Universidade Federal de São Carlos
Departamento de Engenharia de Produção

Otimização Linear Contínua e Discreta (Tópicos Avançados em PCSP)

PPGEP, UFSCar - Semestre 01/2022
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Tópico 6.3: Métodos de pontos interiores: Exercício resolvido

Método primal-dual de pontos interiores

▷ Exercício

Determine a solução ótima usando o método primal-dual de pontos interiores:

$$
\begin{aligned}
\text{max} \quad & f(x_1, x_2) = 3x_1 + 2x_2 \\
\text{s.a} \quad & 0{,}5x_1 + 0{,}3x_2 \leq 3 \\
& 0{,}1x_1 + 0{,}2x_2 \leq 1 \\
& 0{,}4x_1 + 0{,}5x_2 \leq 3 \\
& x_1 \geq 0, x_2 \geq 0
\end{aligned}
$$

Método primal-dual de pontos interiores

▷ Exercício

Determine a solução ótima usando o método primal-dual de pontos interiores:

$$
\begin{aligned}
\text{min} \quad & -3x_1 - 2x_2 + 0x_3 + 0x_4 + 0x_5 \\
\text{s.a} \quad & 0{,}5x_1 + 0{,}3x_2 + x_3 = 3 \\
& 0{,}1x_1 + 0{,}2x_2 + x_4 = 1 \\
& 0{,}4x_1 + 0{,}5x_2 + x_5 = 3 \\
& x_1, x_2, x_3, x_4, x_5 \geq 0
\end{aligned}
$$

Método primal-dual de pontos interiores

▷ Exercício: Inicialização

Dados do problema:

$$c^T = \begin{bmatrix} -3 & -2 & 0 & 0 & 0 \end{bmatrix}$$

$$A = \begin{bmatrix} 0{,}5 & 0{,}3 & 1 & 0 & 0 \\ 0{,}1 & 0{,}2 & 0 & 1 & 0 \\ 0{,}4 & 0{,}5 & 0 & 0 & 1 \end{bmatrix} \quad b = \begin{bmatrix} 3 \\ 1 \\ 3 \end{bmatrix}$$

Começamos com a solução inicial arbitrária:

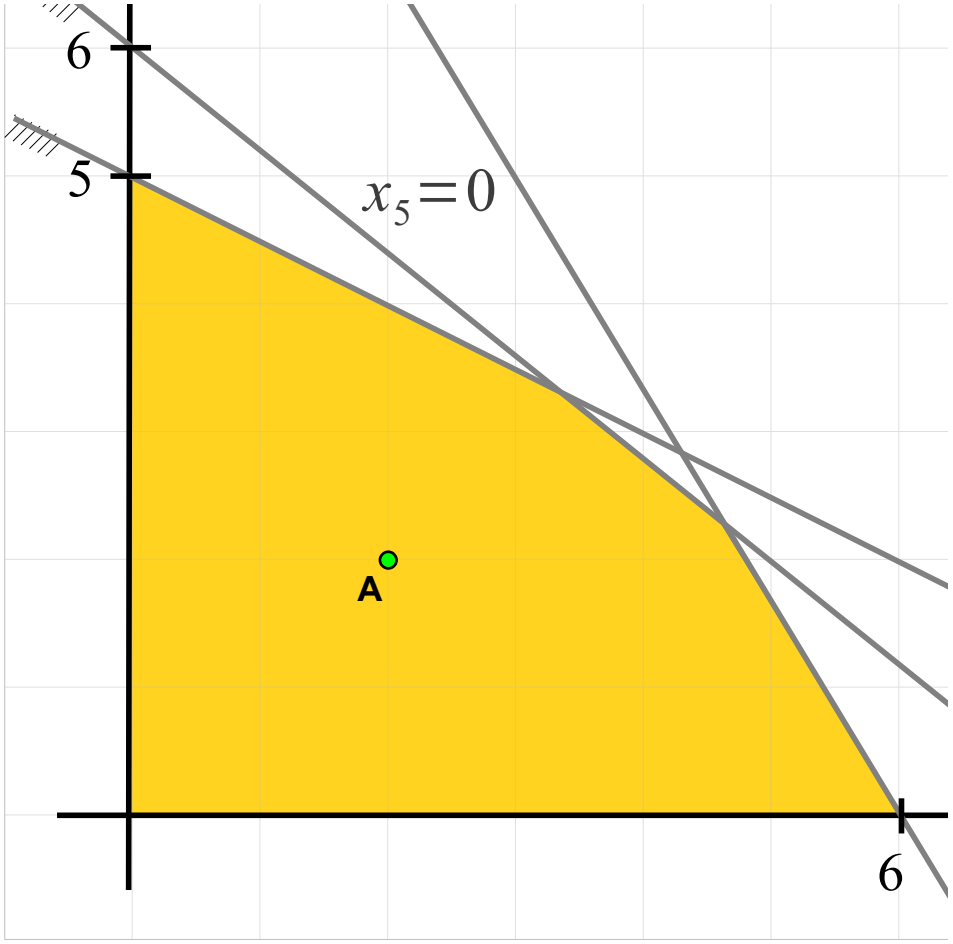
$$\bar{x} = (2,\ 2,\ 1{,}4,\ 0{,}4,\ 1{,}2), \quad \bar{p} = (-5,\ -5,\ -5), \quad \bar{s} = (2,\ 3,\ 5,\ 5,\ 5)$$

(escolhemos $x_1 = x_2 = 2$ e as demais são determinadas pelo sistema primal; de forma análoga, escolhemos $\bar{p}$ de modo a se ter $\bar{s} > 0$ pelo sistema dual)

Parâmetros: $\sigma = 0{,}5$; $\delta_p = \delta_d = \delta_o = 0{,}01$; $\alpha_0 = 0{,}95$.

Método primal-dual de pontos interiores

▷ Exercício: Inicialização



Método primal-dual de pontos interiores

▷ Exercício: Código em Octave

```
A = [0.5 0.3 1 0 0; 0.1 0.2 0 1 0; 0.4 0.5 0 0 1]
c = [-3; -2; 0; 0; 0]
b = [3; 1; 3]

n = 5
m = 3

x = [2 ; 2; 1.4; 0.4; 1.2]
p = [-5; -5; -5]
s = [2; 3; 5; 5; 5]

sigma = 0.5
alpha0 = 0.95

e = [1; 1; 1; 1; 1]
```

Método primal-dual de pontos interiores

▷ Exercício: Código em Octave

```
mu = (x' * s) / n

X = diag(x)
S = diag(s)

J = [A zeros(m,m) zeros(m,n); zeros(n,n) A' eye(n); S zeros(n,m) X]
F = [A * x - b; A' * p + s - c; X * S * e - sigma * mu *e]
D = J \ (-F)

Dx = D(1:n)
Dp = D(n+1:n+m)
Ds = D(n+m+1:2*n+m)

-x ./ Dx
-s ./ Ds

alpha = alpha0 * (- s(1)/Ds(1)) /* Coloque aqui a variável com menor razao */

x = x + alpha * Dx
p = p + alpha * Dp
s = s + alpha * Ds
```

Iteração 1:

- $\bar{x} = \begin{bmatrix} 2.0 \\ 2.0 \\ 1.4 \\ 0.4 \\ 1.2 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -5 \\ -5 \\ -5 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 2 \\ 3 \\ 5 \\ 5 \\ 5 \end{bmatrix}.$

Iteração 1:

- $\bar{x} = \begin{bmatrix} 2.0 \\ 2.0 \\ 1.4 \\ 0.4 \\ 1.2 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -5 \\ -5 \\ -5 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 2 \\ 3 \\ 5 \\ 5 \\ 5 \end{bmatrix}.$
- $\bar{\mu} =$

Iteração 1:

- $\bar{x} = \begin{bmatrix} 2.0 \\ 2.0 \\ 1.4 \\ 0.4 \\ 1.2 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -5 \\ -5 \\ -5 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 2 \\ 3 \\ 5 \\ 5 \\ 5 \end{bmatrix}.$
- $\bar{\mu} = \bar{x}^T \bar{s}/n =$

Iteração 1:

- $\bar{x} = \begin{bmatrix} 2.0 \\ 2.0 \\ 1.4 \\ 0.4 \\ 1.2 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -5 \\ -5 \\ -5 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 2 \\ 3 \\ 5 \\ 5 \\ 5 \end{bmatrix}.$
- $\bar{\mu} = \bar{x}^T \bar{s}/n = (2 * 2 + 2 * 3 + 1.4 * 5 + 0.4 * 5 + 1.2 * 5)/5 = 25/5 = 5;$

Iteração 1:

- $\bar{x} = \begin{bmatrix} 2.0 \\ 2.0 \\ 1.4 \\ 0.4 \\ 1.2 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -5 \\ -5 \\ -5 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 2 \\ 3 \\ 5 \\ 5 \\ 5 \end{bmatrix}.$
- $\bar{\mu} = \bar{x}^T \bar{s}/n = (2 * 2 + 2 * 3 + 1.4 * 5 + 0.4 * 5 + 1.2 * 5)/5 = 25/5 = 5;$
- Calcular as componentes de $F(\bar{x}, \bar{p}, \bar{s})$:

Iteração 1:

- $\bar{x} = \begin{bmatrix} 2.0 \\ 2.0 \\ 1.4 \\ 0.4 \\ 1.2 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -5 \\ -5 \\ -5 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 2 \\ 3 \\ 5 \\ 5 \\ 5 \end{bmatrix}.$
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- Calcular as componentes de $F(\bar{x}, \bar{p}, \bar{s})$:

$$r_p = A\bar{x} - b = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix},$$

Iteração 1:

- $\bar{x} = \begin{bmatrix} 2.0 \\ 2.0 \\ 1.4 \\ 0.4 \\ 1.2 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -5 \\ -5 \\ -5 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 2 \\ 3 \\ 5 \\ 5 \\ 5 \end{bmatrix}.$
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- Calcular as componentes de $F(\bar{x}, \bar{p}, \bar{s})$:

$$r_p = A\bar{x} - b = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_d = A^T \bar{p} + \bar{s} - c = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix},$$

Iteração 1:

- $\bar{x} = \begin{bmatrix} 2.0 \\ 2.0 \\ 1.4 \\ 0.4 \\ 1.2 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -5 \\ -5 \\ -5 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 2 \\ 3 \\ 5 \\ 5 \\ 5 \end{bmatrix}.$
- $\bar{\mu} = \bar{x}^T \bar{s}/n = (2 * 2 + 2 * 3 + 1.4 * 5 + 0.4 * 5 + 1.2 * 5)/5 = 25/5 = 5;$
- Calcular as componentes de $F(\bar{x}, \bar{p}, \bar{s})$:

$$r_p = A\bar{x} - b = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_d = A^T \bar{p} + \bar{s} - c = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_\mu = \bar{X}\bar{s} - \sigma\bar{\mu}e = \begin{bmatrix} 1.5 \\ 3.5 \\ 4.5 \\ -0.5 \\ 3.5 \end{bmatrix}.$$

Iteração 1:

- $\bar{x} = \begin{bmatrix} 2.0 \\ 2.0 \\ 1.4 \\ 0.4 \\ 1.2 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -5 \\ -5 \\ -5 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 2 \\ 3 \\ 5 \\ 5 \\ 5 \end{bmatrix}.$
- $\bar{\mu} = \bar{x}^T \bar{s}/n = (2 * 2 + 2 * 3 + 1.4 * 5 + 0.4 * 5 + 1.2 * 5)/5 = 25/5 = 5;$
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- Resolvendo-se $\nabla F(\bar{x}, \bar{p}, \bar{s})(\Delta x, \Delta p, \Delta s)^T = -F(\bar{x}, \bar{p}, \bar{s})$:

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- $\bar{x} = \begin{bmatrix} 2.0 \\ 2.0 \\ 1.4 \\ 0.4 \\ 1.2 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -5 \\ -5 \\ -5 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 2 \\ 3 \\ 5 \\ 5 \\ 5 \end{bmatrix}.$
- $\bar{\mu} = \bar{x}^T \bar{s}/n = (2 * 2 + 2 * 3 + 1.4 * 5 + 0.4 * 5 + 1.2 * 5)/5 = 25/5 = 5;$
- Calcular as componentes de $F(\bar{x}, \bar{p}, \bar{s})$:

$$r_p = A\bar{x} - b = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_d = A^T \bar{p} + \bar{s} - c = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_\mu = \bar{X}\bar{s} - \sigma\bar{\mu}e = \begin{bmatrix} 1.5 \\ 3.5 \\ 4.5 \\ -0.5 \\ 3.5 \end{bmatrix}.$$

- Resolvendo-se $\nabla F(\bar{x}, \bar{p}, \bar{s})(\Delta x, \Delta p, \Delta s)^T = -F(\bar{x}, \bar{p}, \bar{s})$:

$$\Delta x = \begin{bmatrix} 0.889908 \\ -0.302752 \\ -0.354128 \\ -0.028440 \\ -0.204587 \end{bmatrix},$$

Iteração 1:

- $\bar{x} = \begin{bmatrix} 2.0 \\ 2.0 \\ 1.4 \\ 0.4 \\ 1.2 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -5 \\ -5 \\ -5 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 2 \\ 3 \\ 5 \\ 5 \\ 5 \end{bmatrix}.$
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- Resolvendo-se $\nabla F(\bar{x}, \bar{p}, \bar{s})(\Delta x, \Delta p, \Delta s)^T = -F(\bar{x}, \bar{p}, \bar{s})$:

$$\Delta x = \begin{bmatrix} 0.889908 \\ -0.302752 \\ -0.354128 \\ -0.028440 \\ -0.204587 \end{bmatrix}, \quad \Delta p = \begin{bmatrix} 1.9495 \\ -1.6055 \\ 2.0642 \end{bmatrix},$$

Iteração 1:

- $\bar{x} = \begin{bmatrix} 2.0 \\ 2.0 \\ 1.4 \\ 0.4 \\ 1.2 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -5 \\ -5 \\ -5 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 2 \\ 3 \\ 5 \\ 5 \\ 5 \end{bmatrix}.$
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Iteração 1:

- $\bar{x} = \begin{bmatrix} 2.0 \\ 2.0 \\ 1.4 \\ 0.4 \\ 1.2 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -5 \\ -5 \\ -5 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 2 \\ 3 \\ 5 \\ 5 \\ 5 \end{bmatrix}.$
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- $\bar{\alpha} = \min\{1, \alpha_0(s_1/ - \Delta s_1)\} = \min\{1, 0.95 * (2.0/1.6399)\} = 1$;

Iteração 1:

- $\bar{x} = \begin{bmatrix} 2.0 \\ 2.0 \\ 1.4 \\ 0.4 \\ 1.2 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -5 \\ -5 \\ -5 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 2 \\ 3 \\ 5 \\ 5 \\ 5 \end{bmatrix}.$
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- $\bar{\alpha} = \min\{1, \alpha_0(s_1/ - \Delta s_1)\} = \min\{1, 0.95 * (2.0/1.6399)\} = 1$;
- $\bar{x} = \bar{x} + \bar{\alpha}\Delta x; \quad \bar{p} = \bar{p} + \bar{\alpha}\Delta p; \quad \bar{s} = \bar{s} + \bar{\alpha}\Delta s;$

Iteração 2:

- $\bar{x} = \begin{bmatrix} 2.88991 \\ 1.69725 \\ 1.04587 \\ 0.37156 \\ 0.99541 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -3.0505 \\ -6.6055 \\ -2.9358 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 0.36009 \\ 1.70413 \\ 3.05046 \\ 6.60550 \\ 2.93578 \end{bmatrix}.$

Iteração 2:

- $\bar{x} = \begin{bmatrix} 2.88991 \\ 1.69725 \\ 1.04587 \\ 0.37156 \\ 0.99541 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -3.0505 \\ -6.6055 \\ -2.9358 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 0.36009 \\ 1.70413 \\ 3.05046 \\ 6.60550 \\ 2.93578 \end{bmatrix}.$
- $\bar{\mu} = \bar{x}^T \bar{s}/n = 2.5;$

Iteração 2:

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- $\bar{\mu} = \bar{x}^T \bar{s}/n = 2.5$;
- Calcular as componentes de $F(\bar{x}, \bar{p}, \bar{s})$:

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$$r_p = A\bar{x} - b = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix},$$

Iteração 2:

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$$r_p = A\bar{x} - b = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_d = A^T \bar{p} + \bar{s} - c = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_\mu = \bar{X}\bar{s} - \sigma\bar{\mu}e = \begin{bmatrix} -0.20937 \\ 1.64233 \\ 1.94039 \\ 1.20434 \\ 1.67231 \end{bmatrix}.$$

Iteração 2:

- $\bar{x} = \begin{bmatrix} 2.88991 \\ 1.69725 \\ 1.04587 \\ 0.37156 \\ 0.99541 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -3.0505 \\ -6.6055 \\ -2.9358 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 0.36009 \\ 1.70413 \\ 3.05046 \\ 6.60550 \\ 2.93578 \end{bmatrix}.$
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- Resolvendo-se $\nabla F(\bar{x}, \bar{p}, \bar{s})(\Delta x, \Delta p, \Delta s)^T = -F(\bar{x}, \bar{p}, \bar{s})$:

Iteração 2:

- $\bar{x} = \begin{bmatrix} 2.88991 \\ 1.69725 \\ 1.04587 \\ 0.37156 \\ 0.99541 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -3.0505 \\ -6.6055 \\ -2.9358 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 0.36009 \\ 1.70413 \\ 3.05046 \\ 6.60550 \\ 2.93578 \end{bmatrix}.$
- $\bar{\mu} = \bar{x}^T \bar{s}/n = 2.5;$
- Calcular as componentes de $F(\bar{x}, \bar{p}, \bar{s})$:

$$r_p = A\bar{x} - b = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_d = A^T \bar{p} + \bar{s} - c = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_\mu = \bar{X}\bar{s} - \sigma\bar{\mu}e = \begin{bmatrix} -0.20937 \\ 1.64233 \\ 1.94039 \\ 1.20434 \\ 1.67231 \end{bmatrix}.$$

- Resolvendo-se $\nabla F(\bar{x}, \bar{p}, \bar{s})(\Delta x, \Delta p, \Delta s)^T = -F(\bar{x}, \bar{p}, \bar{s})$:

$$\Delta x = \begin{bmatrix} 1.811616 \\ -0.526005 \\ -0.748006 \\ -0.075960 \\ -0.461644 \end{bmatrix},$$

Iteração 2:

- $\bar{x} = \begin{bmatrix} 2.88991 \\ 1.69725 \\ 1.04587 \\ 0.37156 \\ 0.99541 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -3.0505 \\ -6.6055 \\ -2.9358 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 0.36009 \\ 1.70413 \\ 3.05046 \\ 6.60550 \\ 2.93578 \end{bmatrix}.$
- $\bar{\mu} = \bar{x}^T \bar{s}/n = 2.5;$
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$$r_p = A\bar{x} - b = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_d = A^T\bar{p} + \bar{s} - c = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_\mu = \bar{X}\bar{s} - \sigma\bar{\mu}e = \begin{bmatrix} -0.20937 \\ 1.64233 \\ 1.94039 \\ 1.20434 \\ 1.67231 \end{bmatrix}.$$

- Resolvendo-se $\nabla F(\bar{x}, \bar{p}, \bar{s})(\Delta x, \Delta p, \Delta s)^T = -F(\bar{x}, \bar{p}, \bar{s})$:

$$\Delta x = \begin{bmatrix} 1.811616 \\ -0.526005 \\ -0.748006 \\ -0.075960 \\ -0.461644 \end{bmatrix}, \quad \Delta p = \begin{bmatrix} -0.32640 \\ 1.89090 \\ 0.31849 \end{bmatrix},$$

Iteração 2:

- $\bar{x} = \begin{bmatrix} 2.88991 \\ 1.69725 \\ 1.04587 \\ 0.37156 \\ 0.99541 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -3.0505 \\ -6.6055 \\ -2.9358 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 0.36009 \\ 1.70413 \\ 3.05046 \\ 6.60550 \\ 2.93578 \end{bmatrix}.$
- $\bar{\mu} = \bar{x}^T \bar{s}/n = 2.5;$
- Calcular as componentes de $F(\bar{x}, \bar{p}, \bar{s})$:

$$r_p = A\bar{x} - b = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_d = A^T\bar{p} + \bar{s} - c = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_\mu = \bar{X}\bar{s} - \sigma\bar{\mu}e = \begin{bmatrix} -0.20937 \\ 1.64233 \\ 1.94039 \\ 1.20434 \\ 1.67231 \end{bmatrix}.$$

- Resolvendo-se $\nabla F(\bar{x}, \bar{p}, \bar{s})(\Delta x, \Delta p, \Delta s)^T = -F(\bar{x}, \bar{p}, \bar{s})$:

$$\Delta x = \begin{bmatrix} 1.811616 \\ -0.526005 \\ -0.748006 \\ -0.075960 \\ -0.461644 \end{bmatrix}, \quad \Delta p = \begin{bmatrix} -0.32640 \\ 1.89090 \\ 0.31849 \end{bmatrix}, \quad \Delta s = \begin{bmatrix} -0.15329 \\ -0.43950 \\ 0.32640 \\ -1.89090 \\ -0.31849 \end{bmatrix}.$$

Iteração 2:

- $\bar{x} = \begin{bmatrix} 2.88991 \\ 1.69725 \\ 1.04587 \\ 0.37156 \\ 0.99541 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -3.0505 \\ -6.6055 \\ -2.9358 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 0.36009 \\ 1.70413 \\ 3.05046 \\ 6.60550 \\ 2.93578 \end{bmatrix}.$
- $\bar{\mu} = \bar{x}^T \bar{s}/n = 2.5;$
- Calcular as componentes de $F(\bar{x}, \bar{p}, \bar{s})$:

$$r_p = A\bar{x} - b = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_d = A^T\bar{p} + \bar{s} - c = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_\mu = \bar{X}\bar{s} - \sigma\bar{\mu}e = \begin{bmatrix} -0.20937 \\ 1.64233 \\ 1.94039 \\ 1.20434 \\ 1.67231 \end{bmatrix}.$$

- Resolvendo-se $\nabla F(\bar{x}, \bar{p}, \bar{s})(\Delta x, \Delta p, \Delta s)^T = -F(\bar{x}, \bar{p}, \bar{s})$:

$$\Delta x = \begin{bmatrix} 1.811616 \\ -0.526005 \\ -0.748006 \\ -0.075960 \\ -0.461644 \end{bmatrix}, \quad \Delta p = \begin{bmatrix} -0.32640 \\ 1.89090 \\ 0.31849 \end{bmatrix}, \quad \Delta s = \begin{bmatrix} -0.15329 \\ -0.43950 \\ 0.32640 \\ -1.89090 \\ -0.31849 \end{bmatrix}.$$

- $\bar{\alpha} = \min\{1, \alpha_0(x_3/ - \Delta x_3)\} = \min\{1, 1.3283\} = 1;$

Iteração 2:

- $\bar{x} = \begin{bmatrix} 2.88991 \\ 1.69725 \\ 1.04587 \\ 0.37156 \\ 0.99541 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -3.0505 \\ -6.6055 \\ -2.9358 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 0.36009 \\ 1.70413 \\ 3.05046 \\ 6.60550 \\ 2.93578 \end{bmatrix}.$
- $\bar{\mu} = \bar{x}^T \bar{s}/n = 2.5;$
- Calcular as componentes de $F(\bar{x}, \bar{p}, \bar{s})$:

$$r_p = A\bar{x} - b = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_d = A^T\bar{p} + \bar{s} - c = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_\mu = \bar{X}\bar{s} - \sigma\bar{\mu}e = \begin{bmatrix} -0.20937 \\ 1.64233 \\ 1.94039 \\ 1.20434 \\ 1.67231 \end{bmatrix}.$$

- Resolvendo-se $\nabla F(\bar{x}, \bar{p}, \bar{s})(\Delta x, \Delta p, \Delta s)^T = -F(\bar{x}, \bar{p}, \bar{s})$:

$$\Delta x = \begin{bmatrix} 1.811616 \\ -0.526005 \\ -0.748006 \\ -0.075960 \\ -0.461644 \end{bmatrix}, \quad \Delta p = \begin{bmatrix} -0.32640 \\ 1.89090 \\ 0.31849 \end{bmatrix}, \quad \Delta s = \begin{bmatrix} -0.15329 \\ -0.43950 \\ 0.32640 \\ -1.89090 \\ -0.31849 \end{bmatrix}.$$

- $\bar{\alpha} = \min\{1, \alpha_0(x_3/-\Delta x_3)\} = \min\{1, 1.3283\} = 1;$
- $\bar{x} = \bar{x} + \bar{\alpha}\Delta x; \quad \bar{p} = \bar{p} + \bar{\alpha}\Delta p; \quad \bar{s} = \bar{s} + \bar{\alpha}\Delta s;$

Iteração 3:

- $\bar{x} = \begin{bmatrix} 4.70152 \\ 1.17124 \\ 0.29787 \\ 0.29560 \\ 0.53377 \end{bmatrix}$, $\bar{p} = \begin{bmatrix} -3.3769 \\ -4.7146 \\ -2.6173 \end{bmatrix}$, $\bar{s} = \begin{bmatrix} 0.20681 \\ 1.26462 \\ 3.37686 \\ 4.71461 \\ 2.61729 \end{bmatrix}$.

Iteração 3:

- $\bar{x} = \begin{bmatrix} 4.70152 \\ 1.17124 \\ 0.29787 \\ 0.29560 \\ 0.53377 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -3.3769 \\ -4.7146 \\ -2.6173 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 0.20681 \\ 1.26462 \\ 3.37686 \\ 4.71461 \\ 2.61729 \end{bmatrix}.$
- $\bar{\mu} = \bar{x}^T \bar{s}/n = 1.25;$

Iteração 3:

- $\bar{x} = \begin{bmatrix} 4.70152 \\ 1.17124 \\ 0.29787 \\ 0.29560 \\ 0.53377 \end{bmatrix}$, $\bar{p} = \begin{bmatrix} -3.3769 \\ -4.7146 \\ -2.6173 \end{bmatrix}$, $\bar{s} = \begin{bmatrix} 0.20681 \\ 1.26462 \\ 3.37686 \\ 4.71461 \\ 2.61729 \end{bmatrix}$.
- $\bar{\mu} = \bar{x}^T \bar{s}/n = 1.25$;
- Calcular as componentes de $F(\bar{x}, \bar{p}, \bar{s})$:

Iteração 3:

- $\bar{x} = \begin{bmatrix} 4.70152 \\ 1.17124 \\ 0.29787 \\ 0.29560 \\ 0.53377 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -3.3769 \\ -4.7146 \\ -2.6173 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 0.20681 \\ 1.26462 \\ 3.37686 \\ 4.71461 \\ 2.61729 \end{bmatrix}.$
- $\bar{\mu} = \bar{x}^T \bar{s}/n = 1.25;$
- Calcular as componentes de $F(\bar{x}, \bar{p}, \bar{s})$:

$$r_p = A\bar{x} - b = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix},$$

Iteração 3:

- $\bar{x} = \begin{bmatrix} 4.70152 \\ 1.17124 \\ 0.29787 \\ 0.29560 \\ 0.53377 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -3.3769 \\ -4.7146 \\ -2.6173 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 0.20681 \\ 1.26462 \\ 3.37686 \\ 4.71461 \\ 2.61729 \end{bmatrix}.$
- $\bar{\mu} = \bar{x}^T \bar{s}/n = 1.25;$
- Calcular as componentes de $F(\bar{x}, \bar{p}, \bar{s})$:

$$r_p = A\bar{x} - b = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_d = A^T \bar{p} + \bar{s} - c = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix},$$

Iteração 3:

- $\bar{x} = \begin{bmatrix} 4.70152 \\ 1.17124 \\ 0.29787 \\ 0.29560 \\ 0.53377 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -3.3769 \\ -4.7146 \\ -2.6173 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 0.20681 \\ 1.26462 \\ 3.37686 \\ 4.71461 \\ 2.61729 \end{bmatrix}.$
- $\bar{\mu} = \bar{x}^T \bar{s}/n = 1.25;$
- Calcular as componentes de $F(\bar{x}, \bar{p}, \bar{s})$:

$$r_p = A\bar{x} - b = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_d = A^T \bar{p} + \bar{s} - c = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_\mu = \bar{X}\bar{s} - \sigma\bar{\mu}e = \begin{bmatrix} 0.34731 \\ 0.85618 \\ 0.38085 \\ 0.76863 \\ 0.77203 \end{bmatrix}.$$

Iteração 3:

- $\bar{x} = \begin{bmatrix} 4.70152 \\ 1.17124 \\ 0.29787 \\ 0.29560 \\ 0.53377 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -3.3769 \\ -4.7146 \\ -2.6173 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 0.20681 \\ 1.26462 \\ 3.37686 \\ 4.71461 \\ 2.61729 \end{bmatrix}.$
- $\bar{\mu} = \bar{x}^T \bar{s}/n = 1.25;$
- Calcular as componentes de $F(\bar{x}, \bar{p}, \bar{s})$:

$$r_p = A\bar{x} - b = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_d = A^T \bar{p} + \bar{s} - c = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_\mu = \bar{X}\bar{s} - \sigma\bar{\mu}e = \begin{bmatrix} 0.34731 \\ 0.85618 \\ 0.38085 \\ 0.76863 \\ 0.77203 \end{bmatrix}.$$

- Resolvendo-se $\nabla F(\bar{x}, \bar{p}, \bar{s})(\Delta x, \Delta p, \Delta s)^T = -F(\bar{x}, \bar{p}, \bar{s})$:

Iteração 3:

- $\bar{x} = \begin{bmatrix} 4.70152 \\ 1.17124 \\ 0.29787 \\ 0.29560 \\ 0.53377 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -3.3769 \\ -4.7146 \\ -2.6173 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 0.20681 \\ 1.26462 \\ 3.37686 \\ 4.71461 \\ 2.61729 \end{bmatrix}.$
- $\bar{\mu} = \bar{x}^T \bar{s}/n = 1.25;$
- Calcular as componentes de $F(\bar{x}, \bar{p}, \bar{s})$:

$$r_p = A\bar{x} - b = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_d = A^T \bar{p} + \bar{s} - c = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_\mu = \bar{X}\bar{s} - \sigma\bar{\mu}e = \begin{bmatrix} 0.34731 \\ 0.85618 \\ 0.38085 \\ 0.76863 \\ 0.77203 \end{bmatrix}.$$

- Resolvendo-se $\nabla F(\bar{x}, \bar{p}, \bar{s})(\Delta x, \Delta p, \Delta s)^T = -F(\bar{x}, \bar{p}, \bar{s})$:

$$\Delta x = \begin{bmatrix} 0.467937 \\ -0.128180 \\ -0.195514 \\ -0.021158 \\ -0.123085 \end{bmatrix},$$

Iteração 3:

- $\bar{x} = \begin{bmatrix} 4.70152 \\ 1.17124 \\ 0.29787 \\ 0.29560 \\ 0.53377 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -3.3769 \\ -4.7146 \\ -2.6173 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 0.20681 \\ 1.26462 \\ 3.37686 \\ 4.71461 \\ 2.61729 \end{bmatrix}.$
- $\bar{\mu} = \bar{x}^T \bar{s}/n = 1.25;$
- Calcular as componentes de $F(\bar{x}, \bar{p}, \bar{s})$:

$$r_p = A\bar{x} - b = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_d = A^T \bar{p} + \bar{s} - c = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_\mu = \bar{X}\bar{s} - \sigma\bar{\mu}e = \begin{bmatrix} 0.34731 \\ 0.85618 \\ 0.38085 \\ 0.76863 \\ 0.77203 \end{bmatrix}.$$

- Resolvendo-se $\nabla F(\bar{x}, \bar{p}, \bar{s})(\Delta x, \Delta p, \Delta s)^T = -F(\bar{x}, \bar{p}, \bar{s})$:

$$\Delta x = \begin{bmatrix} 0.467937 \\ -0.128180 \\ -0.195514 \\ -0.021158 \\ -0.123085 \end{bmatrix}, \quad \Delta p = \begin{bmatrix} -0.93792 \\ 2.26281 \\ 0.84284 \end{bmatrix},$$

Iteração 3:

- $\bar{x} = \begin{bmatrix} 4.70152 \\ 1.17124 \\ 0.29787 \\ 0.29560 \\ 0.53377 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -3.3769 \\ -4.7146 \\ -2.6173 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 0.20681 \\ 1.26462 \\ 3.37686 \\ 4.71461 \\ 2.61729 \end{bmatrix}.$
- $\bar{\mu} = \bar{x}^T \bar{s}/n = 1.25;$
- Calcular as componentes de $F(\bar{x}, \bar{p}, \bar{s})$:

$$r_p = A\bar{x} - b = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_d = A^T \bar{p} + \bar{s} - c = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_\mu = \bar{X}\bar{s} - \sigma\bar{\mu}e = \begin{bmatrix} 0.34731 \\ 0.85618 \\ 0.38085 \\ 0.76863 \\ 0.77203 \end{bmatrix}.$$

- Resolvendo-se $\nabla F(\bar{x}, \bar{p}, \bar{s})(\Delta x, \Delta p, \Delta s)^T = -F(\bar{x}, \bar{p}, \bar{s})$:

$$\Delta x = \begin{bmatrix} 0.467937 \\ -0.128180 \\ -0.195514 \\ -0.021158 \\ -0.123085 \end{bmatrix}, \quad \Delta p = \begin{bmatrix} -0.93792 \\ 2.26281 \\ 0.84284 \end{bmatrix}, \quad \Delta s = \begin{bmatrix} -0.094454 \\ -0.592603 \\ 0.937923 \\ -2.262806 \\ -0.842837 \end{bmatrix}.$$

Iteração 3:

- $\bar{x} = \begin{bmatrix} 4.70152 \\ 1.17124 \\ 0.29787 \\ 0.29560 \\ 0.53377 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -3.3769 \\ -4.7146 \\ -2.6173 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 0.20681 \\ 1.26462 \\ 3.37686 \\ 4.71461 \\ 2.61729 \end{bmatrix}.$
- $\bar{\mu} = \bar{x}^T \bar{s}/n = 1.25;$
- Calcular as componentes de $F(\bar{x}, \bar{p}, \bar{s})$:

$$r_p = A\bar{x} - b = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_d = A^T\bar{p} + \bar{s} - c = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_\mu = \bar{X}\bar{s} - \sigma\bar{\mu}e = \begin{bmatrix} 0.34731 \\ 0.85618 \\ 0.38085 \\ 0.76863 \\ 0.77203 \end{bmatrix}.$$

- Resolvendo-se $\nabla F(\bar{x}, \bar{p}, \bar{s})(\Delta x, \Delta p, \Delta s)^T = -F(\bar{x}, \bar{p}, \bar{s})$:

$$\Delta x = \begin{bmatrix} 0.467937 \\ -0.128180 \\ -0.195514 \\ -0.021158 \\ -0.123085 \end{bmatrix}, \quad \Delta p = \begin{bmatrix} -0.93792 \\ 2.26281 \\ 0.84284 \end{bmatrix}, \quad \Delta s = \begin{bmatrix} -0.094454 \\ -0.592603 \\ 0.937923 \\ -2.262806 \\ -0.842837 \end{bmatrix}.$$

- $\bar{\alpha} = \min\{1, \alpha_0(x_3/ - \Delta x_3)\} = \min\{1, 1.4473\} = 1;$

Iteração 3:

- $\bar{x} = \begin{bmatrix} 4.70152 \\ 1.17124 \\ 0.29787 \\ 0.29560 \\ 0.53377 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -3.3769 \\ -4.7146 \\ -2.6173 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 0.20681 \\ 1.26462 \\ 3.37686 \\ 4.71461 \\ 2.61729 \end{bmatrix}.$
- $\bar{\mu} = \bar{x}^T \bar{s}/n = 1.25;$
- Calcular as componentes de $F(\bar{x}, \bar{p}, \bar{s})$:

$$r_p = A\bar{x} - b = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_d = A^T\bar{p} + \bar{s} - c = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_\mu = \bar{X}\bar{s} - \sigma\bar{\mu}e = \begin{bmatrix} 0.34731 \\ 0.85618 \\ 0.38085 \\ 0.76863 \\ 0.77203 \end{bmatrix}.$$

- Resolvendo-se $\nabla F(\bar{x}, \bar{p}, \bar{s})(\Delta x, \Delta p, \Delta s)^T = -F(\bar{x}, \bar{p}, \bar{s})$:

$$\Delta x = \begin{bmatrix} 0.467937 \\ -0.128180 \\ -0.195514 \\ -0.021158 \\ -0.123085 \end{bmatrix}, \quad \Delta p = \begin{bmatrix} -0.93792 \\ 2.26281 \\ 0.84284 \end{bmatrix}, \quad \Delta s = \begin{bmatrix} -0.094454 \\ -0.592603 \\ 0.937923 \\ -2.262806 \\ -0.842837 \end{bmatrix}.$$

- $\bar{\alpha} = \min\{1, \alpha_0(x_3/ - \Delta x_3)\} = \min\{1, 1.4473\} = 1;$
- $\bar{x} = \bar{x} + \bar{\alpha}\Delta x; \quad \bar{p} = \bar{p} + \bar{\alpha}\Delta p; \quad \bar{s} = \bar{s} + \bar{\alpha}\Delta s;$

Iteração 4:

- $\bar{x} = \begin{bmatrix} 5.16946 \\ 1.04306 \\ 0.10235 \\ 0.27444 \\ 0.41068 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -4.3148 \\ -2.4518 \\ -1.7745 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 0.11235 \\ 0.67202 \\ 4.31478 \\ 2.45180 \\ 1.77445 \end{bmatrix}.$

Iteração 4:

- $\bar{x} = \begin{bmatrix} 5.16946 \\ 1.04306 \\ 0.10235 \\ 0.27444 \\ 0.41068 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -4.3148 \\ -2.4518 \\ -1.7745 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 0.11235 \\ 0.67202 \\ 4.31478 \\ 2.45180 \\ 1.77445 \end{bmatrix}.$
- $\bar{\mu} = \bar{x}^T \bar{s}/n = 0.62500;$

Iteração 4:

- $\bar{x} = \begin{bmatrix} 5.16946 \\ 1.04306 \\ 0.10235 \\ 0.27444 \\ 0.41068 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -4.3148 \\ -2.4518 \\ -1.7745 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 0.11235 \\ 0.67202 \\ 4.31478 \\ 2.45180 \\ 1.77445 \end{bmatrix}.$
- $\bar{\mu} = \bar{x}^T \bar{s}/n = 0.62500$;
- Calcular as componentes de $F(\bar{x}, \bar{p}, \bar{s})$:

Iteração 4:

- $\bar{x} = \begin{bmatrix} 5.16946 \\ 1.04306 \\ 0.10235 \\ 0.27444 \\ 0.41068 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -4.3148 \\ -2.4518 \\ -1.7745 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 0.11235 \\ 0.67202 \\ 4.31478 \\ 2.45180 \\ 1.77445 \end{bmatrix}.$
- $\bar{\mu} = \bar{x}^T \bar{s}/n = 0.62500;$
- Calcular as componentes de $F(\bar{x}, \bar{p}, \bar{s})$:

$$r_p = A\bar{x} - b = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix},$$

Iteração 4:

- $\bar{x} = \begin{bmatrix} 5.16946 \\ 1.04306 \\ 0.10235 \\ 0.27444 \\ 0.41068 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -4.3148 \\ -2.4518 \\ -1.7745 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 0.11235 \\ 0.67202 \\ 4.31478 \\ 2.45180 \\ 1.77445 \end{bmatrix}.$
- $\bar{\mu} = \bar{x}^T \bar{s}/n = 0.62500;$
- Calcular as componentes de $F(\bar{x}, \bar{p}, \bar{s})$:

$$r_p = A\bar{x} - b = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_d = A^T \bar{p} + \bar{s} - c = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix},$$

Iteração 4:

- $\bar{x} = \begin{bmatrix} 5.16946 \\ 1.04306 \\ 0.10235 \\ 0.27444 \\ 0.41068 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -4.3148 \\ -2.4518 \\ -1.7745 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 0.11235 \\ 0.67202 \\ 4.31478 \\ 2.45180 \\ 1.77445 \end{bmatrix}.$
- $\bar{\mu} = \bar{x}^T \bar{s}/n = 0.62500;$
- Calcular as componentes de $F(\bar{x}, \bar{p}, \bar{s})$:

$$r_p = A\bar{x} - b = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_d = A^T \bar{p} + \bar{s} - c = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_\mu = \bar{X}\bar{s} - \sigma\bar{\mu}e = \begin{bmatrix} 0.26830 \\ 0.38846 \\ 0.12912 \\ 0.36038 \\ 0.41624 \end{bmatrix}.$$

Iteração 4:

- $\bar{x} = \begin{bmatrix} 5.16946 \\ 1.04306 \\ 0.10235 \\ 0.27444 \\ 0.41068 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -4.3148 \\ -2.4518 \\ -1.7745 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 0.11235 \\ 0.67202 \\ 4.31478 \\ 2.45180 \\ 1.77445 \end{bmatrix}.$
- $\bar{\mu} = \bar{x}^T \bar{s}/n = 0.62500;$
- Calcular as componentes de $F(\bar{x}, \bar{p}, \bar{s})$:

$$r_p = A\bar{x} - b = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_d = A^T \bar{p} + \bar{s} - c = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_\mu = \bar{X}\bar{s} - \sigma\bar{\mu}e = \begin{bmatrix} 0.26830 \\ 0.38846 \\ 0.12912 \\ 0.36038 \\ 0.41624 \end{bmatrix}.$$

- Resolvendo-se $\nabla F(\bar{x}, \bar{p}, \bar{s})(\Delta x, \Delta p, \Delta s)^T = -F(\bar{x}, \bar{p}, \bar{s})$:

Iteração 4:

- $\bar{x} = \begin{bmatrix} 5.16946 \\ 1.04306 \\ 0.10235 \\ 0.27444 \\ 0.41068 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -4.3148 \\ -2.4518 \\ -1.7745 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 0.11235 \\ 0.67202 \\ 4.31478 \\ 2.45180 \\ 1.77445 \end{bmatrix}.$
- $\bar{\mu} = \bar{x}^T \bar{s}/n = 0.62500;$
- Calcular as componentes de $F(\bar{x}, \bar{p}, \bar{s})$:

$$r_p = A\bar{x} - b = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_d = A^T\bar{p} + \bar{s} - c = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_\mu = \bar{X}\bar{s} - \sigma\bar{\mu}e = \begin{bmatrix} 0.26830 \\ 0.38846 \\ 0.12912 \\ 0.36038 \\ 0.41624 \end{bmatrix}.$$

- Resolvendo-se $\nabla F(\bar{x}, \bar{p}, \bar{s})(\Delta x, \Delta p, \Delta s)^T = -F(\bar{x}, \bar{p}, \bar{s})$:

$$\Delta x = \begin{bmatrix} 0.068105 \\ 0.046590 \\ -0.048029 \\ -0.016128 \\ -0.050537 \end{bmatrix},$$

Iteração 4:

- $\bar{x} = \begin{bmatrix} 5.16946 \\ 1.04306 \\ 0.10235 \\ 0.27444 \\ 0.41068 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -4.3148 \\ -2.4518 \\ -1.7745 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 0.11235 \\ 0.67202 \\ 4.31478 \\ 2.45180 \\ 1.77445 \end{bmatrix}.$
- $\bar{\mu} = \bar{x}^T \bar{s}/n = 0.62500;$
- Calcular as componentes de $F(\bar{x}, \bar{p}, \bar{s})$:

$$r_p = A\bar{x} - b = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_d = A^T\bar{p} + \bar{s} - c = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_\mu = \bar{X}\bar{s} - \sigma\bar{\mu}e = \begin{bmatrix} 0.26830 \\ 0.38846 \\ 0.12912 \\ 0.36038 \\ 0.41624 \end{bmatrix}.$$

- Resolvendo-se $\nabla F(\bar{x}, \bar{p}, \bar{s})(\Delta x, \Delta p, \Delta s)^T = -F(\bar{x}, \bar{p}, \bar{s})$:

$$\Delta x = \begin{bmatrix} 0.068105 \\ 0.046590 \\ -0.048029 \\ -0.016128 \\ -0.050537 \end{bmatrix}, \quad \Delta p = \begin{bmatrix} -0.76318 \\ 1.16904 \\ 0.79517 \end{bmatrix},$$

Iteração 4:

- $\bar{x} = \begin{bmatrix} 5.16946 \\ 1.04306 \\ 0.10235 \\ 0.27444 \\ 0.41068 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -4.3148 \\ -2.4518 \\ -1.7745 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 0.11235 \\ 0.67202 \\ 4.31478 \\ 2.45180 \\ 1.77445 \end{bmatrix}.$
- $\bar{\mu} = \bar{x}^T \bar{s}/n = 0.62500;$
- Calcular as componentes de $F(\bar{x}, \bar{p}, \bar{s})$:

$$r_p = A\bar{x} - b = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_d = A^T\bar{p} + \bar{s} - c = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_\mu = \bar{X}\bar{s} - \sigma\bar{\mu}e = \begin{bmatrix} 0.26830 \\ 0.38846 \\ 0.12912 \\ 0.36038 \\ 0.41624 \end{bmatrix}.$$

- Resolvendo-se $\nabla F(\bar{x}, \bar{p}, \bar{s})(\Delta x, \Delta p, \Delta s)^T = -F(\bar{x}, \bar{p}, \bar{s})$:

$$\Delta x = \begin{bmatrix} 0.068105 \\ 0.046590 \\ -0.048029 \\ -0.016128 \\ -0.050537 \end{bmatrix}, \quad \Delta p = \begin{bmatrix} -0.76318 \\ 1.16904 \\ 0.79517 \end{bmatrix}, \quad \Delta s = \begin{bmatrix} -0.053381 \\ -0.402439 \\ 0.763183 \\ -1.169037 \\ -0.795174 \end{bmatrix}.$$

Iteração 4:

- $\bar{x} = \begin{bmatrix} 5.16946 \\ 1.04306 \\ 0.10235 \\ 0.27444 \\ 0.41068 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -4.3148 \\ -2.4518 \\ -1.7745 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 0.11235 \\ 0.67202 \\ 4.31478 \\ 2.45180 \\ 1.77445 \end{bmatrix}.$
- $\bar{\mu} = \bar{x}^T \bar{s}/n = 0.62500;$
- Calcular as componentes de $F(\bar{x}, \bar{p}, \bar{s})$:

$$r_p = A\bar{x} - b = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_d = A^T\bar{p} + \bar{s} - c = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_\mu = \bar{X}\bar{s} - \sigma\bar{\mu}e = \begin{bmatrix} 0.26830 \\ 0.38846 \\ 0.12912 \\ 0.36038 \\ 0.41624 \end{bmatrix}.$$

- Resolvendo-se $\nabla F(\bar{x}, \bar{p}, \bar{s})(\Delta x, \Delta p, \Delta s)^T = -F(\bar{x}, \bar{p}, \bar{s})$:

$$\Delta x = \begin{bmatrix} 0.068105 \\ 0.046590 \\ -0.048029 \\ -0.016128 \\ -0.050537 \end{bmatrix}, \quad \Delta p = \begin{bmatrix} -0.76318 \\ 1.16904 \\ 0.79517 \end{bmatrix}, \quad \Delta s = \begin{bmatrix} -0.053381 \\ -0.402439 \\ 0.763183 \\ -1.169037 \\ -0.795174 \end{bmatrix}.$$

- $\bar{\alpha} = \min\{1, \alpha_0(s_2/ - \Delta s_2)\} = \min\{1, 1.5864\} = 1;$

Iteração 4:

- $\bar{x} = \begin{bmatrix} 5.16946 \\ 1.04306 \\ 0.10235 \\ 0.27444 \\ 0.41068 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -4.3148 \\ -2.4518 \\ -1.7745 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 0.11235 \\ 0.67202 \\ 4.31478 \\ 2.45180 \\ 1.77445 \end{bmatrix}.$
- $\bar{\mu} = \bar{x}^T \bar{s}/n = 0.62500;$
- Calcular as componentes de $F(\bar{x}, \bar{p}, \bar{s})$:

$$r_p = A\bar{x} - b = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_d = A^T \bar{p} + \bar{s} - c = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_\mu = \bar{X}\bar{s} - \sigma\bar{\mu}e = \begin{bmatrix} 0.26830 \\ 0.38846 \\ 0.12912 \\ 0.36038 \\ 0.41624 \end{bmatrix}.$$

- Resolvendo-se $\nabla F(\bar{x}, \bar{p}, \bar{s})(\Delta x, \Delta p, \Delta s)^T = -F(\bar{x}, \bar{p}, \bar{s})$:

$$\Delta x = \begin{bmatrix} 0.068105 \\ 0.046590 \\ -0.048029 \\ -0.016128 \\ -0.050537 \end{bmatrix}, \quad \Delta p = \begin{bmatrix} -0.76318 \\ 1.16904 \\ 0.79517 \end{bmatrix}, \quad \Delta s = \begin{bmatrix} -0.053381 \\ -0.402439 \\ 0.763183 \\ -1.169037 \\ -0.795174 \end{bmatrix}.$$

- $\bar{\alpha} = \min\{1, \alpha_0(s_2/ - \Delta s_2)\} = \min\{1, 1.5864\} = 1;$
- $\bar{x} = \bar{x} + \bar{\alpha}\Delta x; \quad \bar{p} = \bar{p} + \bar{\alpha}\Delta p; \quad \bar{s} = \bar{s} + \bar{\alpha}\Delta s;$

Iteração 5:

- $\bar{x} = \begin{bmatrix} 5.237565 \\ 1.089652 \\ 0.054322 \\ 0.258313 \\ 0.360148 \end{bmatrix}$, $\bar{p} = \begin{bmatrix} -5.07797 \\ -1.28276 \\ -0.97928 \end{bmatrix}$, $\bar{s} = \begin{bmatrix} 0.058971 \\ 0.269582 \\ 5.077966 \\ 1.282764 \\ 0.979279 \end{bmatrix}$.

Iteração 5:

- $\bar{x} = \begin{bmatrix} 5.237565 \\ 1.089652 \\ 0.054322 \\ 0.258313 \\ 0.360148 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -5.07797 \\ -1.28276 \\ -0.97928 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 0.058971 \\ 0.269582 \\ 5.077966 \\ 1.282764 \\ 0.979279 \end{bmatrix}.$
- $\bar{\mu} = \bar{x}^T \bar{s}/n = 0.3125;$

Iteração 5:

- $\bar{x} = \begin{bmatrix} 5.237565 \\ 1.089652 \\ 0.054322 \\ 0.258313 \\ 0.360148 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -5.07797 \\ -1.28276 \\ -0.97928 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 0.058971 \\ 0.269582 \\ 5.077966 \\ 1.282764 \\ 0.979279 \end{bmatrix}.$
- $\bar{\mu} = \bar{x}^T \bar{s}/n = 0.3125;$
- Calcular as componentes de $F(\bar{x}, \bar{p}, \bar{s})$:

Iteração 5:

- $\bar{x} = \begin{bmatrix} 5.237565 \\ 1.089652 \\ 0.054322 \\ 0.258313 \\ 0.360148 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -5.07797 \\ -1.28276 \\ -0.97928 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 0.058971 \\ 0.269582 \\ 5.077966 \\ 1.282764 \\ 0.979279 \end{bmatrix}.$
- $\bar{\mu} = \bar{x}^T \bar{s}/n = 0.3125;$
- Calcular as componentes de $F(\bar{x}, \bar{p}, \bar{s})$:

$$r_p = A\bar{x} - b = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix},$$

Iteração 5:

- $\bar{x} = \begin{bmatrix} 5.237565 \\ 1.089652 \\ 0.054322 \\ 0.258313 \\ 0.360148 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -5.07797 \\ -1.28276 \\ -0.97928 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 0.058971 \\ 0.269582 \\ 5.077966 \\ 1.282764 \\ 0.979279 \end{bmatrix}.$
- $\bar{\mu} = \bar{x}^T \bar{s}/n = 0.3125;$
- Calcular as componentes de $F(\bar{x}, \bar{p}, \bar{s})$:

$$r_p = A\bar{x} - b = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_d = A^T \bar{p} + \bar{s} - c = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix},$$

Iteração 5:

- $\bar{x} = \begin{bmatrix} 5.237565 \\ 1.089652 \\ 0.054322 \\ 0.258313 \\ 0.360148 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -5.07797 \\ -1.28276 \\ -0.97928 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 0.058971 \\ 0.269582 \\ 5.077966 \\ 1.282764 \\ 0.979279 \end{bmatrix}.$
- $\bar{\mu} = \bar{x}^T \bar{s}/n = 0.3125;$
- Calcular as componentes de $F(\bar{x}, \bar{p}, \bar{s})$:

$$r_p = A\bar{x} - b = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_d = A^T \bar{p} + \bar{s} - c = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_\mu = \bar{X}\bar{s} - \sigma\bar{\mu}e = \begin{bmatrix} 0.15261 \\ 0.13750 \\ 0.11959 \\ 0.17510 \\ 0.19644 \end{bmatrix}.$$

Iteração 5:

- $\bar{x} = \begin{bmatrix} 5.237565 \\ 1.089652 \\ 0.054322 \\ 0.258313 \\ 0.360148 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -5.07797 \\ -1.28276 \\ -0.97928 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 0.058971 \\ 0.269582 \\ 5.077966 \\ 1.282764 \\ 0.979279 \end{bmatrix}.$
- $\bar{\mu} = \bar{x}^T \bar{s}/n = 0.3125;$
- Calcular as componentes de $F(\bar{x}, \bar{p}, \bar{s})$:

$$r_p = A\bar{x} - b = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_d = A^T \bar{p} + \bar{s} - c = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_\mu = \bar{X}\bar{s} - \sigma\bar{\mu}e = \begin{bmatrix} 0.15261 \\ 0.13750 \\ 0.11959 \\ 0.17510 \\ 0.19644 \end{bmatrix}.$$

- Resolvendo-se $\nabla F(\bar{x}, \bar{p}, \bar{s})(\Delta x, \Delta p, \Delta s)^T = -F(\bar{x}, \bar{p}, \bar{s})$:

Iteração 5:

- $\bar{x} = \begin{bmatrix} 5.237565 \\ 1.089652 \\ 0.054322 \\ 0.258313 \\ 0.360148 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -5.07797 \\ -1.28276 \\ -0.97928 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 0.058971 \\ 0.269582 \\ 5.077966 \\ 1.282764 \\ 0.979279 \end{bmatrix}.$
- $\bar{\mu} = \bar{x}^T \bar{s}/n = 0.3125;$
- Calcular as componentes de $F(\bar{x}, \bar{p}, \bar{s})$:

$$r_p = A\bar{x} - b = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_d = A^T \bar{p} + \bar{s} - c = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_\mu = \bar{X}\bar{s} - \sigma\bar{\mu}e = \begin{bmatrix} 0.15261 \\ 0.13750 \\ 0.11959 \\ 0.17510 \\ 0.19644 \end{bmatrix}.$$

- Resolvendo-se $\nabla F(\bar{x}, \bar{p}, \bar{s})(\Delta x, \Delta p, \Delta s)^T = -F(\bar{x}, \bar{p}, \bar{s})$:

$$\Delta x = \begin{bmatrix} -0.069311 \\ 0.205371 \\ -0.026956 \\ -0.034143 \\ -0.074961 \end{bmatrix},$$

Iteração 5:

- $\bar{x} = \begin{bmatrix} 5.237565 \\ 1.089652 \\ 0.054322 \\ 0.258313 \\ 0.360148 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -5.07797 \\ -1.28276 \\ -0.97928 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 0.058971 \\ 0.269582 \\ 5.077966 \\ 1.282764 \\ 0.979279 \end{bmatrix}.$
- $\bar{\mu} = \bar{x}^T \bar{s}/n = 0.3125;$
- Calcular as componentes de $F(\bar{x}, \bar{p}, \bar{s})$:

$$r_p = A\bar{x} - b = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_d = A^T \bar{p} + \bar{s} - c = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_\mu = \bar{X}\bar{s} - \sigma\bar{\mu}e = \begin{bmatrix} 0.15261 \\ 0.13750 \\ 0.11959 \\ 0.17510 \\ 0.19644 \end{bmatrix}.$$

- Resolvendo-se $\nabla F(\bar{x}, \bar{p}, \bar{s})(\Delta x, \Delta p, \Delta s)^T = -F(\bar{x}, \bar{p}, \bar{s})$:

$$\Delta x = \begin{bmatrix} -0.069311 \\ 0.205371 \\ -0.026956 \\ -0.034143 \\ -0.074961 \end{bmatrix}, \quad \Delta p = \begin{bmatrix} -0.31823 \\ 0.50832 \\ 0.34160 \end{bmatrix},$$

Iteração 5:

- $\bar{x} = \begin{bmatrix} 5.237565 \\ 1.089652 \\ 0.054322 \\ 0.258313 \\ 0.360148 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -5.07797 \\ -1.28276 \\ -0.97928 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 0.058971 \\ 0.269582 \\ 5.077966 \\ 1.282764 \\ 0.979279 \end{bmatrix}.$
- $\bar{\mu} = \bar{x}^T \bar{s}/n = 0.3125;$
- Calcular as componentes de $F(\bar{x}, \bar{p}, \bar{s})$:

$$r_p = A\bar{x} - b = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_d = A^T \bar{p} + \bar{s} - c = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_\mu = \bar{X}\bar{s} - \sigma\bar{\mu}e = \begin{bmatrix} 0.15261 \\ 0.13750 \\ 0.11959 \\ 0.17510 \\ 0.19644 \end{bmatrix}.$$

- Resolvendo-se $\nabla F(\bar{x}, \bar{p}, \bar{s})(\Delta x, \Delta p, \Delta s)^T = -F(\bar{x}, \bar{p}, \bar{s})$:

$$\Delta x = \begin{bmatrix} -0.069311 \\ 0.205371 \\ -0.026956 \\ -0.034143 \\ -0.074961 \end{bmatrix}, \quad \Delta p = \begin{bmatrix} -0.31823 \\ 0.50832 \\ 0.34160 \end{bmatrix}, \quad \Delta s = \begin{bmatrix} -0.028358 \\ -0.176997 \\ 0.318230 \\ -0.508325 \\ -0.341602 \end{bmatrix}.$$

Iteração 5:

- $\bar{x} = \begin{bmatrix} 5.237565 \\ 1.089652 \\ 0.054322 \\ 0.258313 \\ 0.360148 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -5.07797 \\ -1.28276 \\ -0.97928 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 0.058971 \\ 0.269582 \\ 5.077966 \\ 1.282764 \\ 0.979279 \end{bmatrix}.$
- $\bar{\mu} = \bar{x}^T \bar{s}/n = 0.3125;$
- Calcular as componentes de $F(\bar{x}, \bar{p}, \bar{s})$:

$$r_p = A\bar{x} - b = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_d = A^T \bar{p} + \bar{s} - c = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_\mu = \bar{X}\bar{s} - \sigma\bar{\mu}e = \begin{bmatrix} 0.15261 \\ 0.13750 \\ 0.11959 \\ 0.17510 \\ 0.19644 \end{bmatrix}.$$

- Resolvendo-se $\nabla F(\bar{x}, \bar{p}, \bar{s})(\Delta x, \Delta p, \Delta s)^T = -F(\bar{x}, \bar{p}, \bar{s})$:

$$\Delta x = \begin{bmatrix} -0.069311 \\ 0.205371 \\ -0.026956 \\ -0.034143 \\ -0.074961 \end{bmatrix}, \quad \Delta p = \begin{bmatrix} -0.31823 \\ 0.50832 \\ 0.34160 \end{bmatrix}, \quad \Delta s = \begin{bmatrix} -0.028358 \\ -0.176997 \\ 0.318230 \\ -0.508325 \\ -0.341602 \end{bmatrix}.$$

- $\bar{\alpha} = \min\{1, \alpha_0(s_2/-\Delta s_2)\} = \min\{1, 1.4469\} = 1;$

Iteração 5:

- $\bar{x} = \begin{bmatrix} 5.237565 \\ 1.089652 \\ 0.054322 \\ 0.258313 \\ 0.360148 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -5.07797 \\ -1.28276 \\ -0.97928 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 0.058971 \\ 0.269582 \\ 5.077966 \\ 1.282764 \\ 0.979279 \end{bmatrix}.$
- $\bar{\mu} = \bar{x}^T \bar{s}/n = 0.3125;$
- Calcular as componentes de $F(\bar{x}, \bar{p}, \bar{s})$:

$$r_p = A\bar{x} - b = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_d = A^T \bar{p} + \bar{s} - c = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_\mu = \bar{X}\bar{s} - \sigma\bar{\mu}e = \begin{bmatrix} 0.15261 \\ 0.13750 \\ 0.11959 \\ 0.17510 \\ 0.19644 \end{bmatrix}.$$

- Resolvendo-se $\nabla F(\bar{x}, \bar{p}, \bar{s})(\Delta x, \Delta p, \Delta s)^T = -F(\bar{x}, \bar{p}, \bar{s})$:

$$\Delta x = \begin{bmatrix} -0.069311 \\ 0.205371 \\ -0.026956 \\ -0.034143 \\ -0.074961 \end{bmatrix}, \quad \Delta p = \begin{bmatrix} -0.31823 \\ 0.50832 \\ 0.34160 \end{bmatrix}, \quad \Delta s = \begin{bmatrix} -0.028358 \\ -0.176997 \\ 0.318230 \\ -0.508325 \\ -0.341602 \end{bmatrix}.$$

- $\bar{\alpha} = \min\{1, \alpha_0(s_2/-\Delta s_2)\} = \min\{1, 1.4469\} = 1;$
- $\bar{x} = \bar{x} + \bar{\alpha}\Delta x; \quad \bar{p} = \bar{p} + \bar{\alpha}\Delta p; \quad \bar{s} = \bar{s} + \bar{\alpha}\Delta s;$

Iteração 6:

- $\bar{x} = \begin{bmatrix} 5.168254 \\ 1.295023 \\ 0.027366 \\ 0.224170 \\ 0.285187 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -5.39620 \\ -0.77444 \\ -0.63768 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 0.030613 \\ 0.092585 \\ 5.396197 \\ 0.774439 \\ 0.637677 \end{bmatrix}.$

Iteração 6:

- $\bar{x} = \begin{bmatrix} 5.168254 \\ 1.295023 \\ 0.027366 \\ 0.224170 \\ 0.285187 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -5.39620 \\ -0.77444 \\ -0.63768 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 0.030613 \\ 0.092585 \\ 5.396197 \\ 0.774439 \\ 0.637677 \end{bmatrix}.$
- $\bar{\mu} = \bar{x}^T \bar{s}/n = 0.15625;$

Iteração 6:

- $\bar{x} = \begin{bmatrix} 5.168254 \\ 1.295023 \\ 0.027366 \\ 0.224170 \\ 0.285187 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -5.39620 \\ -0.77444 \\ -0.63768 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 0.030613 \\ 0.092585 \\ 5.396197 \\ 0.774439 \\ 0.637677 \end{bmatrix}.$
- $\bar{\mu} = \bar{x}^T \bar{s}/n = 0.15625$;
- Calcular as componentes de $F(\bar{x}, \bar{p}, \bar{s})$:

Iteração 6:

- $\bar{x} = \begin{bmatrix} 5.168254 \\ 1.295023 \\ 0.027366 \\ 0.224170 \\ 0.285187 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -5.39620 \\ -0.77444 \\ -0.63768 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 0.030613 \\ 0.092585 \\ 5.396197 \\ 0.774439 \\ 0.637677 \end{bmatrix}.$
- $\bar{\mu} = \bar{x}^T \bar{s}/n = 0.15625$;
- Calcular as componentes de $F(\bar{x}, \bar{p}, \bar{s})$:

$$r_p = A\bar{x} - b = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix},$$

Iteração 6:

- $\bar{x} = \begin{bmatrix} 5.168254 \\ 1.295023 \\ 0.027366 \\ 0.224170 \\ 0.285187 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -5.39620 \\ -0.77444 \\ -0.63768 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 0.030613 \\ 0.092585 \\ 5.396197 \\ 0.774439 \\ 0.637677 \end{bmatrix}.$
- $\bar{\mu} = \bar{x}^T \bar{s}/n = 0.15625;$
- Calcular as componentes de $F(\bar{x}, \bar{p}, \bar{s})$:

$$r_p = A\bar{x} - b = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_d = A^T \bar{p} + \bar{s} - c = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix},$$

Iteração 6:

- $\bar{x} = \begin{bmatrix} 5.168254 \\ 1.295023 \\ 0.027366 \\ 0.224170 \\ 0.285187 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -5.39620 \\ -0.77444 \\ -0.63768 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 0.030613 \\ 0.092585 \\ 5.396197 \\ 0.774439 \\ 0.637677 \end{bmatrix}.$
- $\bar{\mu} = \bar{x}^T \bar{s}/n = 0.15625;$
- Calcular as componentes de $F(\bar{x}, \bar{p}, \bar{s})$:

$$r_p = A\bar{x} - b = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_d = A^T \bar{p} + \bar{s} - c = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_\mu = \bar{X}\bar{s} - \sigma\bar{\mu}e = \begin{bmatrix} 0.08009 \\ 0.04177 \\ 0.06955 \\ 0.09548 \\ 0.10373 \end{bmatrix}.$$

Iteração 6:

- $\bar{x} = \begin{bmatrix} 5.168254 \\ 1.295023 \\ 0.027366 \\ 0.224170 \\ 0.285187 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -5.39620 \\ -0.77444 \\ -0.63768 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 0.030613 \\ 0.092585 \\ 5.396197 \\ 0.774439 \\ 0.637677 \end{bmatrix}.$
- $\bar{\mu} = \bar{x}^T \bar{s}/n = 0.15625$;
- Calcular as componentes de $F(\bar{x}, \bar{p}, \bar{s})$:

$$r_p = A\bar{x} - b = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_d = A^T \bar{p} + \bar{s} - c = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_\mu = \bar{X}\bar{s} - \sigma\bar{\mu}e = \begin{bmatrix} 0.08009 \\ 0.04177 \\ 0.06955 \\ 0.09548 \\ 0.10373 \end{bmatrix}.$$

- Resolvendo-se $\nabla F(\bar{x}, \bar{p}, \bar{s})(\Delta x, \Delta p, \Delta s)^T = -F(\bar{x}, \bar{p}, \bar{s})$:

Iteração 6:

- $\bar{x} = \begin{bmatrix} 5.168254 \\ 1.295023 \\ 0.027366 \\ 0.224170 \\ 0.285187 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -5.39620 \\ -0.77444 \\ -0.63768 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 0.030613 \\ 0.092585 \\ 5.396197 \\ 0.774439 \\ 0.637677 \end{bmatrix}.$
- $\bar{\mu} = \bar{x}^T \bar{s}/n = 0.15625;$
- Calcular as componentes de $F(\bar{x}, \bar{p}, \bar{s})$:

$$r_p = A\bar{x} - b = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_d = A^T \bar{p} + \bar{s} - c = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_\mu = \bar{X}\bar{s} - \sigma\bar{\mu}e = \begin{bmatrix} 0.08009 \\ 0.04177 \\ 0.06955 \\ 0.09548 \\ 0.10373 \end{bmatrix}.$$

- Resolvendo-se $\nabla F(\bar{x}, \bar{p}, \bar{s})(\Delta x, \Delta p, \Delta s)^T = -F(\bar{x}, \bar{p}, \bar{s})$:

$$\Delta x = \begin{bmatrix} -0.227362 \\ 0.423402 \\ -0.013340 \\ -0.061944 \\ -0.120756 \end{bmatrix},$$

Iteração 6:

- $\bar{x} = \begin{bmatrix} 5.168254 \\ 1.295023 \\ 0.027366 \\ 0.224170 \\ 0.285187 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -5.39620 \\ -0.77444 \\ -0.63768 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 0.030613 \\ 0.092585 \\ 5.396197 \\ 0.774439 \\ 0.637677 \end{bmatrix}.$
- $\bar{\mu} = \bar{x}^T \bar{s}/n = 0.15625;$
- Calcular as componentes de $F(\bar{x}, \bar{p}, \bar{s})$:

$$r_p = A\bar{x} - b = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_d = A^T \bar{p} + \bar{s} - c = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_\mu = \bar{X}\bar{s} - \sigma\bar{\mu}e = \begin{bmatrix} 0.08009 \\ 0.04177 \\ 0.06955 \\ 0.09548 \\ 0.10373 \end{bmatrix}.$$

- Resolvendo-se $\nabla F(\bar{x}, \bar{p}, \bar{s})(\Delta x, \Delta p, \Delta s)^T = -F(\bar{x}, \bar{p}, \bar{s})$:

$$\Delta x = \begin{bmatrix} -0.227362 \\ 0.423402 \\ -0.013340 \\ -0.061944 \\ -0.120756 \end{bmatrix}, \quad \Delta p = \begin{bmatrix} -0.089065 \\ 0.211932 \\ 0.093723 \end{bmatrix},$$

Iteração 6:

- $\bar{x} = \begin{bmatrix} 5.168254 \\ 1.295023 \\ 0.027366 \\ 0.224170 \\ 0.285187 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -5.39620 \\ -0.77444 \\ -0.63768 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 0.030613 \\ 0.092585 \\ 5.396197 \\ 0.774439 \\ 0.637677 \end{bmatrix}.$
- $\bar{\mu} = \bar{x}^T \bar{s}/n = 0.15625;$
- Calcular as componentes de $F(\bar{x}, \bar{p}, \bar{s})$:

$$r_p = A\bar{x} - b = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_d = A^T \bar{p} + \bar{s} - c = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_\mu = \bar{X}\bar{s} - \sigma\bar{\mu}e = \begin{bmatrix} 0.08009 \\ 0.04177 \\ 0.06955 \\ 0.09548 \\ 0.10373 \end{bmatrix}.$$

- Resolvendo-se $\nabla F(\bar{x}, \bar{p}, \bar{s})(\Delta x, \Delta p, \Delta s)^T = -F(\bar{x}, \bar{p}, \bar{s})$:

$$\Delta x = \begin{bmatrix} -0.227362 \\ 0.423402 \\ -0.013340 \\ -0.061944 \\ -0.120756 \end{bmatrix}, \quad \Delta p = \begin{bmatrix} -0.089065 \\ 0.211932 \\ 0.093723 \end{bmatrix}, \quad \Delta s = \begin{bmatrix} -0.014150 \\ -0.062528 \\ 0.089065 \\ -0.211932 \\ -0.093723 \end{bmatrix}.$$

Iteração 6:

- $\bar{x} = \begin{bmatrix} 5.168254 \\ 1.295023 \\ 0.027366 \\ 0.224170 \\ 0.285187 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -5.39620 \\ -0.77444 \\ -0.63768 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 0.030613 \\ 0.092585 \\ 5.396197 \\ 0.774439 \\ 0.637677 \end{bmatrix}.$
- $\bar{\mu} = \bar{x}^T \bar{s}/n = 0.15625;$
- Calcular as componentes de $F(\bar{x}, \bar{p}, \bar{s})$:

$$r_p = A\bar{x} - b = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_d = A^T \bar{p} + \bar{s} - c = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_\mu = \bar{X}\bar{s} - \sigma\bar{\mu}e = \begin{bmatrix} 0.08009 \\ 0.04177 \\ 0.06955 \\ 0.09548 \\ 0.10373 \end{bmatrix}.$$

- Resolvendo-se $\nabla F(\bar{x}, \bar{p}, \bar{s})(\Delta x, \Delta p, \Delta s)^T = -F(\bar{x}, \bar{p}, \bar{s})$:

$$\Delta x = \begin{bmatrix} -0.227362 \\ 0.423402 \\ -0.013340 \\ -0.061944 \\ -0.120756 \end{bmatrix}, \quad \Delta p = \begin{bmatrix} -0.089065 \\ 0.211932 \\ 0.093723 \end{bmatrix}, \quad \Delta s = \begin{bmatrix} -0.014150 \\ -0.062528 \\ 0.089065 \\ -0.211932 \\ -0.093723 \end{bmatrix}.$$

- $\bar{\alpha} = \min\{1, \alpha_0(x_2/-\Delta x_2)\} = \min\{1, 1.4067\} = 1;$

Iteração 6:

- $\bar{x} = \begin{bmatrix} 5.168254 \\ 1.295023 \\ 0.027366 \\ 0.224170 \\ 0.285187 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -5.39620 \\ -0.77444 \\ -0.63768 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 0.030613 \\ 0.092585 \\ 5.396197 \\ 0.774439 \\ 0.637677 \end{bmatrix}.$
- $\bar{\mu} = \bar{x}^T \bar{s}/n = 0.15625;$
- Calcular as componentes de $F(\bar{x}, \bar{p}, \bar{s})$:

$$r_p = A\bar{x} - b = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_d = A^T\bar{p} + \bar{s} - c = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_\mu = \bar{X}\bar{s} - \sigma\bar{\mu}e = \begin{bmatrix} 0.08009 \\ 0.04177 \\ 0.06955 \\ 0.09548 \\ 0.10373 \end{bmatrix}.$$

- Resolvendo-se $\nabla F(\bar{x}, \bar{p}, \bar{s})(\Delta x, \Delta p, \Delta s)^T = -F(\bar{x}, \bar{p}, \bar{s})$:

$$\Delta x = \begin{bmatrix} -0.227362 \\ 0.423402 \\ -0.013340 \\ -0.061944 \\ -0.120756 \end{bmatrix}, \quad \Delta p = \begin{bmatrix} -0.089065 \\ 0.211932 \\ 0.093723 \end{bmatrix}, \quad \Delta s = \begin{bmatrix} -0.014150 \\ -0.062528 \\ 0.089065 \\ -0.211932 \\ -0.093723 \end{bmatrix}.$$

- $\bar{\alpha} = \min\{1, \alpha_0(x_2/-\Delta x_2)\} = \min\{1, 1.4067\} = 1;$
- $\bar{x} = \bar{x} + \bar{\alpha}\Delta x; \quad \bar{p} = \bar{p} + \bar{\alpha}\Delta p; \quad \bar{s} = \bar{s} + \bar{\alpha}\Delta s;$

Iteração 7:

- $\bar{x} = \begin{bmatrix} 4.940893 \\ 1.718425 \\ 0.014026 \\ 0.162226 \\ 0.164430 \end{bmatrix}$, $\bar{p} = \begin{bmatrix} -5.48526 \\ -0.56251 \\ -0.54395 \end{bmatrix}$, $\bar{s} = \begin{bmatrix} 0.016463 \\ 0.030057 \\ 5.485261 \\ 0.562506 \\ 0.543954 \end{bmatrix}$.

Iteração 7:

- $\bar{x} = \begin{bmatrix} 4.940893 \\ 1.718425 \\ 0.014026 \\ 0.162226 \\ 0.164430 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -5.48526 \\ -0.56251 \\ -0.54395 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 0.016463 \\ 0.030057 \\ 5.485261 \\ 0.562506 \\ 0.543954 \end{bmatrix}.$
- $\bar{\mu} = \bar{x}^T \bar{s}/n = 0.078125;$

Iteração 7:

- $\bar{x} = \begin{bmatrix} 4.940893 \\ 1.718425 \\ 0.014026 \\ 0.162226 \\ 0.164430 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -5.48526 \\ -0.56251 \\ -0.54395 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 0.016463 \\ 0.030057 \\ 5.485261 \\ 0.562506 \\ 0.543954 \end{bmatrix}.$
- $\bar{\mu} = \bar{x}^T \bar{s}/n = 0.078125$;
- Calcular as componentes de $F(\bar{x}, \bar{p}, \bar{s})$:

Iteração 7:

- $\bar{x} = \begin{bmatrix} 4.940893 \\ 1.718425 \\ 0.014026 \\ 0.162226 \\ 0.164430 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -5.48526 \\ -0.56251 \\ -0.54395 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 0.016463 \\ 0.030057 \\ 5.485261 \\ 0.562506 \\ 0.543954 \end{bmatrix}.$
- $\bar{\mu} = \bar{x}^T \bar{s}/n = 0.078125;$
- Calcular as componentes de $F(\bar{x}, \bar{p}, \bar{s})$:

$$r_p = A\bar{x} - b = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix},$$

Iteração 7:

- $\bar{x} = \begin{bmatrix} 4.940893 \\ 1.718425 \\ 0.014026 \\ 0.162226 \\ 0.164430 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -5.48526 \\ -0.56251 \\ -0.54395 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 0.016463 \\ 0.030057 \\ 5.485261 \\ 0.562506 \\ 0.543954 \end{bmatrix}.$
- $\bar{\mu} = \bar{x}^T \bar{s}/n = 0.078125;$
- Calcular as componentes de $F(\bar{x}, \bar{p}, \bar{s})$:

$$r_p = A\bar{x} - b = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_d = A^T \bar{p} + \bar{s} - c = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix},$$

Iteração 7:

- $\bar{x} = \begin{bmatrix} 4.940893 \\ 1.718425 \\ 0.014026 \\ 0.162226 \\ 0.164430 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -5.48526 \\ -0.56251 \\ -0.54395 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 0.016463 \\ 0.030057 \\ 5.485261 \\ 0.562506 \\ 0.543954 \end{bmatrix}.$
- $\bar{\mu} = \bar{x}^T \bar{s}/n = 0.078125;$
- Calcular as componentes de $F(\bar{x}, \bar{p}, \bar{s})$:

$$r_p = A\bar{x} - b = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_d = A^T \bar{p} + \bar{s} - c = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_\mu = \bar{X}\bar{s} - \sigma\bar{\mu}e = \begin{bmatrix} 0.042280 \\ 0.012588 \\ 0.037874 \\ 0.052190 \\ 0.050380 \end{bmatrix}.$$

Iteração 7:

- $\bar{x} = \begin{bmatrix} 4.940893 \\ 1.718425 \\ 0.014026 \\ 0.162226 \\ 0.164430 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -5.48526 \\ -0.56251 \\ -0.54395 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 0.016463 \\ 0.030057 \\ 5.485261 \\ 0.562506 \\ 0.543954 \end{bmatrix}.$
- $\bar{\mu} = \bar{x}^T \bar{s}/n = 0.078125;$
- Calcular as componentes de $F(\bar{x}, \bar{p}, \bar{s})$:

$$r_p = A\bar{x} - b = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_d = A^T \bar{p} + \bar{s} - c = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_\mu = \bar{X}\bar{s} - \sigma\bar{\mu}e = \begin{bmatrix} 0.042280 \\ 0.012588 \\ 0.037874 \\ 0.052190 \\ 0.050380 \end{bmatrix}.$$

- Resolvendo-se $\nabla F(\bar{x}, \bar{p}, \bar{s})(\Delta x, \Delta p, \Delta s)^T = -F(\bar{x}, \bar{p}, \bar{s})$:

Iteração 7:

- $\bar{x} = \begin{bmatrix} 4.940893 \\ 1.718425 \\ 0.014026 \\ 0.162226 \\ 0.164430 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -5.48526 \\ -0.56251 \\ -0.54395 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 0.016463 \\ 0.030057 \\ 5.485261 \\ 0.562506 \\ 0.543954 \end{bmatrix}.$
- $\bar{\mu} = \bar{x}^T \bar{s}/n = 0.078125;$
- Calcular as componentes de $F(\bar{x}, \bar{p}, \bar{s})$:

$$r_p = A\bar{x} - b = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_d = A^T \bar{p} + \bar{s} - c = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_\mu = \bar{X}\bar{s} - \sigma\bar{\mu}e = \begin{bmatrix} 0.042280 \\ 0.012588 \\ 0.037874 \\ 0.052190 \\ 0.050380 \end{bmatrix}.$$

- Resolvendo-se $\nabla F(\bar{x}, \bar{p}, \bar{s})(\Delta x, \Delta p, \Delta s)^T = -F(\bar{x}, \bar{p}, \bar{s})$:

$$\Delta x = \begin{bmatrix} -0.2128270 \\ 0.3775727 \\ -0.0068583 \\ -0.0542318 \\ -0.1036555 \end{bmatrix},$$

Iteração 7:

- $\bar{x} = \begin{bmatrix} 4.940893 \\ 1.718425 \\ 0.014026 \\ 0.162226 \\ 0.164430 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -5.48526 \\ -0.56251 \\ -0.54395 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 0.016463 \\ 0.030057 \\ 5.485261 \\ 0.562506 \\ 0.543954 \end{bmatrix}.$
- $\bar{\mu} = \bar{x}^T \bar{s}/n = 0.078125;$
- Calcular as componentes de $F(\bar{x}, \bar{p}, \bar{s})$:

$$r_p = A\bar{x} - b = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_d = A^T \bar{p} + \bar{s} - c = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_\mu = \bar{X}\bar{s} - \sigma\bar{\mu}e = \begin{bmatrix} 0.042280 \\ 0.012588 \\ 0.037874 \\ 0.052190 \\ 0.050380 \end{bmatrix}.$$

- Resolvendo-se $\nabla F(\bar{x}, \bar{p}, \bar{s})(\Delta x, \Delta p, \Delta s)^T = -F(\bar{x}, \bar{p}, \bar{s})$:

$$\Delta x = \begin{bmatrix} -0.2128270 \\ 0.3775727 \\ -0.0068583 \\ -0.0542318 \\ -0.1036555 \end{bmatrix}, \quad \Delta p = \begin{bmatrix} 0.018172 \\ 0.133670 \\ -0.036513 \end{bmatrix},$$

Iteração 7:

- $\bar{x} = \begin{bmatrix} 4.940893 \\ 1.718425 \\ 0.014026 \\ 0.162226 \\ 0.164430 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -5.48526 \\ -0.56251 \\ -0.54395 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 0.016463 \\ 0.030057 \\ 5.485261 \\ 0.562506 \\ 0.543954 \end{bmatrix}.$
- $\bar{\mu} = \bar{x}^T \bar{s}/n = 0.078125;$
- Calcular as componentes de $F(\bar{x}, \bar{p}, \bar{s})$:

$$r_p = A\bar{x} - b = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_d = A^T \bar{p} + \bar{s} - c = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_\mu = \bar{X}\bar{s} - \sigma\bar{\mu}e = \begin{bmatrix} 0.042280 \\ 0.012588 \\ 0.037874 \\ 0.052190 \\ 0.050380 \end{bmatrix}.$$

- Resolvendo-se $\nabla F(\bar{x}, \bar{p}, \bar{s})(\Delta x, \Delta p, \Delta s)^T = -F(\bar{x}, \bar{p}, \bar{s})$:

$$\Delta x = \begin{bmatrix} -0.2128270 \\ 0.3775727 \\ -0.0068583 \\ -0.0542318 \\ -0.1036555 \end{bmatrix}, \quad \Delta p = \begin{bmatrix} 0.018172 \\ 0.133670 \\ -0.036513 \end{bmatrix}, \quad \Delta s = \begin{bmatrix} -0.0078479 \\ -0.0139293 \\ -0.0181719 \\ -0.1336701 \\ 0.0365125 \end{bmatrix}.$$

Iteração 7:

- $\bar{x} = \begin{bmatrix} 4.940893 \\ 1.718425 \\ 0.014026 \\ 0.162226 \\ 0.164430 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -5.48526 \\ -0.56251 \\ -0.54395 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 0.016463 \\ 0.030057 \\ 5.485261 \\ 0.562506 \\ 0.543954 \end{bmatrix}.$
- $\bar{\mu} = \bar{x}^T \bar{s}/n = 0.078125;$
- Calcular as componentes de $F(\bar{x}, \bar{p}, \bar{s})$:

$$r_p = A\bar{x} - b = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_d = A^T \bar{p} + \bar{s} - c = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_\mu = \bar{X}\bar{s} - \sigma\bar{\mu}e = \begin{bmatrix} 0.042280 \\ 0.012588 \\ 0.037874 \\ 0.052190 \\ 0.050380 \end{bmatrix}.$$

- Resolvendo-se $\nabla F(\bar{x}, \bar{p}, \bar{s})(\Delta x, \Delta p, \Delta s)^T = -F(\bar{x}, \bar{p}, \bar{s})$:

$$\Delta x = \begin{bmatrix} -0.2128270 \\ 0.3775727 \\ -0.0068583 \\ -0.0542318 \\ -0.1036555 \end{bmatrix}, \quad \Delta p = \begin{bmatrix} 0.018172 \\ 0.133670 \\ -0.036513 \end{bmatrix}, \quad \Delta s = \begin{bmatrix} -0.0078479 \\ -0.0139293 \\ -0.0181719 \\ -0.1336701 \\ 0.0365125 \end{bmatrix}.$$

- $\bar{\alpha} = \min\{1, \alpha_0(x_5/-\Delta x_5)\} = \min\{1, 1.5070\} = 1;$

Iteração 7:

- $\bar{x} = \begin{bmatrix} 4.940893 \\ 1.718425 \\ 0.014026 \\ 0.162226 \\ 0.164430 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -5.48526 \\ -0.56251 \\ -0.54395 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 0.016463 \\ 0.030057 \\ 5.485261 \\ 0.562506 \\ 0.543954 \end{bmatrix}.$
- $\bar{\mu} = \bar{x}^T \bar{s}/n = 0.078125;$
- Calcular as componentes de $F(\bar{x}, \bar{p}, \bar{s})$:

$$r_p = A\bar{x} - b = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_d = A^T\bar{p} + \bar{s} - c = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_\mu = \bar{X}\bar{s} - \sigma\bar{\mu}e = \begin{bmatrix} 0.042280 \\ 0.012588 \\ 0.037874 \\ 0.052190 \\ 0.050380 \end{bmatrix}.$$

- Resolvendo-se $\nabla F(\bar{x}, \bar{p}, \bar{s})(\Delta x, \Delta p, \Delta s)^T = -F(\bar{x}, \bar{p}, \bar{s})$:

$$\Delta x = \begin{bmatrix} -0.2128270 \\ 0.3775727 \\ -0.0068583 \\ -0.0542318 \\ -0.1036555 \end{bmatrix}, \quad \Delta p = \begin{bmatrix} 0.018172 \\ 0.133670 \\ -0.036513 \end{bmatrix}, \quad \Delta s = \begin{bmatrix} -0.0078479 \\ -0.0139293 \\ -0.0181719 \\ -0.1336701 \\ 0.0365125 \end{bmatrix}.$$

- $\bar{\alpha} = \min\{1, \alpha_0(x_5/-\Delta x_5)\} = \min\{1, 1.5070\} = 1;$
- $\bar{x} = \bar{x} + \bar{\alpha}\Delta x; \quad \bar{p} = \bar{p} + \bar{\alpha}\Delta p; \quad \bar{s} = \bar{s} + \bar{\alpha}\Delta s;$

Iteração 8:

- $\bar{x} = \begin{bmatrix} 4.7280657 \\ 2.0959978 \\ 0.0071678 \\ 0.1079939 \\ 0.0607748 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -5.46709 \\ -0.42884 \\ -0.58047 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 0.0086151 \\ 0.0161275 \\ 5.4670895 \\ 0.4288361 \\ 0.5804668 \end{bmatrix}.$

Iteração 8:

- $\bar{x} = \begin{bmatrix} 4.7280657 \\ 2.0959978 \\ 0.0071678 \\ 0.1079939 \\ 0.0607748 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -5.46709 \\ -0.42884 \\ -0.58047 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 0.0086151 \\ 0.0161275 \\ 5.4670895 \\ 0.4288361 \\ 0.5804668 \end{bmatrix}.$
- $\bar{\mu} = \bar{x}^T \bar{s}/n = 0.039063;$

Iteração 8:

- $\bar{x} = \begin{bmatrix} 4.7280657 \\ 2.0959978 \\ 0.0071678 \\ 0.1079939 \\ 0.0607748 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -5.46709 \\ -0.42884 \\ -0.58047 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 0.0086151 \\ 0.0161275 \\ 5.4670895 \\ 0.4288361 \\ 0.5804668 \end{bmatrix}.$
- $\bar{\mu} = \bar{x}^T \bar{s}/n = 0.039063;$
- Calcular as componentes de $F(\bar{x}, \bar{p}, \bar{s})$:

Iteração 8:

- $\bar{x} = \begin{bmatrix} 4.7280657 \\ 2.0959978 \\ 0.0071678 \\ 0.1079939 \\ 0.0607748 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -5.46709 \\ -0.42884 \\ -0.58047 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 0.0086151 \\ 0.0161275 \\ 5.4670895 \\ 0.4288361 \\ 0.5804668 \end{bmatrix}.$
- $\bar{\mu} = \bar{x}^T \bar{s}/n = 0.039063;$
- Calcular as componentes de $F(\bar{x}, \bar{p}, \bar{s})$:

$$r_p = A\bar{x} - b = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix},$$

Iteração 8:

- $\bar{x} = \begin{bmatrix} 4.7280657 \\ 2.0959978 \\ 0.0071678 \\ 0.1079939 \\ 0.0607748 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -5.46709 \\ -0.42884 \\ -0.58047 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 0.0086151 \\ 0.0161275 \\ 5.4670895 \\ 0.4288361 \\ 0.5804668 \end{bmatrix}.$
- $\bar{\mu} = \bar{x}^T \bar{s}/n = 0.039063;$
- Calcular as componentes de $F(\bar{x}, \bar{p}, \bar{s})$:

$$r_p = A\bar{x} - b = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_d = A^T \bar{p} + \bar{s} - c = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix},$$

Iteração 8:

- $\bar{x} = \begin{bmatrix} 4.7280657 \\ 2.0959978 \\ 0.0071678 \\ 0.1079939 \\ 0.0607748 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -5.46709 \\ -0.42884 \\ -0.58047 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 0.0086151 \\ 0.0161275 \\ 5.4670895 \\ 0.4288361 \\ 0.5804668 \end{bmatrix}.$
- $\bar{\mu} = \bar{x}^T \bar{s}/n = 0.039063;$
- Calcular as componentes de $F(\bar{x}, \bar{p}, \bar{s})$:

$$r_p = A\bar{x} - b = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_d = A^T \bar{p} + \bar{s} - c = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_\mu = \bar{X}\bar{s} - \sigma\bar{\mu}e = \begin{bmatrix} 0.021202 \\ 0.014272 \\ 0.019656 \\ 0.026780 \\ 0.015747 \end{bmatrix}.$$

Iteração 8:

- $\bar{x} = \begin{bmatrix} 4.7280657 \\ 2.0959978 \\ 0.0071678 \\ 0.1079939 \\ 0.0607748 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -5.46709 \\ -0.42884 \\ -0.58047 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 0.0086151 \\ 0.0161275 \\ 5.4670895 \\ 0.4288361 \\ 0.5804668 \end{bmatrix}.$
- $\bar{\mu} = \bar{x}^T \bar{s}/n = 0.039063;$
- Calcular as componentes de $F(\bar{x}, \bar{p}, \bar{s})$:

$$r_p = A\bar{x} - b = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_d = A^T \bar{p} + \bar{s} - c = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_\mu = \bar{X}\bar{s} - \sigma\bar{\mu}e = \begin{bmatrix} 0.021202 \\ 0.014272 \\ 0.019656 \\ 0.026780 \\ 0.015747 \end{bmatrix}.$$

- Resolvendo-se $\nabla F(\bar{x}, \bar{p}, \bar{s})(\Delta x, \Delta p, \Delta s)^T = -F(\bar{x}, \bar{p}, \bar{s})$:

Iteração 8:

- $\bar{x} = \begin{bmatrix} 4.7280657 \\ 2.0959978 \\ 0.0071678 \\ 0.1079939 \\ 0.0607748 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -5.46709 \\ -0.42884 \\ -0.58047 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 0.0086151 \\ 0.0161275 \\ 5.4670895 \\ 0.4288361 \\ 0.5804668 \end{bmatrix}.$
- $\bar{\mu} = \bar{x}^T \bar{s}/n = 0.039063;$
- Calcular as componentes de $F(\bar{x}, \bar{p}, \bar{s})$:

$$r_p = A\bar{x} - b = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_d = A^T\bar{p} + \bar{s} - c = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_\mu = \bar{X}\bar{s} - \sigma\bar{\mu}e = \begin{bmatrix} 0.021202 \\ 0.014272 \\ 0.019656 \\ 0.026780 \\ 0.015747 \end{bmatrix}.$$

- Resolvendo-se $\nabla F(\bar{x}, \bar{p}, \bar{s})(\Delta x, \Delta p, \Delta s)^T = -F(\bar{x}, \bar{p}, \bar{s})$:

$$\Delta x = \begin{bmatrix} -0.0671122 \\ 0.1236912 \\ -0.0035513 \\ -0.0180270 \\ -0.0350007 \end{bmatrix},$$

Iteração 8:

- $\bar{x} = \begin{bmatrix} 4.7280657 \\ 2.0959978 \\ 0.0071678 \\ 0.1079939 \\ 0.0607748 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -5.46709 \\ -0.42884 \\ -0.58047 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 0.0086151 \\ 0.0161275 \\ 5.4670895 \\ 0.4288361 \\ 0.5804668 \end{bmatrix}.$
- $\bar{\mu} = \bar{x}^T \bar{s}/n = 0.039063;$
- Calcular as componentes de $F(\bar{x}, \bar{p}, \bar{s})$:

$$r_p = A\bar{x} - b = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_d = A^T\bar{p} + \bar{s} - c = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_\mu = \bar{X}\bar{s} - \sigma\bar{\mu}e = \begin{bmatrix} 0.021202 \\ 0.014272 \\ 0.019656 \\ 0.026780 \\ 0.015747 \end{bmatrix}.$$

- Resolvendo-se $\nabla F(\bar{x}, \bar{p}, \bar{s})(\Delta x, \Delta p, \Delta s)^T = -F(\bar{x}, \bar{p}, \bar{s})$:

$$\Delta x = \begin{bmatrix} -0.0671122 \\ 0.1236912 \\ -0.0035513 \\ -0.0180270 \\ -0.0350007 \end{bmatrix}, \quad \Delta p = \begin{bmatrix} 0.033604 \\ 0.176397 \\ -0.075199 \end{bmatrix},$$

Iteração 8:

- $\bar{x} = \begin{bmatrix} 4.7280657 \\ 2.0959978 \\ 0.0071678 \\ 0.1079939 \\ 0.0607748 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -5.46709 \\ -0.42884 \\ -0.58047 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 0.0086151 \\ 0.0161275 \\ 5.4670895 \\ 0.4288361 \\ 0.5804668 \end{bmatrix}.$
- $\bar{\mu} = \bar{x}^T \bar{s}/n = 0.039063;$
- Calcular as componentes de $F(\bar{x}, \bar{p}, \bar{s})$:

$$r_p = A\bar{x} - b = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_d = A^T \bar{p} + \bar{s} - c = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_\mu = \bar{X}\bar{s} - \sigma\bar{\mu}e = \begin{bmatrix} 0.021202 \\ 0.014272 \\ 0.019656 \\ 0.026780 \\ 0.015747 \end{bmatrix}.$$

- Resolvendo-se $\nabla F(\bar{x}, \bar{p}, \bar{s})(\Delta x, \Delta p, \Delta s)^T = -F(\bar{x}, \bar{p}, \bar{s})$:

$$\Delta x = \begin{bmatrix} -0.0671122 \\ 0.1236912 \\ -0.0035513 \\ -0.0180270 \\ -0.0350007 \end{bmatrix}, \quad \Delta p = \begin{bmatrix} 0.033604 \\ 0.176397 \\ -0.075199 \end{bmatrix}, \quad \Delta s = \begin{bmatrix} -0.0043619 \\ -0.0077609 \\ -0.0336039 \\ -0.1763969 \\ 0.0751994 \end{bmatrix}.$$

Iteração 8:

- $\bar{x} = \begin{bmatrix} 4.7280657 \\ 2.0959978 \\ 0.0071678 \\ 0.1079939 \\ 0.0607748 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -5.46709 \\ -0.42884 \\ -0.58047 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 0.0086151 \\ 0.0161275 \\ 5.4670895 \\ 0.4288361 \\ 0.5804668 \end{bmatrix}.$
- $\bar{\mu} = \bar{x}^T \bar{s}/n = 0.039063;$
- Calcular as componentes de $F(\bar{x}, \bar{p}, \bar{s})$:

$$r_p = A\bar{x} - b = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_d = A^T \bar{p} + \bar{s} - c = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_\mu = \bar{X}\bar{s} - \sigma\bar{\mu}e = \begin{bmatrix} 0.021202 \\ 0.014272 \\ 0.019656 \\ 0.026780 \\ 0.015747 \end{bmatrix}.$$

- Resolvendo-se $\nabla F(\bar{x}, \bar{p}, \bar{s})(\Delta x, \Delta p, \Delta s)^T = -F(\bar{x}, \bar{p}, \bar{s})$:

$$\Delta x = \begin{bmatrix} -0.0671122 \\ 0.1236912 \\ -0.0035513 \\ -0.0180270 \\ -0.0350007 \end{bmatrix}, \quad \Delta p = \begin{bmatrix} 0.033604 \\ 0.176397 \\ -0.075199 \end{bmatrix}, \quad \Delta s = \begin{bmatrix} -0.0043619 \\ -0.0077609 \\ -0.0336039 \\ -0.1763969 \\ 0.0751994 \end{bmatrix}.$$

- $\bar{\alpha} = \min\{1, \alpha_0(x_5/-\Delta x_5)\} = \min\{1, 1.6496\} = 1;$

Iteração 8:

- $\bar{x} = \begin{bmatrix} 4.7280657 \\ 2.0959978 \\ 0.0071678 \\ 0.1079939 \\ 0.0607748 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -5.46709 \\ -0.42884 \\ -0.58047 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 0.0086151 \\ 0.0161275 \\ 5.4670895 \\ 0.4288361 \\ 0.5804668 \end{bmatrix}.$
- $\bar{\mu} = \bar{x}^T \bar{s}/n = 0.039063;$
- Calcular as componentes de $F(\bar{x}, \bar{p}, \bar{s})$:

$$r_p = A\bar{x} - b = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_d = A^T\bar{p} + \bar{s} - c = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_\mu = \bar{X}\bar{s} - \sigma\bar{\mu}e = \begin{bmatrix} 0.021202 \\ 0.014272 \\ 0.019656 \\ 0.026780 \\ 0.015747 \end{bmatrix}.$$

- Resolvendo-se $\nabla F(\bar{x}, \bar{p}, \bar{s})(\Delta x, \Delta p, \Delta s)^T = -F(\bar{x}, \bar{p}, \bar{s})$:

$$\Delta x = \begin{bmatrix} -0.0671122 \\ 0.1236912 \\ -0.0035513 \\ -0.0180270 \\ -0.0350007 \end{bmatrix}, \quad \Delta p = \begin{bmatrix} 0.033604 \\ 0.176397 \\ -0.075199 \end{bmatrix}, \quad \Delta s = \begin{bmatrix} -0.0043619 \\ -0.0077609 \\ -0.0336039 \\ -0.1763969 \\ 0.0751994 \end{bmatrix}.$$

- $\bar{\alpha} = \min\{1, \alpha_0(x_5/-\Delta x_5)\} = \min\{1, 1.6496\} = 1;$
- $\bar{x} = \bar{x} + \bar{\alpha}\Delta x; \quad \bar{p} = \bar{p} + \bar{\alpha}\Delta p; \quad \bar{s} = \bar{s} + \bar{\alpha}\Delta s;$

Iteração 9:

- $\bar{x} = \begin{bmatrix} 4.6609535 \\ 2.2196890 \\ 0.0036166 \\ 0.0899669 \\ 0.0257741 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -5.43349 \\ -0.25244 \\ -0.65567 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 0.0042532 \\ 0.0083666 \\ 5.4334856 \\ 0.2524392 \\ 0.6556662 \end{bmatrix}.$

Iteração 9:

- $\bar{x} = \begin{bmatrix} 4.6609535 \\ 2.2196890 \\ 0.0036166 \\ 0.0899669 \\ 0.0257741 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -5.43349 \\ -0.25244 \\ -0.65567 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 0.0042532 \\ 0.0083666 \\ 5.4334856 \\ 0.2524392 \\ 0.6556662 \end{bmatrix}.$
- $\bar{\mu} = \bar{x}^T \bar{s}/n = 0.019531;$

Iteração 9:

- $\bar{x} = \begin{bmatrix} 4.6609535 \\ 2.2196890 \\ 0.0036166 \\ 0.0899669 \\ 0.0257741 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -5.43349 \\ -0.25244 \\ -0.65567 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 0.0042532 \\ 0.0083666 \\ 5.4334856 \\ 0.2524392 \\ 0.6556662 \end{bmatrix}.$
- $\bar{\mu} = \bar{x}^T \bar{s}/n = 0.019531;$
- Calcular as componentes de $F(\bar{x}, \bar{p}, \bar{s})$:

Iteração 9:

- $\bar{x} = \begin{bmatrix} 4.6609535 \\ 2.2196890 \\ 0.0036166 \\ 0.0899669 \\ 0.0257741 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -5.43349 \\ -0.25244 \\ -0.65567 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 0.0042532 \\ 0.0083666 \\ 5.4334856 \\ 0.2524392 \\ 0.6556662 \end{bmatrix}.$
- $\bar{\mu} = \bar{x}^T \bar{s}/n = 0.019531;$
- Calcular as componentes de $F(\bar{x}, \bar{p}, \bar{s})$:

$$r_p = A\bar{x} - b = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix},$$

Iteração 9:

- $\bar{x} = \begin{bmatrix} 4.6609535 \\ 2.2196890 \\ 0.0036166 \\ 0.0899669 \\ 0.0257741 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -5.43349 \\ -0.25244 \\ -0.65567 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 0.0042532 \\ 0.0083666 \\ 5.4334856 \\ 0.2524392 \\ 0.6556662 \end{bmatrix}.$
- $\bar{\mu} = \bar{x}^T \bar{s}/n = 0.019531;$
- Calcular as componentes de $F(\bar{x}, \bar{p}, \bar{s})$:

$$r_p = A\bar{x} - b = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_d = A^T \bar{p} + \bar{s} - c = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix},$$

Iteração 9:

- $\bar{x} = \begin{bmatrix} 4.6609535 \\ 2.2196890 \\ 0.0036166 \\ 0.0899669 \\ 0.0257741 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -5.43349 \\ -0.25244 \\ -0.65567 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 0.0042532 \\ 0.0083666 \\ 5.4334856 \\ 0.2524392 \\ 0.6556662 \end{bmatrix}.$
- $\bar{\mu} = \bar{x}^T \bar{s}/n = 0.019531;$
- Calcular as componentes de $F(\bar{x}, \bar{p}, \bar{s})$:

$$r_p = A\bar{x} - b = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_d = A^T \bar{p} + \bar{s} - c = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_\mu = \bar{X}\bar{s} - \sigma\bar{\mu}e = \begin{bmatrix} 0.010058 \\ 0.008806 \\ 0.009885 \\ 0.012946 \\ 0.007134 \end{bmatrix}.$$

Iteração 9:

- $\bar{x} = \begin{bmatrix} 4.6609535 \\ 2.2196890 \\ 0.0036166 \\ 0.0899669 \\ 0.0257741 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -5.43349 \\ -0.25244 \\ -0.65567 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 0.0042532 \\ 0.0083666 \\ 5.4334856 \\ 0.2524392 \\ 0.6556662 \end{bmatrix}.$
- $\bar{\mu} = \bar{x}^T \bar{s}/n = 0.019531;$
- Calcular as componentes de $F(\bar{x}, \bar{p}, \bar{s})$:

$$r_p = A\bar{x} - b = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_d = A^T \bar{p} + \bar{s} - c = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_\mu = \bar{X}\bar{s} - \sigma\bar{\mu}e = \begin{bmatrix} 0.010058 \\ 0.008806 \\ 0.009885 \\ 0.012946 \\ 0.007134 \end{bmatrix}.$$

- Resolvendo-se $\nabla F(\bar{x}, \bar{p}, \bar{s})(\Delta x, \Delta p, \Delta s)^T = -F(\bar{x}, \bar{p}, \bar{s})$:

Iteração 9:

- $\bar{x} = \begin{bmatrix} 4.6609535 \\ 2.2196890 \\ 0.0036166 \\ 0.0899669 \\ 0.0257741 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -5.43349 \\ -0.25244 \\ -0.65567 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 0.0042532 \\ 0.0083666 \\ 5.4334856 \\ 0.2524392 \\ 0.6556662 \end{bmatrix}.$
- $\bar{\mu} = \bar{x}^T \bar{s}/n = 0.019531;$
- Calcular as componentes de $F(\bar{x}, \bar{p}, \bar{s})$:

$$r_p = A\bar{x} - b = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_d = A^T \bar{p} + \bar{s} - c = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_\mu = \bar{X}\bar{s} - \sigma\bar{\mu}e = \begin{bmatrix} 0.010058 \\ 0.008806 \\ 0.009885 \\ 0.012946 \\ 0.007134 \end{bmatrix}.$$

- Resolvendo-se $\nabla F(\bar{x}, \bar{p}, \bar{s})(\Delta x, \Delta p, \Delta s)^T = -F(\bar{x}, \bar{p}, \bar{s})$:

$$\Delta x = \begin{bmatrix} -0.0232959 \\ 0.0448365 \\ -0.0018030 \\ -0.0066377 \\ -0.0130999 \end{bmatrix},$$

Iteração 9:

- $\bar{x} = \begin{bmatrix} 4.6609535 \\ 2.2196890 \\ 0.0036166 \\ 0.0899669 \\ 0.0257741 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -5.43349 \\ -0.25244 \\ -0.65567 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 0.0042532 \\ 0.0083666 \\ 5.4334856 \\ 0.2524392 \\ 0.6556662 \end{bmatrix}.$
- $\bar{\mu} = \bar{x}^T \bar{s}/n = 0.019531;$
- Calcular as componentes de $F(\bar{x}, \bar{p}, \bar{s})$:

$$r_p = A\bar{x} - b = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_d = A^T \bar{p} + \bar{s} - c = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_\mu = \bar{X}\bar{s} - \sigma\bar{\mu}e = \begin{bmatrix} 0.010058 \\ 0.008806 \\ 0.009885 \\ 0.012946 \\ 0.007134 \end{bmatrix}.$$

- Resolvendo-se $\nabla F(\bar{x}, \bar{p}, \bar{s})(\Delta x, \Delta p, \Delta s)^T = -F(\bar{x}, \bar{p}, \bar{s})$:

$$\Delta x = \begin{bmatrix} -0.0232959 \\ 0.0448365 \\ -0.0018030 \\ -0.0066377 \\ -0.0130999 \end{bmatrix}, \quad \Delta p = \begin{bmatrix} 0.024400 \\ 0.125267 \\ -0.056475 \end{bmatrix},$$

Iteração 9:

- $\bar{x} = \begin{bmatrix} 4.6609535 \\ 2.2196890 \\ 0.0036166 \\ 0.0899669 \\ 0.0257741 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -5.43349 \\ -0.25244 \\ -0.65567 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 0.0042532 \\ 0.0083666 \\ 5.4334856 \\ 0.2524392 \\ 0.6556662 \end{bmatrix}.$
- $\bar{\mu} = \bar{x}^T \bar{s}/n = 0.019531;$
- Calcular as componentes de $F(\bar{x}, \bar{p}, \bar{s})$:

$$r_p = A\bar{x} - b = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_d = A^T \bar{p} + \bar{s} - c = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_\mu = \bar{X}\bar{s} - \sigma\bar{\mu}e = \begin{bmatrix} 0.010058 \\ 0.008806 \\ 0.009885 \\ 0.012946 \\ 0.007134 \end{bmatrix}.$$

- Resolvendo-se $\nabla F(\bar{x}, \bar{p}, \bar{s})(\Delta x, \Delta p, \Delta s)^T = -F(\bar{x}, \bar{p}, \bar{s})$:

$$\Delta x = \begin{bmatrix} -0.0232959 \\ 0.0448365 \\ -0.0018030 \\ -0.0066377 \\ -0.0130999 \end{bmatrix}, \quad \Delta p = \begin{bmatrix} 0.024400 \\ 0.125267 \\ -0.056475 \end{bmatrix}, \quad \Delta s = \begin{bmatrix} -0.0021367 \\ -0.0041361 \\ -0.0243997 \\ -0.1252674 \\ 0.0564747 \end{bmatrix}.$$

Iteração 9:

- $\bar{x} = \begin{bmatrix} 4.6609535 \\ 2.2196890 \\ 0.0036166 \\ 0.0899669 \\ 0.0257741 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -5.43349 \\ -0.25244 \\ -0.65567 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 0.0042532 \\ 0.0083666 \\ 5.4334856 \\ 0.2524392 \\ 0.6556662 \end{bmatrix}.$
- $\bar{\mu} = \bar{x}^T \bar{s}/n = 0.019531;$
- Calcular as componentes de $F(\bar{x}, \bar{p}, \bar{s})$:

$$r_p = A\bar{x} - b = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_d = A^T \bar{p} + \bar{s} - c = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_\mu = \bar{X}\bar{s} - \sigma\bar{\mu}e = \begin{bmatrix} 0.010058 \\ 0.008806 \\ 0.009885 \\ 0.012946 \\ 0.007134 \end{bmatrix}.$$

- Resolvendo-se $\nabla F(\bar{x}, \bar{p}, \bar{s})(\Delta x, \Delta p, \Delta s)^T = -F(\bar{x}, \bar{p}, \bar{s})$:

$$\Delta x = \begin{bmatrix} -0.0232959 \\ 0.0448365 \\ -0.0018030 \\ -0.0066377 \\ -0.0130999 \end{bmatrix}, \quad \Delta p = \begin{bmatrix} 0.024400 \\ 0.125267 \\ -0.056475 \end{bmatrix}, \quad \Delta s = \begin{bmatrix} -0.0021367 \\ -0.0041361 \\ -0.0243997 \\ -0.1252674 \\ 0.0564747 \end{bmatrix}.$$

- $\bar{\alpha} = \min\{1, \alpha_0(x_5/-\Delta x_5)\} = \min\{1, 1.8691\} = 1;$

Iteração 9:

- $\bar{x} = \begin{bmatrix} 4.6609535 \\ 2.2196890 \\ 0.0036166 \\ 0.0899669 \\ 0.0257741 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -5.43349 \\ -0.25244 \\ -0.65567 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 0.0042532 \\ 0.0083666 \\ 5.4334856 \\ 0.2524392 \\ 0.6556662 \end{bmatrix}.$
- $\bar{\mu} = \bar{x}^T \bar{s}/n = 0.019531;$
- Calcular as componentes de $F(\bar{x}, \bar{p}, \bar{s})$:

$$r_p = A\bar{x} - b = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_d = A^T \bar{p} + \bar{s} - c = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_\mu = \bar{X}\bar{s} - \sigma\bar{\mu}e = \begin{bmatrix} 0.010058 \\ 0.008806 \\ 0.009885 \\ 0.012946 \\ 0.007134 \end{bmatrix}.$$

- Resolvendo-se $\nabla F(\bar{x}, \bar{p}, \bar{s})(\Delta x, \Delta p, \Delta s)^T = -F(\bar{x}, \bar{p}, \bar{s})$:

$$\Delta x = \begin{bmatrix} -0.0232959 \\ 0.0448365 \\ -0.0018030 \\ -0.0066377 \\ -0.0130999 \end{bmatrix}, \quad \Delta p = \begin{bmatrix} 0.024400 \\ 0.125267 \\ -0.056475 \end{bmatrix}, \quad \Delta s = \begin{bmatrix} -0.0021367 \\ -0.0041361 \\ -0.0243997 \\ -0.1252674 \\ 0.0564747 \end{bmatrix}.$$

- $\bar{\alpha} = \min\{1, \alpha_0(x_5/-\Delta x_5)\} = \min\{1, 1.8691\} = 1;$
- $\bar{x} = \bar{x} + \bar{\alpha}\Delta x; \quad \bar{p} = \bar{p} + \bar{\alpha}\Delta p; \quad \bar{s} = \bar{s} + \bar{\alpha}\Delta s;$

Iteração 10:

- $\bar{x} = \begin{bmatrix} 4.6376576 \\ 2.2645255 \\ 0.0018135 \\ 0.0833291 \\ 0.0126742 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -5.40909 \\ -0.12717 \\ -0.71214 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 0.0021165 \\ 0.0042305 \\ 5.4090859 \\ 0.1271718 \\ 0.7121408 \end{bmatrix}.$

Iteração 10:

- $\bar{x} = \begin{bmatrix} 4.6376576 \\ 2.2645255 \\ 0.0018135 \\ 0.0833291 \\ 0.0126742 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -5.40909 \\ -0.12717 \\ -0.71214 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 0.0021165 \\ 0.0042305 \\ 5.4090859 \\ 0.1271718 \\ 0.7121408 \end{bmatrix}.$
- $\bar{\mu} = \bar{x}^T \bar{s}/n = 0.0097656;$

Iteração 10:

- $\bar{x} = \begin{bmatrix} 4.6376576 \\ 2.2645255 \\ 0.0018135 \\ 0.0833291 \\ 0.0126742 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -5.40909 \\ -0.12717 \\ -0.71214 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 0.0021165 \\ 0.0042305 \\ 5.4090859 \\ 0.1271718 \\ 0.7121408 \end{bmatrix}.$
- $\bar{\mu} = \bar{x}^T \bar{s}/n = 0.0097656$;
- Calcular as componentes de $F(\bar{x}, \bar{p}, \bar{s})$:

Iteração 10:

- $\bar{x} = \begin{bmatrix} 4.6376576 \\ 2.2645255 \\ 0.0018135 \\ 0.0833291 \\ 0.0126742 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -5.40909 \\ -0.12717 \\ -0.71214 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 0.0021165 \\ 0.0042305 \\ 5.4090859 \\ 0.1271718 \\ 0.7121408 \end{bmatrix}.$
- $\bar{\mu} = \bar{x}^T \bar{s}/n = 0.0097656$;
- Calcular as componentes de $F(\bar{x}, \bar{p}, \bar{s})$:

$$r_p = A\bar{x} - b = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix},$$

Iteração 10:

- $\bar{x} = \begin{bmatrix} 4.6376576 \\ 2.2645255 \\ 0.0018135 \\ 0.0833291 \\ 0.0126742 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -5.40909 \\ -0.12717 \\ -0.71214 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 0.0021165 \\ 0.0042305 \\ 5.4090859 \\ 0.1271718 \\ 0.7121408 \end{bmatrix}.$
- $\bar{\mu} = \bar{x}^T \bar{s}/n = 0.0097656$;
- Calcular as componentes de $F(\bar{x}, \bar{p}, \bar{s})$:

$$r_p = A\bar{x} - b = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_d = A^T \bar{p} + \bar{s} - c = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix},$$

Iteração 10:

- $\bar{x} = \begin{bmatrix} 4.6376576 \\ 2.2645255 \\ 0.0018135 \\ 0.0833291 \\ 0.0126742 \end{bmatrix}, \quad \bar{p} = \begin{bmatrix} -5.40909 \\ -0.12717 \\ -0.71214 \end{bmatrix}, \quad \bar{s} = \begin{bmatrix} 0.0021165 \\ 0.0042305 \\ 5.4090859 \\ 0.1271718 \\ 0.7121408 \end{bmatrix}.$
- $\bar{\mu} = \bar{x}^T \bar{s}/n = 0.0097656$;
- Calcular as componentes de $F(\bar{x}, \bar{p}, \bar{s})$:

$$r_p = A\bar{x} - b = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_d = A^T \bar{p} + \bar{s} - c = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}, \quad r_\mu = \bar{X}\bar{s} - \sigma\bar{\mu}e = \begin{bmatrix} 0.0049326 \\ 0.0046974 \\ 0.0049268 \\ 0.0057143 \\ 0.0041430 \end{bmatrix}.$$

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- Critérios de parada satisfeitos!

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- Critérios de parada satisfeitos!
- A solução ótima (com precisão de 10^{-2}) é:
  $(\bar{x}_1, \bar{x}_2) \approx (4.64, 2.26)$, com valor ótimo ≈ 18.44;

Método simplex

Iteração 3: $\mathcal{B} = \{1, 4, 2\}$ e $\mathcal{N} = \{3, 5\}$;

$$B = \begin{bmatrix} 0.5 & 0 & 0.3 \\ 0.1 & 1 & 0.2 \\ 0.4 & 0 & 0.5 \end{bmatrix} \quad B^{-1} = \begin{bmatrix} 3.84 & 0 & -2.30 \\ 0.23 & 1 & -0.54 \\ -3.07 & 0 & 3.84 \end{bmatrix}$$

- Calcular a solução básica primal:

$$\bar{x}_{\mathcal{B}} = B^{-1} b = \begin{bmatrix} 4.62 \\ 0.08 \\ 2.30 \end{bmatrix}$$

- Calcular a solução básica dual:

$$\bar{p}^T = c_{\mathcal{B}}^T B^{-1} = \begin{bmatrix} -5.36 & 0 & -0.78 \end{bmatrix}$$

$$\bar{s}_3 = c_3 - \bar{p}^T a_3 = 5.36$$
$$\bar{s}_5 = c_5 - \bar{p}^T a_5 = 0.78$$

$$c^T = \begin{bmatrix} -3 & -2 & 0 & 0 & 0 \end{bmatrix}$$

$$A = \begin{bmatrix} 0.5 & 0.3 & 1 & 0 & 0 \\ 0.1 & 0.2 & 0 & 1 & 0 \\ 0.4 & 0.5 & 0 & 0 & 1 \end{bmatrix} \quad b = \begin{bmatrix} 3 \\ 1 \\ 3 \end{bmatrix}$$

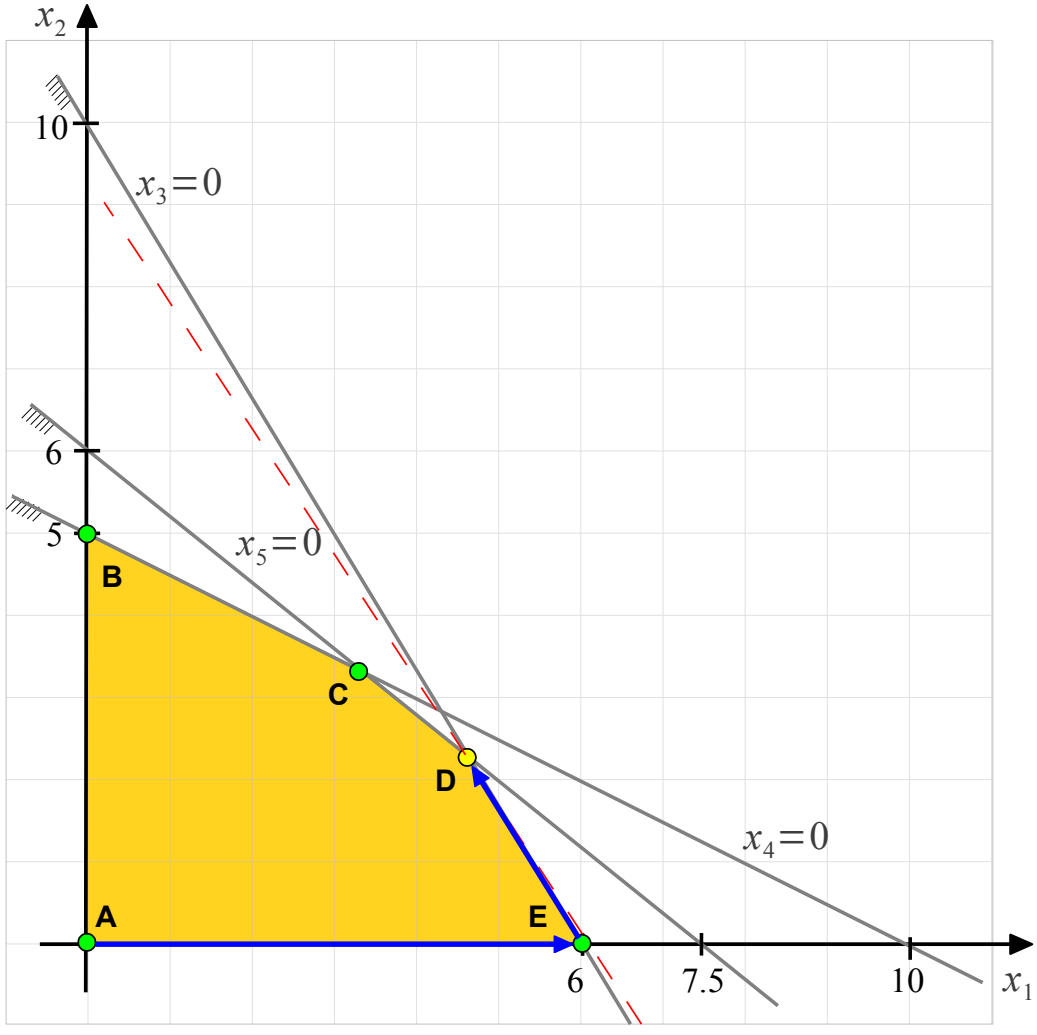
- É possível melhorar essa solução?
- Não! Os custos relativos são ≥ 0.
- Ou seja, a solução dual é factível.
- Portanto: solução ótima encontrada!
- $x^\star = (4.62,\ 2.3,\ 0,\ 0.08,\ 0)$;
- $f(x^\star) = c_{\mathcal{B}}^T x_{\mathcal{B}} = -18.46$;

Método simplex

▷ Ilustração

Para $x = (x_1, x_2, x_3, x_4, x_5)$:

- **A**: $(0,\ 0,\ 3,\ 1,\ 3)$
- **B**: $(0,\ 5,\ 1.5,\ 0,\ 0.5)$
- **C**: $(3.33,\ 3.33,\ 0.33,\ 0,\ 0)$
- **D**: $(4.62,\ 2.3,\ 0,\ 0.08,\ 0)$
- **E**: $(6,\ 0,\ 0,\ 0.4,\ 0.6)$

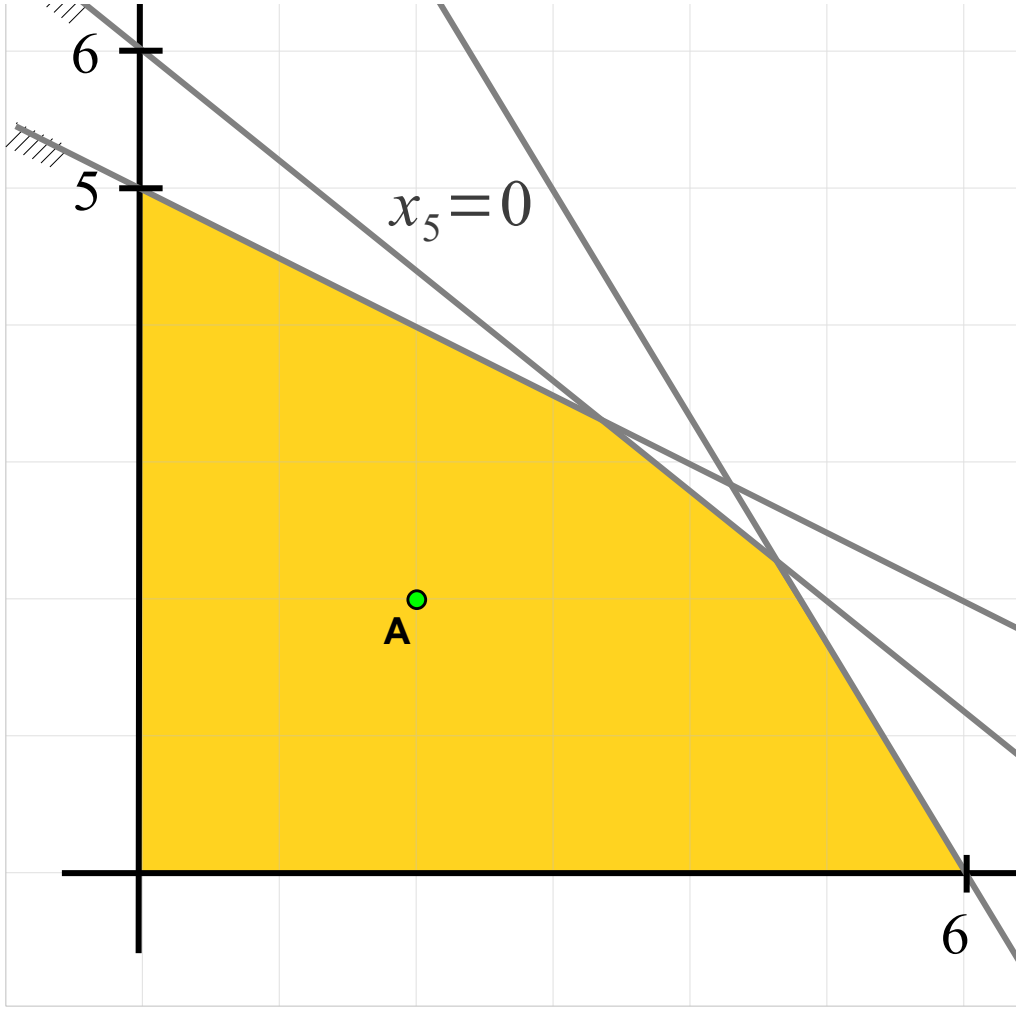


Método primal-dual de pontos interiores

▷ Ilustração

Para $x = (x_1, x_2, x_3, x_4, x_5)$:

- **A** $\approx (2,\ 2,\ 1.4,\ 0.4,\ 1.2)$

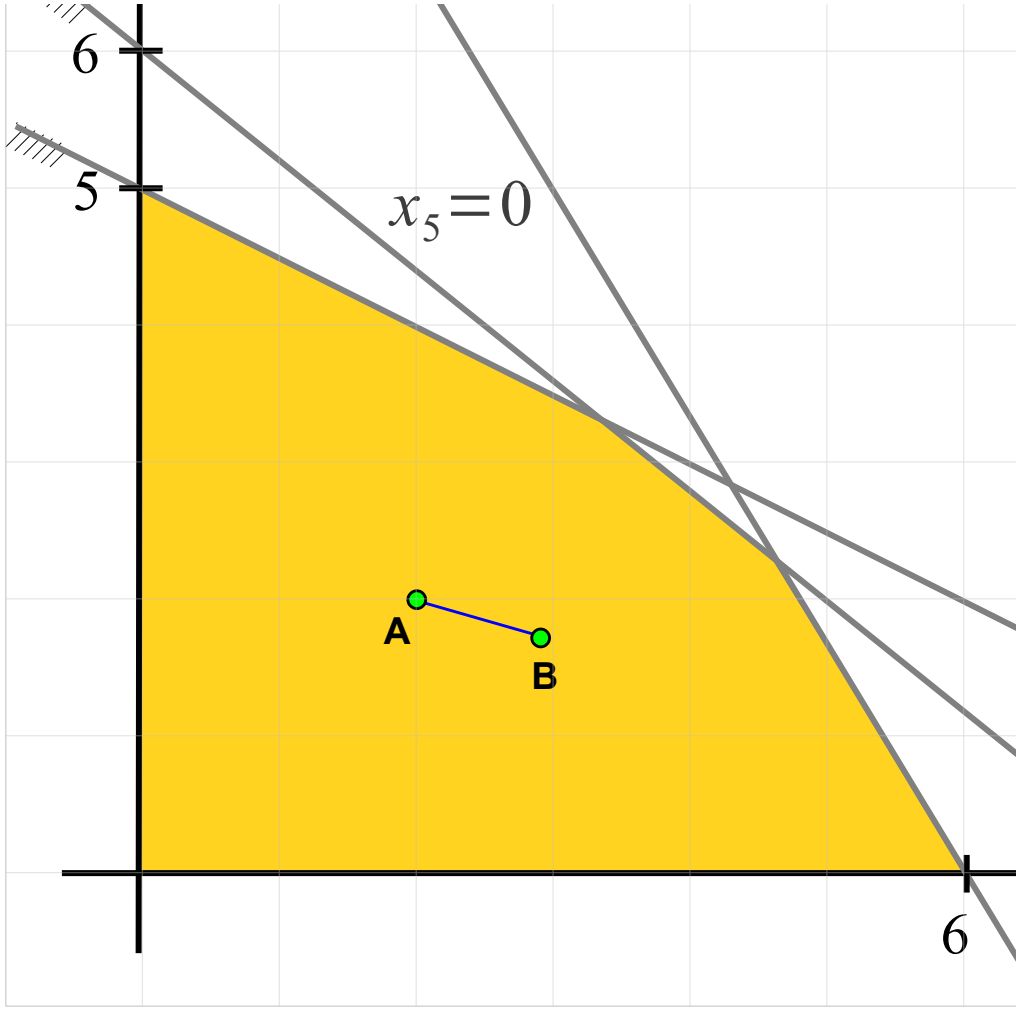


Método primal-dual de pontos interiores

▷ Ilustração

Para $x = (x_1, x_2, x_3, x_4, x_5)$:

- **A** $\approx (2,\ 2,\ 1.4,\ 0.4,\ 1.2)$
- **B** $\approx (2.89,\ 1.70,\ 1.05,\ 0.37,\ 0.99)$



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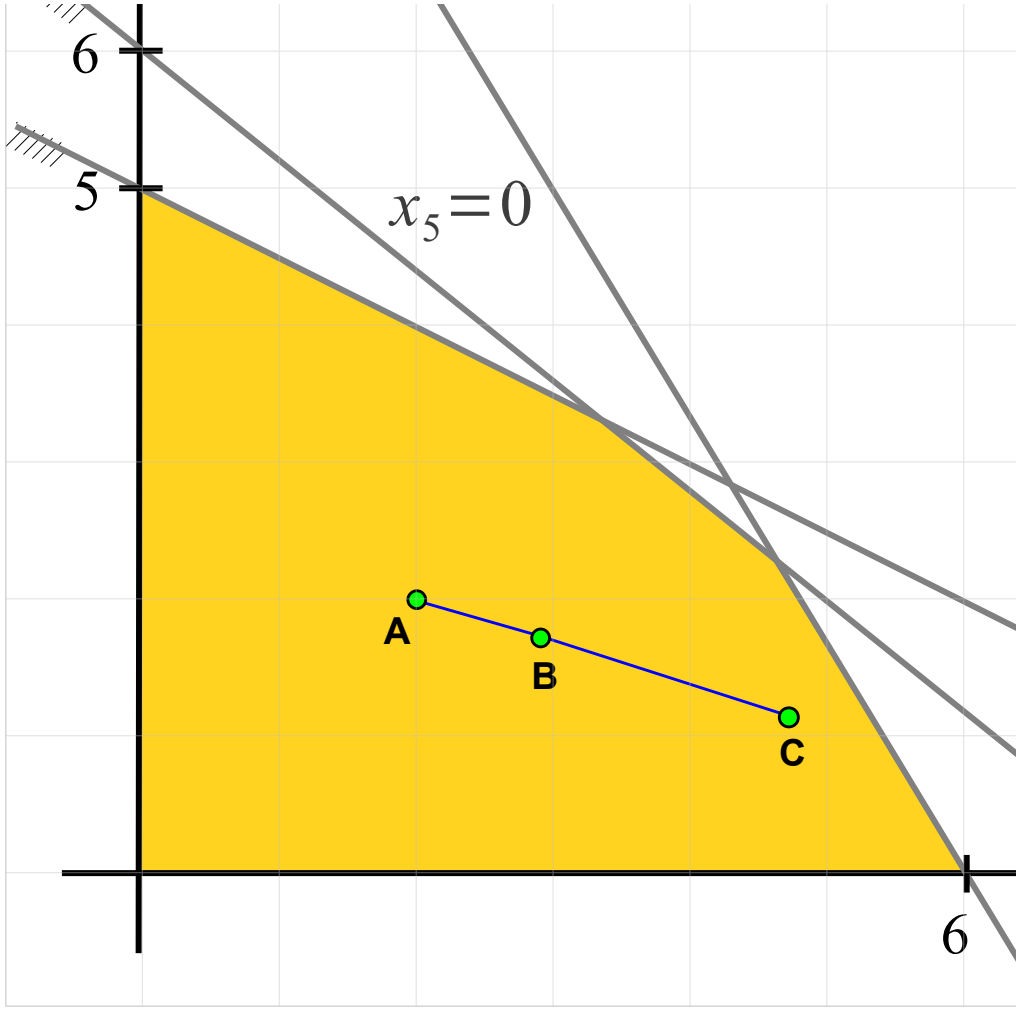

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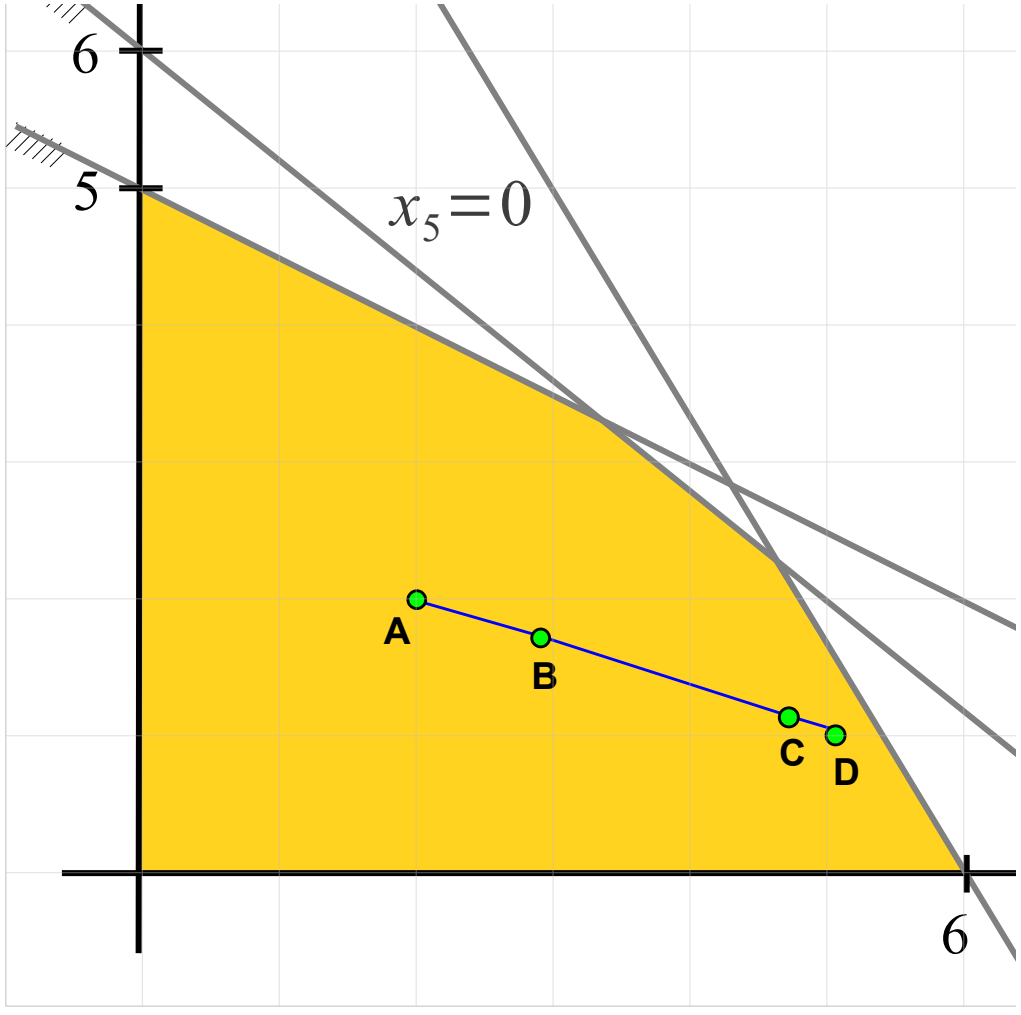
- **D** $\approx (5.17,\ 1.04\ 0.10,\ 0.27,\ 0.41)$



Método primal-dual de pontos interiores

▷ Ilustração

Para $x = (x_1, x_2, x_3, x_4, x_5)$:

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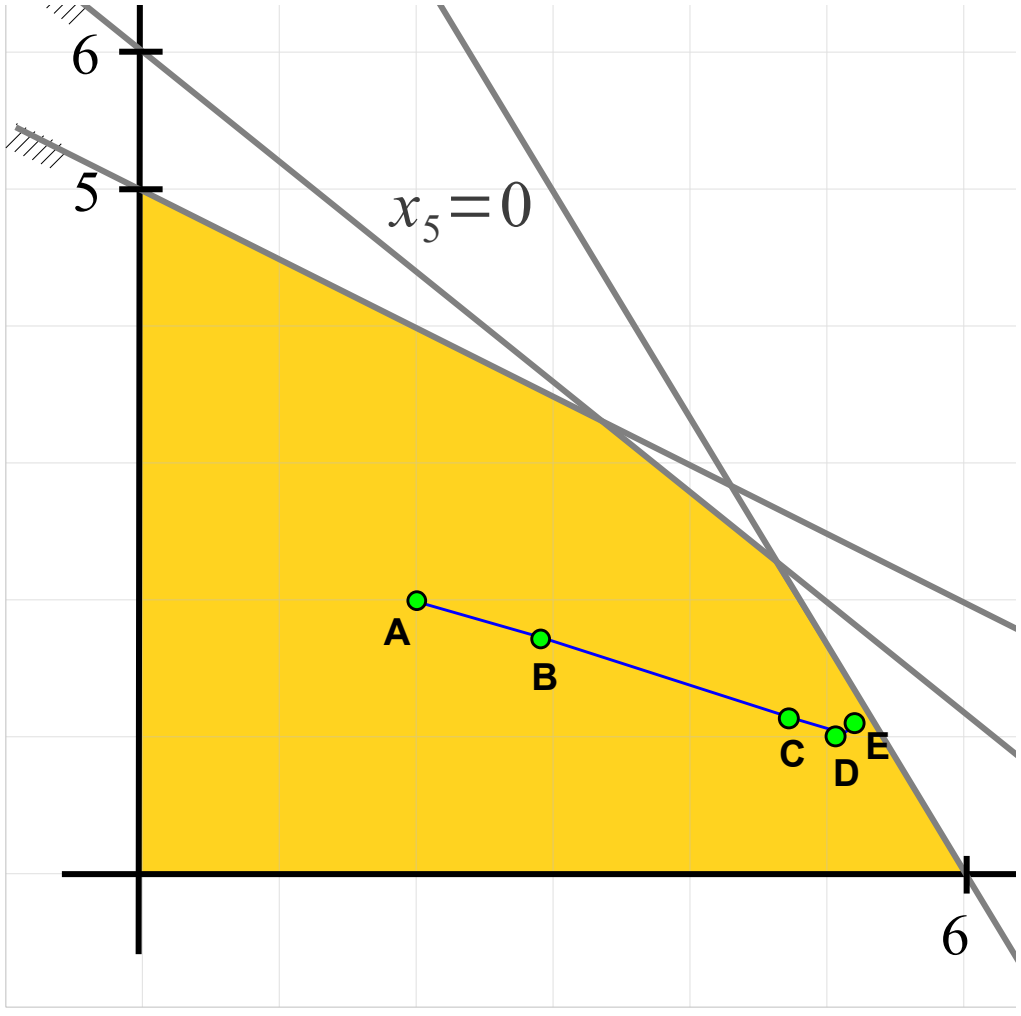

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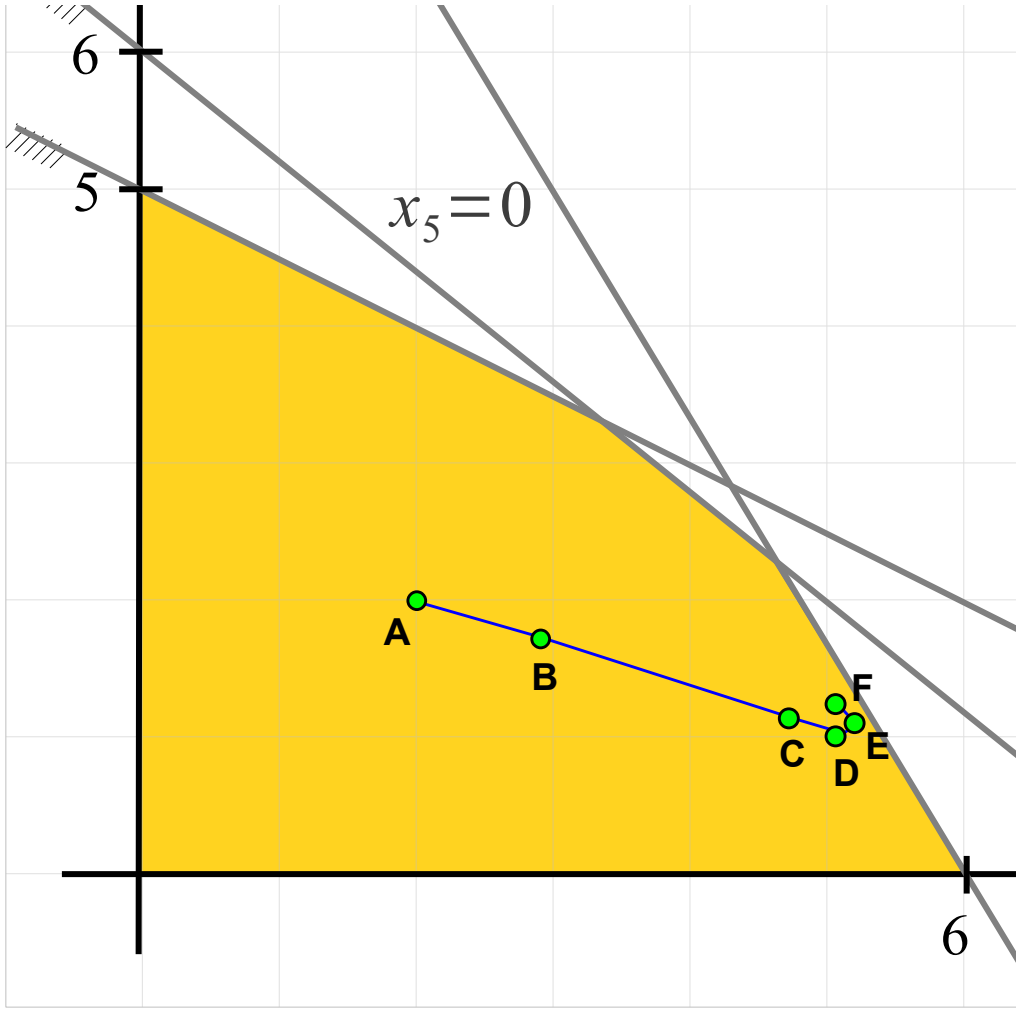
- **F** $\approx (5.17,\ 1.30,\ 0.02,\ 0.22,\ 0.29)$



Método primal-dual de pontos interiores

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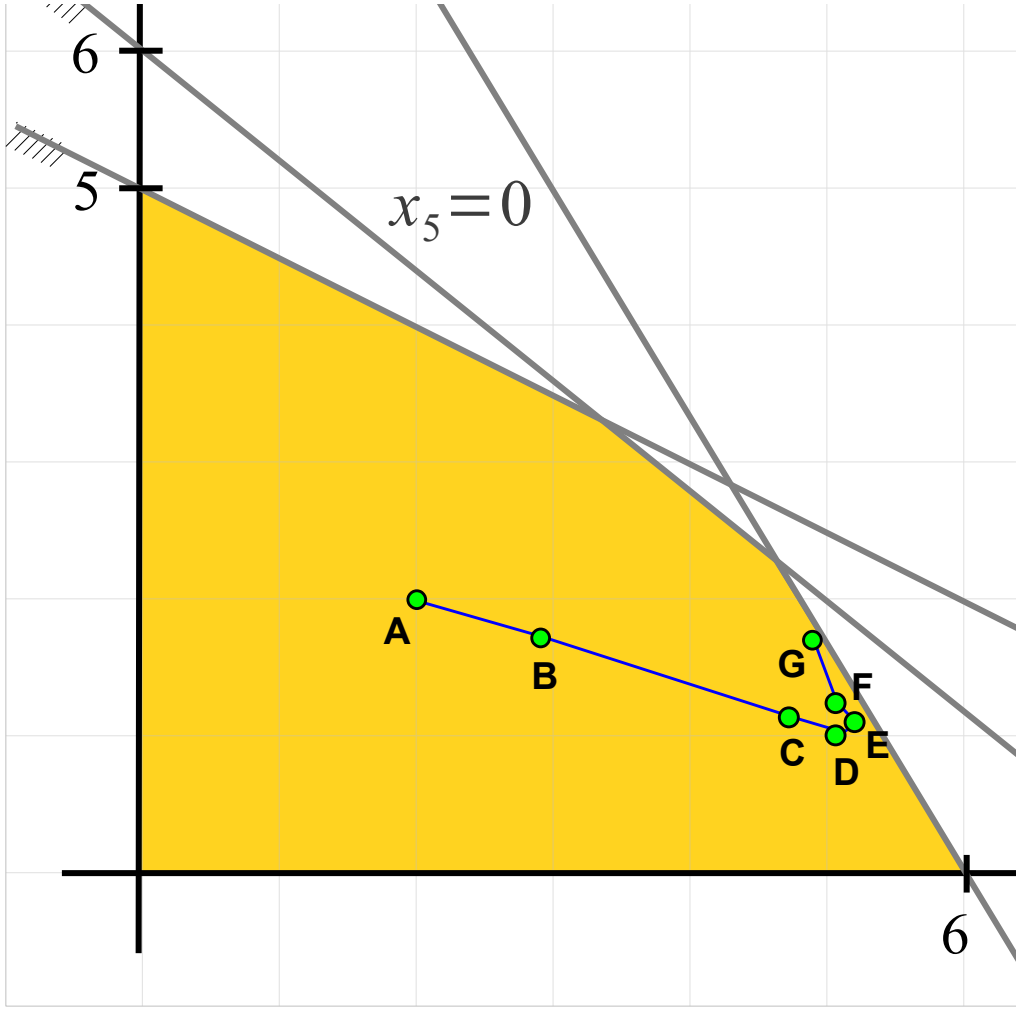
- **F** $\approx (5.17,\ 1.30,\ 0.02,\ 0.22,\ 0.29)$
- **G** $\approx (4.94,\ 1.71,\ 0.01,\ 0.16,\ 0.16)$



Método primal-dual de pontos interiores

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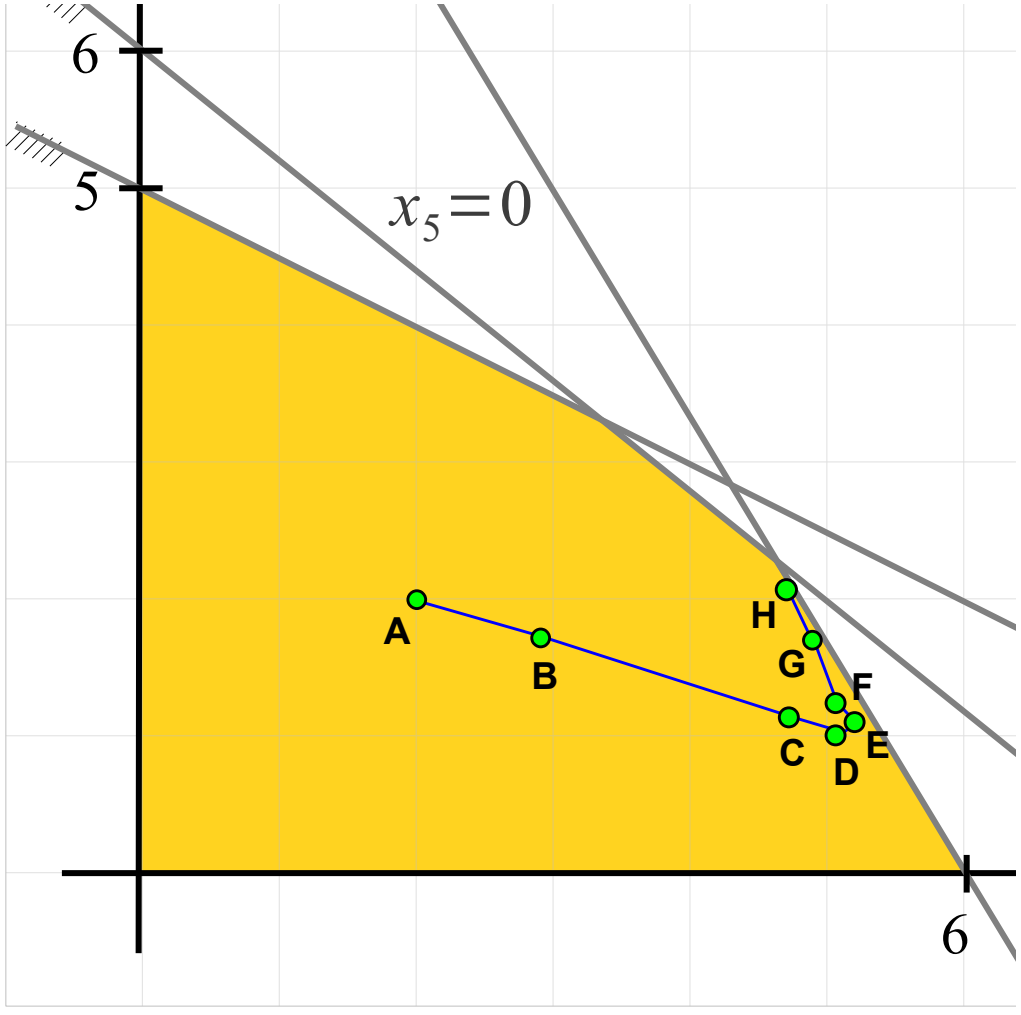
- **G** $\approx (4.94,\ 1.71,\ 0.01,\ 0.16,\ 0.16)$
- **H** $\approx (4.73,\ 2.10,\ 0.01,\ 0.11,\ 0.06)$



Método primal-dual de pontos interiores

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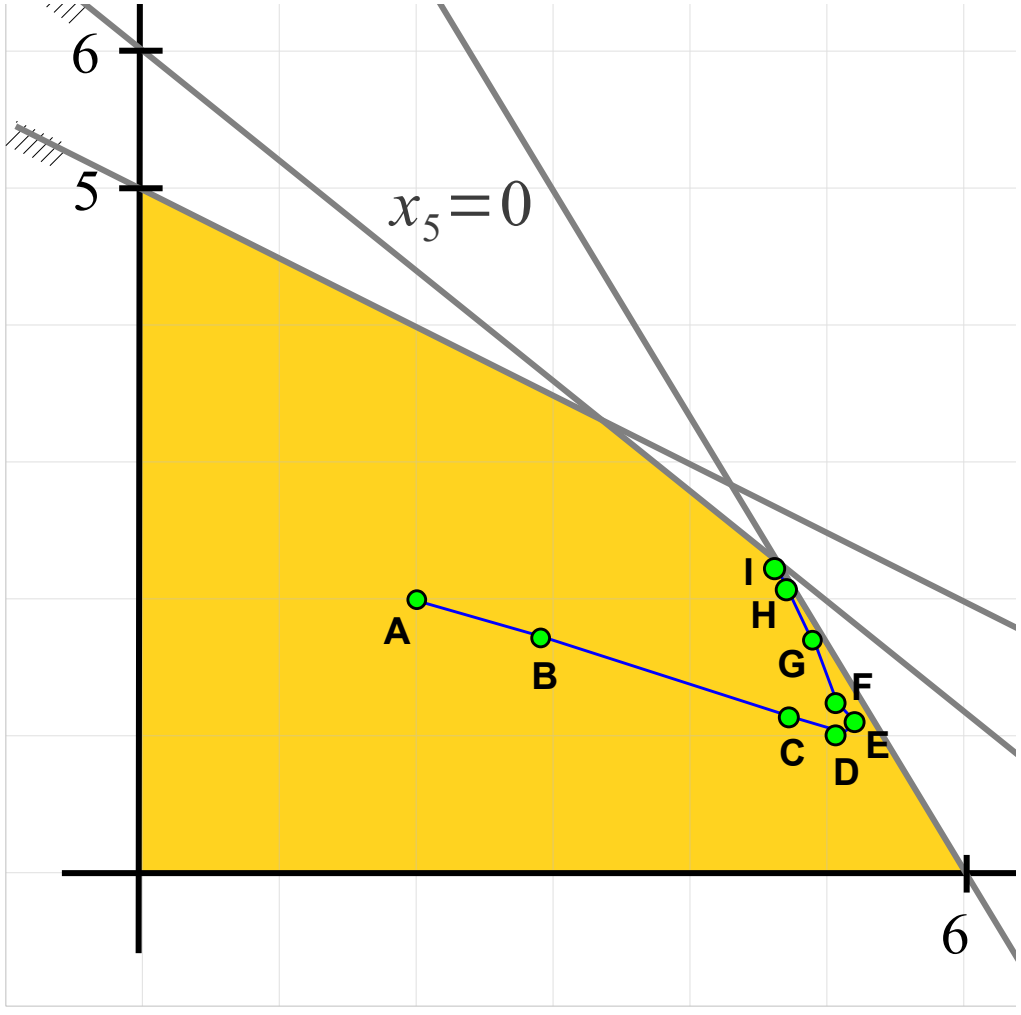
- **G** $\approx (4.94,\ 1.71,\ 0.01,\ 0.16,\ 0.16)$
- **H** $\approx (4.73,\ 2.10,\ 0.01,\ 0.11,\ 0.06)$
- **I** $\approx (4.66,\ 2.22,\ 0.00,\ 0.09,\ 0.03)$



Método primal-dual de pontos interiores

▷ Ilustração

Para $x = (x_1, x_2, x_3, x_4, x_5)$:

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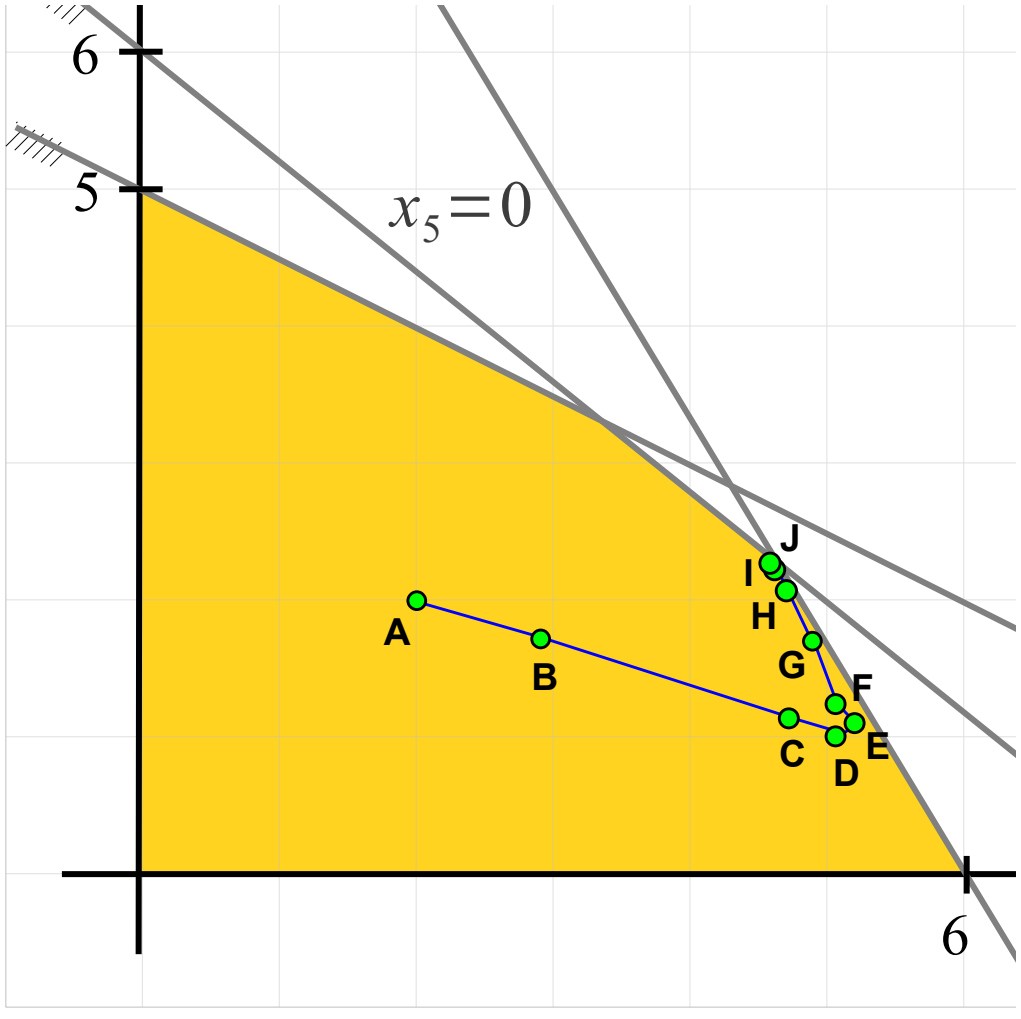
- **J** $\approx (4.64,\ 2.26,\ 0.00,\ 0.08,\ 0.01)$



Método primal-dual de pontos interiores

▷ Exercício

Determine a solução ótima usando o método primal-dual de pontos interiores, *permitindo tamanhos de passo diferentes para os espaços primal e dual, e usando uma das vizinhanças definidas em aula*:

$$\begin{aligned} \max \quad & f(x_1, x_2) = 3x_1 + 2x_2 \\ \text{s.a} \quad & 0{,}5x_1 + 0{,}3x_2 \leq 3 \\ & 0{,}1x_1 + 0{,}2x_2 \leq 1 \\ & 0{,}4x_1 + 0{,}5x_2 \leq 3 \\ & x_1 \geq 0, x_2 \geq 0 \end{aligned}$$

- Obrigado pela atenção!
- Dúvidas?