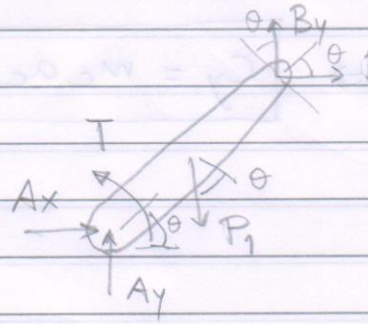
EXERCÍCIO 1

1 Método de Newto-Euler

DCL corpo 1



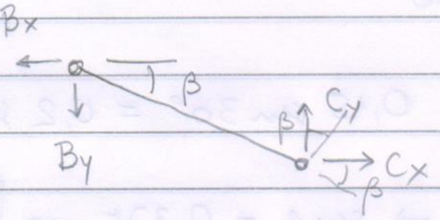
$$\sum \vec{F} = m_{AB}\,\vec{a}_{CG} \Rightarrow \vec{A} + \vec{P}_1 + \vec{B} = m_{AB}\,\vec{a}_{CG} \Rightarrow$$

$$\Rightarrow m_{AB}\begin{Bmatrix} a_x \\ a_y \end{Bmatrix} = \begin{Bmatrix} A_x \\ A_y \end{Bmatrix} + \begin{Bmatrix} 0 \\ -m_{AB}\,g \end{Bmatrix} + \begin{Bmatrix} B_x \\ B_y \end{Bmatrix} \Rightarrow \boxed{\begin{array}{l} A_x + B_x = m_{AB}\,a_x \\ A_y + B_y = m_{AB}(a_y + g) \end{array}} \quad (1,2)$$

$$\sum \vec{M}_A = I_{AB}\,\ddot{\theta} \Rightarrow \vec{T} + \vec{r}_{CG} \times \vec{P}_1 + \vec{r}_B \times \vec{B} = I_{AB}\,\ddot{\theta} \Rightarrow$$

$$\Rightarrow \boxed{T - m_{AB}\,g\,\frac{a}{2}\cos\theta - B_x\,a\,\mathrm{sen}\,\theta + B_y\,a\cos\theta = I_{AB}\,\ddot{\theta}} \quad (3)$$

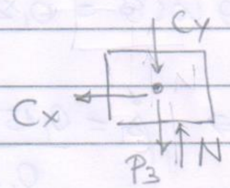
DCL corpo 2



$$\sum \vec{F} = \vec{0} \text{ (massa desprezível)} \Rightarrow \begin{cases} C_x - B_x = 0 \\ C_y - B_y = 0 \end{cases} \Rightarrow \boxed{\begin{array}{l} C_x = B_x \\ C_y = B_y \end{array}} \quad \begin{array}{l} (4) \\ (5) \end{array}$$

$$\sum \vec{M}_B = \vec{0} \text{ (massa desprezível)} \Rightarrow \boxed{C_x\,b\,\mathrm{sen}\,\beta + C_y\,b\cos\beta = 0} \quad (6)$$

DCL corpo 3



$$\sum \vec{F} = m_c\,\vec{a}_c \Rightarrow \begin{cases} -C_x = m_c\,a_c \\ N - C_y - m_c\,g = 0 \end{cases} \Rightarrow \boxed{\begin{array}{l} C_x = -m_c\,a_c \\ N = m_c\,g + C_y \end{array}} \quad \begin{array}{l} (7) \\ (8) \end{array}$$

Então, de (7): $\boxed{C_x = -m_C a_C}$

Em (6): $C_y = -\dfrac{C_x b \operatorname{sen}\beta}{b\cos\beta} \Rightarrow \boxed{C_y = m_C a_C \operatorname{tg}\beta}$

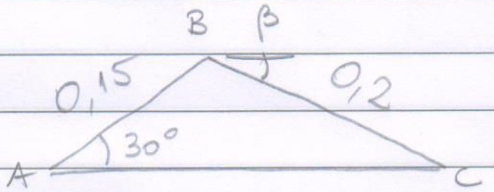
De (4) e (5): $\boxed{\begin{array}{l} B_x = C_x \\ B_y = C_y \end{array}}$

Então, de (3): $T = I_{AB}\ddot{\theta} + m_{AB}\, g\, \dfrac{a}{2}\cos\theta + B_x\, a \operatorname{sen}\theta + {}$
$- B_y\, a\cos\theta$

$\Rightarrow T = I_{AB}\ddot{\theta} + m_{AB}\, g\, a/2 \cos\theta - m_C a_C a \operatorname{sen}\theta - m_C a_C \operatorname{tg}\beta\, a\cos\theta$

$\Rightarrow \boxed{T = I_{AB}\ddot{\theta} + m_{AB}\, g\, a/2\cos\theta - m_C a_C\, a\left(\operatorname{sen}\theta + \operatorname{tg}\beta\cos\theta\right)}$

Nesse instante: $\ddot{\theta} = 0$ (velocidade constante)
$\theta = 30°$



$0{,}15 \operatorname{sen} 30° = 0{,}2 \operatorname{sen}\beta \Rightarrow$

$\Rightarrow \operatorname{sen}\beta = 0{,}375 \Rightarrow \boxed{\beta = 22°}$

Análise de Posição: $\begin{cases} x_C = 0{,}15\cos\theta + 0{,}2\cos\beta \\ 0{,}15\operatorname{sen}\theta = 0{,}2\operatorname{sen}\beta \end{cases}$

Análise de Velocidade: $\begin{cases} v_C = \dot{x}_C = -0{,}15\,\dot{\theta}\operatorname{sen}\theta - 0{,}2\,\dot{\beta}\operatorname{sen}\beta \\ 0{,}15\,\dot{\theta}\cos\theta = 0{,}2\,\dot{\beta}\cos\beta \quad (9) \end{cases}$

De (9): $\dot{\beta} = \dfrac{0{,}15\,\dot{\theta}\cos\theta}{0{,}2\cos\beta} \Rightarrow \dot{\beta} = \dfrac{0{,}15 \cdot 2\pi\cos 30°}{0{,}2\cos 22°} \Rightarrow \boxed{\dot{\beta} = 4{,}4 \text{ rad/s}}$

Análise de Acelerações :
$$\begin{cases} a_C = -0{,}15\ddot\theta \operatorname{sen}\theta - 0{,}15\dot\theta^2\cos\theta - 0{,}2\ddot\beta\operatorname{sen}\beta - 0{,}2\dot\beta^2\cos\beta & (10) \\ 0{,}15\ddot\theta\cos\theta - 0{,}15\dot\theta^2\operatorname{sen}\theta = 0{,}2\ddot\beta\operatorname{sen}\beta - 0{,}2\dot\beta^2\cos\beta & (11) \end{cases}$$

De (11) : $\ddot\beta = \dfrac{0{,}15\ddot\theta\cos\theta - 0{,}15\dot\theta^2\operatorname{sen}\theta + 0{,}2\dot\beta^2\cos\beta}{0{,}2\operatorname{sen}\beta} \Rightarrow$

$\Rightarrow \ddot\beta = \dfrac{0 - 0{,}15(2\pi)^2\operatorname{sen}30° + 0{,}2(4{,}4)^2\cos 22°}{0{,}2\operatorname{sen}22°} \Rightarrow \boxed{\ddot\beta = 8{,}4 \text{ rad/s}^2}$

Portanto, de (10) : $a_C = 0 - 0{,}15(2\pi)^2\cos 30° - 0{,}2 \cdot 8{,}4\operatorname{sen}22° - 0{,}2(4{,}4^2)\cos 22°$

$\Rightarrow \boxed{a_C = -9{,}35 \text{ m/s}^2}$

Assim :

$T = 0 + 0{,}5 \cdot 9{,}81 \cdot 0{,}075\cos 30° - 2 \cdot (-9{,}35) \cdot 0{,}15(\operatorname{sen}30° + \operatorname{tg}22°\cos 30°)$

$\Rightarrow \boxed{T = 2{,}7 \text{ Nm}}$ (a)

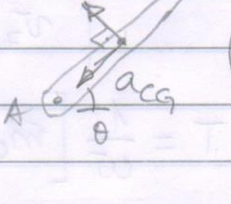
(b) Forças atuantes nos componentes:

$C_x = -m_C a_C = -2 \cdot (-9{,}35) \Rightarrow$ $\boxed{C_x = 18{,}7 \text{ N} = B_x}$

$C_y = m_C a_C \operatorname{tg}\beta = 2(-9{,}35)\operatorname{tg}22° \Rightarrow$ $\boxed{C_y = -7{,}56 \text{ N} = B_y}$

De (1) : $A_x = m_{AB}a_x - B_x$

De (2) : $A_y = m_{AB}(a_y + g) - B_y$



(velocidade angular constante)

$v_{CG} = \dot\theta\, a/2 = 2\pi \cdot 0{,}075 = 0{,}47$ m/s

$a_{CG} = \dfrac{v_{CG}^2}{R} = \dfrac{0{,}47^2}{0{,}075} = 2{,}95$ m/s²

Portanto : $\begin{cases} a_x = -2{,}95\cos 30° \\ a_y = -2{,}95\operatorname{sen}30° \end{cases} \Rightarrow \boxed{\begin{array}{l} a_x = -2{,}55 \\ a_y = -1{,}475 \end{array}}$

Assim: $A_x = 0{,}5(-2{,}55) - 18{,}7$ $\Rightarrow$ $\boxed{A_x = -19{,}975\ N}$

$A_y = 0{,}5(-1{,}475 + 9{,}81) - (-7{,}56)$ $\Rightarrow$ $\boxed{A_y = +11{,}73\ N}$

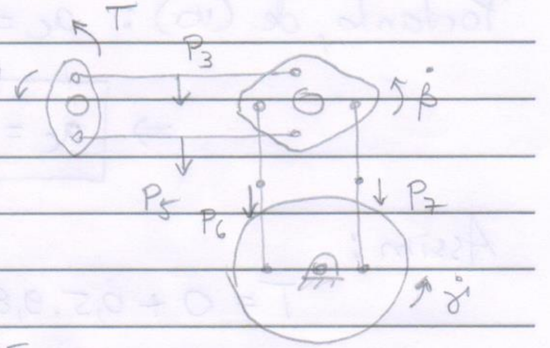
De (8): $N = m_C g + C_y = 2 \cdot 9{,}81 + (-7{,}56) \Rightarrow \boxed{N = 12{,}06\ N}$

(c) A potencia necessária é dada por:

$$Pot = T \cdot \omega = 2{,}7 \cdot (2\pi) \Rightarrow \boxed{Pot = 16{,}96\ W}$$

EXERCÍCIO 2

2 $\boxed{\text{Método das Potências}}$



$$\sum Pot_{\substack{\text{forças}\\ \text{externas}}} = \sum Pot_{\substack{\text{forças}\\ \text{internas}}}$$

$$T \cdot \omega - P_3 \cdot \underbrace{\cancel{v_{3y}}}_{\approx 0} - P_5 \underbrace{\cancel{v_{5y}}}_{\approx 0} + P_6 v_{6y} - P_7 v_{7y} =$$

$$= I_2 \alpha \cdot \omega + I_4 \ddot{\beta} \cdot \dot{\beta} + I_8 \ddot{\gamma} \cdot \dot{\gamma} + m_3 a_3 v_{3x} + m_5 a_5 v_{5x} +$$
$$+ m_6 a_6 v_{6y} + m_7 a_7 v_{7y}$$

Mas, pela cinemática do mecanismo: $\theta = \beta = \gamma \Rightarrow \begin{cases} \dot{\theta} = \dot{\beta} = \dot{\gamma} \\ \ddot{\theta} = \ddot{\beta} = \ddot{\gamma} \end{cases}$

Além disso: $\begin{cases} v_{3x} = -\omega O_{2A} & \Rightarrow a_3 = -\alpha O_{2A} \\ v_{5x} = +\omega O_{2A} & \Rightarrow a_5 = +\alpha O_{2A} \\ v_{6y} = -\dot{\beta} O_{4E} & \Rightarrow a_6 = -\ddot{\beta} O_{4E} \\ v_{7y} = +\dot{\beta} O_{4G} & \Rightarrow a_7 = +\ddot{\beta} O_{4E} \end{cases}$

Então: $T = \dfrac{1}{\omega} \Big[m_6 g(-\omega O_{4E}) + m_7 g(\omega O_{4G}) + (I_2 + I_4 + I_8)\alpha\omega$

$+ m_3(-\alpha O_{2A})(-\omega O_{2A}) + m_5 \alpha O_{2A} \omega O_{2A} +$

$+ m_6(-\alpha O_{4E})(-\omega O_{4E}) + m_7 \alpha O_{4E} \omega O_{4E} \Big]$

Assim: $T = \dfrac{1}{2\pi}\Big[\cancel{-1 \cdot 9{,}81 \cdot 2\pi} \cdot 0{,}03 + \cancel{1 \cdot 9{,}81 \cdot 2\pi} \cdot 0{,}03 +$

$+ (0{,}001 + 0{,}002 + 0{,}005)\,\pi \cdot 2\pi + 1{,}5 \cdot \pi \cdot 2\pi \cdot 0{,}02^2 +$

$+ 1{,}5\,\pi\,2\pi\,0{,}02^2 + 1 \cdot \pi \cdot 2\pi \cdot 0{,}03^2 + 1 \cdot \pi \cdot 2\pi \cdot 0{,}03^2\Big]$

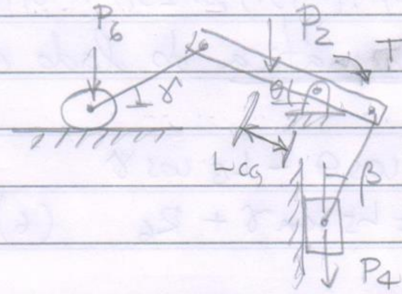
$\Rightarrow \boxed{T = 0{,}035\ \text{Nm}}$

A potência é dada por: $Pot = T \cdot \omega = 0{,}035 \cdot 2\pi \Rightarrow$

$\Rightarrow \boxed{Pot = 0{,}217\ W}$

EXERCÍCIO 3

3 Método das Potências



$$T\omega - m_2 g L_{cg} \cos\theta \cdot \omega - m_4 g v_4 = I_2 \alpha \omega + m_4 a_4 v_4 + m_6 a_6 v_6 + I_6 \alpha_6 \omega_6$$

Pela análise cinemática: $\begin{cases} L_{03} \cos\theta = L_3 \operatorname{sen}\beta & (1) \\ y_4 = -L_{03} \operatorname{sen}\theta - L_3 \cos\beta \end{cases}$

De (1): $\operatorname{sen}\beta = \dfrac{0{,}05 \cos 30^\circ}{0{,}1} \Rightarrow \boxed{\beta = 25{,}7^\circ}$

Derivando no tempo: $\begin{cases} -L_{03}\dot\theta \operatorname{sen}\theta = L_3 \dot\beta \cos\beta & (2) \\ v_4 = -L_{03}\dot\theta \cos\theta + L_3 \dot\beta \operatorname{sen}\beta & (3) \end{cases}$

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De (2): $\dot{\beta} = -\frac{L_{03}\dot{\theta}\,sen\theta}{L_3\cos\beta} = -\frac{0{,}05 \cdot 2 \cdot sen 30°}{0{,}1\cos 25{,}7°} \Rightarrow \boxed{\dot{\beta} = -0{,}555\ rad/s}$

De (3): $v_4 = -0{,}05 \cdot 2 \cdot \cos 30° + 0{,}1(-0{,}555)\,sen\,25{,}7° \Rightarrow \boxed{v_4 = -0{,}327\ m/s}$

Derivando no tempo:
$$\begin{cases} -L_{03}\ddot{\theta}\,sen\theta - L_{03}\dot{\theta}^2\cos\theta = L_3\ddot{\beta}\cos\beta - L_3\dot{\beta}^2\,sen\beta & (4) \\ a_4 = -L_{03}\ddot{\theta}\cos\theta + L_{03}\dot{\theta}^2\,sen\theta + L_3\ddot{\beta}\,sen\beta + L_3\dot{\beta}^2\cos\beta & (5) \end{cases}$$

De (4): $\ddot{\beta} = \frac{L_3\dot{\beta}^2 sen\beta - L_{03}\ddot{\theta}\,sen\theta - L_{03}\dot{\theta}^2\cos\theta}{L_3\cos\beta} \Rightarrow$

$\Rightarrow \ddot{\beta} = \frac{0{,}1(-0{,}555)^2 sen\,25{,}7° - 0{,}05 \cdot 0{,}5 \cdot sen\,30° - 0{,}05(2^2)\cos 30°}{0{,}1\cos 25{,}7°} \Rightarrow$

$\Rightarrow \boxed{\ddot{\beta} = -1{,}91\ rad/s^2}$

De (5): $a_4 = -0{,}05 \cdot 0{,}5 \cdot \cos 30° + 0{,}05 \cdot 2^2 sen\,30° +$
$+ 0{,}1 \cdot (-1{,}91)\,sen\,25{,}7° + 0{,}1(-0{,}555)^2\cos 25{,}7° \Rightarrow \boxed{a_4 = -0{,}032\ m/s^2}$

Pela análise cinemática do lado esquerdo do mecanismo:

$$\begin{cases} x_6 = -L_{05}\cos\theta - L_5\cos\gamma \\ L_{05}\,sen\theta = L_5\,sen\gamma + R_6 & (6) \end{cases}$$

De (6): $sen\gamma = \frac{L_{05}\,sen\theta - R_6}{L_5} = \frac{0{,}1\,sen\,30° - 0{,}03}{0{,}1} \Rightarrow \boxed{\gamma = 11{,}5°}$

Derivando-se no tempo:
$$\begin{cases} v_6 = L_{05}\dot{\theta}\,sen\theta + L_5\dot{\gamma}\,sen\gamma & (7) \\ L_{05}\dot{\theta}\cos\theta = L_5\dot{\gamma}\cos\gamma & (8) \end{cases}$$

De (8): $\dot{\gamma} = \frac{L_{05}\dot{\theta}\cos\theta}{L_5\cos\gamma} = \frac{0{,}1 \cdot 2 \cdot \cos 30°}{0{,}1\cos 11{,}5°} \Rightarrow \boxed{\dot{\gamma} = 1{,}77\ rad/s}$

De (7): $v_6 = 0{,}1 \cdot 2\,sen\,30° + 0{,}1 \cdot 1{,}77\,sen\,11{,}5 \Rightarrow \boxed{v_6 = 0{,}135\ m/s}$

Assim: $w_6 = \frac{v_6}{R_6} = \frac{0{,}135}{0{,}03} \Rightarrow \boxed{w_6 = 4{,}5\ rad/s}$

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Derivando-se no tempo:

$$\begin{cases} a_6 = L_{05}\ddot{\theta}\,\text{sen}\,\theta + L_{05}\dot{\theta}^2\cos\theta + L_5\ddot{\gamma}\,\text{sen}\,\gamma + L_5\dot{\gamma}^2\cos\gamma & (9) \\ L_{05}\ddot{\theta}\cos\theta - L_{05}\dot{\theta}^2\,\text{sen}\,\theta = L_5\ddot{\gamma}\cos\gamma - L_5\dot{\gamma}^2\,\text{sen}\,\gamma & (10) \end{cases}$$

De (10): $\ddot{\gamma} = \dfrac{L_{05}\ddot{\theta}\cos\theta - L_{05}\dot{\theta}^2\,\text{sen}\,\theta + L_5\dot{\gamma}^2\,\text{sen}\,\gamma}{L_5\cos\gamma} =$

$$= \frac{0{,}1 \cdot 0{,}5\cos 30° - 0{,}1 \cdot 2^2\,\text{sen}\,30° + 0{,}1 \cdot 1{,}77^2\,\text{sen}\,11{,}5°}{0{,}1\cos 11{,}5°} \Rightarrow$$

$$\Rightarrow \boxed{\ddot{\gamma} = -0{,}96 \text{ rad/s}^2}$$

De (9): $a_6 = 0{,}1 \cdot 0{,}5 \cdot \text{sen}\,30° + 0{,}1 \cdot 2^2\cos 30° + 0{,}1 \cdot (-0{,}96)\,\text{sen}\,11{,}5°$
$+ 0{,}1 \cdot 1{,}77^2\cos 11{,}5°$

$$\Rightarrow \boxed{a_6 = 0{,}66 \text{ m/s}^2}$$

Assim: $\alpha_6 = \dfrac{a_6}{R_6} = \dfrac{0{,}66}{0{,}03} \Rightarrow \boxed{\alpha_6 = 22 \text{ rad/s}^2}$

Portanto: $T = \dfrac{1}{2}\Big[0{,}001 \cdot 0{,}5 \cdot 2 + 0{,}5 \cdot (-0{,}032) \cdot (-0{,}327) +$

$+ 0{,}5 \cdot 0{,}135 \cdot 0{,}66 + 0{,}0002 \cdot 4{,}5 \cdot 22 + 0{,}5 \cdot 9{,}81 \cdot (-0{,}327)$
$+ 1 \cdot 9{,}81 \cdot 0{,}025\cos 30° \cdot 2\Big]$

$$\Rightarrow \boxed{\boxed{T = -0{,}55 \text{ Nm}}}$$

A potência é dada por: $Pot = T \cdot \omega = -0{,}55 \cdot 2 \Rightarrow$

$$\Rightarrow \boxed{Pot = -1{,}1 \text{ W}}$$

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EXERCÍCIO 4

(3) $\sum Pot_{ext} = \sum Pot_{inércia}$

$$T\omega + F_{mola} \cdot v = mav \Rightarrow \boxed{T = \frac{1}{\omega}\left[mav - F_{mola}v\right]}$$

$\omega = 300\ rpm = 5\ Hz = 31,42\ rad/s$
$m = 1\ kg$

$$s = R + e\cos\theta \Rightarrow v = -e\omega\,\text{sen}\,\theta \Rightarrow a = -e\omega^2\cos\theta$$

$e = 0,02\ m$

$$F_{mola} = -kx = -k(s - R + e) = -k(\cancel{R} + e\cos\theta - \cancel{R} + e)$$

$$\Rightarrow F_{mola} = -ke(1+\cos\theta)$$

onde $k = 10\ N/m$

Portanto: $$T = \frac{1}{\omega}\Big[-me\omega^2\cos\theta(-e\omega\,\text{sen}\,\theta) + {} + ke(1+\cos\theta)(-e\omega\,\text{sen}\,\theta)\Big] \Rightarrow$$

$$\Rightarrow T = -me^2\omega^2\,\text{sen}\,\theta\cos\theta - ke^2\,\text{sen}\,\theta - ke^2\,\text{sen}\,\theta\cos\theta \Rightarrow$$

$$\Rightarrow T = -ke^2\,\text{sen}\,\theta - (m\omega^2 + k)e^2\,\text{sen}\,\theta\cos\theta \Rightarrow$$

$$\Rightarrow T = -\left[k + (m\omega^2 + k)\cos\theta\right]e^2\,\text{sen}\,\theta =$$

$$= -\left[10 + (31,42^2 + 10)\cos\theta\right](0,02)^2\,\text{sen}\,\theta \Rightarrow$$

$$\Rightarrow \boxed{T = -(10 + 997,2\cos\theta)\,0,0004\,\text{sen}\,\theta}$$

EXERCÍCIO 5

③ $V = \frac{\omega}{\beta}\left[C_1 + 2C_2\left(\frac{\theta}{\beta}\right) + 3C_3\left(\frac{\theta}{\beta}\right)^2\right]$ onde $\beta = \pi$

$\boxed{\theta = 0,\ V = 0}$ $V = \frac{1}{\pi}C_1 = 0 \Rightarrow \boxed{C_1 = 0}$

$\boxed{\theta = \pi,\ V = 0}$ $V = \frac{1}{\pi}\left[2C_2 + 3C_3\right] = 0 \Rightarrow 2C_2 + 3C_3 = 0$ (1)

$\boxed{\theta = \frac{\pi}{2},\ V = 7{,}86}$ $V = \frac{1}{\pi}\left[2C_2\left(\frac{1}{2}\right) + 3C_3\left(\frac{1}{4}\right)\right] = 7{,}86 \Rightarrow$

$\Rightarrow C_2 + \frac{3}{4}C_3 = 24{,}693$ (2)

Assim: $C_2 = -\frac{3}{2}C_3$

Em (2): $-\frac{3}{2}C_3 + \frac{3}{4}C_3 = 24{,}693 \Rightarrow -\frac{3}{4}C_3 = 24{,}693 \Rightarrow \boxed{C_3 = -32{,}92}$

Então: $\boxed{C_2 = 49{,}385}$

Portanto: $\boxed{V = 31{,}44\left(\frac{\theta}{\pi}\right) - 31{,}44\left(\frac{\theta}{\pi}\right)^2}$

Deslocamento: $S = C_0 + C_1\left(\frac{\theta}{\beta}\right) + C_2\left(\frac{\theta}{\beta}\right)^2 + C_3\left(\frac{\theta}{\beta}\right)^3$

$\boxed{\theta = 0,\ S = 10}$ $S = \boxed{C_0 = 10}$

Portanto: $\boxed{S = 10 + 49{,}385\left(\frac{\theta}{\pi}\right)^2 - 32{,}92\left(\frac{\theta}{\pi}\right)^3}$

Para $\theta = 180° = \pi \Rightarrow \boxed{S_{max} = 26{,}47 \text{ mm}}$

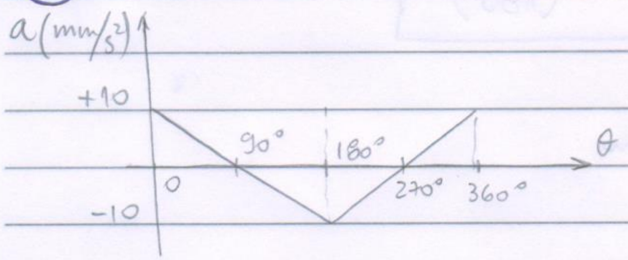
Alternativa: $\Delta S = \int_0^{\pi} V\, d\theta = \int_0^{\pi} 31{,}44\left(\frac{\theta}{\pi}\right) - 31{,}44\left(\frac{\theta}{\pi}\right)^2 d\theta =$

$= 31{,}44\left[\frac{\theta^2}{2\pi} - \frac{\theta^3}{3\pi^2}\right]_0^{\pi} \Rightarrow \boxed{\Delta S = 16{,}46} \Rightarrow S_{max} = 10 + \Delta S \Rightarrow$

$\Rightarrow \boxed{S_{max} = 26{,}46 \text{ mm}}$

EXERCÍCIO 6

6



TRECHO I sabemos que: $\boxed{A_1 = 10 - 20\frac{\theta}{180°}}$ (conhecido)

Também sabemos que, pelo método polinomial:

$$A = \left(\frac{\dot{\theta}}{\Delta\theta}\right)^2\left[2C_2 + 6C_3\frac{\theta}{\Delta\theta} + 12C_4\left(\frac{\theta}{\Delta\theta}\right)^2 + 20C_5\left(\frac{\theta}{\Delta\theta}\right)^3\right]$$

Então, considerando $\dot{\theta} = 1$ rad/s e $\Delta\theta = 180°$: $\left\{\begin{array}{l} C_2 = 43,35 \\ C_3 = -32,9 \\ C_4 = 0 \\ C_5 = 0 \end{array}\right.$

Pelo método polinomial, a velocidade é dada por:

$$V = \frac{\dot{\theta}}{\Delta\theta}\left[C_1 + 2C_2\frac{\theta}{\Delta\theta} + 3C_3\left(\frac{\theta}{\Delta\theta}\right)^2 + 4C_4\left(\frac{\theta}{\Delta\theta}\right)^3 + 5C_5\left(\frac{\theta}{\Delta\theta}\right)^4\right]$$

Considerando $V_1 = 0$ em $\theta = 0°$: $\underline{C_1 = 0}$

Portanto: $\boxed{V_1 = 31,4\left(\frac{\theta}{180°}\right) - 31,4\left(\frac{\theta}{180°}\right)^2}$

Pelo método polinomial, o deslocamento é dado por:

$$S = C_0 + C_1\frac{\theta}{\Delta\theta} + C_2\left(\frac{\theta}{\Delta\theta}\right)^2 + C_3\left(\frac{\theta}{\Delta\theta}\right)^3 + C_4\left(\frac{\theta}{\Delta\theta}\right)^4 + C_5\left(\frac{\theta}{\Delta\theta}\right)^5$$

Considerando-se $S = R_{min}$ em $\theta = 0°$: $\underline{C_0 = R_{min} = 10 \text{ mm}}$

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Então: $\boxed{S_1 = 10 + 49{,}4\left(\frac{\theta}{180°}\right)^2 - 32{,}9\left(\frac{\theta}{180°}\right)^3}$

Assim, em $\theta = 180°$: $\begin{cases} S = 26{,}5 \text{ mm} \\ V = 0 \text{ mm/s} \end{cases}$

TRECHO II

Sabemos que: $\boxed{A_2 = -10 + 20\left(\frac{\theta - 180°}{180°}\right)}$ (conhecido)

Pelo método polinomial,

$$A = \left(\frac{\dot{\theta}}{\Delta\theta}\right)^2 \left[2C_2 + 6C_3\frac{\theta}{\Delta\theta} + 12C_4\left(\frac{\theta}{\Delta\theta}\right)^2 + 20C_5\left(\frac{\theta}{\Delta\theta}\right)^3\right]$$

Considerando-se $\dot{\theta} = 1$ rad/s e $\Delta\theta = 180°$ no trecho II: $\begin{cases} C_2 = -49{,}35 \\ C_3 = 32{,}9 \\ C_4 = 0 \\ C_5 = 0 \end{cases}$

Pelo método polinomial: $V = \frac{\dot{\theta}}{\Delta\theta}\left[C_1 + 2C_2\left(\frac{\theta}{\Delta\theta}\right) + 3C_3\left(\frac{\theta}{\Delta\theta}\right)^2 + 4C_4\left(\frac{\theta}{\Delta\theta}\right)^3 + 5C_5\left(\frac{\theta}{\Delta\theta}\right)^4\right]$

Para $\theta = 180° \Rightarrow V = 0$ mm/s $\Rightarrow \underline{C_1 = 0}$

Então: $\boxed{V_2 = -31{,}4\left(\frac{\theta - 180°}{180°}\right) + 31{,}4\left(\frac{\theta - 180°}{180°}\right)^2}$

Para $\theta = 180° \Rightarrow S = 26{,}5$ mm $\Rightarrow \underline{C_1 = 26{,}5}$

Então: $\boxed{S_2 = 26{,}5 - 49{,}4\left(\frac{\theta - 180°}{180°}\right)^2 + 32{,}9\left(\frac{\theta - 180°}{180°}\right)^3}$

spiral®

S T Q Q S S D

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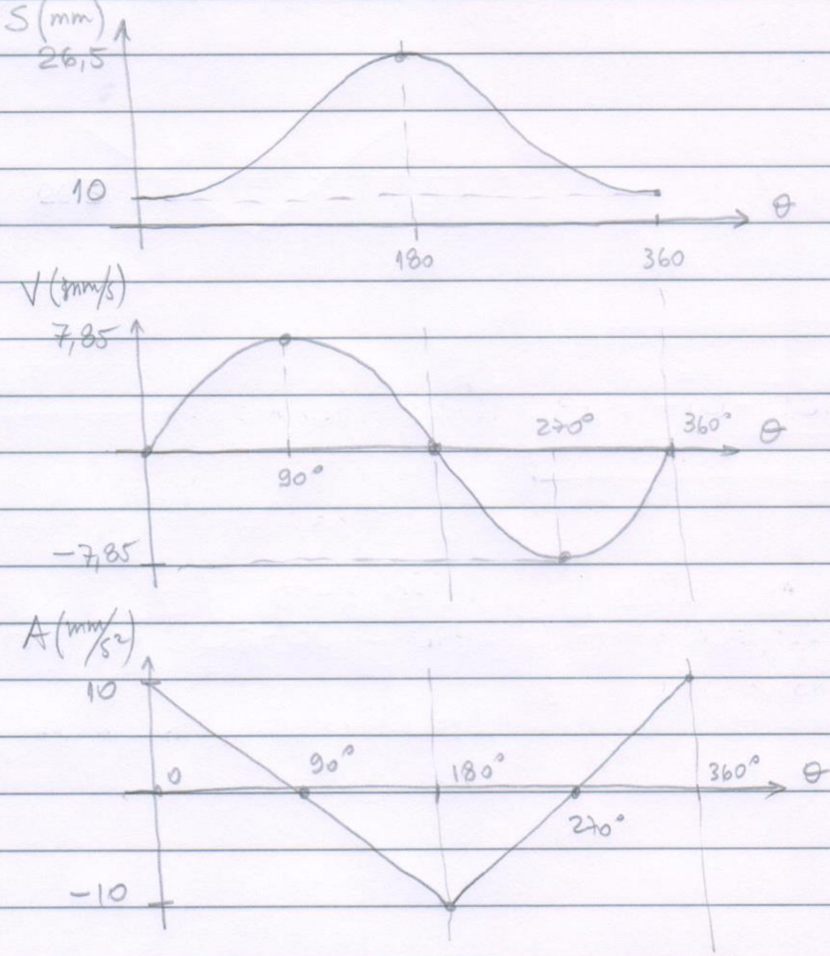
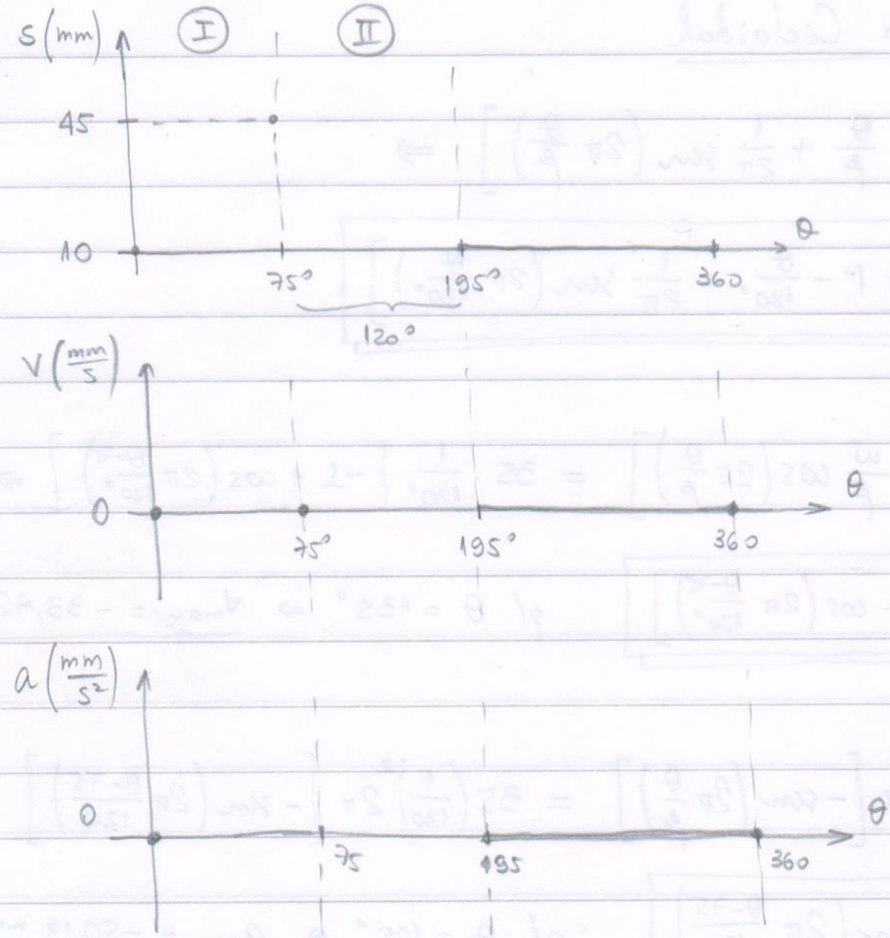


S (mm)
26,5
10
θ
180
360
V (mm/s)
7,85
270°
360°
θ
90°
-7,85
A (mm/s²)
10
0
90°
180°
360°
θ
270°
-10

EXERCÍCIO 7

Ex: Projète o perfil do came de forma a se ter:

- subida de R_{min} a $R_{min} + 35$ mm em $75°$
- descida de $R_{min} + 35$ mm a R_{min} em $120°$
- deslocamento nulo no restante
- $\omega = 1$ rad/s e $R_{min} = 10$ mm



$\boxed{\text{Trecho I}}$ Movimento Cicloidal:

$$s = R_{min} + h\left[\frac{\theta}{\beta} - \frac{1}{2\pi}\,sen\left(2\pi\frac{\theta}{\beta}\right)\right] \Rightarrow \boxed{s = 10 + 35\left[\frac{\theta}{75°} - \frac{1}{2\pi}\,sen\left(2\pi\frac{\theta}{75°}\right)\right]}$$

$$v = \frac{ds}{dt} = h\left[\frac{\omega}{\beta} - \frac{\omega}{\beta}\cdot\cos\left(2\pi\frac{\theta}{\beta}\right)\right] \Rightarrow$$

$$\Rightarrow \boxed{v = 26{,}74\left[1 - \cos\left(2\pi\frac{\theta}{75°}\right)\right]}$$

p/ $\theta = 75° \Rightarrow \underline{v = 0}$

p/ $\theta = 37{,}5° \Rightarrow \underline{v_{max} = 53{,}48 \text{ mm/s}}$

$$a = \frac{dv}{dt} = 26,74 \left[2\pi \frac{\omega}{75°} \, sen\left(2\pi \frac{\theta}{75°}\right) \right] \Rightarrow$$

$$\Rightarrow \boxed{a = 128,352 \, sen\left(2\pi \frac{\theta}{75}\right)}$$

p/ $\theta = 18,75° \Rightarrow a_{max} = 128,352 \ \frac{mm}{s^2}$

p/ $\theta = 56,25° \Rightarrow a_{min} = -128,352 \ \frac{mm}{s^2}$

Trecho II Movimento Cicloidal

$$S = R_{min} + h \left[1 - \frac{\theta}{\beta} + \frac{1}{2\pi} sen\left(2\pi \frac{\theta}{\beta}\right) \right] \Rightarrow$$

$$\Rightarrow \boxed{S = 10 + 35 \left[1 - \frac{\theta}{120°} + \frac{1}{2\pi} sen\left(2\pi \frac{\theta}{120°}\right) \right]}$$

$$V = \frac{ds}{dt} = h \left[\frac{-\omega}{\beta} + \frac{\omega}{\beta} \cos\left(2\pi \frac{\theta}{\beta}\right) \right] = 35 \cdot \frac{1}{120°} \left[-1 + \cos\left(2\pi \frac{\theta - 75}{120°}\right) \right] \Rightarrow$$

$$\Rightarrow \boxed{V = 16,71 \left[-1 + \cos\left(2\pi \frac{\theta - 75}{120°}\right) \right]}$$

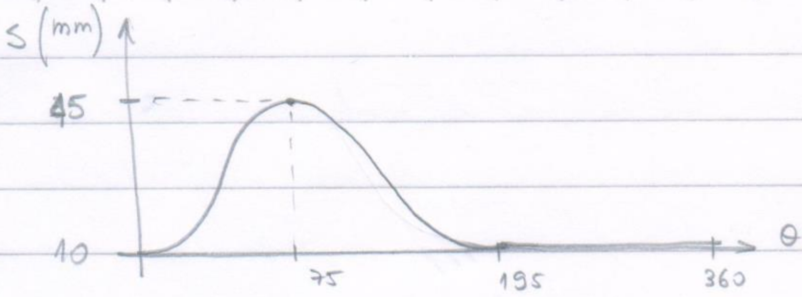
p/ $\theta = 135° \Rightarrow \underline{V_{max} = -33,42 \ mm/s}$

$$a = \frac{dv}{dt} = h \left(\frac{\omega}{\beta}\right)^2 2\pi \left[-sen\left(2\pi \frac{\theta}{\beta}\right) \right] = 35 \left(\frac{1}{120}\right)^2 2\pi \left[-sen\left(2\pi \frac{\theta - 75}{120}\right) \right] \Rightarrow$$

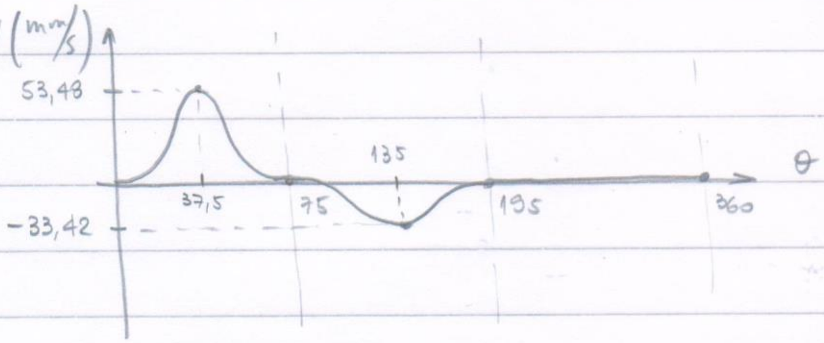
$$\Rightarrow \boxed{a = -50,13 \, sen\left(2\pi \frac{\theta - 75}{120}\right)}$$

p/ $\theta = 105° \Rightarrow a_{min} = -50,13 \ mm/s^2$

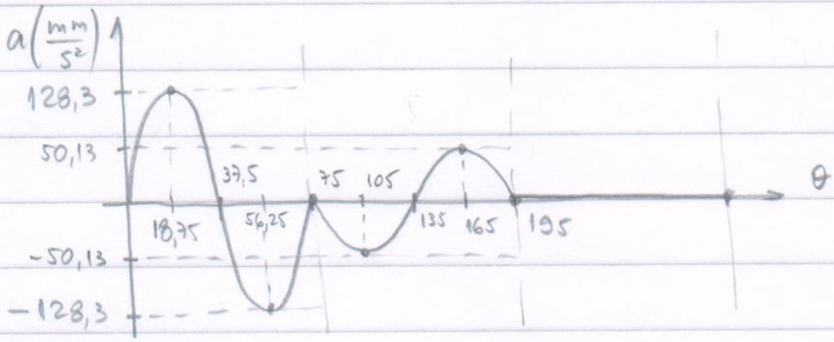
p/ $\theta = 165° \Rightarrow a_{max} = +50,13 \ mm/s^2$



s (mm)
45
10
75
195
360
θ



v (mm/s)
53,48
-33,42
37,5
75
135
195
360
θ



a (mm/s²)
128,3
50,13
-50,13
-128,3
18,75
37,5
56,25
75
105
135
165
195
θ