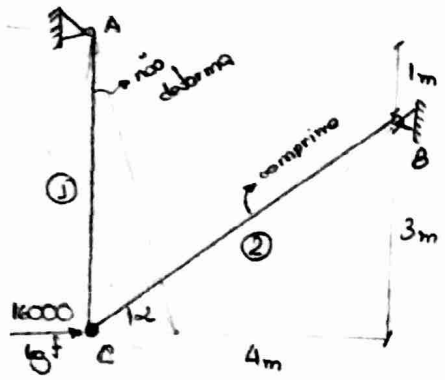
Problemas de Resistência dos Materiais

3.1) Paulo Akira 2017 2




$\sin\alpha = 0,6$

$\cos\alpha = 0,8$

Nó C:

$\Sigma F_H = 0 \cdot N_2 \cos\alpha + 16000 = 0$

$\Rightarrow 0,8\, N_2 = -16000 \Rightarrow$

$\Rightarrow N_2 = -20000$

$\Sigma F_V = 0 \cdot N_1 + N_2 \sin\alpha = 0 \Rightarrow N_1 = 20000 \cdot 0,6 \Rightarrow$

$\Rightarrow N_1 = 12000$

$\sigma_T = 2000 \frac{kgf}{cm^2} \therefore \frac{N_1}{A_1} \leq \frac{\sigma_T}{FS} \Rightarrow A_1 \geq \frac{N_1 FS}{\sigma_T} \Rightarrow$

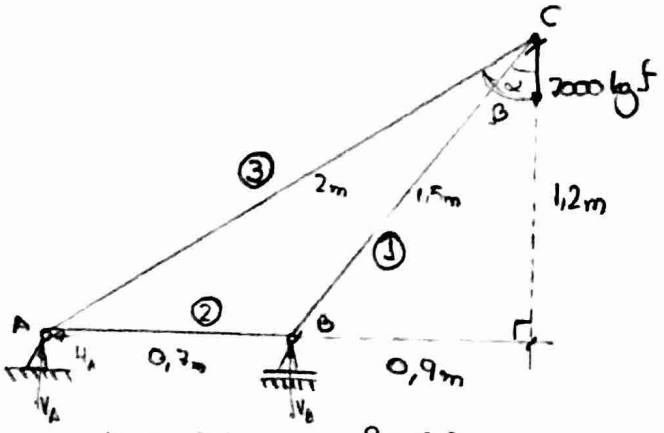
$\Rightarrow A_1 \geq \frac{12000}{2000} FS \Rightarrow A_1 \geq 6FS$

$\sigma_c = 500 \frac{kgf}{cm^2} \therefore \frac{N_2}{A_2} \leq \frac{\sigma_c}{FS} \Rightarrow A_2 \geq \frac{N_2 FS}{\sigma_c} \Rightarrow$

$\Rightarrow A_2 \geq \frac{20000 FS}{500} \Rightarrow A_2 \geq 40 FS$

Para $FS = 1 \cdot \begin{cases} A_1 \geq 6\ cm^2 \\ A_2 \geq 40\ cm^2 \end{cases}$

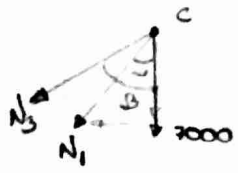
3.2)




$\sin\alpha = 0,6$ $\sin\beta = 0,8$

$\cos\alpha = 0,8$ $\cos\beta = 0,6$

Nó C




$\Sigma F_x = 0 \cdot -N_1 \cdot \sin\alpha - N_3 \sin\beta = 0 \Rightarrow$

$\Rightarrow N_1 = -N_3 \frac{8}{6}$

$\Sigma F_V = 0 \cdot -N_1 \cos\alpha - N_3 \cos\beta - 7000 = 0 \Rightarrow$

$\Rightarrow -N_1 0,8 - N_3 0,6 = 7000 \Rightarrow$

$\Rightarrow N_3 \frac{6,4}{6} - N_3 0,6 = 7000 \Rightarrow$

$\Rightarrow N_3 = 15000 \quad N_1 = -20000$

Equações de equilíbrio:

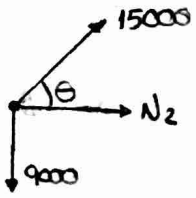
$\Sigma F_x = 0 \cdot H_A = 0$

$\Sigma F_V = 0 \cdot V_A + V_B = 7000$

$\Sigma M_{(A)} = 0 \cdot 0,7 V_B - 7000 \cdot 1,6 = 0 \Rightarrow$

$\Rightarrow V_B = 16000 \quad V_A = 9000$

Nó A:




$\sin\theta = 0,6$

$\cos\theta = 0,8$

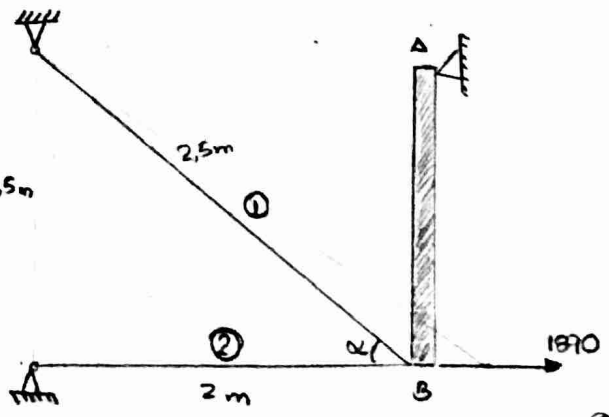
$\Sigma F_x = 0 \cdot N_2 + 15000 = 0 \Rightarrow N_2 = -12000$

$\sigma_{N_3} \leq \overline{\sigma} \Rightarrow \frac{20000}{10} \leq \frac{3200}{FS_1} \Rightarrow FS_1 \leq 1,6$

$\sigma_{N_2} \leq \overline{\sigma} \Rightarrow \frac{12000}{10} \leq \frac{3200}{FS_2} \Rightarrow FS_2 \leq 2,67$

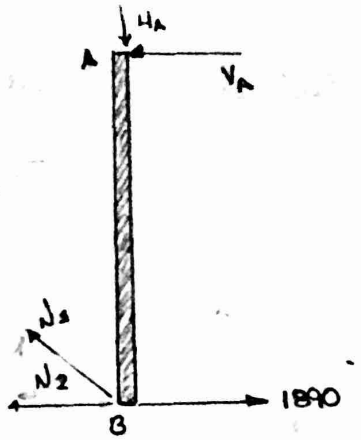
$\sigma_{N_3} \leq \overline{\sigma} \Rightarrow \frac{15000}{10} \leq \frac{3200}{FS_3} \Rightarrow FS_3 \leq 2,13$

3.7)




$\sin\alpha = 0,6$

$\cos\alpha = 0,8$




$\Sigma F_x = 0 \cdot N_2 + V_A + N_1 \cos\alpha = 1890 \Rightarrow$

$\Rightarrow N_2 + V_A + 0{,}8 N_1 = 1890$

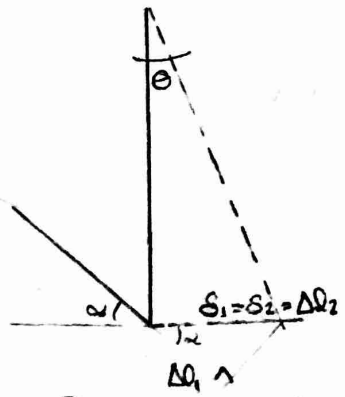
$\Sigma F_y = 0 \cdot -H_A + N_1 \operatorname{sen}\alpha = 0 \Rightarrow$

$\Rightarrow 0{,}6 N_1 = H_A$

$\therefore \Sigma M_{(A)} = 0 \cdot 1890 \cdot 1{,}5 - N_1 \cos\alpha \cdot 1{,}5 - N_2 1{,}5 = 0 \Rightarrow$

$\Rightarrow N_1 0{,}8 + N_2 = 1890 \quad (1)$

3 equações e 4 incógnitas




$\cos\alpha = \frac{\Delta\ell_1}{\delta_1} \Rightarrow \delta_1 = \frac{\Delta\ell_1}{0{,}8} \Rightarrow \Delta\ell_2 = \frac{\Delta\ell_1}{0{,}8}$

$\sigma_N = \frac{N}{A} = \varepsilon E \Rightarrow \frac{N}{A} = \frac{\Delta\ell}{\ell} \cdot E \Rightarrow \Delta\ell = \frac{N\ell}{EA}$

$\frac{N_2 \ell_2}{EA} = \frac{N_1 \ell_1}{EA} \cdot \frac{1}{0{,}8} \Rightarrow 1{,}6 N_2 = 2{,}5 N_1 \Rightarrow$

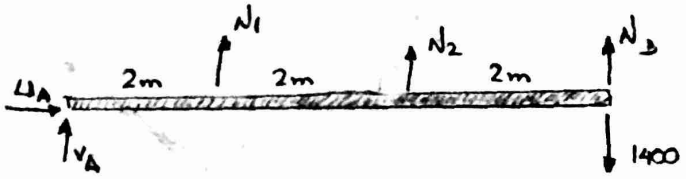
$\Rightarrow N_2 = \frac{2{,}5 N_1}{1{,}6} \quad (2)$ $\qquad 1{,}6 N_2 = 2{,}5 N_1$

$\Rightarrow N_2 = \frac{2{,}5 N_1}{1{,}6}$

De (2) em (1):

$N_1 = 800\,kgf \quad N_2 = 1250\,kgf$

3.11) Tensão admissível: $\bar{\sigma} = 1800\,kgf/cm^2$
$\theta_{máx} = 0{,}002\,rad$
$E = 360000\,kgf/cm^2$

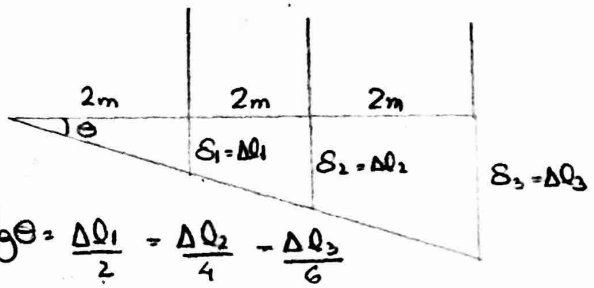



$\Sigma F_x = 0 \cdot H_A = 0$

$\Sigma F_y = 0 \cdot V_A + N_1 + N_2 + N_3 = 1400$

$\Sigma M_{(A)} = 0 \cdot N_1 2 + N_2 4 + N_3 6 - 1400\,6 = 0 \Rightarrow$

$\Rightarrow 2N_1 + 4N_2 + 6N_3 = 8400$




$\operatorname{tg}\theta = \frac{\Delta\ell_1}{2} = \frac{\Delta\ell_2}{4} = \frac{\Delta\ell_3}{6}$

$\Delta\ell_1 = \frac{\Delta\ell_2}{2} \Rightarrow \frac{N_1 \ell_1}{EA} = \frac{N_2 \ell_2}{2EA} \Rightarrow N_1 = \frac{N_2}{2}$

$\frac{\Delta\ell_2}{2} = \frac{\Delta\ell_3}{3} \Rightarrow \frac{N_2 \ell_2}{2EA} = \frac{N_3 \ell_3}{3EA} \Rightarrow N_2 = \frac{2N_3}{3} \Rightarrow N_3 = \frac{3N_2}{2}$

$N_2 + 4N_2 + 9N_2 = 8400 \Rightarrow 14N_2 = 8400 \Rightarrow$

$\Rightarrow N_2 = 600 \therefore N_1 = 300 \text{ e } N_3 = 900$

Critério da tensão máxima:

$\sigma_{N_3} \leq \bar{\sigma} \Rightarrow \frac{900}{A} \leq 1800 \Rightarrow A \geq 0{,}5\,cm^2$

Critério da rotação máxima:

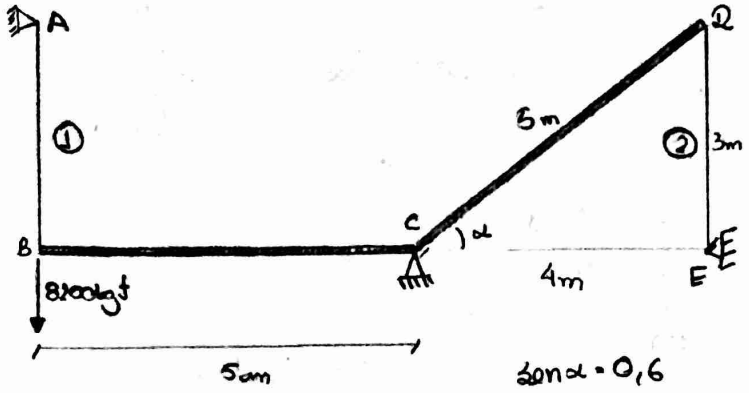
$\operatorname{tg}\theta_{máx} \geq \frac{\Delta\ell_3}{6} \Rightarrow \operatorname{tg}(0{,}002) \geq \frac{N_3 \ell_3}{6 \cdot EA} \Rightarrow$

$\Rightarrow A \geq \frac{N_3 \cdot \ell_3}{6 E \operatorname{tg} 0{,}002} = \frac{900 \cdot 3}{6 \cdot 36 \cdot 10^4 \operatorname{tg} 0{,}002} \Rightarrow$

$\Rightarrow A \geq \frac{1}{1{,}6} \Rightarrow A \geq 0{,}625\,cm^2$

$\therefore A_{min} = 0{,}625\,cm^2$

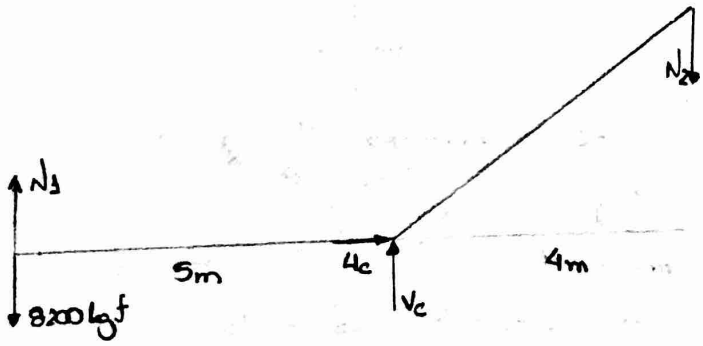
3.13) $\sigma_e = 2000\,kgf/cm^2$
$E = 30000\,kgf/cm^2$
$\xi = 2$
$V_B \leq 8\,cm$




$\sin\alpha = 0,6$

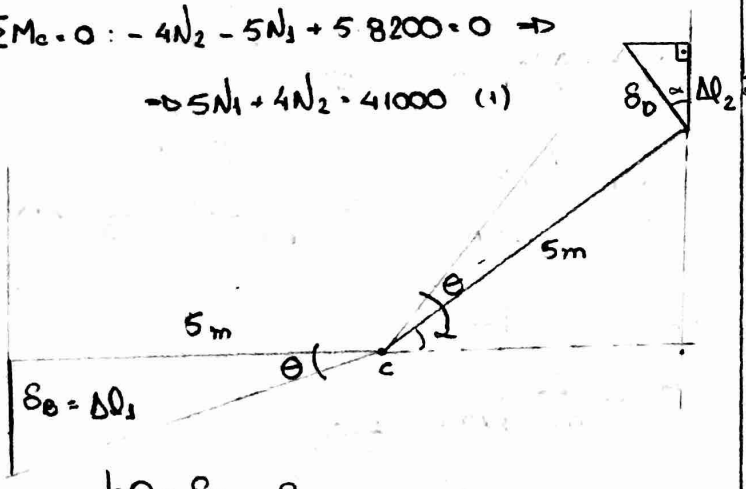
$\cos\alpha = 0,8$

Equilíbrio:




$\Sigma M_c = 0 : -4N_2 - 5N_1 + 5\,8200 = 0 \Rightarrow$

$\Rightarrow 5N_1 + 4N_2 = 41000 \quad (1)$




$\operatorname{tg}\theta = \frac{\delta_D}{5} = \frac{\delta_B}{6}$ ; $\delta_B = \Delta l_1$

$\cos\alpha = \frac{\Delta l_2}{\delta_D} \Rightarrow \delta_D = \frac{\Delta l_2}{\cos\alpha} \Rightarrow \delta_D = \frac{5\Delta l_2}{4}$

$\frac{5\Delta l_2}{4}\cdot\frac{1}{5} = \frac{\Delta l_1}{5} \Rightarrow \Delta l_2 = 0,8\,\Delta l_1$

Lembrando: $\frac{N}{A} = \varepsilon \cdot E \Rightarrow \frac{N}{A} = \frac{\Delta l}{l} E \Rightarrow \Delta l = \frac{Nl}{EA}$

$\frac{N_2 \ell_2}{EA} = 0,8\frac{N_1 \ell_1}{EA} \Rightarrow N_2 = 0,8N_1 \quad (2)$

(2) em (1):

$5N_1 + 3,2N_1 = 41000 \Rightarrow 8,2N_1 = 41000 \Rightarrow$

$\Rightarrow \boxed{N_1 = 5000\,kgf}$ $\boxed{N_2 = 4000\,kgf}$

$\bar{\sigma} = \frac{\sigma_e}{2} = \frac{2000}{2} = 1000\,kgf/cm^2$

Critério 1:

$\sigma_{N1} > \sigma_{N2}$ · $\sigma_{N1} \leq \bar{\sigma} \Rightarrow \frac{N_1}{A} \leq 1000 \Rightarrow$

$\Rightarrow A \geq \frac{5000}{1000} \Rightarrow A \geq 5cm^2$

Critério 2:

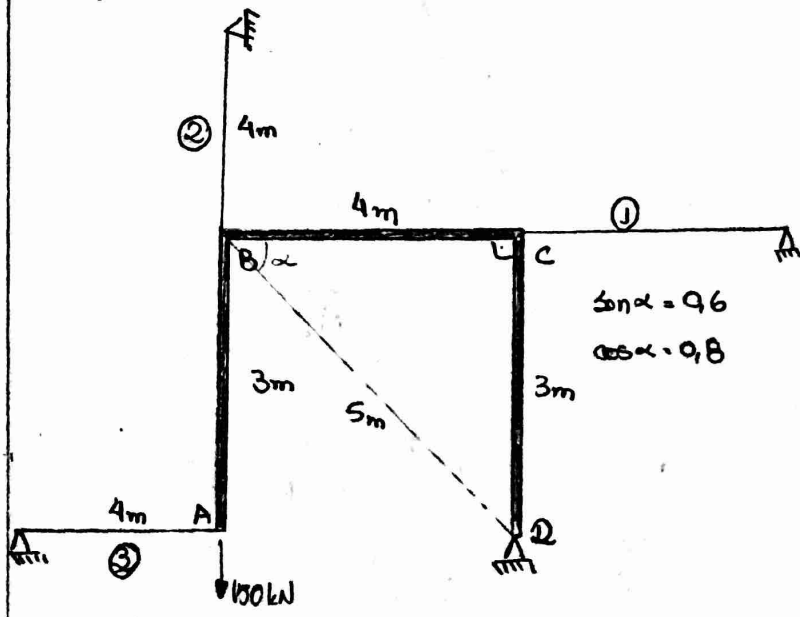
$\Delta l_1 = \frac{N_1 \cdot l_1}{EA} = \frac{5000\,kgf \cdot 300cm}{30000\,kgf/cm^2 \cdot A} = \frac{5\,300}{30A} = \frac{50}{A}$

$\Rightarrow \Delta l_1 = \frac{50}{A}$

$\delta_B = \Delta l_1 \leq V_B \Rightarrow \frac{50}{A} \leq 8cm \Rightarrow A \geq 6,25cm^2$

Logo, a área mínima é $6,25cm^2$

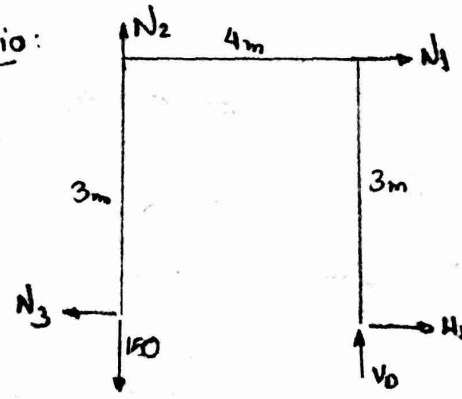
3.9) $\begin{cases} A = 8\cdot10^{-4}m^2 \\ E = 9,6GPa \end{cases}$




$\sin\alpha = 0,6$

$\cos\alpha = 0,8$

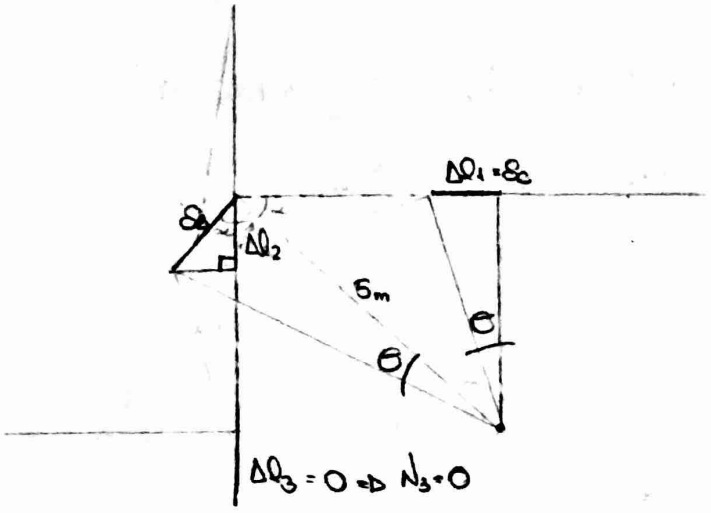
Equilíbrio:



$\Sigma M_D = 0 : -3N_1 - 4N_2 + 600 = 0 \Rightarrow 3N_1 + 4N_2 = 600 \ (1)$

$\Sigma F_H = 0 : H_D + N_1 - N_3 = 0$

$\Sigma F_V = 0 : V_D + N_2 = 150$




$tg\theta = \frac{\delta_B}{5} = \frac{\delta_C}{3}$

$\cos\alpha = \frac{\Delta l_2}{\delta_B} \Rightarrow \delta_B = \frac{\Delta l_2}{\cos\alpha} = \frac{5\Delta l_2}{4}$

$\frac{\Delta l_2}{4}\frac{1}{5} = \frac{\Delta l_1}{3} \Rightarrow \Delta l_2 = \frac{4}{3}\Delta l_1$

$\frac{N_2 l_2}{EA} = \frac{4}{3}\frac{N_1 l_1}{EA} \Rightarrow N_2 = \frac{4}{3}N_1 \ (2)$

De (2) em (1):

$\frac{9N_1}{3} + \frac{16N_1}{3} = 600 \Rightarrow N_1 = \frac{1800}{25} = 72kN \Rightarrow$

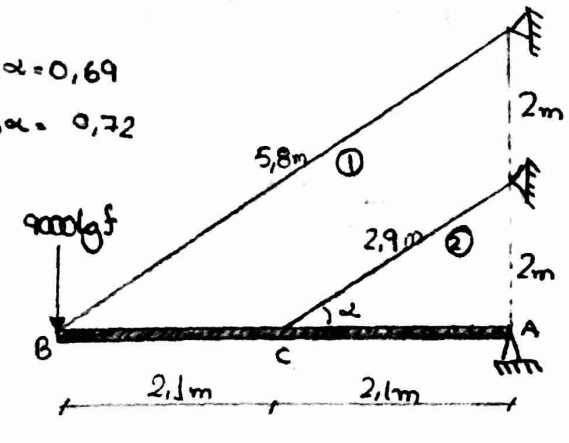
$\Rightarrow \boxed{N_1 = 72000N} \quad \boxed{N_2 = 96000N}$

$\delta_B = \frac{5}{4}\frac{N_2 l_2}{EA} = \frac{5}{4}\frac{96000}{9{,}6\cdot10^9 \cdot 8\cdot10^{-4}} = 0{,}0625$

$h_B = 0{,}0625 \sin\alpha = 0{,}0375\,m$

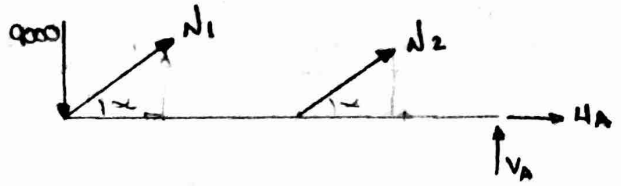
3.16) $\sin\alpha = 0{,}69$

$\cos\alpha = 0{,}72$



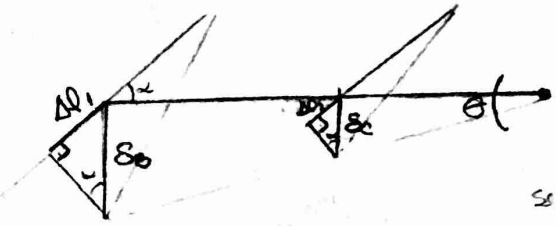

Dados: $\bar{\sigma} = 2175 kgf/cm^2$; $E = 243890 kgf/cm^2$; $V_B = 5cm$

Equilíbrio:




$\Sigma M_A = 0 \ -2{,}1N_2\sin\alpha - 4N_1\sin\alpha + 9000 \cdot 4{,}2 = 0 \Rightarrow$

$\Rightarrow 4{,}2N_1 + 2{,}1N_2 = \frac{9000 \cdot 4{,}2}{0{,}69}$




$tg\theta = \frac{\delta_C}{2{,}1} = \frac{\delta_B}{4{,}2} \Rightarrow \delta_C = \frac{\delta_B}{2}$

$\sin\alpha = \frac{\Delta l_2}{\delta_C} \Rightarrow \delta_C = \frac{\Delta l_2}{\sin\alpha} \ e \ \delta_B = \frac{\Delta l_1}{\sin\alpha}$

$\frac{\Delta l_2}{\sin\alpha} = \frac{\Delta l_1}{\sin\alpha}\frac{1}{2} \Rightarrow \frac{N_2 l_2}{EA} = \frac{1}{2}\frac{N_1 l_1}{EA} \Rightarrow$

$\Rightarrow N_2\,2{,}9 = \frac{N_1\,5{,}8}{2} \Rightarrow N_2 = N_1 \ (2)$

De (2) em (1):

$6{,}3N_1 = \frac{9000}{0{,}69}4{,}2 \Rightarrow$

$\Rightarrow \boxed{N_1 = 8695\,kgf} \quad \boxed{N_2 = 8695\,kgf}$

Critério 1:

$\sigma_{N_1} = \sigma_{N_2} \quad \frac{N_2}{A} \le 2175 \Rightarrow A \ge \frac{8695}{2175} \Rightarrow A \ge 4cm^2$

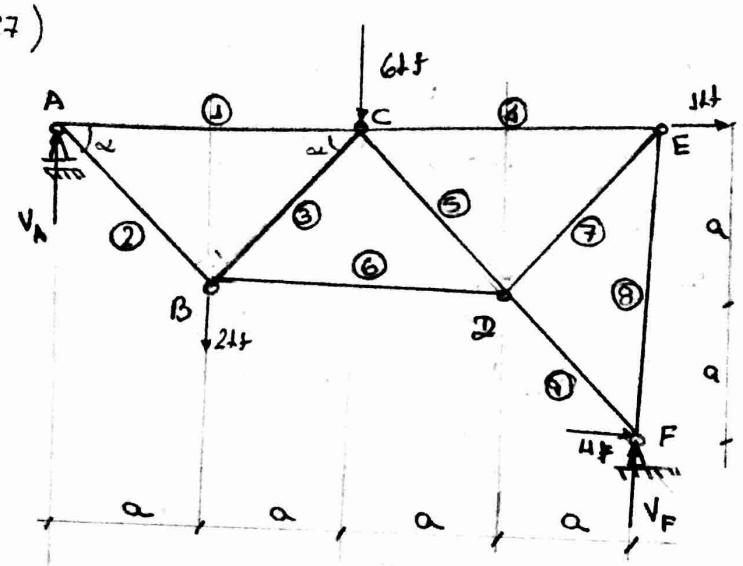
Critério 2:

$\delta_B = \frac{N_1 l_1}{EA}\frac{1}{\sin\alpha} = \frac{4348\,580}{243890\,A} \approx \frac{21}{A}$

$\delta_B \le 5cm \Rightarrow A \ge \frac{21}{5} = 4{,}2cm^2$

Logo, $A_{min} = 4{,}2cm^2$

3.27)




$\sin\alpha = \frac{1}{\sqrt{2}}$

$\cos\alpha = \frac{1}{\sqrt{2}}$

| | | | |
|---|---|---|---|
| $V_A$ | 4 | $N_4$ | $-2$ |
| $V_F$ | 4 | $N_5$ | $-4\sqrt{2}$ |
| $H_F$ | $-1$ | $N_6$ | 6 |
| $N_1$ | $-4$ | $N_7$ | $3\sqrt{2}$ |
| $N_2$ | $4\sqrt{2}$ | $N_8$ | $-3$ |
| $N_3$ | $2\sqrt{2}$ | $N_9$ | $-\sqrt{2}$ |

Reações de equilíbrio:

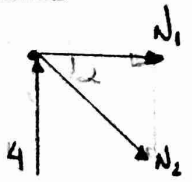
$\Sigma F_x = 0 : H_F = -11f$

$\Sigma F_y = 0 : V_A + V_F - 2 - 6 = 0 \Rightarrow V_A + V_F = 8$

$\Sigma M_{(F)} = 0 : -2a + 12a + 6a - 4V_A a = 0 \Rightarrow$

$\Rightarrow 4V_A = 16 \Rightarrow V_A = 4\,1f \quad V_F = 4$

Nó A:

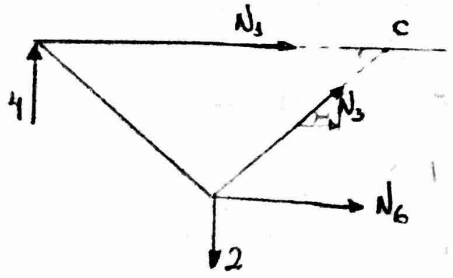



$N_1 + \frac{N_2}{\sqrt{2}} = 0$

$4 - \frac{N_2}{\sqrt{2}} = 0 \Rightarrow N_2 = 4\sqrt{2}$

$\therefore N_1 = -4$

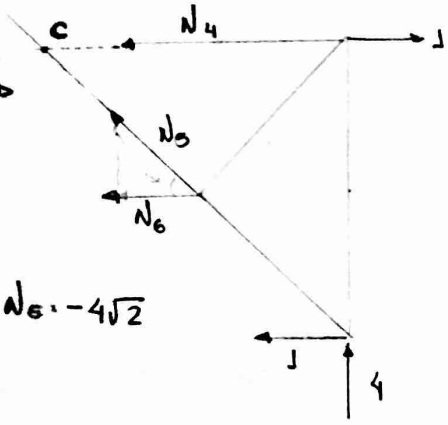
Corte 1:




$4 + \frac{N_3}{\sqrt{2}} - 2 = 0 \Rightarrow N_3 = -2\sqrt{2}$

$\Sigma M_{(C)} = 0 : -8a + aN_6 + 2a = 0 \Rightarrow N_6 = 6$

Corte 2:



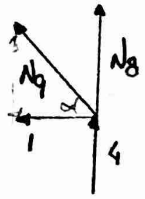

$-N_4 - \frac{N_5}{\sqrt{2}} - N_6 = 0 \Rightarrow$

$N_4 + \frac{N_5}{\sqrt{2}} = -6$

$\frac{N_5}{\sqrt{2}} + 4 = 0 \Rightarrow N_5 = -4\sqrt{2}$

$\therefore N_4 = -2$

Nó F:



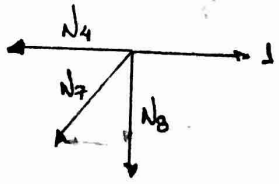

$N_8 + 4 + \frac{N_9}{\sqrt{2}} = 0 \Rightarrow$

$\Rightarrow N_8 + \frac{N_9}{\sqrt{2}} = -4$

$-\frac{N_9}{\sqrt{2}} - 1 = 0 \Rightarrow N_9 = -\sqrt{2}$

$\therefore N_8 = -3$

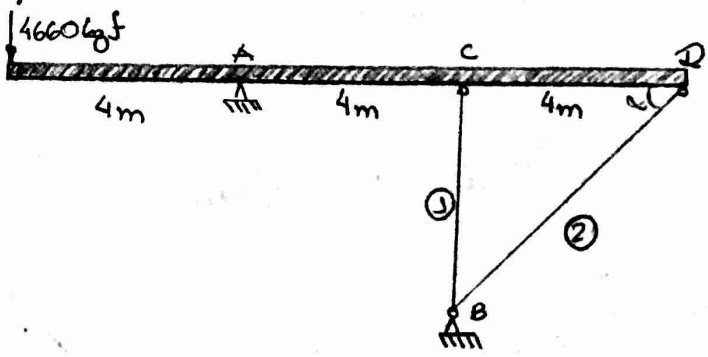
Nó E:



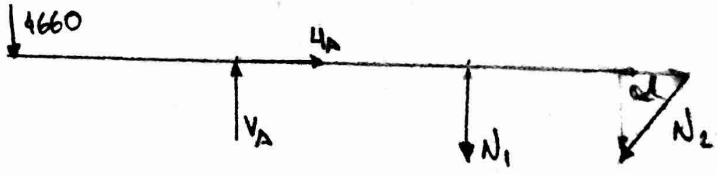

$-N_4 + 1 - \frac{N_7}{\sqrt{2}} = 0 \Rightarrow$

$\Rightarrow 2 + 1 = \frac{N_7}{\sqrt{2}} \Rightarrow N_7 = 3\sqrt{2}$

3.15)




Equilíbrio:

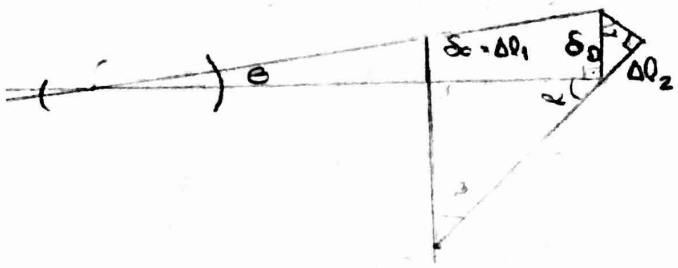



$\Sigma F_x = 0 : H_A - N_2 \cos\alpha = 0$

$\Sigma F_y = 0 : V_A - N_1 - N_2 \cos\alpha - 4660 = 0$

$\Sigma M_{(A)} = 0 \cdot 4660 \cdot 4 - 4N_1 - 8N_2 \cos\alpha = 0 \Rightarrow$

$\Rightarrow N_1 + 1{,}2 N_2 = 4660 \quad (1)$




$\operatorname{tg}\theta = \frac{\delta_c}{4} = \frac{\delta_0}{8} \Rightarrow \delta_c = \frac{\delta_0}{2}$

$\cos\alpha = \frac{\Delta l_2}{\delta_0} \Rightarrow \delta_0 = \frac{\Delta l_2}{\cos\alpha} \quad \Delta l_1 = \frac{1}{2} \cdot \frac{\Delta l_2}{\cos\alpha}$

$\sigma = \frac{N_i}{A} = \varepsilon_i \cdot E \Rightarrow \frac{N_i}{A} = \frac{\Delta l_i}{l_i} \cdot E \Rightarrow \Delta l_i = \frac{N_i \cdot l_i}{E \cdot A}, \; i = 1,2$

$\operatorname{tg}\alpha = \frac{l_1}{4} \Rightarrow \frac{6}{8_2} = \frac{l_1}{4} \Rightarrow l_1 = 3\,m \;\therefore\; l_2 = 5\,m$

$\frac{N_1 l_1}{EA} = \frac{1}{2} \cdot \frac{N_2 l_2}{EA} \cdot \frac{10^5}{6} \Rightarrow N_1 3 = N_2 5 \frac{5}{6} \Rightarrow$

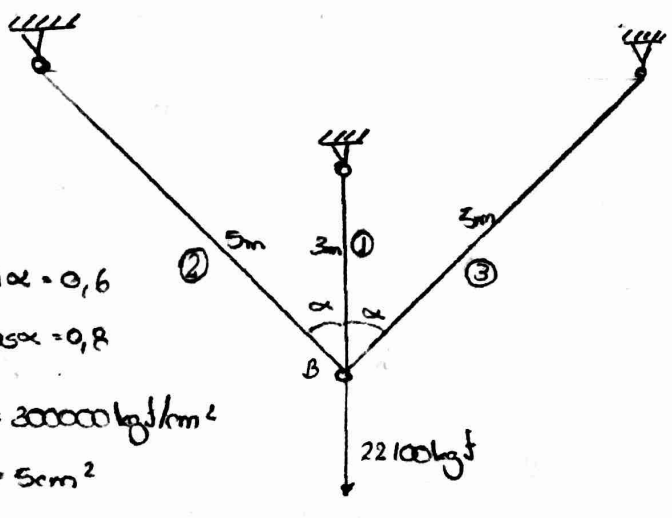
$\Rightarrow N_1 = \frac{25}{18} N_2 \quad (2)$

De (2) em (1):

$\frac{25}{18} N_2 + \frac{12}{10} N_2 = 4660 \Rightarrow \boxed{N_2 = 1800\,kgf}$

$\therefore \boxed{N_1 = 2500\,kgf}$

3.8)

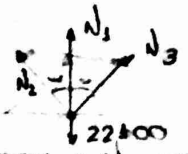



$\begin{cases} \operatorname{sen}\alpha = 0{,}6 \\ \cos\alpha = 0{,}8 \end{cases}$

$E = 300000\,kgf/cm^2$

$A = 5\,cm^2$

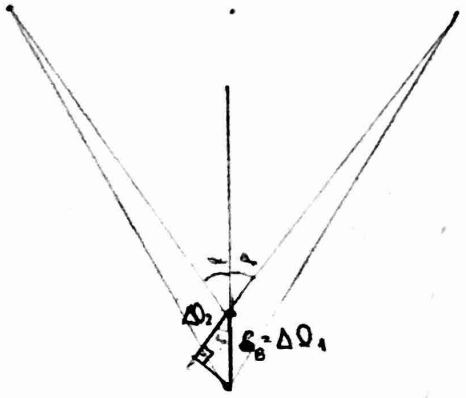
a)




$\Sigma F_x = 0 : -N_2 \operatorname{sen}\alpha + N_3 \operatorname{sen}\alpha = 0 \Rightarrow N_2 = N_3$

$\Sigma F_y = 0 \quad N_2 \cos\alpha + N_3 \cos\alpha + N_1 - 22100 = 0 \Rightarrow$

$\Rightarrow 2N_2 \cos\alpha + N_1 = 22100 \quad (1)$




$\cos\alpha = \frac{\Delta l_2}{\delta_B} \Rightarrow \Delta l_2 = \Delta l_1 \cos\alpha \Rightarrow \Delta l_2 = 0{,}8 \Delta l_1$

$\sigma = \varepsilon_i E \Rightarrow \frac{N_i}{A} = \varepsilon_i \cdot E \Rightarrow \frac{N_i}{A} = \frac{\Delta l_i}{l_i} \cdot E \Rightarrow$

$\Rightarrow \Delta l_i = \frac{N_i \cdot l_i}{E \cdot A}$

$\frac{N_2 l_2}{EA} = \frac{0{,}8 N_1 l_1}{EA} \Rightarrow 5N_2 = 0{,}8 \cdot 3 \cdot N_1 \Rightarrow$

$\Rightarrow 5N_2 = 2{,}4 N_1 \Rightarrow N_2 = 0{,}48 N_1 \quad (2)$

De (2) em (1):

$0{,}768 N_1 + N_1 = 22100 \Rightarrow 1{,}768 N_1 = 22100 \Rightarrow$

$\Rightarrow N_1 = 12500\,kgf$

$N_2 = 6000\,kgf$

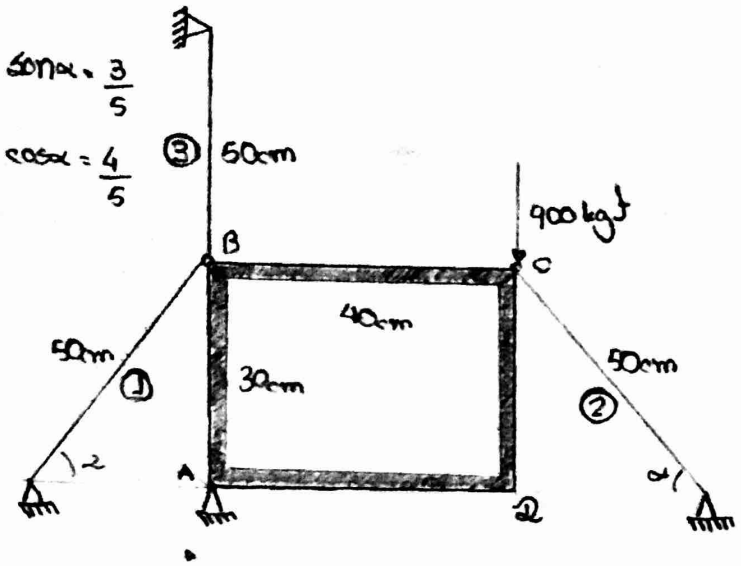
b) $\delta_B = \Delta l_1 \Rightarrow \delta_B = \frac{N_1 l_1}{E \cdot A} \Rightarrow \delta_B = \frac{12500\,kgf \cdot 300\,cm}{300000 \frac{kgf}{cm^2} \cdot 5\,cm^2} =$

$= \frac{12500 \cdot 300}{300000 \cdot 5} = 2{,}5\,cm$

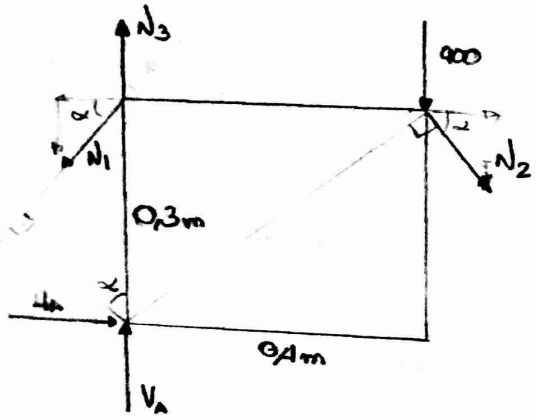
c) $\sigma = \frac{N_1}{A} = \frac{12500}{5} = 2500\,kgf/cm^2$

3.14) Critérios: $\begin{cases} \bar{\sigma} = 480\,kgf/cm^2 \\ \varphi \leq 0{,}025\,rad \end{cases}$

Dados: $\begin{cases} l = 50\,cm \\ E = 10^5\,kgf/cm^2 \end{cases}$

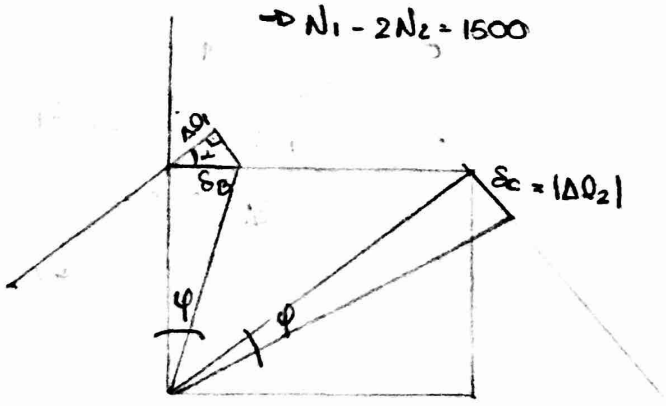



Equilibrio:




$\Sigma M_{(A)} = 0 \cdot N_1 \cos\alpha \cdot 0{,}3 - N_2 \cos\alpha\ 0{,}3 - N_2 \operatorname{sen}\alpha\, 0{,}9 + -900 \cdot 0{,}4 = 0 \Rightarrow 0{,}24 N_1 - 0{,}48 N_2 = 360 \Rightarrow$

$\Rightarrow N_1 - 2N_2 = 1500$




$tg\varphi = \frac{\delta_B}{0{,}3} = \frac{\delta_c}{0{,}5}$ ; $\cos\alpha = \frac{\Delta l_1}{\delta_B} \Rightarrow \delta_B = \frac{\Delta l_1}{0{,}8}$

$\frac{1}{0{,}8} \frac{N_1 l_1}{EA} \frac{1}{0{,}3} = \frac{-1}{0{,}5} \frac{N_2 l_2}{EA} \Rightarrow \frac{5N_1}{4} = -N_2$

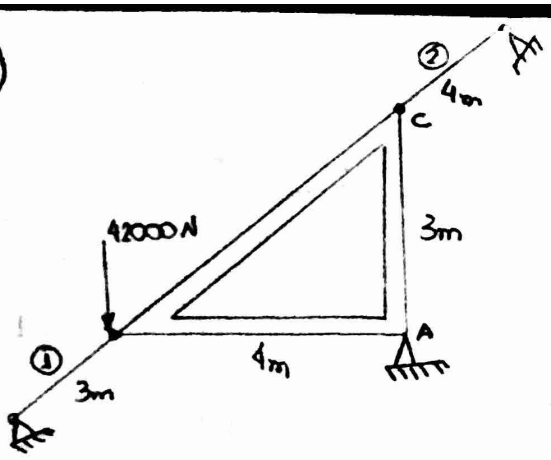
$\therefore N_1 + 2{,}5 N_1 = 1500 \Rightarrow N_1 = 428{,}57$ kgf

$N_2 = -535{,}7125$ kgf

Critério 1: $\frac{|N_2|}{A} \leq 480 \Rightarrow A \geq \frac{535{,}7125}{480} = 1{,}12\,cm^2$

Critério 2: $\frac{1}{30} \frac{535{,}7125}{10^5 A} 50 \leq 0{,}025\,rad \Rightarrow A \geq 0{,}36\,cm^2$

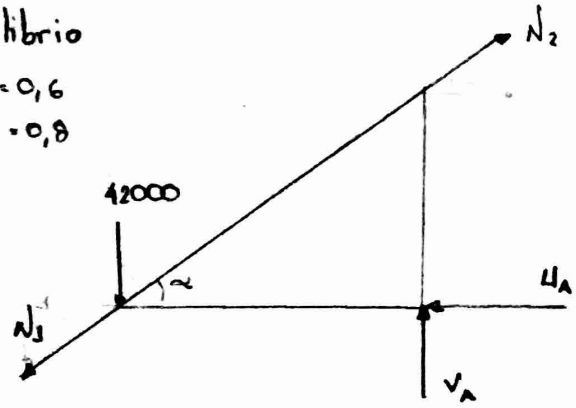
3.19)




Equilibrio

$\operatorname{sen}\alpha = 0{,}6$

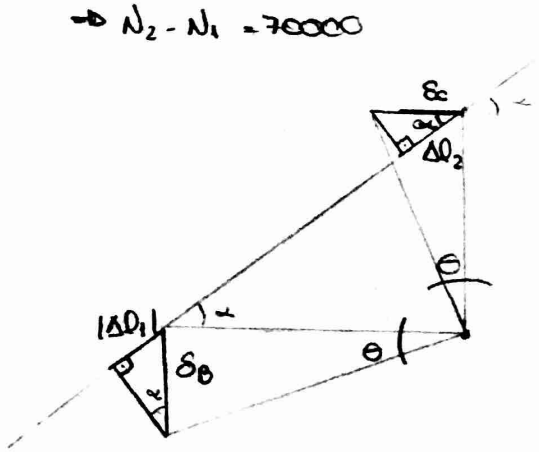
$\cos\alpha = 0{,}8$




$\Sigma M_{(A)} = 0 : N_1 \operatorname{sen}\alpha \cdot 4 + 42000\ 4 - N_2 \cos\alpha \cdot 3 = 0 \Rightarrow$

$\Rightarrow 2{,}4 N_2 - 2{,}4 N_1 = 168000 \Rightarrow$

$\Rightarrow N_2 - N_1 = 70000$




$tg\theta = \frac{\delta_B}{4} = \frac{\delta_c}{3}$

$\operatorname{sen}\alpha = \frac{|\Delta l_1|}{\delta_B} \Rightarrow \delta_B = \frac{|\Delta l_1|}{\operatorname{sen}\alpha}$

$\cos\alpha = \frac{\Delta l_2}{\delta_c} \Rightarrow \delta_c = \frac{\Delta l_2}{\cos\alpha}$

$\therefore -\frac{1}{4} \frac{1}{0{,}6} \frac{N_1 l_1}{EA} = \frac{1}{3} \frac{1}{0{,}8} \frac{N_2 l_2}{EA}$

$\Rightarrow -\frac{1}{2{,}4} N_1 3 = \frac{1}{2{,}4} 4 N_2 \Rightarrow N_2 = -0{,}75 N_1$

$\therefore N_1 = -40000\,N$ e $N_2 = 30000\,N$

$\delta_B = \frac{1}{0{,}6} \left| \frac{N_1 l_1}{EA} \right| = \frac{1}{0{,}6} \frac{40000 \cdot 3}{10^9 \cdot A} = \frac{0{,}0002}{A}$

Critério 1:

$$\frac{|N_1|}{A} \leq 40 \cdot 10^6 \rightarrow \frac{40 \cdot 10^3}{40 \cdot 10^6} \leq A \rightarrow 0{,}001 \leq A$$

Critério 2:

$$\delta_B \leq 0{,}10 \rightarrow \frac{0{,}002}{A} \leq 0{,}10 \rightarrow A \geq 0{,}002$$

Logo, a área mínima é 0,002.