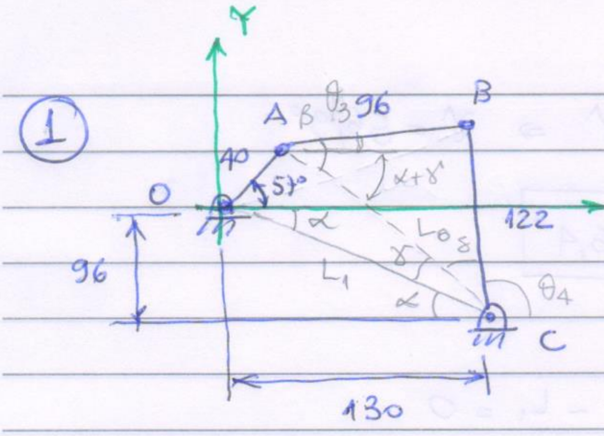
S T Q Q S S D   __/__/__

(1)



$$L_1 = \sqrt{130^2 + 96^2} = 161{,}6 \text{ mm}$$

$$\alpha = tg^{-1}\left(\frac{96}{130}\right) = 36{,}4°$$

$$L_0^2 = 40^2 + 161{,}6^2 - 2.40.161{,}6 \cos(57 + 36{,}4) \Rightarrow L_0 = 168{,}8 \text{ mm}$$

$$40^2 = 161{,}6^2 + 168{,}8^2 - 2.161{,}6.168{,}8 \cos\gamma \Rightarrow \gamma = 13{,}7°$$

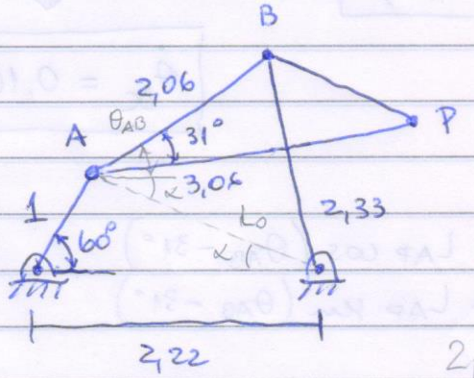
$$96^2 = 168{,}8^2 + 122^2 - 2.168{,}8.122 \cos\delta \Rightarrow \delta = 34°$$

Portanto: $\pi = \theta_4 + \delta + \gamma + \alpha \Rightarrow \boxed{\theta_4 = 95{,}9°}$

$$122^2 = 168{,}8^2 + 96^2 - 2.168{,}8.96 \cos\beta \Rightarrow \beta = 45{,}2°$$

Portanto: $\beta = \theta_3 + \alpha + \gamma \Rightarrow \boxed{\theta_3 = -4{,}9°}$

(2)



$$L_0^2 = 1^2 + 2{,}22^2 - 2.2{,}22 \cos 60° \Rightarrow$$
$$\Rightarrow L_0 = 1{,}93$$

$$1^2 = 2{,}22^2 + 1{,}93^2 - 2.2{,}22.1{,}93 \cos\alpha$$
$$\Rightarrow \alpha = 26{,}7°$$

$$2{,}33^2 = 1{,}93^2 + 2{,}06^2 - 2.1{,}93.2{,}06 \cos\beta$$
$$\Rightarrow \beta = 71{,}4°$$

Então: $\theta_{AB} = \beta - \alpha \Rightarrow \boxed{\theta_{AB} = 44{,}7°}$

___/___/___

S T Q Q S S D

$$2{,}06^2 = 1{,}93^2 + 2{,}33^2 - 2 \cdot 1{,}93 \cdot 2{,}33 \cos\gamma \Rightarrow \gamma = 56{,}9°$$

Então: $\theta_{BC} = \pi - \alpha - \gamma \Rightarrow \boxed{\theta_{BC} = 96{,}4°}$

$$\begin{cases} L_2 \cos\delta + L_3 \cos\theta_{AB} - L_4 \cos\theta_{BC} - L_1 = 0 \\ L_2 \operatorname{sen}\delta + L_3 \operatorname{sen}\theta_{AB} - L_4 \operatorname{sen}\theta_{BC} = 0 \end{cases}$$

EQS. DE POSIÇÃO

Derivando no tempo:
$$\begin{cases} -L_2 \omega \operatorname{sen}\delta - L_3 \dot\theta_{AB} \operatorname{sen}\theta_{AB} + L_4 \dot\theta_{BC} \operatorname{sen}\theta_{BC} = 0 & (1) \\ L_2 \omega \cos\delta + L_3 \dot\theta_{AB} \cos\theta_{AB} - L_4 \dot\theta_{BC} \cos\theta_{BC} = 0 & (2) \end{cases}$$

De (2): $\boxed{\dot\theta_{BC} = \dfrac{L_2 \omega \cos\delta + L_3 \dot\theta_{AB} \cos\theta_{AB}}{L_4 \cos\theta_{BC}}}$

Em (1): $-L_2 \omega \operatorname{sen}\delta - L_3 \dot\theta_{AB} \operatorname{sen}\theta_{AB} + L_4 \operatorname{sen}\theta_{BC} \left(\dfrac{L_2 \omega \cos\delta + L_3 \dot\theta_{AB} \cos\theta_{AB}}{L_4 \cos\theta_{BC}} \right) = 0$

$\Rightarrow -L_2 \omega \operatorname{sen}\delta - L_3 \dot\theta_{AB} \operatorname{sen}\theta_{AB} + L_2 \omega \cos\delta \operatorname{tg}\theta_{BC} + L_3 \dot\theta_{AB} \cos\theta_{AB} \operatorname{tg}\theta_{BC} = 0$

$\Rightarrow (\cos\theta_{AB} \operatorname{tg}\theta_{BC} - \operatorname{sen}\theta_{AB}) L_3 \dot\theta_{AB} = L_2 \omega (\operatorname{sen}\delta - \cos\delta \operatorname{tg}\theta_{BC}) \Rightarrow$

$\Rightarrow \boxed{\dot\theta_{AB} = \dfrac{L_2 \omega (\operatorname{sen}\delta - \cos\delta \operatorname{tg}\theta_{BC})}{L_3 (\cos\theta_{AB} \operatorname{tg}\theta_{BC} - \operatorname{sen}\theta_{AB})}} \Rightarrow \boxed{\dot\theta_{AB} = -0{,}37 \text{ rad/s}}$

$\Downarrow$

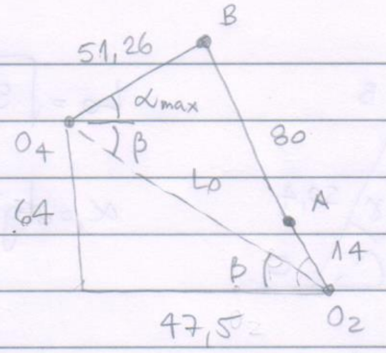
$\boxed{\dot\theta_{BC} = 0{,}16 \text{ rad/s}}$

Posição de P: $\begin{cases} x_P = L_2 \cos\delta + L_{AP} \cos(\theta_{AB} - 31°) \\ y_P = L_2 \operatorname{sen}\delta + L_{AP} \operatorname{sen}(\theta_{AB} - 31°) \end{cases}$

Velocidade de P: $\begin{cases} v_x = -L_2 \omega \operatorname{sen}\delta - L_{AP} \dot\theta_{AB} \operatorname{sen}(\theta_{AB} - 31°) \\ v_y = L_2 \omega \cos\delta + L_{AP} \dot\theta_{AB} \cos(\theta_{AB} - 31°) \end{cases} \Rightarrow \vec{v}_P = \begin{Bmatrix} -0{,}6 \\ -0{,}6 \\ 0 \end{Bmatrix}$

□S □T □Q □Q □S □S □D   __/__/__

(3) <u>Ângulo máximo:</u>



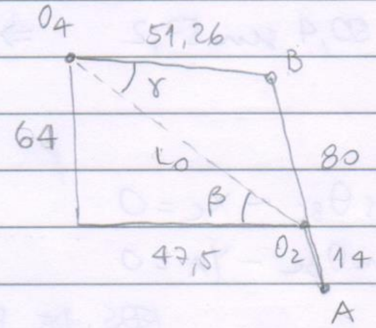
$$L_0 = \sqrt{64^2 + 47{,}5^2} = 79{,}7 \text{ mm}$$

$$\beta = tg\left(\frac{64}{47{,}5}\right) = 53{,}4°$$

$$94^2 = 79{,}7^2 + 51{,}26^2 - 2.79{,}7.51{,}26 \cos \gamma \Rightarrow \gamma = 89°$$

Assim: $\alpha_{max} = \gamma - \beta \Rightarrow \boxed{\alpha_{max} = 35{,}6°}$

<u>Ângulo mínimo:</u>



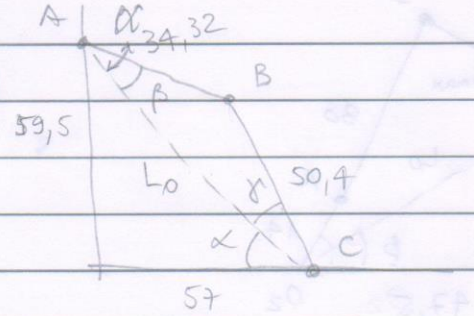
$$66^2 = 79{,}7^2 + 51{,}26^2 - 2.79{,}7.51{,}26 \cos \gamma \Rightarrow \gamma = 55{,}5°$$

Assim: $\alpha_{min} = \gamma - \beta \Rightarrow \boxed{\alpha_{min} = 2{,}1°}$

spiral

___/___/___ S T Q Q S S D

(4) a)



$L_0 = \sqrt{57^2 + 59{,}5^2} = 82{,}4\ mm$

$\alpha = tg^{-1}\left(\frac{59{,}5}{57}\right) = 46{,}2°$

$34{,}32^2 = 82{,}4^2 + 50{,}4^2 - 2.82{,}4.50{,}4 \cos\gamma \Rightarrow \gamma = 11°$

Portanto: $\theta_{BC} = \alpha + \gamma \Rightarrow \boxed{\theta_{BC} = 57{,}2°}$

$50{,}4^2 = 82{,}4^2 + 34{,}32^2 - 2.82{,}4.34{,}32 \cos\beta \Rightarrow \beta = 16{,}3°$

Portanto: $\theta_{AB} = 90 - \alpha + \beta \Rightarrow \boxed{\theta_{AB} = 60{,}1°}$

$x_B = x_C - L_{BC}\cos\theta_{BC} = 57 - 50{,}4\cos 57{,}2 \Rightarrow \boxed{x_B = 29{,}7\ mm}$
$y_B = L_{BC}\,sen\,\theta_{BC} = 50{,}4\,sen\,57{,}2 \Rightarrow \boxed{y_B = 42{,}4\ mm}$

b) $\begin{cases} L_{AB}\,sen\,\theta_{AB} + L_{BC}\cos\theta_{BC} - x_C = 0 \\ L_{AB}\cos\theta_{AB} + L_{BC}\,sen\,\theta_{BC} - y_A = 0 \end{cases}$

EQS. DE POSIÇÃO

Derivando no tempo: $\begin{cases} L_{AB}\dot\theta_{AB}\cos\theta_{AB} - L_{BC}\dot\theta_{BC}\,sen\,\theta_{BC} - v_C = 0 & (1) \\ -L_{AB}\dot\theta_{AB}\,sen\,\theta_{AB} + L_{BC}\dot\theta_{BC}\cos\theta_{BC} - v_A = 0 & (2) \end{cases}$

De (2): $\boxed{\dot\theta_{BC} = \frac{v_A + L_{AB}\dot\theta_{AB}\,sen\,\theta_{AB}}{L_{BC}\cos\theta_{BC}}}$

Em (1): $L_{AB}\dot\theta_{AB}\cos\theta_{AB} - tg\,\theta_{BC}\left(v_A + L_{AB}\dot\theta_{AB}\,sen\,\theta_{AB}\right) - v_C = 0 \Rightarrow$

$\Rightarrow L_{AB}\dot\theta_{AB}\left(\cos\theta_{AB} - tg\,\theta_{BC}\,sen\,\theta_{AB}\right) = v_C + v_A\,tg\,\theta_{BC} \Rightarrow$

$\Rightarrow \boxed{\dot\theta_{AB} = \frac{v_C + v_A\,tg\,\theta_{BC}}{L_{AB}\left(\cos\theta_{AB} - tg\,\theta_{BC}\,sen\,\theta_{AB}\right)}} \Rightarrow \boxed{\dot\theta_{AB} = 0{,}061\ rad/s}$

$\Downarrow$

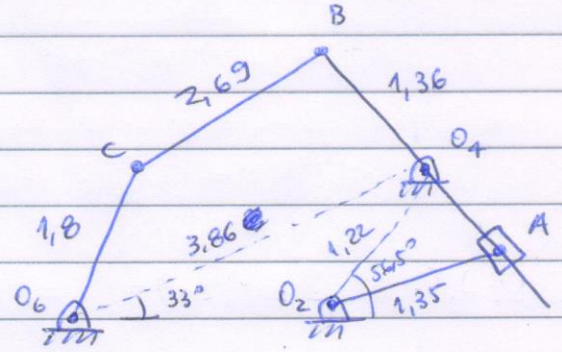
$\boxed{\dot\theta_{BC} = 0{,}048\ rad/s}$

spiral

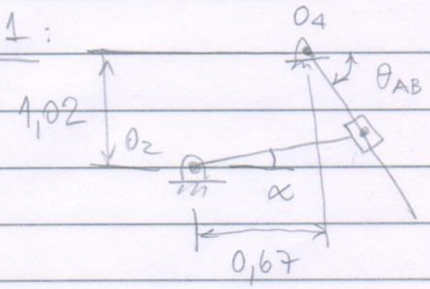
S T Q Q S S D

$$\begin{cases} v_x = v_C + L_{BC}\dot{\theta}_{BC}\,\text{sen}\,\theta_{BC} = -1 + 50{,}4 \cdot 2{,}6 \cdot \text{sen}\,57{,}2^\circ \\ v_y = L_{BC}\dot{\theta}_{BC}\cos\theta_{BC} = 50{,}4 \cdot 2{,}6 \cdot \cos 57{,}2^\circ \end{cases} \Rightarrow \boxed{\begin{aligned} v_x &= 1{,}03 \text{ mm/s} \\ v_y &= 1{,}31 \text{ mm/s} \end{aligned}}$$

5



Mecanismo 1:

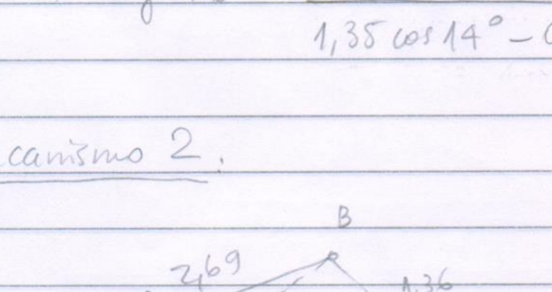


$$\begin{cases} 0{,}67 + L_A\cos\theta_{AB} - L_2\cos\alpha = 0 \\ 1{,}02 - L_A\,\text{sen}\,\theta_{AB} - L_2\,\text{sen}\,\alpha = 0 \end{cases}$$

$$\Rightarrow \begin{aligned} L_A\,\text{sen}\,\theta_{AB} &= 1{,}02 - L_2\,\text{sen}\,\alpha \\ L_A\cos\theta_{AB} &= L_2\cos\alpha - 0{,}67 \end{aligned} \quad \text{tg}\,\theta_{AB} = \frac{1{,}02 - L_2\,\text{sen}\,\alpha}{L_2\cos\alpha - 0{,}67} \Rightarrow$$

$$\Rightarrow \text{tg}\,\theta_{AB} = \frac{1{,}02 - 1{,}35\,\text{sen}\,14^\circ}{1{,}35\cos 14^\circ - 0{,}67} \Rightarrow \boxed{\theta_{AB} = 47{,}3^\circ}$$

Mecanismo 2:



$$L_0^2 = 1{,}36^2 + 3{,}86^2 - 2 \cdot 1{,}36 \cdot 3{,}86\cos(47{,}3^\circ + 33^\circ)$$

$$\Rightarrow L_0 = 3{,}87$$

$$1{,}36^2 = 3{,}87^2 + 3{,}86^2 - 2 \cdot 3{,}87 \cdot 3{,}86\cos\alpha \Rightarrow$$

$$\Rightarrow \alpha = 20{,}3^\circ$$

$$2{,}69^2 = 3{,}87^2 + 1{,}8^2 - 2 \cdot 3{,}87 \cdot 1{,}8\cos\beta \Rightarrow \beta = 38^\circ$$

$$\theta_{OC} = 33^\circ + \alpha + \beta^\circ \Rightarrow \boxed{\theta_{OC} = 91{,}3^\circ}$$

$$3,87^2 = 1,8^2 + 2,69^2 - 2.1,8.2,69 \cos\gamma' \Rightarrow \gamma' = 117,7^\circ$$

$$\theta_{BC} = \gamma' - (180 - \theta_{OC}) = 117,7^\circ - 180 + 91,3^\circ \Rightarrow \boxed{\theta_{BC} = 29^\circ}$$