(A)} = 0 \rightsquigarrow -P_3 \cdot h_3 - G_3 \cdot h_{G3} + l_{23} \cdot h_{23} = 0$$

$$l_{23} = \frac{P_3 \cdot h_3 + G_3 \cdot h_{G3}}{h_{23}} = \frac{100 \cdot 0,64 + 48,48 \cdot 0,33}{0,47} =$$

$$= \frac{67 + 25,89}{0,44} = \frac{92,89}{0,44} = 197,63 \ [N]$$

$$H_F = 20$$

$$(l_{23}) = \frac{l_{23}}{H_F} = \frac{197,63}{20} = 9,88 \ [cm]$$

$$\bar{l}_{03}^{\bar{N}} + \bar{l}_{23} + \bar{P}_3 + \bar{G}_3 + \bar{l}_{03}^{\bar{T}} = 0$$

DF:)

$$\begin{cases} (l_{03}^{\bar{N}}) = 4,80 \ [cm] \\ (l_{03}^{\bar{T}}) = 2,40 \\ (l_{03}) = 5,40 \end{cases} ; \quad H_F = 20$$

$$\rightsquigarrow \begin{cases} l_{03}^{\bar{N}} = (l_{03}^{\bar{N}}) \cdot H_F = 4,80 \cdot 20 = 96 \ [N] \\ l_{03}^{\bar{T}} = (l_{03}^{\bar{T}}) \cdot H_F = 2,40 \cdot 20 = 48 \\ l_{03} = (l_{03}) \cdot H_F = 5,40 \cdot 20 = 108 \end{cases}$$

1:)

$$\sum \bar{T}_{i1} = 0 \rightsquigarrow \bar{l}_{01} + \bar{G}_1 + \bar{l}_{21} = 0$$

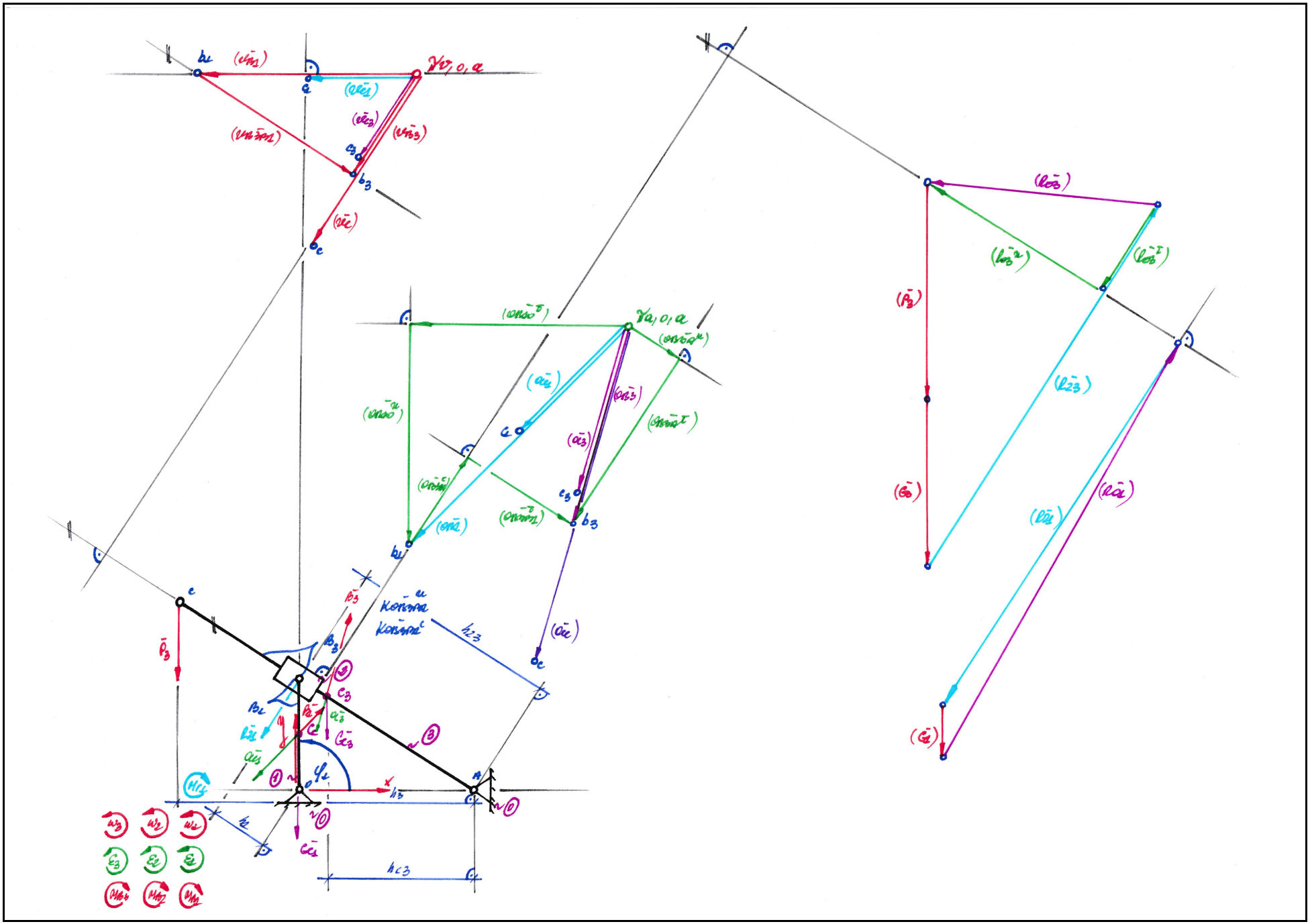
DF:)

$$(l_{01}) = 10,90 \ [cm] \quad ; \quad H_F = 20$$

$$\rightsquigarrow l_{01} = (l_{01}) \cdot H_F = 10,90 \cdot 20 = 218 \ [N]$$

$$\sum M_{i1}^{(O)} = 0 \rightsquigarrow +M_{01} - l_{21} \cdot h_1 = 0$$

$$M_{01} = l_{21} \cdot h_1 = 197,63 \cdot 0,13 = 25,69 \ [Nm]$$



23)

DANE

$|\bar{OB}| = 0{,}25\ [m] = 25\ [cm]$

$|\bar{AC}| = 0{,}80\ [m] = 80\ [cm]$

$|\bar{AD}| = 0{,}40\ [m] = 40\ [cm]$

$\varphi_1 = 120°$

$\omega_1 = 2\ [\frac{rad}{s}]$

$\varepsilon_1 = 4\ [\frac{rad}{s^2}]$

$P_3 = 100\ [N]$

$m_1 = m_3 = 10\ [kg/m]$

$\mu_p = 0{,}10$; $\mu_r = 0{,}08$

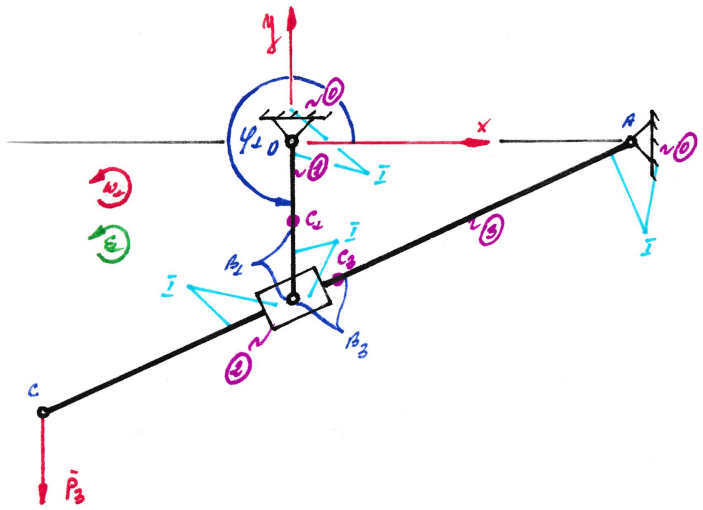
SZUKAM

$\bar{v}, \bar{\omega} = ?$

$\bar{a}, \bar{\varepsilon} = ?$

$\bar{R}, \bar{M}_O = ?$

1) SCHEMAT STRUKTURALNY UKŁADU.



2) ANALIZA STRUKTURALNA - RUCHLIWOŚĆ MECHANIZMU.

$W_R = W_T - W_L + W_B$

$W_T = 3k - 2p_1 - p_2$

$k = 3$

$p_1 = 4$

$p_2 = 0$

$W_T = 3 \cdot 3 - 2 \cdot 4 = 9 - 8 = \underline{1}$

$W_L = 0$

$W_B = 0$

$W_R = W_T = \underline{1}$ ✓

3) PODZADANIA (WYNIKI).

$$\mu_l = \frac{\bar{i}}{(\bar{i})}$$

$$\mu_v = \frac{\bar{v}}{(\bar{v})}$$

$$\mu_a = \frac{\bar{a}}{(\bar{a})}$$

$$\mu_L = \frac{|\bar{IAC}|}{(|\bar{IAC}|)} = \frac{80}{(|\bar{IAC}|)} \Rightarrow (|\bar{IAC}|) = \frac{80}{\mu_L} = \mu_L = 10 \cdot$$

$$= \frac{80}{10} = 8 \Rightarrow (|\underline{\bar{IAC}}|) = \underline{8,0}\ [cm]$$

4) ANALIZA KINEMATYCZNA - POŁOŻENIE I PRZEMIESZCZENIE.

$$(|\bar{IC_3}|) = \frac{|\bar{IC_3}|}{\mu_L} = \frac{35}{10} = 3,50\ [cm]$$

$$(|\bar{IAC}|) = \frac{|\bar{IAC}|}{\mu_L} = \frac{80}{10} = 8,0\ [cm]$$

$$(|\bar{IAO}|) = \frac{|\bar{IAO}|}{\mu_L} = \frac{40}{10} = 4,0\ [cm]$$

$$(|\bar{IO_2}|) = \frac{|\bar{IO_2}|}{\mu_L} = \frac{12,5}{10} = 1,25\ [cm]$$

$$(|\underline{\bar{IAC_3}}|) = \frac{|\bar{IAC_3}|}{\mu_L} = \frac{40}{10} = \underline{4,0}\ [cm]$$

$$\varphi_1 = 120^\circ \quad ; \quad \omega_1 = 2\ [\tfrac{rad}{s}] \quad ; \quad \varepsilon_1 = 4\ [\tfrac{rad}{s^2}]$$

5) ANALIZA KINEMATICZNA - METODĄ WEKTORÓW

$\vec{v}_{B1}$:

$$\vec{v}_{B1} = \vec{v}_0 + \vec{v}_{B1O}$$

$v_0 = 0$ [cm/s]

$v_{B1O} = \omega_1 \cdot |\vec{r}_{B1O}| = 2 \cdot 25 = 50$ [cm/s]

$v_{B1} = v_{B1O} = 50$ [cm/s]

$$H_v = \frac{\vec{v}_{B1}}{(\vec{v}_{B1})}$$

$$H_v = \frac{v_{B1}}{(v_{B1})} = \frac{50}{(v_{B1})} \rightarrow (v_{B1}) = \frac{50}{H_v} = \boxed{H_v = 10} =$$

$$= \frac{50}{10} = 5 \rightarrow (v_{B1}) = 5{,}0 \text{ [cm]}$$

$\vec{v}_{B3}$:

$$\vec{v}_{B3} = \vec{v}_{B1} + \vec{v}_{B3B1}$$

$v_{B1} = 50$ [cm/s]

$v_{B3B1} = K \parallel 3$

$v_{B3} = K \perp 3$

$\vec{H}_v$:

$$\begin{cases} (v_{B3}) = 4{,}0 \text{ [cm]} \\ (v_{B3B1}) = 3{,}0 \end{cases} ; \quad \boxed{H_v = 10}$$

$$\rightarrow \begin{cases} v_{B3} = (v_{B3}) \cdot H_v = 4 \cdot 10 = 40 \text{ [cm/s]} \\ v_{B3B1} = (v_{B3B1}) \cdot H_v = 3 \cdot 10 = 30 \end{cases}$$

v_C:

$$\begin{cases} \bar{v}_C = \bar{v}_{B3} + \bar{v}_{CB3} \\ \bar{v}_C = \bar{v}_A + \bar{v}_{CA} \end{cases} \oplus$$

$$\bar{v}_C = \bar{v}_{B3} + \bar{v}_{CB3} = \bar{v}_A^{\,0} + \bar{v}_{CA}$$

$v_{B3} = 40$ [cm/s]

$v_{CB3} = \omega_3 \cdot |\bar{CB}_3| = ?$; $\omega_3 = ?$

$v_A = 0$ [cm/s]

$v_{CA} = \omega_3 \cdot |\bar{CA}| = ?$; $\omega_3 = ?$

v_{B3}, v_A - K ⊠ 3

$$\frac{|\bar{CB}_3|}{|\bar{AB}_3|} = \frac{|\bar{AC}|}{|\bar{AC}|}$$

$$\rightsquigarrow |\bar{AC}| = \frac{|\bar{CB}_3| \cdot |\bar{AC}|}{|\bar{AB}_3|} = \frac{4 \cdot 80}{57} = \frac{320}{57} = 5{,}61 \text{ [cm]}$$

HV:

$(\bar{v}_C) = 5{,}61$ [cm] ; $H_v = 10$

$\rightsquigarrow \bar{v}_C = (\bar{v}_C) \cdot H_v = 5{,}61 \cdot 10 = 56{,}10$ [cm/s]

ω_1:

$\omega_1 = 2 \left[\frac{rad}{s}\right]$

ω_2:

$\omega_2 = \omega_3 = 0{,}70 \left[\frac{rad}{s}\right]$

ω_3:

$\omega_3 = \frac{v_C}{|AC|} = \frac{56{,}10}{80} = 0{,}70 \left[\frac{rad}{s}\right]$

v_{C1}:

$$\bar{v}_{C1} = \bar{v}_O^{\,0} + \bar{v}_{C1O}$$

$v_O = 0$ [cm/s]

$v_{C1O} = \omega_1 \cdot |\bar{CO}| = 2 \cdot 12{,}5 = 25$ [cm/s]

$v_{C1} = v_{C1O} = 25$ [cm/s] ; $H_v = 10$

$\rightsquigarrow (\bar{v}_{C1}) = \frac{\bar{v}_{C1}}{H_v} = \frac{25}{10} = 2{,}50$ [cm]

v_{C3}:

$$\bar{v}_{C3} = \bar{v}_A^{\,0} + \bar{v}_{C3A}$$

$v_A = 0$ [cm/s]

$v_{C3A} = \omega_3 \cdot |\bar{CA}| = 0{,}40 \cdot 40 = 28$ [cm/s]

$v_{C3} = v_{C3A} = 28$ [cm/s] ; $H_v = 10$

$\rightsquigarrow (\bar{v}_{C3}) = \frac{\bar{v}_{C3}}{H_v} = \frac{28}{10} = 2{,}80$ [cm]

c) ANALIZA KINEMATICKA - ANALITICKA.

$\bar{a}_{A2}$:

$$\bar{a}_{A2} = \bar{a}_O + \bar{a}_{A2O}^{n} + \bar{a}_{A2O}^{\tau}$$

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

$a_{A2O}^{n} = \omega_2^2 \cdot |\bar{B}_2\bar{O}| = 2^2 \cdot 25 = 100 \quad [cm/s^2]$

$a_{A2O}^{\tau} = \varepsilon_2 \cdot |\bar{B}_2\bar{O}| = 4 \cdot 25 = 100 \quad [cm/s^2]$

$$H_a = \frac{a_{A2O}^{n}}{(a_{A2O}^{n})}$$

$H_a = \dfrac{a_{A2O}^{n}}{(a_{A2O}^{n})} = \dfrac{100}{(a_{A2O}^{n})} \rightarrow (a_{A2O}^{n}) = \dfrac{100}{H_a} \cdot \boxed{H_a = 20}$

$= \dfrac{100}{20} = 5 \rightarrow (a_{A2O}^{n}) = 5{,}0 \quad [cm]$

$(a_{A2O}^{\tau}) = \dfrac{a_{A2O}^{\tau}}{H_a} = \dfrac{100}{20} = 5 \rightarrow (a_{A2O}^{\tau}) = 5{,}0 \quad [cm]$

v_a :

$(a_{A2}) = 7{,}10 \quad [cm] \quad ; \quad \boxed{H_a = 20}$

$\rightarrow a_{A2} = (a_{A2}) \cdot H_a = 7{,}10 \cdot 20 = 142 \quad [cm/s^2]$

a_{B3} :

$$\begin{cases} \bar{a}_{B3} = \bar{a}_{A2} + \bar{a}_{B3A2}^{n\,3/0} + \bar{a}_{B3A2}^{\tau} + a_{B3A2}^{c} \\ \bar{a}_{B3} = \bar{a}_{B4}^{3/0} + \bar{a}_{B3B4}^{n} + \bar{a}_{B3B4}^{\tau} \end{cases} \quad (+)$$

$$\bar{a}_{B3} = \bar{a}_{A2} + \bar{a}_{B3A2}^{n} + \bar{a}_{B3A2}^{\tau} + a_{B3A2}^{c} = \bar{a}_{B4} + \bar{a}_{B3B4}^{n} + \bar{a}_{B3B4}^{\tau}$$

$a_{A2} = 142 \quad [cm/s^2]$

$a_{B3A2}^{n} = \dfrac{v_{B3A2}^2}{R} = \dfrac{30^2}{\infty} = 0 \quad [cm/s^2] \quad ; \quad K \in 3$

$a_{B3A2}^{\tau} = K \parallel 3$

$a_{B3A2}^{c} = 2 \cdot \omega_3 \cdot v_{B3A2} \cdot \sin[\omega_3 ; v_{B3A2}] =$

$= 2 \cdot 0{,}40 \cdot 30 \cdot \sin 80° = 42 \quad [cm/s^2]$

$a_{B4} = 0 \quad [cm/s^2]$

$a_{B3B4}^{n} = \omega_3^2 \cdot |\bar{B}_3\bar{A}| = (0{,}40)^2 \cdot 54 = 24{,}83 \quad [cm/s^2]$

$a_{B3B4}^{\tau} = \varepsilon_3 \cdot |\bar{B}_3\bar{A}| = ? \quad ; \quad \varepsilon_3 = ? \quad ; \quad K \in 3$

$\boxed{H_a = 20}$

$(\overline{o_1b_1}) = \frac{\overline{o_1b_1}}{H_a} = \frac{142}{20} = 7,10 \rightarrow (\overline{o_1b_1}) = 7,10\ [cm]$

$(\overline{o_2m_2}^{i}) = \frac{\overline{o_2m_2}^{i}}{H_a} = \frac{42}{20} = 2,10 \rightarrow (\overline{o_2m_2}^{i}) = 2,10\ [cm]$

$(\overline{o_3m_3}^{u}) = \frac{\overline{o_3m_3}^{u}}{H_a} = \frac{27,93}{20} = 1,39 \rightarrow (\overline{o_3m_3}^{u}) = 1,39\ [cm]$

Ha:

$\begin{cases} (\overline{o_1m_2}^{\tau}) = 0,40\ [cm] \\ (\overline{o_2m_3}^{\tau}) = 4,85 \\ (\overline{o_3b_3}) = 5,10 \end{cases}$; $H_a = 20$

$\rightarrow \begin{cases} \overline{o_1m_2}^{\tau} = (\overline{o_1m_2}^{\tau}) \cdot H_a = 0,40 \cdot 20 = 8\ [cm/s^2] \\ \overline{o_2m_3}^{\tau} = (\overline{o_2m_3}^{\tau}) \cdot H_a = 4,85 \cdot 20 = 97 \\ \overline{o_3b_3} = (\overline{o_3b_3}) \cdot H_a = 5,10 \cdot 20 = 102 \end{cases}$

a:

$$\frac{|\overline{ob_3}|}{|\overline{AB_3}|} = \frac{|\overline{ac}|}{|\overline{AC}|}$$

$\rightarrow |\overline{ac}| = \frac{|\overline{ob_3}| \cdot |\overline{AC}|}{|\overline{AB_3}|} = \frac{5,10 \cdot 80}{54} = \frac{408}{64} = 7,154\ [cm]$

Ha:

$(\overline{ac}) = 7,154\ [cm]$; $H_a = 20$

$\rightarrow \overline{a_c} = (\overline{ac}) \cdot H_a = 7,154 \cdot 20 = 143,14\ [cm/s^2]$

ε_1:

$\varepsilon_1 = 4\ [\frac{rad}{s^2}]$

ε_2:

$\varepsilon_2 = \varepsilon_3 = 1,40\ [\frac{rad}{s^2}]$

ε_3:

$\varepsilon_3 = \frac{\overline{o_3m_3}^{\tau}}{|\overline{B_3A}|} = \frac{97}{54} = 1,40\ [\frac{rad}{s^2}]$

a_{t1}:

$$\frac{|\overline{ob_3}|}{|\overline{ob_1}|} = \frac{|\overline{ac}|}{|\overline{oc_4}|}$$

$\rightarrow |\overline{oc_4}| = \frac{|\overline{ob_1}| \cdot |\overline{oc_4}|}{|\overline{ob_3}|} = \frac{7,10 \cdot 12,5}{25} = \frac{88,75}{25} = 3,55\ [cm]$

Ha:

$(\overline{ac_1}) = 3,55\ [cm]$; $H_a = 20$

$\rightarrow \overline{ac_1} = (\overline{ac_1}) \cdot H_a = 3,55 \cdot 20 = 71\ [cm/s^2]$

a_{t3}:

$$\frac{|\overline{ac}|}{|\overline{AC}|} = \frac{|\overline{ac_3}|}{|\overline{AC_3}|}$$

$\rightarrow |\overline{ac_3}| = \frac{|\overline{ac}| \cdot |\overline{AC_3}|}{|\overline{AC}|} = \frac{7,154 \cdot 40}{80} = \frac{286,28}{80} = 3,54\ [cm]$

Ha:

$(\overline{ac_3}) = 3,54\ [cm]$

$\rightarrow \overline{ac_3} = (\overline{ac_3}) \cdot H_a = 3,54 \cdot 20 = 71,40\ [cm/s^2]$

-6-

4) Analiza dinamiczna - wagi i momenty bezwładności.

$$\begin{cases} \bar{G} = m \cdot \bar{g} \\ \bar{B} = -m \cdot \bar{a} \\ \bar{M_B} = -\bar{I} \cdot \bar{\varepsilon} \end{cases}$$

1)

$G_1 = m_1 \cdot g = 0{,}25 \cdot 10 \cdot 3{,}81 = 24{,}52$ [N]

$B_1 = m_1 \cdot a_{c1} = 0{,}25 \cdot 10 \cdot 0{,}41 = 1{,}44$ [N]

$M_{B1} = I_1 \cdot \varepsilon_1 = 0{,}25 \cdot 10 \cdot (0{,}115)^2 \cdot 4 = 0{,}15$ [Nm]

2)

—

3)

$G_3 = m_3 \cdot g = 0{,}8 \cdot 10 \cdot 3{,}81 = 48{,}48$ [N]

$B_3 = m_3 \cdot a_{c3} = 0{,}8 \cdot 10 \cdot 0{,}41 = 3{,}28$ [N]

$M_{B3} = I_3 \cdot \varepsilon_3 = 0{,}8 \cdot 10 \cdot (0{,}4)^2 \cdot 1{,}40 = 2{,}14$ [Nm]

$P_3 = 100$ [N]

$$\begin{cases} \sum F_{ix} = 0 \\ \sum M_{ix} = 0 \end{cases}$$

$$\begin{cases} G_1 = 24{,}52 \quad [N] \\ G_3 = 48{,}48 \\ P_3 = 100 \end{cases}$$

$$H_F = \frac{\bar{F}}{(\bar{F})}$$

$H_F = \frac{\bar{P_3}}{(\bar{P_3})} \cdot \frac{100}{(\bar{P_3})} \Rightarrow (\bar{P_3}) = \frac{100}{H_F} = \left| \frac{H_F \cdot 20}{+} \right| =$

$= \frac{100}{20} = 5 \Rightarrow (\bar{P_3}) = 5{,}0$ [cm]

$(\bar{G_1}) = \frac{\bar{G_1}}{H_F} = \frac{24{,}52}{20} = 1{,}22$ [cm]

$(\bar{G_3}) = \frac{\bar{G_3}}{H_F} = \frac{48{,}48}{20} = 3{,}32$ [cm]

$$\Rightarrow \begin{cases} (\bar{G_1}) = 1{,}22 \quad [cm] \\ (\bar{G_3}) = 3{,}32 \\ (\bar{P_3}) = 5{,}0 \end{cases}$$

3:

$$\sum \bar{F}_{i3} = 0 \rightsquigarrow \bar{l}_{23} + \bar{P}_3 + \bar{G}_3 + \bar{l}_{03} = 0$$

$$\bar{l}_{23} + \bar{P}_3 + \bar{G}_3 + \bar{l}_{03}^{\bar{t}} + \bar{l}_{03}^{u} = 0$$

$$\sum M_{i3}^{(B)} = 0 \rightsquigarrow -P_3 \cdot h_3 - G_3 \cdot h_{c3} + l_{23} \cdot h_{23} = 0$$

$$l_{23} = \frac{P_3 \cdot h_3 + G_3 \cdot h_{c3}}{h_{23}} = \frac{100 \cdot 0{,}44 + 48{,}48 \cdot 0{,}34}{0{,}54} =$$

$$= \frac{44 + 28{,}03}{0{,}54} = \frac{103{,}03}{0{,}54} = 180{,}75 \ [N]$$

$$H_F = 20$$

$$(\bar{l}_{23}) = \frac{\bar{l}_{23}}{H_F} = \frac{180{,}75}{20} = 9{,}03 \ [cm]$$

$$\bar{l}_{03}^{u} + \bar{l}_{23} + \bar{P}_3 + \bar{G}_3 + \bar{l}_{03}^{\bar{t}} = 0$$

DF:

$$\begin{cases} (\bar{l}_{03}^{u}) = 3{,}30 \ [cm] \\ (\bar{l}_{03}^{\bar{t}}) = 0{,}40 \\ (\bar{l}_{03}) = 3{,}40 \end{cases} ; \quad H_F = 20$$

$$\rightsquigarrow \begin{cases} \bar{l}_{03}^{u} = (\bar{l}_{03}^{u}) \cdot H_F = 3{,}30 \cdot 20 = 66 \ [N] \\ \bar{l}_{03}^{\bar{t}} = (\bar{l}_{03}^{\bar{t}}) \cdot H_F = 0{,}40 \cdot 20 = 14 \\ \bar{l}_{03} = (\bar{l}_{03}) \cdot H_F = 3{,}40 \cdot 20 = 68 \end{cases}$$

1:

$$\sum \bar{F}_{i1} = 0 \rightsquigarrow \bar{l}_{21} + \bar{G}_1 + \bar{l}_{01} = 0$$

DF:

$$(\bar{l}_{01}) = 10{,}20 \ [cm] \quad ; \quad H_F = 20$$

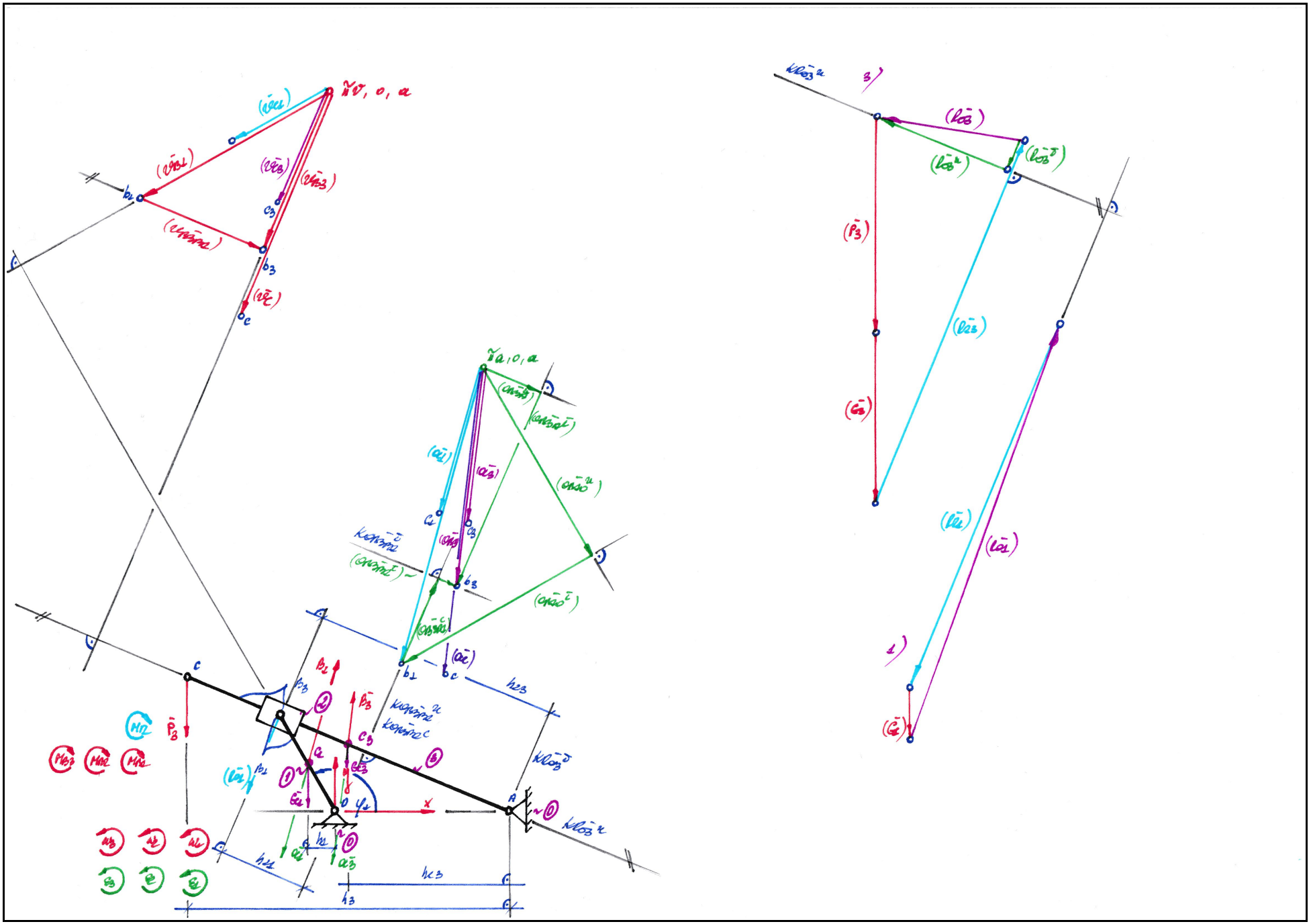
$$\rightsquigarrow \bar{l}_{01} = (\bar{l}_{01}) \cdot H_F = 10{,}20 \cdot 20 = 204 \ [N]$$

$$\sum M_{i1}^{(0)} = 0 \rightsquigarrow +M_{r1} - l_{21} \cdot h_{21} - G_1 \cdot h_1 = 0$$

$$M_{r1} = l_{21} \cdot h_{21} + G_1 \cdot h_1 =$$

$$= 180{,}75 \cdot 0{,}2 + 24{,}52 \cdot 0{,}065 =$$

$$= 36{,}15 + 1{,}59 = 34{,}44 \ [Nm]$$



21)

DANE

$|\bar{OB}| = 0{,}25\ [m] = 25\ [cm]$

$|\bar{AC}| = 0{,}80\ [m] = 80\ [cm]$

$|\bar{AO}| = 0{,}40\ [m] = 40\ [cm]$

$\varphi_1 = 180^\circ$

$\omega_1 = 2\ \left[\frac{rad}{s}\right]$

$\varepsilon_1 = 4\ \left[\frac{rad}{s^2}\right]$

$P_3 = 100\ [N]$

$m_1 = m_3 = 10\ [kg/m]$

$\mu_P = 0{,}10$; $\mu_T = 0{,}08$

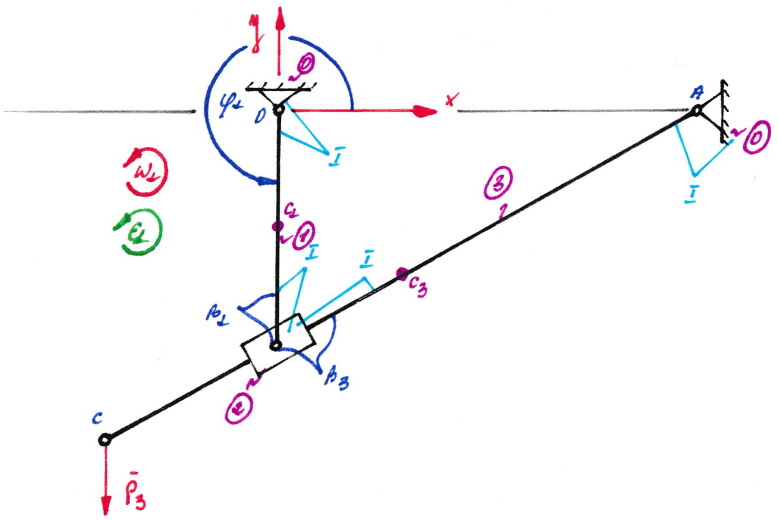
SZUKAM

$\bar{v}, \bar{\omega} = ?$

$\bar{a}, \bar{\varepsilon} = ?$

$\bar{R}, \bar{M}_{T_1} = ?$

1) SCHEMAT KINEMATYCZNY UKŁADU.



2) ANALIZA KINEMATYCZNA - RUCHLIWOŚĆ MECHANIZMU.

$$W_R = W_T - W_L + W_B$$

$$W_T = 3k - 2p_1 - p_2$$

$k = 3$

$p_1 = 4$

$p_2 = 0$

$$\Rightarrow W_T = 3 \cdot 3 - 2 \cdot 4 = 9 - 8 = \underline{1}$$

$W_L = 0$

$W_B = 0$

$$\Rightarrow W_R = W_T = \underline{1} \quad \checkmark$$

3) PODZIAŁKA (SKALA).

$$M_L = \frac{\bar{L}}{(\bar{L})}$$

$$M_v = \frac{\bar{v}}{(\bar{v})}$$

$$M_a = \frac{\bar{a}}{(\bar{a})}$$

$$M_L = \frac{|\bar{IAC}|}{(|\bar{IAC}|)} = \frac{80}{(|\bar{IAC}|)} \Rightarrow (|\bar{IAC}|) = \frac{80}{M_L} = \boxed{M_L = 10} =$$

$$= \frac{80}{10} = 8 \Rightarrow \underline{(|\bar{IAC}|) = 8,0} \ [cm]$$

4) ANALIZA KINEMATYCZNA - POZYCJE I TRAJEKTORIE.

$$(|\bar{OB}_3|) = \frac{|\bar{OB}_3|}{M_L} = \frac{25}{10} = 2,50 \ [cm]$$

$$(|\bar{AC}|) = \frac{|\bar{AC}|}{M_L} = \frac{80}{10} = 8,0 \ [cm]$$

$$(|\bar{AO}|) = \frac{|\bar{AO}|}{M_L} = \frac{40}{10} = 4,0 \ [cm]$$

$$(|\bar{OC}_1|) = \frac{|\bar{OC}_1|}{M_L} = \frac{12,5}{10} = 1,25 \ [cm]$$

$$(|\bar{AC}_3|) = \frac{|\bar{AC}_3|}{M_L} = \frac{40}{10} = \underline{4,0} \ [cm]$$

$$\varphi_L = 180^\circ \ ; \quad \omega_L = 2 \left[\frac{rad}{s}\right] \ ; \quad \varepsilon_L = 4 \left[\frac{rad}{s^2}\right]$$

5) ANALIZA KINEMATYCZNA - PRĘDKOŚCI.

$\bar{v}_{B1}$:

$$\bar{v}_{B1} = \bar{v}_0^{\,0} + \bar{v}_{B10}$$

$v_0 = 0$ [cm/s]

$v_{B10} = \omega_1 \cdot |B_1 O| = 2 \cdot 25 = 50$ [cm/s]

$\underline{v_{B1}} = v_{B10} = \underline{50}$ [cm/s]

$$H_v = \frac{\bar{v}_{B1}}{(\bar{v}_{B1})}$$

$$H_v = \frac{\bar{v}_{B1}}{(\bar{v}_{B1})} = \frac{50}{(\bar{v}_{B1})} \Rightarrow (\bar{v}_{B1}) = \frac{50}{H_v} = \boxed{H_v = 10} =$$

$$= \frac{50}{10} = 5 \Rightarrow (\underline{\bar{v}_{B1}}) = \underline{5{,}0} \text{ [cm]}$$

$\bar{v}_{B3}$:

$$\bar{v}_{B3} = \bar{v}_{B1} + \bar{v}_{B3B1}$$

$v_{B1} = 50$ [cm/s]

$v_{B3B1} - K \perp 3$

$v_{B3} = K \underline{\in} 3$

H_v:

$$\begin{cases} (\bar{v}_{B3}) = 5{,}0 \text{ [cm]} \\ (\underline{\bar{v}_{B3B1}}) = \underline{0} \end{cases} ; \quad \boxed{H_v = 10}$$

$$\Rightarrow \begin{cases} \bar{v}_{B3} = (\bar{v}_{B3}) \cdot H_v = 5 \cdot 10 = 50 \text{ [cm/s]} \\ \underline{\bar{v}_{B3B1}} = (\bar{v}_{B3B1}) \cdot H_v = 0 \cdot 10 = \underline{0} \end{cases}$$

v_C :

$$\begin{cases} \bar{v}_C = \bar{v}_{B3} + \bar{v}_{CB3} \\ \bar{v}_C = \bar{v}_A + \bar{v}_{CA} \end{cases} \quad (+)$$

$$\bar{v}_C = \bar{v}_{B3} + \bar{v}_{CB3} = \bar{v}_A^{\,\nearrow 0} + \bar{v}_{CA}$$

$v_{B3} = 50$ [cm/s]

$v_{CB3} = \omega_3 \cdot |\bar{CB}_3| = ?$; $\omega_3 = ?$

$v_A = 0$ [cm/s]

$v_{CA} = \omega_3 \cdot |\bar{CA}| = ?$; $\omega_3 = ?$

v_{CB3} , v_{CA} = K la 3

$$\frac{|\bar{ab}_3|}{|\bar{AB}_3|} = \frac{|\bar{ac}|}{|\bar{AC}|}$$

$$\rightsquigarrow |\bar{ac}| = \frac{|\bar{ab}_3| \cdot |\bar{AC}|}{|\bar{AB}_3|} = \frac{5 \cdot 80}{65} = \frac{400}{65} = 6{,}153 \text{ [cm]}$$

H_v :

$(\bar{v}_c) = 6{,}153$ [cm] ; $H_v = 10$

$\rightsquigarrow \bar{v}_c = (\bar{v}_c) \cdot H_v = 6{,}153 \cdot 10 = 61{,}53$ [cm/s]

ω_1 : $\omega_1 = 2 \left[\frac{rad}{s}\right]$

ω_2 : $\omega_2 = \omega_3 = 0{,}76 \left[\frac{rad}{s}\right]$

ω_3 : $\omega_3 = \frac{v_c}{|CA|} = \frac{61{,}53}{80} = 0{,}76 \left[\frac{rad}{s}\right]$

v_{c_1} :

$$\bar{v}_{c_1} = \bar{v}_O^{\,\nearrow 0} + \bar{v}_{c_1 O}$$

$v_O = 0$ [cm/s]

$v_{c_1 O} = \omega_1 \cdot |\bar{CO}| = 2 \cdot 12{,}5 = 25$ [cm/s]

$v_{c_1} = v_{c_1 O} = 25$ [cm/s]

$H_v = 10$

$\rightsquigarrow (\bar{v}_{c_1}) = \frac{v_{c_1}}{H_v} = \frac{25}{10} = 2{,}50$ [cm]

v_{c_3} :

$$\bar{v}_{c_3} = \bar{v}_A^{\,\nearrow 0} + \bar{v}_{c_3 A}$$

$v_A = 0$ [cm/s]

$v_{c_3 A} = \omega_3 \cdot |\bar{CA}| = 0{,}76 \cdot 40 = 30{,}4$ [cm/s]

$v_{c_3} = v_{c_3 A} = 30{,}4$ [cm/s] ; $H_v = 10$

$\rightsquigarrow (\bar{v}_{c_3}) = \frac{v_{c_3}}{H_v} = \frac{30{,}4}{10} = 3{,}04$ [cm]

-4-

6) ANALIZA KINEMATYCZNA - PRZYSPIESZENIA.

a_{A1} :)

$$\bar{a}_{A1} = \bar{a}_O^{\,\not=0} + \bar{a}_{A1O}^{\,u} + \bar{a}_{A1O}^{\,\tau}$$

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

$a_{A1O}^{u} = \omega_1^2 \cdot |A_1O| = 2^2 \cdot 25 = 100 \quad [cm/s^2]$

$a_{A1O}^{\tau} = \varepsilon_1 \cdot |A_1O| = 4 \cdot 25 = 100 \quad [cm/s^2]$

$$H_a = \frac{a_{A1O}^{u}}{(a_{A1O}^{u})}$$

$$H_a = \frac{a_{A1O}^{u}}{(a_{A1O}^{u})} = \frac{100}{(a_{A1O}^{u})} \Rightarrow (a_{A1O}^{u}) = \frac{100}{H_a} \quad \boxed{H_a = 20} =$$

$$= \frac{100}{20} = 5 \Rightarrow (a_{A1O}^{u}) = 5{,}0 \quad [cm]$$

$$(a_{A1O}^{\tau}) = \frac{a_{A1O}^{\tau}}{H_a} = \frac{100}{20} = 5 \Rightarrow (a_{A1O}^{\tau}) = 5{,}0 \quad [cm]$$

$\tilde{a}_2$:)

$(a_{A1}) = 7{,}10 \quad [cm] \quad ; \quad \boxed{H_a = 20}$

$\Rightarrow a_{A1} = (a_{A1}) \cdot H_a = 7{,}10 \cdot 20 = 142 \quad [cm/s^2]$

a_{B3} :)

$$\begin{cases} \bar{a}_{B3} = \bar{a}_{A1} + \bar{a}_{B3A1}^{\,u} + \bar{a}_{B3A1}^{\,\tau} + \bar{a}_{B3A1}^{\,c} \\ \bar{a}_{B3} = \bar{a}_M^{\,\not=0} + \bar{a}_{B3A}^{\,u} + \bar{a}_{B3A}^{\,\tau} \end{cases} \quad (+)$$

$$\bar{a}_{B3} = \bar{a}_{A1} + \bar{a}_{B3A1}^{\,u} + \bar{a}_{B3A1}^{\,\tau} + \bar{a}_{B3A1}^{\,c} = \bar{a}_M + \bar{a}_{B3A}^{\,u} + \bar{a}_{B3A}^{\,\tau}$$

$a_{A1} = 142 \quad [cm/s^2]$

$a_{B3A1}^{u} = \frac{v_{B3A1}^2}{R} = \frac{0^2}{R} = 0 \quad [cm/s^2] \quad ; \quad K \in 3$

$a_{B3A1}^{\tau} = K \parallel 3$

$a_{B3A1}^{c} = 2 \cdot \omega_3 \cdot v_{B3A1} \cdot \sin[\omega_3 ; v_{B3A1}] = 0 \quad [cm/s^2]$

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

$a_{B3A}^{u} = \omega_3^2 \cdot |B_3A| = (0{,}76)^2 \cdot 65 = 37{,}54 \quad [cm/s^2]$

$a_{B3A}^{\tau} = \varepsilon_3 \cdot |B_3A| = ? \quad ; \quad \varepsilon_3 = ? \quad ; \quad K \in 3$

$$\boxed{H_a = 20}$$

$(\overline{OP_{z1}}) = \frac{\overline{OP_{z1}}}{H_a} = \frac{142}{20} = 7,10 \rightarrow (\overline{OP_{z1}}) = 7,10 \ [cm]$

$(\overline{OP_{3A}^{u}}) = \frac{\overline{OP_{3A}^{u}}}{H_a} = \frac{36,54}{20} = 1,84 \rightarrow (\overline{OP_{3A}^{u}}) = 1,84 \ [cm]$

v_a:

$$\begin{cases} (\overline{OP_{3z1}^{t}}) = 3,20 \ [cm] \\ (\overline{OP_{3A}^{t}}) = 5,10 \\ (\overline{OP_3}) = 5,40 \end{cases} ; \quad H_a = 20$$

$$\rightarrow \begin{cases} \overline{OP_{3z1}^{t}} = (\overline{OP_{3z1}^{t}}) \cdot H_a = 3,20 \cdot 20 = 64 \ [cm/s^2] \\ \overline{OP_{3A}^{t}} = (\overline{OP_{3A}^{t}}) \cdot H_a = 5,10 \cdot 20 = 102 \\ \overline{OP_3} = (\overline{OP_3}) \cdot H_a = 5,40 \cdot 20 = 108 \end{cases}$$

a_c:

$$\frac{|\overline{ab_3}|}{|\overline{AB_3}|} = \frac{|\overline{ac}|}{|\overline{AC}|}$$

$$\rightarrow |\overline{ac}| = \frac{|\overline{ab_3}| \cdot |\overline{AC}|}{|\overline{AB_3}|} = \frac{5,4 \cdot 80}{65} = 6,650 \ [cm]$$

v_a: $(\overline{ac}) = 6,650 \ [cm]$; $H_a = 20$

$$\rightarrow \overline{ac} = (\overline{ac}) \cdot H_a = 6,650 \cdot 20 = 133 \ [cm/s^2]$$

ε:

ε_1: $\varepsilon_1 = 4 \ [\frac{rad}{s^2}]$

ε_2: $\varepsilon_2 = \varepsilon_3 = 1,66 \ [\frac{rad}{s^2}]$

ε_3: $\varepsilon_3 = \frac{\overline{OP_{3A}^{t}}}{|\overline{B_3A}|} = \frac{102}{65} = 1,56 \ [\frac{rad}{s^2}]$

a_{c1}:

$$\frac{|\overline{ob_1}|}{|\overline{OP_{z1}}|} = \frac{|\overline{oc_1}|}{|\overline{OC}|}$$

$$\rightarrow |\overline{oc_1}| = \frac{|\overline{ob_1}| \cdot |\overline{OC}|}{|\overline{OP_{z1}}|} = \frac{7,10 \cdot 12,5}{25} = \frac{88,75}{25} = 3,55 \ [cm]$$

v_a: $(\overline{ac_1}) = 3,55 \ [cm]$; $H_a = 20$

$$\rightarrow \overline{ac_1} = (\overline{ac_1}) \cdot H_a = 3,55 \cdot 20 = 71 \ [cm/s^2]$$

a_{c3}:

$$\frac{|\overline{ac}|}{|\overline{AC}|} = \frac{|\overline{ac_3}|}{|\overline{AC_3}|}$$

$$\rightarrow |\overline{ac_3}| = \frac{|\overline{ac}| \cdot |\overline{AC_3}|}{|\overline{AC}|} = \frac{6,65 \cdot 40}{80} = \frac{266}{80} = 3,325 \ [cm]$$

v_a: $(\overline{ac_3}) = 3,325 \ [cm]$; $H_a = 20$

$$\rightarrow \overline{ac_3} = (\overline{ac_3}) \cdot H_a = 3,325 \cdot 20 = 66,50 \ [cm/s^2]$$

4) ANALIZA DYNAMICZNA - MOC I MOMENTY BEZWŁADNOŚCI.

$$\begin{cases} \bar{G} = m \cdot \bar{g} \\ \bar{P}_B = -m \cdot \bar{a} \\ \bar{M}_B = -\underline{J} \cdot \bar{\varepsilon} \end{cases}$$

1)

$G_1 = m_1 \cdot g = 0{,}25 \cdot 10 \cdot 9{,}81 = 24{,}52 \ [N]$

$P_{B1} = m_1 \cdot a_{m1} = 0{,}25 \cdot 10 \cdot 0{,}41 = 1{,}44 \ [N]$

$\underline{M_{B1}} = \underline{J_1} \cdot \varepsilon_1 = 0{,}25 \cdot 10 \cdot (0{,}145)^2 \cdot 4 = \underline{0{,}15} \ [Nm]$

2)

—

3)

$G_3 = m_3 \cdot g = 0{,}8 \cdot 10 \cdot 9{,}81 = 78{,}48 \ [N]$

$P_{B3} = m_3 \cdot a_{m3} = 0{,}8 \cdot 10 \cdot 0{,}665 = 5{,}32 \ [N]$

$M_{B3} = \underline{J_3} \cdot \varepsilon_3 = 0{,}8 \cdot 10 \cdot (0{,}4)^2 \cdot 1{,}56 = 1{,}99 \ [Nm]$

$\underline{P_3} = \underline{100} \ [N]$

$$\begin{cases} \sum F_{ix} = 0 \\ \sum M_{iz} = 0 \end{cases}$$

$$\begin{cases} G_1 = 24{,}52 \ [N] \\ G_3 = 78{,}48 \\ \underline{P_3} = \underline{100} \end{cases}$$

$$\underline{H_F = \frac{\bar{F}}{(\bar{F})}}$$

$$H_F = \frac{\bar{P}_3}{(\bar{P}_3)} = \frac{100}{(\bar{P}_3)} \Rightarrow (\bar{P}_3) = \frac{100}{H_F} \quad \boxed{H_F = 20}$$

$$= \frac{100}{20} = 5 \Rightarrow \underline{(\bar{P}_3)} = \underline{5{,}0} \ [cm]$$

$$(\bar{G}_1) = \frac{\bar{G}_1}{H_F} = \frac{24{,}52}{20} = 1{,}22 \ [cm]$$

$$\underline{(\bar{G}_3)} = \frac{\bar{G}_3}{H_F} = \frac{78{,}48}{20} = \underline{3{,}92} \ [cm]$$

$$\Rightarrow \begin{cases} (\bar{G}_1) = 1{,}22 \ [cm] \\ \underline{(\bar{G}_3)} = 3{,}92 \\ \underline{(\bar{P}_3)} = \underline{5{,}0} \end{cases}$$

3)

$$\sum_i \vec{F}_{i3} = 0 \rightsquigarrow \vec{R}_{23} + \vec{P}_3 + \vec{G}_3 + \vec{R}_{03} = 0$$

$$\vec{R}_{23} + \vec{P}_3 + \vec{G}_3 + \vec{R}_{03}^{\,t} + \vec{R}_{03}^{\,n} = 0$$

$$\sum_i M_{i3}^{(A)} = 0 \rightsquigarrow -P_3 \cdot h_3 - G_3 \cdot h_{c3} + R_{23} \cdot h_{23} = 0$$

$$R_{23} = \frac{P_3 \cdot h_3 + G_3 \cdot h_{c3}}{h_{23}} = \frac{100 \cdot 0{,}8 + 78{,}48 \cdot 0{,}4}{0{,}65} =$$

$$= \frac{80 + 31{,}38}{0{,}65} = \frac{111{,}69}{0{,}65} = 171{,}36 \ [N]$$

$$\boxed{H_F = 20}$$

$$(\bar{R}_{23}) = \frac{R_{23}}{H_F} = \frac{171{,}36}{20} = 8{,}56 \ [cm]$$

$$\vec{R}_{03}^{\,n} + \vec{R}_{23} + \vec{P}_3 + \vec{G}_3 + \vec{R}_{03}^{\,t} = 0$$

DF:

$$\begin{cases} (\bar{R}_{03}^{\,n}) = 0 \ [cm] \\ (\bar{R}_{03}^{\,t}) = 0{,}35 \\ (\bar{R}_{03}) = 0{,}35 \end{cases} ; \quad \boxed{H_F = 20}$$

$$\rightsquigarrow \begin{cases} R_{03}^{\,n} = (\bar{R}_{03}^{\,n}) \cdot H_F = 0 \cdot 20 = 0 \ [N] \\ R_{03}^{\,t} = (\bar{R}_{03}^{\,t}) \cdot H_F = 0{,}35 \cdot 20 = 7 \\ R_{03} = (\bar{R}_{03}) \cdot H_F = 0{,}35 \cdot 20 = 7 \end{cases}$$

1:)

$$\sum_i \vec{F}_{i1} = 0 \rightsquigarrow \vec{R}_{21} + \vec{G}_1 + \vec{R}_{01} = 0$$

DF:

$$(\bar{R}_{01}) = 9{,}80 \ [cm] \quad ; \quad \boxed{H_F = 20}$$

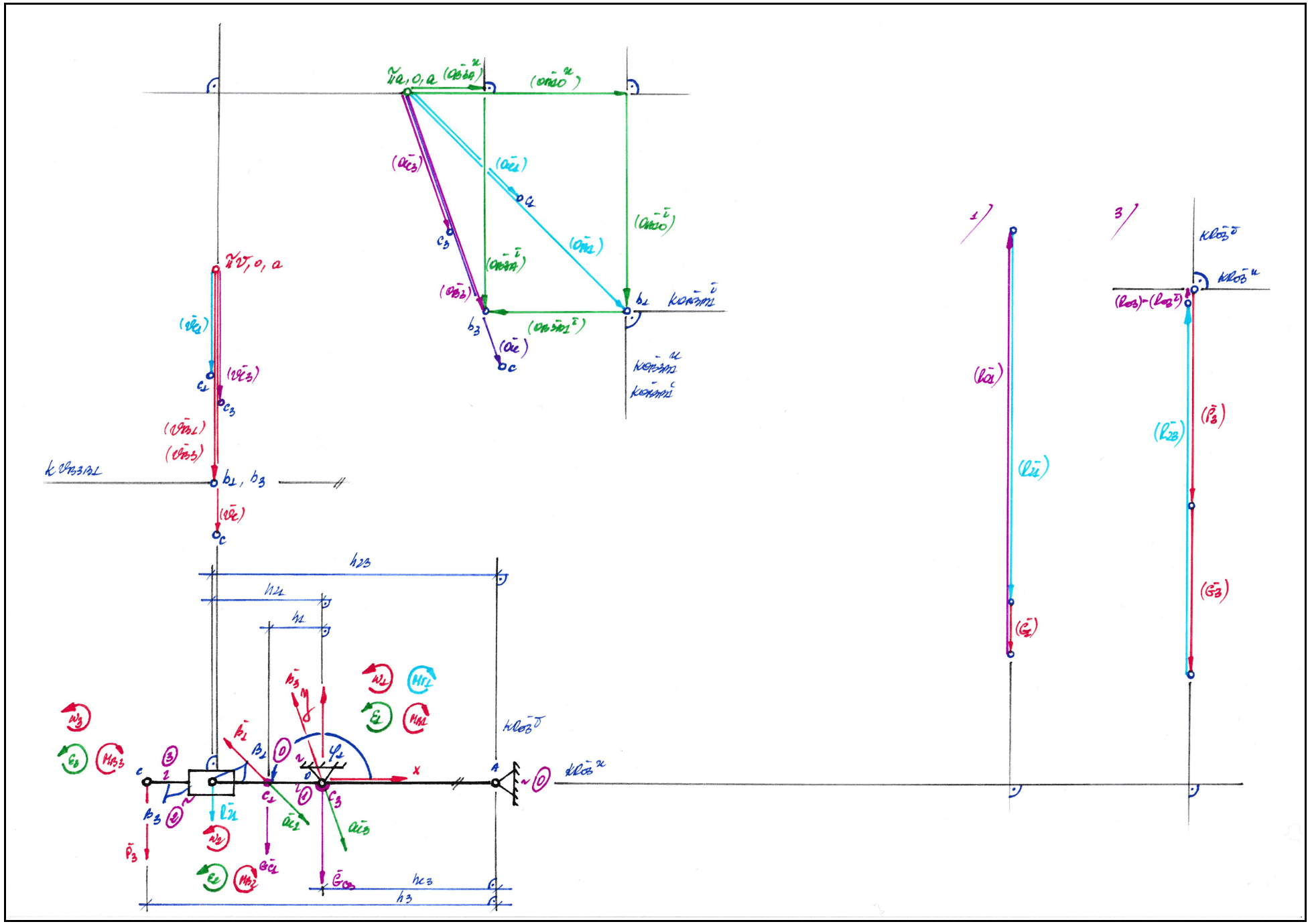
$$\rightsquigarrow R_{01} = (\bar{R}_{01}) \cdot H_F = 9{,}80 \cdot 20 = 196 \ [N]$$

$$\sum_i M_{i1}^{(O)} = 0 \rightsquigarrow +M_{01} - R_{21} \cdot h_{21} - G_1 \cdot h_1 = 0$$

$$M_{01} = R_{21} \cdot h_{21} + G_1 \cdot h_1 =$$

$$= 141{,}36 \cdot 0{,}25 + 24{,}52 \cdot 0{,}125 =$$

$$= 42{,}84 + 3{,}06 = 45{,}90 \ [Nm]$$



24)

DANE

$|\bar{OB}| = 0{,}25\ [m] = 25\ [cm]$

$|\bar{AC}| = 0{,}80\ [m] = 80\ [cm]$

$|\bar{AD}| = 0{,}40\ [m] = 40\ [cm]$

$\varphi_1 = 270°$

$\omega_1 = 2\ [\frac{rad}{s}]$

$\varepsilon_1 = 4\ [\frac{rad}{s^2}]$

$P_3 = 100\ [N]$

$m_1 = m_3 = 10\ [kg/m]$

$\mu_p = 0{,}10$; $\mu_r = 0{,}08$

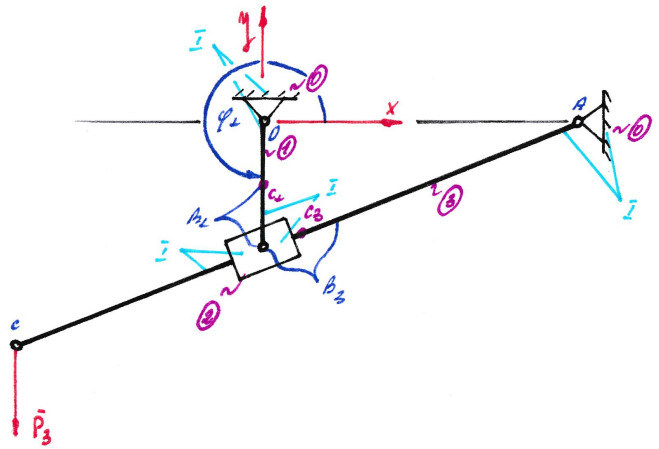
SZUKANE

$\bar{v}, \bar{\omega} = ?$

$\bar{a}, \bar{\varepsilon} = ?$

$\bar{R}, \bar{M}_D = ?$

1) SCHEMAT STRUKTURALNY UKŁADU.



2) ANALIZA STRUKTURALNA - RUCHLIWOŚĆ MECHANIZMU.

$W_k = W_T - W_L + W_B$

$W_T = 3k - 2p_1 - p_2$

$k = 3$

$p_1 = 4$

$p_2 = 0$

$W_T = 3 \cdot 3 - 2 \cdot 4 = 9 - 8 = \underline{1}$

$W_L = 0$

$W_B = 0$

$W_k = W_T = \underline{1}$

3) Podobnost (úvaha).

$$\mu_l = \frac{\bar{l}}{(\bar{l})}$$

$$\mu_v = \frac{\bar{v}}{(\bar{v})}$$

$$\mu_a = \frac{\bar{a}}{(\bar{a})}$$

$$\mu_l = \frac{|A\bar{C}|}{(|A\bar{C}|)} = \frac{80}{(|A\bar{C}|)} \rightsquigarrow (|A\bar{C}|) = \frac{80}{\mu_l} = \mu_l = 10 =$$

$$= \frac{80}{10} = 8 \rightsquigarrow (|A\underline{\bar{C}}|) = \underline{8,0}\ [cm]$$

4) Analýza pohybu - rozbor, trajektorie.

$$(|\bar{OB}|) = \frac{|\bar{OB}|}{\mu_l} = \frac{25}{10} = 2,60\ [cm]$$

$$(|A\bar{C}|) = \frac{|A\bar{C}|}{\mu_l} = \frac{80}{10} = 8,0\ [cm]$$

$$(|A\bar{O}|) = \frac{|A\bar{O}|}{\mu_l} = \frac{40}{10} = 4,0\ [cm]$$

$$(|O\bar{C}_1|) = \frac{|O\bar{C}_1|}{\mu_l} = \frac{12,5}{10} = 1,25\ [cm]$$

$$(|A\underline{\bar{C}_3}|) = \frac{|A\bar{C}_3|}{\mu_l} = \frac{40}{10} = \underline{4,0}\ [cm]$$

$\varphi_l = 270°$; $\omega_l = 2\ [\frac{rad}{s}]$; $\varepsilon_l = 4\ [\frac{rad}{s^2}]$

5) ANALIZA KINEMATYCZNA - PRĘDKOŚCI:

v_{A1}:)

$$\bar{v}_{A1} = \bar{v}_0 + \bar{v}_{A10}$$

$v_0 = 0$ [cm/s]

$v_{A10} = \omega_1 \cdot |A_0| = 2 \cdot 25 = 50$ [cm/s]

$v_{A1} = v_{A10} = 60$ [cm/s]

$$H_v = \frac{\bar{v}_{A1}}{(\bar{v}_{A1})}$$

$$H_v = \frac{v_{A1}}{(v_{A1})} = \frac{60}{(v_{A1})} \Rightarrow (v_{A1}) = \frac{60}{H_v} \quad \vdash H_v = 10 \dashv$$

$$= \frac{60}{10} = 5 \Rightarrow (v_{A1}) = 5{,}0 \text{ [cm]}$$

v_{A3}:)

$$\bar{v}_{A3} = \bar{v}_{A1} + \bar{v}_{A1A3}$$

$v_{A1} = 50$ [cm/s]

$v_{A1A3} = K \parallel 3$

$v_{A3} = K \perp 3$

H_v:)

$$\begin{cases} (v_{A3}) = 2{,}60 \text{ [cm]} \\ (v_{A1A3}) = 4{,}30 \end{cases} ; \quad \vdash H_v = 10 \dashv$$

$$\Rightarrow \begin{cases} v_{A3} = (v_{A3}) \cdot H_v = 2{,}60 \cdot 10 = 26 \text{ [cm/s]} \\ v_{A1A3} = (v_{A1A3}) \cdot H_v = 4{,}30 \cdot 10 = 43 \end{cases}$$

v_C:

$$\begin{cases} \bar{v}_C = \bar{v}_{B_3} + \bar{v}_{CB_3} \\ \bar{v}_C = \bar{v}_A + \bar{v}_{CA} \end{cases} \oplus$$

$$\bar{v}_C = \bar{v}_{B_3} + \bar{v}_{CB_3} = \bar{v}_A + \bar{v}_{CA}$$

$v_{B_3} = 26$ [cm/s]

$v_{CB_3} = \omega_3 \cdot |\bar{CB}_3| = ?$; $\omega_3 = ?$

$v_A = 0$ [cm/s]

$v_{CA} = \omega_3 \cdot |\bar{CA}| = ?$; $\omega_3 = ?$

v_{B_3}, v_{CA} = K la 3

$$\frac{|\bar{ab}_3|}{|\bar{AB}_3|} = \frac{|\bar{ac}|}{|\bar{AC}|}$$

$$\Rightarrow |\bar{ac}| = \frac{|\bar{ab}_3| \cdot |\bar{AC}|}{|\bar{AB}_3|} = \frac{2{,}60 \cdot 80}{44} = \frac{208}{44} = 4{,}425 \text{ [cm]}$$

v_C:

$(\bar{v}_c) = 4{,}425$ [cm] ; $\mu_v = 10$

$\Rightarrow \bar{v}_C = (\bar{v}_c) \cdot \mu_v = 4{,}425 \cdot 10 = 44{,}25$ [cm/s]

ω_1:

$\omega_1 = 2 \left[\frac{\text{rad}}{\text{s}}\right]$

ω_2:

$\omega_2 = \omega_3 = 0{,}55 \left[\frac{\text{rad}}{\text{s}}\right]$

ω_3:

$\omega_3 = \frac{v_C}{|\bar{AC}|} = \frac{44{,}25}{80} = 0{,}55 \left[\frac{\text{rad}}{\text{s}}\right]$

v_{C_1}:

$\bar{v}_{C_1} = \bar{v}_O + \bar{v}_{C_1O}$ (0)

$v_O = 0$ [cm/s]

$v_{C_1O} = \omega_1 \cdot |C_1O| = 2 \cdot 12{,}5 = 25$ [cm/s]

$v_{C_1} = v_{C_1O} = 25$ [cm/s] ; $\mu_v = 10$

$\Rightarrow (\bar{v}_{C_1}) = \frac{\bar{v}_{C_1}}{\mu_v} = \frac{25}{10} = 2{,}50$ [cm]

v_{C_3}:

$\bar{v}_{C_3} = \bar{v}_A + \bar{v}_{C_3A}$ (0)

$v_A = 0$ [cm/s]

$v_{C_3A} = \omega_3 \cdot |C_3A| = 0{,}55 \cdot 40 = 22$ [cm/s]

$v_{C_3} = v_{C_3A} = 22$ [cm/s] ; $\mu_v = 10$

$\Rightarrow (\bar{v}_{C_3}) = \frac{\bar{v}_{C_3}}{\mu_v} = \frac{22}{10} = 2{,}20$ [cm]

6) ANALIZA CINEMATICĂ GRAFO-ANALITICĂ.

$\vec{a}_1$:)

$$\vec{a}_1 = \vec{a}_0^{\,\not 0} + \vec{a}_{10}^{\,u} + \vec{a}_{10}^{\,\tau}$$

$a_0 = 0 \quad [cm/s^2]$

$a_{10}^{u} = \omega_1^2 \cdot |B_1O| = 2^2 \cdot 25 = 100 \quad [cm/s^2]$

$a_{10}^{\tau} = \varepsilon_1 \cdot |B_1O| = 4 \cdot 25 = 100 \quad [cm/s^2]$

$$H_a = \frac{a_{10}^{u}}{(a_{10}^{u})}$$

$$H_a = \frac{a_{10}^{u}}{(a_{10}^{u})} = \frac{100}{(a_{10}^{u})} \Rightarrow (a_{10}^{u}) = \frac{100}{H_a} = \boxed{H_a = 20} =$$

$$= \frac{100}{20} = 5 \Rightarrow (a_{10}^{u}) = 5{,}10 \quad [cm]$$

$$(a_{10}^{\tau}) = \frac{a_{10}^{\tau}}{H_a} = \frac{100}{20} = 5 \Rightarrow (a_{10}^{\tau}) = 5{,}10 \quad [cm]$$

H_a :)

$(a_1) = 7{,}10 \quad [cm]$; $\boxed{H_a = 20}$

$\Rightarrow a_1 = (a_1) \cdot H_a = 7{,}10 \cdot 20 = 142 \quad [cm/s^2]$

$\vec{a}_3$:)

$$\begin{cases} \vec{a}_3 = \vec{a}_1 + \vec{a}_{32}^{\,u} + \vec{a}_{32}^{\,\tau} + \vec{a}_{32}^{\,c} \\ \vec{a}_3 = \vec{a}_0^{\,\not 0} + \vec{a}_{30}^{\,u} + \vec{a}_{30}^{\,\tau} \end{cases}$$

$$\vec{a}_3 = \vec{a}_1 + \vec{a}_{32}^{\,u} + \vec{a}_{32}^{\,\tau} + \vec{a}_{32}^{\,c} = \vec{a}_0 + \vec{a}_{30}^{\,u} + \vec{a}_{30}^{\,\tau}$$

$a_1 = 142 \quad [cm/s^2]$

$a_{32}^{n} = \frac{v_{32}^2}{\ell} = \frac{43^2}{\infty} = 0 \quad [cm/s^2]$; $K \in 3$

$a_{32}^{\tau} = K \parallel 3$

$a_{32}^{c} = 2 \cdot \omega_3 \cdot v_{32} \cdot \sin[\omega_3 ; v_{32}] =$

$= 2 \cdot 0{,}55 \cdot 43 \cdot \sin 80^\circ = 47{,}30 \quad [cm/s^2]$

$a_0 = 0 \quad [cm/s^2]$

$a_{30}^{u} = \omega_3 \cdot |B_3A| = 0{,}55 \cdot 47 = 25{,}85 \quad [cm/s^2]$

$a_{30}^{\tau} = \varepsilon_3 \cdot |B_3A| = ? \quad ; \quad \varepsilon_3 = ? \quad ; \quad K \in 3$

$\boxed{H_a = 20}$

$(\overline{o_1 s_1}) = \frac{\overline{o_1 s_1}}{H_a} = \frac{142}{20} = 7{,}10 \Rightarrow (\overline{o_1 s_1}) = 7{,}10 \ [cm]$

$(\overline{o_1 s_1}^{c}) = \frac{\overline{o_1 s_1}^{c}}{H_a} = \frac{44{,}30}{20} = 2{,}36 \Rightarrow (\overline{o_1 s_1}^{c}) = 2{,}36 \ [cm]$

$(\overline{o_1 s_1}^{u}) = \frac{\overline{o_1 s_1}^{u}}{H_a} = \frac{25{,}85}{20} = 1{,}29 \Rightarrow (\overline{o_1 s_1}^{u}) = 1{,}28 \ [cm]$

Da:

$$\begin{cases} (\overline{o_1 s_1}^{\tilde{c}}) = 5{,}60 \ [cm] \\ (\overline{o_1 s_1}^{\tilde{t}}) = 0{,}75 \\ (\overline{o_1 s_3}) = 1{,}80 \end{cases} ; \quad H_a = 20$$

$$\Rightarrow \begin{cases} \overline{o_1 s_1}^{\tilde{c}} = (\overline{o_1 s_1}^{\tilde{c}}) \cdot H_a = 5{,}60 \cdot 20 = 112 \ [cm/s^2] \\ \overline{o_1 s_1}^{\tilde{t}} = (\overline{o_1 s_1}^{\tilde{t}}) \cdot H_a = 0{,}75 \cdot 20 = 15 \\ \overline{o_1 s_3} = (\overline{o_1 s_3}) \cdot H_a = 1{,}80 \cdot 20 = 30 \end{cases}$$

ε:

$\varepsilon_1 = 4 \ [\frac{rad}{s^2}]$

ε_2:

$\varepsilon_2 = \varepsilon_3 = 0{,}31 \ [\frac{rad}{s^2}]$

ε_3:

$\underline{\varepsilon_3} = \frac{\overline{o_1 s_3}^{t}}{|\overline{B_3 A}|} = \frac{15}{47} = 0{,}31 \ [\frac{rad}{s^2}]$

a_{s1}:

$$\frac{|\overline{o b_2}|}{|\overline{o_1 s_3}|} = \frac{|\overline{o c_1}|}{|\overline{o c_1}|}$$

$$\Rightarrow |\overline{o c_1}| = \frac{|\overline{o b_2}| \cdot |\overline{o c_1}|}{|\overline{o_1 s_2}|} = \frac{7{,}10 \cdot 125}{25} = \frac{88{,}75}{25} = 3{,}55 \ [cm]$$

Da:

$(\overline{o c_1}) = 3{,}55 \ [cm]$; $H_a = 20$

$\Rightarrow \overline{a c_1} = (\overline{a c_1}) \cdot H_a = 3{,}55 \cdot 20 = 71 \ [cm/s^2]$

a_c:

$$\frac{|\overline{a b_3}|}{|\overline{A B_3}|} = \frac{|\overline{a c}|}{|\overline{A C}|}$$

$$\Rightarrow |\overline{a c}| = \frac{|\overline{a b_3}| \cdot |\overline{A C}|}{|\overline{A B_3}|} = \frac{1{,}80 \cdot 80}{44} = \frac{120}{44} = 2{,}55 \ [cm]$$

Da:

$(\overline{a c}) = 2{,}55 \ [cm]$; $H_a = 20$

$\Rightarrow \overline{a c} = (\overline{a c}) \cdot H_a = 2{,}55 \cdot 20 = 51 \ [cm/s^2]$

a_{c3}:

$$\frac{|\overline{a c}|}{|\overline{A C}|} = \frac{|\overline{a c_3}|}{|\overline{A C_3}|}$$

$$\Rightarrow |\overline{a c_3}| = \frac{|\overline{a c}| \cdot |\overline{A C_3}|}{|\overline{A C}|} = \frac{2{,}55 \cdot 40}{80} = \frac{102}{80} = 1{,}27 \ [cm]$$

Da:

$(\overline{a c_3}) = 1{,}27 \ [cm]$; $H_a = 20$

$\Rightarrow \overline{a c_3} = (\overline{a c_3}) \cdot H_a = 1{,}27 \cdot 20 = 25{,}40 \ [cm/s^2]$

4) ANALIZA DINAMICII - INDICI I NOTAREA VECTORILOR.

$$\begin{cases} \bar{G} = m \cdot \bar{g} \\ \bar{R} = -m \cdot \bar{a}_c \\ \bar{M}_R = -\underline{I} \cdot \bar{\varepsilon} \end{cases}$$

1)

$G_1 = m_1 \cdot g = 0{,}25 \cdot 10 \cdot 9{,}81 = 24{,}52 \ [N]$

$R_1 = m_1 \cdot a_{c_1} = 0{,}25 \cdot 10 \cdot 0{,}71 = 1{,}77 \ [N]$

$M_{R_1} = \underline{I}_1 \cdot \varepsilon_1 = 0{,}25 \cdot 10 \cdot (0{,}125)^2 \cdot 4 = 0{,}15 \ [Nm]$

2)

—

3)

$G_3 = m_3 \cdot g = 0{,}8 \cdot 10 \cdot 9{,}81 = 78{,}48 \ [N]$

$R_3 = m_3 \cdot a_{c_3} = 0{,}8 \cdot 10 \cdot 0{,}25 = 2{,}00 \ [N]$

$M_{R_3} = \underline{J}_3 \cdot \varepsilon_3 = 0{,}8 \cdot 10 \cdot (0{,}4)^2 \cdot 0{,}31 = 0{,}38 \ [Nm]$

$\underline{P_3} = \underline{100} \ [N]$

$$\begin{cases} \sum F_{in} = 0 \\ \sum M_{in} = 0 \end{cases}$$

$$\begin{cases} G_1 = 24{,}52 \ [N] \\ G_3 = 78{,}48 \\ \underline{P_3} = \underline{100} \end{cases}$$

$$\mathcal{M}_F = \frac{\bar{F}}{(\bar{F})}$$

$$\mathcal{M}_F = \frac{\bar{P}_3}{(\bar{P}_3)} = \frac{100}{(\bar{P}_3)} \rightsquigarrow (\bar{P}_3) = \frac{100}{\mathcal{M}_F} \cdot \begin{vmatrix} \mathcal{M}_F = 20 \\ + \end{vmatrix} =$$

$$= \frac{100}{20} = 5 \rightsquigarrow (\bar{P}_3) = \underline{5{,}0} \ [cm]$$

$$(\bar{G}_1) = \frac{\bar{G}_1}{\mathcal{M}_F} = \frac{24{,}52}{20} = 1{,}22 \ [cm]$$

$$(\bar{G}_3) = \frac{\bar{G}_3}{\mathcal{M}_F} = \frac{78{,}48}{20} = \underline{3{,}92} \ [cm]$$

$$\rightsquigarrow \begin{cases} (\bar{G}_1) = 1{,}22 \ [cm] \\ (\bar{G}_3) = 3{,}92 \\ \underline{(\bar{P}_3)} = \underline{5{,}0} \end{cases}$$

3:)

$$\sum \bar{T}_{i3} = 0 \rightarrow \bar{R}_{23} + \bar{P}_3 + \bar{G}_3 + \bar{R}_{o3} = 0$$

$$\underline{\bar{R}}_{23} + \underline{\bar{P}}_3 + \underline{\bar{G}}_3 + \underline{\bar{R}}_{o3}^{\bar{U}} + \underline{\bar{R}}_{o3}^{\bar{D}} = 0$$

$$\sum M_{i3}^{(A)} = 0 \rightarrow -P_3 \cdot h_3 - G_3 \cdot h_{c3} + R_{23} \cdot h_{23} = 0$$

$$\underline{R}_{23} = \frac{P_3 \cdot h_3 + G_3 \cdot h_{c3}}{h_{23}} = \frac{100 \cdot 0{,}64 + 48{,}48 \cdot 0{,}33}{0{,}44} =$$

$$= \frac{64 + 25{,}89}{0{,}44} = \frac{92{,}89}{0{,}44} = \underline{194{,}63} \quad [N]$$

$$+H_F = 20+$$

$$(\bar{R}_{23}) = \frac{\bar{R}_{23}}{H_F} = \frac{194{,}63}{20} = \underline{9{,}88} \quad [cm]$$

$$\underline{\bar{R}}_{o3}^{\bar{U}} + \underline{\bar{R}}_{23} + \underline{\bar{P}}_3 + \underline{\bar{G}}_3 + \underline{\bar{R}}_{o3}^{\bar{D}} = 0$$

II F:)

$$\begin{cases} (\bar{R}_{o3}^{\bar{U}}) = 4{,}80 & [cm] \\ (\bar{R}_{o3}^{\bar{D}}) = 2{,}40 \\ (\bar{R}_{o3}) = 5{,}40 \end{cases} ; \quad +H_F = 20+$$

$$\rightarrow \begin{cases} \bar{R}_{o3}^{\bar{U}} = (\bar{R}_{o3}^{\bar{U}}) \cdot H_F = 4{,}80 \cdot 20 = 96 & [N] \\ \bar{R}_{o3}^{\bar{D}} = (\bar{R}_{o3}^{\bar{D}}) \cdot H_F = 2{,}40 \cdot 20 = 48 \\ \bar{R}_{o3} = (\bar{R}_{o3}) \cdot H_F = 5{,}40 \cdot 20 = \underline{108} \end{cases}$$

1:)

$$\sum \bar{T}_{i1} = 0 \rightarrow \bar{R}_{z1} + \bar{G}_1 + \bar{R}_{o1} = 0$$

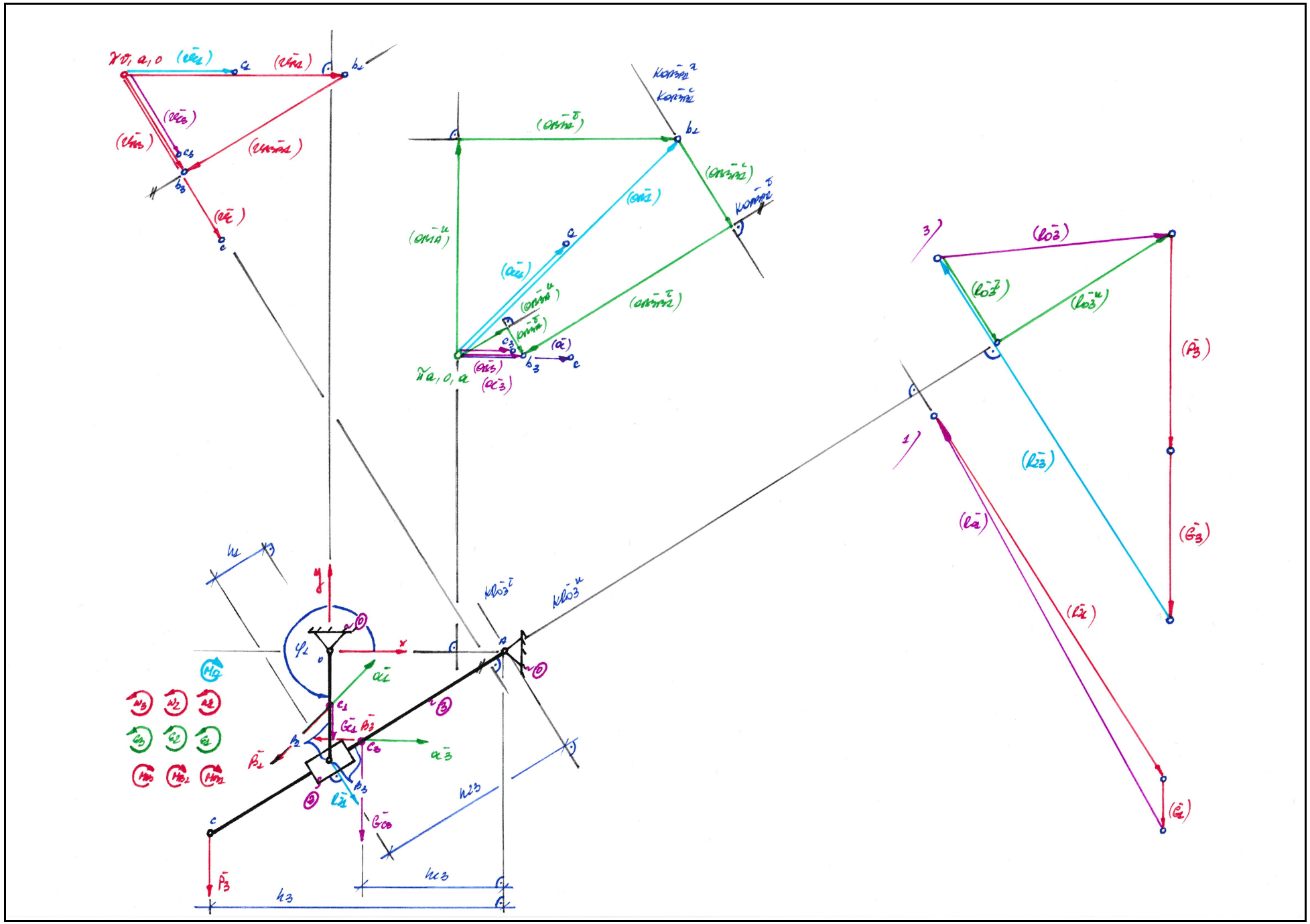
II F:)

$$(\bar{R}_{o1}) = 10{,}90 \quad [cm] \quad ; \quad +H_F = 20+$$

$$\rightarrow \bar{R}_{o1} = (\bar{R}_{o1}) \cdot H_F = 10{,}90 \cdot 20 = \underline{218} \quad [N]$$

$$\sum M_{i1}^{(O)} = 0 \rightarrow +M_{rL} - R_{z1} \cdot h_L = 0$$

$$M_{rL} = R_{z1} \cdot h_1 = 194{,}63 \cdot 0{,}13 = \underline{25{,}68} \quad [Nm]$$



22)

DANE

$|OB| = 0{,}25\ [m] = 25\ [cm]$

$|AC| = 0{,}80\ [m] = 80\ [cm]$

$|AD| = 0{,}40\ [m] = 40\ [cm]$

$\varphi_L = 285°$

$\omega_L = 2\ \left[\frac{rad}{s}\right]$

$\varepsilon_L = 4\ \left[\frac{rad}{s^2}\right]$

$P_3 = 100\ [N]$

$m_1 = m_3 = 10\ [kg/m]$

$\mu_P = 0{,}10$; $\mu_T = 0{,}08$

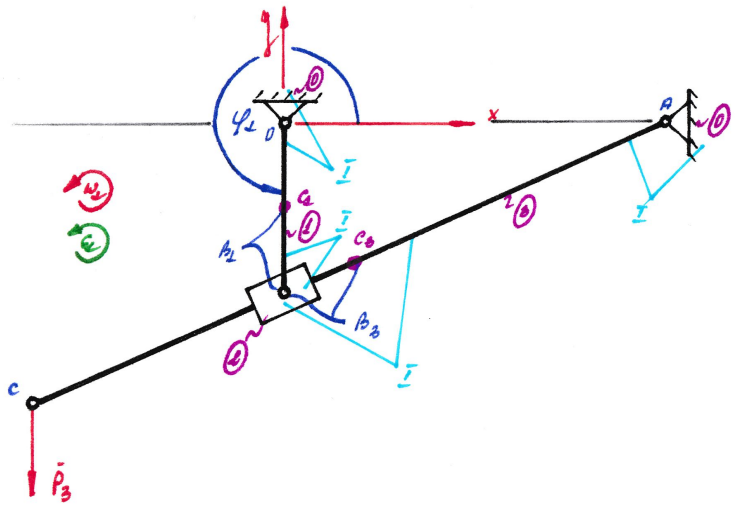
SZUKANY

$\bar{v}, \bar{\omega} = ?$

$\bar{a}, \bar{\varepsilon} = ?$

$\bar{R}, \bar{M}_B = ?$

1) SCHEMAT BUDOWY MECHANIZMU.



2) ANALIZA BUDOWY KINEMATYCZNEJ - RUCHLIWOŚĆ MECHANIZMU.

$$W_R = W_T - W_L + W_B$$

$$W_T = 3k - 2p_1 - p_2$$

$k = 3$

$p_1 = 4$

$p_2 = 0$

$$W_T = 3 \cdot 3 - 2 \cdot 4 = 9 - 8 = 1$$

$W_L = 0$

$W_B = 0$

$$W_R = W_T = 1$$ ✓

3) PODZIAŁKA (SKALA).

$$\mu_L = \frac{\bar{i}}{(\bar{i})}$$

$$\mu_v = \frac{\bar{v}}{(\bar{v})}$$

$$\mu_a = \frac{\bar{a}}{(\bar{a})}$$

$$\mu_L = \frac{|\bar{AC}|}{(|\bar{AC}|)} = \frac{80}{(|\bar{AC}|)} \rightsquigarrow (|\bar{AC}|) = \frac{80}{\mu_L} = \boxed{\mu_L = 10} =$$

$$= \frac{80}{10} = 8 \rightsquigarrow (|\underline{A\bar{C}}|) = \underline{8,0} \ [cm]$$

4) ANALIZA KINEMATYCZNA - RODZAJE I TRAJEKTORIE.

$$(|\bar{OB}|) = \frac{|\bar{OB}|}{\mu_L} = \frac{25}{10} = 2,50 \ [cm]$$

$$(|\bar{AC}|) = \frac{|\bar{AC}|}{\mu_L} = \frac{80}{10} = 8,0 \ [cm]$$

$$(|\bar{AD}|) = \frac{|\bar{AD}|}{\mu_L} = \frac{40}{10} = 4,0 \ [cm]$$

$$(|\bar{OG}|) = \frac{|\bar{OG}|}{\mu_L} = \frac{12,5}{10} = 1,25 \ [cm]$$

$$(|\underline{A\bar{C}_3}|) = \frac{|\bar{AC_3}|}{\mu_L} = \frac{40}{10} = \underline{4,0} \ [cm]$$

$\varphi_L = 265°$; $\omega_L = 2 \left[\frac{rad}{s}\right]$; $\varepsilon_L = 4 \left[\frac{rad}{s^2}\right]$

5) ANALIZA KINEMATICKA - PRIMJENOM.

$\vec{v}_{B1}$:

$$\vec{v}_{B1} = \vec{v}_O^{\,\nearrow 0} + \vec{v}_{B1O}$$

$v_O = 0$ [cm/s]

$v_{B1O} = \omega_1 \cdot |B1O| = 2 \cdot 25 = 50$ [cm/s]

$\underline{v_{B1}} = v_{B1O} = \underline{50}$ [cm/s]

$$H_v = \frac{\vec{v}_{B1}}{(\vec{v}_{B1})}$$

$$H_v = \frac{\vec{v}_{B1}}{(\vec{v}_{B1})} = \frac{60}{(\vec{v}_{B1})} \Rightarrow (\vec{v}_{B1}) = \frac{60}{H_v} \Rightarrow \boxed{H_v = 10} =$$

$$= \frac{60}{10} = 5 \Rightarrow (\underline{\vec{v}_{B1}}) = \underline{5,0} \text{ [cm/s]}$$

$\vec{v}_{B3}$:

$$\vec{v}_{B3} = \vec{v}_{B1} + \vec{v}_{B3B1}$$

$v_{B1} = 50$ [cm/s]

$v_{B3B1} = K \parallel 3$

$\underline{v_{B3}} = K \perp 3$

H_v:

$$\begin{cases} (\vec{v}_{B3}) = 1,80 \text{ [cm]} \\ (\underline{\vec{v}_{B3B1}}) = 4,\underline{70} \end{cases} ; \quad \boxed{H_v = 10}$$

$$\Rightarrow \begin{cases} \vec{v}_{B3} = (\vec{v}_{B3}) \cdot H_v = 1,80 \cdot 10 = 18,0 \text{ [cm/s]} \\ \underline{\vec{v}_{B3B1}} = (\vec{v}_{B3B1}) \cdot H_v = 4,70 \cdot 10 = \underline{47,0} \end{cases}$$

v_C:

$$\left.\begin{array}{l} \bar{v}_C = \bar{v}_{B3} + \bar{v}_{CB3} \\ \bar{v}_C = \bar{v}_A + \bar{v}_{CA} \end{array}\right| \oplus$$

$$\bar{v}_C = \bar{v}_{B3} + \bar{v}_{CB3} = \bar{v}_A^{\,0} + \bar{v}_{CA}$$

$v_{B3} = 18$ [cm/s]

$v_{CB3} = \omega_3 \cdot |\bar{CB}_3| = ?$; $\omega_3 = ?$

$v_A = 0$ [cm/s]

$v_{CA} = \omega_3 \cdot |\bar{CA}| = ?$; $\omega_3 = ?$

v_{CB3} , v_{CA} = K k 3

$$\frac{|a\bar{b}_3|}{|A\bar{B}_3|} = \frac{|a\bar{c}|}{|A\bar{C}|}$$

$$\rightsquigarrow |a\bar{c}| = \frac{|a\bar{b}_3| \cdot |A\bar{C}|}{|A\bar{B}_3|} = \frac{4{,}80 \cdot 80}{41} = \frac{144}{41} = 3{,}512 \text{ [cm]}$$

v_v:

$(\bar{v}_C) = 3{,}512$ [cm] ; $\vdash H_v = 10 \dashv$

$\rightsquigarrow \bar{v}_C = (\bar{v}_C) \cdot H_v = 3{,}512 \cdot 10 = 35{,}12$ [cm/s]

ω_1:

$\omega_1 = 2 \left[\frac{\text{rad}}{\text{s}}\right]$

ω_2:

$\omega_2 = \omega_3 = 0{,}44 \left[\frac{\text{rad}}{\text{s}}\right]$

ω_3:

$\omega_3 = \frac{v_C}{|AC|} = \frac{35{,}12}{80} = 0{,}44 \left[\frac{\text{rad}}{\text{s}}\right]$

v_{c1}:

$$\bar{v}_{c1} = \bar{v}_0^{\,0} + \bar{v}_{c10}$$

$v_0 = 0$ [cm/s]

$v_{c10} = \omega_1 \cdot |\bar{c0}| = 2 \cdot 12{,}5 = 25$ [cm/s]

$v_{c1} = v_{c10} = 25$ [cm/s]

$\vdash H_v = 10 \dashv$

$\rightsquigarrow (\bar{v}_{c1}) = \frac{\bar{v}_{c1}}{H_v} = \frac{25}{10} = 2{,}50$ [cm]

v_{c3}:

$$\bar{v}_{c3} = \bar{v}_A^{\,0} + \bar{v}_{cA}$$

$v_A = 0$ [cm/s]

$v_{cA} = \omega_3 \cdot |c_3A| = 0{,}44 \cdot 17{,}60$ [cm/s]

$v_{c3} = v_{cA} = 17{,}60$ [cm/s] ; $\vdash H_v = 10 \dashv$

$\rightsquigarrow (\bar{v}_{c3}) = \frac{\bar{v}_{c3}}{H_v} = \frac{17{,}60}{10} = 1{,}76$ [cm]

6) ANALIZA KINEMATICZNA - PRZYKŁADY.

a_{B1} :)

$$\bar{a}_{B1} = \bar{a}_O^{\,0} + \bar{a}_{B1O}^{\,n} + \bar{a}_{B1O}^{\,t}$$

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

$a_{B1O}^{\,n} = \omega_1^2 \cdot |\bar{R}_{B1O}| = 2^2 \cdot 25 = 100 \quad [cm/s^2]$

$a_{B1O}^{\,t} = \varepsilon_1 \cdot |\bar{R}_{B1O}| = 4 \cdot 25 = 100 \quad [cm/s^2]$

$$H_a = \frac{a_{B1O}^{\,n}}{(a_{B1O}^{\,n})}$$

$H_a = \dfrac{a_{B1O}^{\,n}}{(a_{B1O}^{\,n})} = \dfrac{100}{(a_{B1O}^{\,n})} \rightsquigarrow (a_{B1O}^{\,n}) = \dfrac{100}{H_a} = \boxed{H_a = 20}$

$= \dfrac{100}{20} = 5 \rightsquigarrow (a_{B1O}^{\,n}) = 5{,}0 \quad [cm]$

$(a_{B1O}^{\,t}) = \dfrac{a_{B1O}^{\,t}}{H_a} = \dfrac{100}{20} = 5 \rightsquigarrow (a_{B1O}^{\,t}) = 5{,}0 \quad [cm]$

H_a :)

$(a_{B1}) = 7{,}10 \quad [cm] \quad ; \quad \boxed{H_a = 20}$

$\rightsquigarrow a_{B1} = (a_{B1}) \cdot H_a = 7{,}10 \cdot 20 = 142 \quad [cm/s^2]$

a_{B3} :)

$$\begin{cases} \bar{a}_{B3} = \bar{a}_{B1} + \bar{a}_{B3B1}^{\,n} + \bar{a}_{B3B1}^{\,t} + \bar{a}_{B3B1}^{\,c} \\ \bar{a}_{B3} = \bar{a}_M + \bar{a}_{B3M}^{\,n} + \bar{a}_{B3M}^{\,t} \end{cases} \quad \oplus$$

$$\bar{a}_{B3} = \bar{a}_{B1} + \bar{a}_{B3B1}^{\,n} + \bar{a}_{B3B1}^{\,t} + \bar{a}_{B3B1}^{\,c} = \bar{a}_M + \bar{a}_{B3M}^{\,n} + \bar{a}_{B3M}^{\,t}$$

$a_{B1} = 142 \quad [cm/s^2]$

$a_{B3B1}^{\,n} = \dfrac{v_{B3B1}^2}{R} = \dfrac{44^2}{\infty} = 0 \quad [cm/s^2] \quad ; \quad K \in 3$

$a_{B3B1}^{\,t} = K \parallel 3$

$a_{B3B1}^{\,c} = 2 \cdot \omega_3 \cdot v_{B3B1} \cdot \sin[\omega_3 ; v_{B3B1}] =$

$= 2 \cdot 0{,}44 \cdot 44 \cdot \sin 80^\circ = 41{,}36 \quad [cm/s^2]$

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

$a_{B3M}^{\,n} = \omega_3^2 \cdot |\bar{R}_{B3A}| = (0{,}44)^2 \cdot 41 = 7{,}93 \quad [cm/s^2]$

$a_{B3M}^{\,t} = \varepsilon_3 \cdot |\bar{R}_{B3A}| = \,?\, \quad ; \quad \varepsilon_3 = \,?\, \quad ; \quad K \in 3$

$\boxed{H_a = 20}$

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$(\overline{o_1 L}) = \frac{\overline{o_1}}{H_a} = \frac{142}{20} = 7,10 \rightsquigarrow (\overline{o_1}) = 7,10$ [cm]

$(\overline{o_1 m_1^c}) = \frac{\overline{o_1 m_1^c}}{H_a} = \frac{41,36}{20} = 2,06 \rightsquigarrow (\overline{o_1 m_1^c}) = 2,06$ [cm]

$(\overline{o_1 m_1^u}) = \frac{\overline{o_1 m_1^u}}{H_a} = \frac{7,93}{20} = 0,39 \rightsquigarrow (\overline{o_1 m_1^u}) = 0,39$ [cm]

Ña:

$\begin{cases} (\overline{o_1 m_1^t}) = 6,10 \text{ [cm]} \\ (\overline{o_1 m^t}) = 0,70 \\ (\overline{o_1 3}) = 0,80 \end{cases}$; $H_a = 20$

$\rightsquigarrow \begin{cases} \overline{o_1 m_1^t} = (\overline{o_1 m_1^t}) \cdot H_a = 6,10 \cdot 20 = 122 \text{ [cm/s}^2\text{]} \\ \overline{o_1 m^t} = (\overline{o_1 m^t}) \cdot H_a = 0,70 \cdot 20 = 14 \\ \overline{o_1 3} = (\overline{o_1 3}) \cdot H_a = 0,80 \cdot 20 = 16 \end{cases}$

ε:

$\varepsilon_1 = 4 \left[\frac{rad}{s^2}\right]$

ε_2:

$\varepsilon_2 = \varepsilon_3 = 0,34 \left[\frac{rad}{s^2}\right]$

ε_3:

$\varepsilon_3 = \frac{\overline{o_1 m^t}}{|B_3 A|} = \frac{14}{41} = 0,34 \left[\frac{rad}{s^2}\right]$

a_{e1}:

$\frac{|ob_1|}{|o\overline{P_{21}}|} = \frac{|o\overline{c_1}|}{|o\overline{c_1}|}$

$\rightsquigarrow |o\overline{c_1}| = \frac{|\overline{ob_1}| \cdot |o\overline{c_1}|}{|\overline{o_1 2}|} = \frac{7,10 \cdot 12,5}{25} = \frac{88,75}{25} = 3,55$ [cm]

Va:

$(\overline{a_{e1}}) = 3,55$ [cm] ; $H_a = 20$

$\rightsquigarrow \overline{a_{e1}} = (\overline{a_{e1}}) \cdot H_a = 3,55 \cdot 20 = 71$ [cm/s^2]

a_e:

$\frac{|ab_3|}{|A\overline{B_3}|} = \frac{|\overline{ac}|}{|\overline{AC}|}$

$\rightsquigarrow |\overline{ac}| = \frac{|\overline{ab_3}| \cdot |\overline{AC}|}{|\overline{AB_3}|} = \frac{0,80 \cdot 80}{41} = \frac{64}{41} = 1,56$ [cm]

Va:

$(\overline{a_e}) = 1,56$ [cm] ; $H_a = 20$

$\rightsquigarrow \overline{a_e} = (\overline{a_e}) \cdot H_a = 1,56 \cdot 20 = 31,20$ [cm/s^2]

a_{e3}:

$\frac{|\overline{ac}|}{|\overline{AC}|} = \frac{|\overline{a_2 c_3}|}{|\overline{AC_3}|}$

$\rightsquigarrow |\overline{a_{e3}}| = \frac{|\overline{ac}| \cdot |\overline{AC_3}|}{|\overline{AC}|} = \frac{1,56 \cdot 40}{80} = \frac{62,4}{80} = 0,48$ [cm]

Ña:

$(\overline{a_{e3}}) = 0,48$ [cm]

$\rightsquigarrow \overline{a_{e3}} = (\overline{a_{e3}}) \cdot H_a = 0,48 \cdot 20 = 15,60$ [cm/s^2]

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4) Анализ движения - ПЦМ с неизвестной массой:

$$\begin{cases} G = m \cdot g \\ P_3 = -m \cdot a_m \\ M_{P3} = -\Sigma \cdot \varepsilon \end{cases}$$

1)

$G_1 = m_1 \cdot g = 0,25 \cdot 10 \cdot 9,81 = 24,52$ [N]

$P_1 = m_1 \cdot a_m = 0,25 \cdot 10 \cdot 0,41 = 1,44$ [N]

$M_{P1} = \Sigma_1 \cdot \varepsilon_1 = 0,25 \cdot 10 \cdot (0,115)^2 : 4 = 0,15$ [Nm]

2)

—

3)

$G_3 = m_3 \cdot g = 0,8 \cdot 10 \cdot 9,81 = 78,48$ [N]

$P_3 = m_3 \cdot a_3 = 0,8 \cdot 10 \cdot 0,156 = 1,44$ [N]

$M_{P3} = \Sigma_3 \cdot \varepsilon_3 = 0,8 \cdot 10 \cdot (0,4)^2 \cdot 0,34 = 0,43$ [Nm]

$P_3 = 100$ [N]

$$\begin{cases} \frac{1}{3} Fiz = 0 \\ \frac{1}{3} Miz = 0 \end{cases}$$

$$\begin{cases} G_1 = 24,52 \text{ [N]} \\ G_3 = 78,48 \\ P_3 = 100 \end{cases}$$

$$H_F = \frac{\bar{F}}{(\bar{F})}$$

$H_F = \frac{\bar{P}_3}{(\bar{P}_3)} = \frac{100}{(\bar{P}_3)} \Rightarrow (\bar{P}_3) = \frac{100}{H_F} = \left| H_F = 20 \right| =$

$= \frac{100}{20} = 5 \Rightarrow (\bar{P}_3) = 5,0$ [cm]

$(\bar{G}_1) = \frac{\bar{G}_1}{H_F} = \frac{24,52}{20} = 1,22$ [cm]

$(\bar{G}_3) = \frac{\bar{G}_3}{H_F} = \frac{78,48}{20} = 3,92$ [cm]

$$\Rightarrow \begin{cases} (\bar{G}_1) = 1,22 \text{ [cm]} \\ (\bar{G}_3) = 3,92 \\ (\bar{P}_3) = 5,0 \end{cases}$$

3)

$$\sum \bar{F}_{i3} = 0 \rightsquigarrow \bar{R}_{23} + \bar{P}_3 + \bar{G}_3 + \bar{R}_{03} = 0$$

$$\bar{R}_{23} + \bar{P}_3 + \bar{G}_3 + \bar{R}_{03}^{\tau} + \bar{R}_{03}^{u} = 0$$

$$\sum M_{i3}^{(A)} = 0 \rightsquigarrow -P_3 \cdot h_3 - G_3 \cdot h_{c3} + R_{23} \cdot h_{23} = 0$$

$$R_{23} = \frac{P_3 \cdot h_3 + G_3 \cdot h_{c3}}{h_{23}} = \frac{100 \cdot 0{,}65 + 48{,}48 \cdot 0{,}33}{0{,}41} =$$

$$= \frac{65 + 15{,}85}{0{,}41} = \frac{92{,}85}{0{,}41} = 226{,}66 \ [N]$$

$$\top \mu_F = 20 \dashv$$

$$(\bar{R}_{23}) = \frac{\bar{R}_{23}}{\mu_F} = \frac{226{,}66}{20} = 11{,}32 \ [cm]$$

$$\bar{R}_{03}^{u} + \bar{R}_{23} + \bar{P}_3 + \bar{G}_3 + \bar{R}_{03}^{\tau} = 0$$

Z:

$$\begin{cases} (\bar{R}_{03}^{u}) = 5{,}30 \ [cm] \\ (\bar{R}_{03}^{\tau}) = 4{,}10 \\ (\bar{R}_{03}) = 6{,}70 \end{cases} ; \quad \top \mu_F = 20 \dashv$$

$$\rightsquigarrow \begin{cases} \bar{R}_{03}^{u} = (\bar{R}_{03}^{u}) \cdot \mu_F = 5{,}30 \cdot 20 = 106 \ [N] \\ \bar{R}_{03}^{\tau} = (\bar{R}_{03}^{\tau}) \cdot \mu_F = 4{,}10 \cdot 20 = 82 \\ \bar{R}_{03} = (\bar{R}_{03}) \cdot \mu_F = 6{,}70 \cdot 20 = 134 \end{cases}$$

1:)

$$\sum \bar{F}_{i1} = 0 \rightsquigarrow \bar{R}_{21} + \bar{G}_1 + \bar{R}_{01} = 0$$

Z:

$$(\bar{R}_{01}) = 12{,}30 \ [cm] \quad ; \quad \top \mu_F = 20 \dashv$$

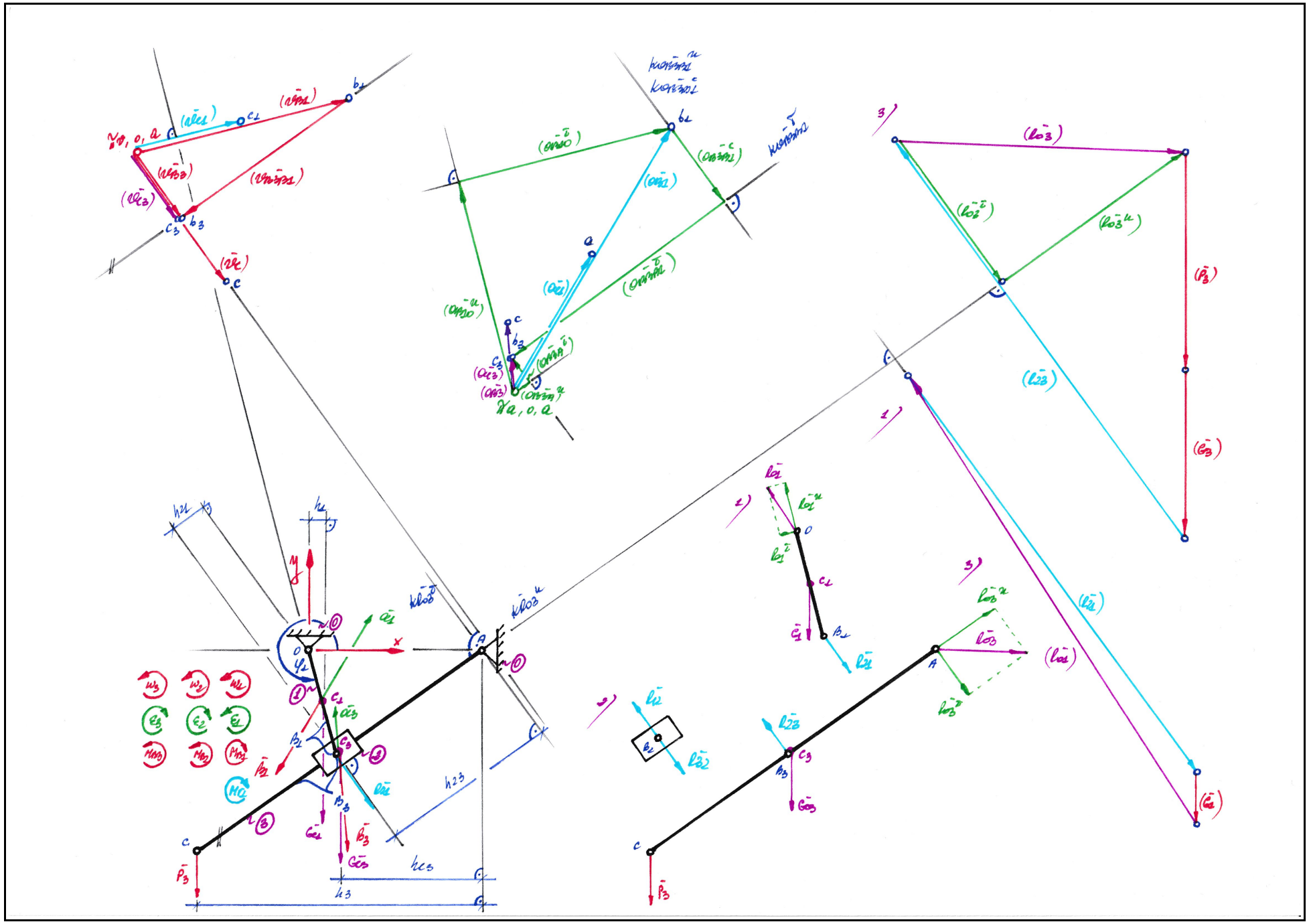
$$\rightsquigarrow \bar{R}_{01} = (\bar{R}_{01}) \cdot \mu_F = 12{,}30 \cdot 20 = 246 \ [N]$$

$$\sum M_{i1}^{(O)} = 0 \rightsquigarrow +M_{r1} - R_{21} \cdot h_{21} + G_1 \cdot h_1 = 0$$

$$M_{r1} = R_{21} \cdot h_{21} - G_1 \cdot h_1 =$$

$$= 226{,}66 \cdot 0{,}08 - 24{,}52 \cdot 0{,}04 =$$

$$= 18{,}12 - 0{,}98 = 17{,}14 \ [Nm]$$




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