Gauss-Jacobi y Gauss-Seidel

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Tabla de Contenidos


```
import numpy as np
```

```
%load_ext autoreload

%autoreload 2
from src import gauss_jacobi, gauss_seidel
```

```
The autoreload extension is already loaded. To reload it, use:
  %reload_ext autoreload
```

1 CONJUNTO DE EJERCICIOS

1.1 Ejercicio 1

Encuentre las primeras dos iteraciones del método de Jacobi para los siguientes sistemas lineales, por medio de $x^{(0)} = 0$:

a.

$$
\begin{aligned}
3x_1 - x_2 + x_3 &= 1,\\
3x_1 + 6x_2 + 2x_3 &= 0,\\
3x_1 + 3x_2 + 7x_3 &= 4.
\end{aligned}
$$

```
A1 = np.array([[3, -1, 1], [3, 6, 2], [3, 3, 7]])
b1 = np.array([1, 0, 4])
x0_1 = np.zeros(len(b1))
```

```
print('Resultado tras 2 primeras iteraciones:')
sol1, tray1 = gauss_jacobi(A=A1, b=b1, x0=x0_1, tol=1e-6, max_iter=3)
```

```
Resultado tras 2 primeras iteraciones:
[02-03 19:19:05][INFO] i= 0 x: [0. 0. 0.]
[02-03 19:19:05][INFO] i= 1 x: [[0.33333333 0.         0.57142857]]
[02-03 19:19:05][INFO] i= 2 x: [[ 0.14285714 -0.35714286  0.42857143]]
```

b.

$$
\begin{aligned}
10x_1 - x_2 &= 9,\\
-x_1 + 10x_2 - 2x_3 &= 7,\\
-2x_2 + 10x_3 &= 6.
\end{aligned}
$$

```
A2 = np.array([[10, -1, 0], [-1, 10, -2], [0, -2, 10]])
b2 = np.array([9, 7, 6])
x0_2 = np.zeros(len(b2))
```

```
print("Resultado tras 2 primeras iteraciones:")
sol2, tray2 = gauss_jacobi(A=A2, b=b2, x0=x0_2, tol=1e-6, max_iter=3)
```

```
Resultado tras 2 primeras iteraciones:
[02-03 19:19:09][INFO] i= 0 x: [0. 0. 0.]
[02-03 19:19:09][INFO] i= 1 x: [[0.9 0.7 0.6]]
[02-03 19:19:09][INFO] i= 2 x: [[0.97 0.91 0.74]]
```

c.

$$\begin{aligned} 10x_1 + 5x_2 &= 6, \\ 5x_1 + 10x_2 - 4x_3 &= 25, \\ -4x_2 + 8x_3 - x_4 &= -11, \\ -x_3 + 5x_4 &= -11. \end{aligned}$$

```
A3 = np.array([[10, 5, 0, 0], [5, 10, -4, 0], [0, -4, 8, -1], [0, 0, -1, 5]])
b3 = np.array([6, 25, -11, -11])
x0_3 = np.zeros(len(b3))
```

```
print("Resultado tras 2 primeras iteraciones:")
sol3, tray3 = gauss_jacobi(A=A3, b=b3, x0=x0_3, tol=1e-6, max_iter=3)
```

```
Resultado tras 2 primeras iteraciones:
[02-03 19:19:12][INFO] i= 0 x: [0. 0. 0. 0.]
[02-03 19:19:12][INFO] i= 1 x: [[ 0.6    2.5   -1.375 -2.2  ]]
[02-03 19:19:12][INFO] i= 2 x: [[-0.65   1.65  -0.4   -2.475]]
```

d.

$$\begin{aligned} 4x_1 + x_2 + x_3 + x_5 &= 6, \\ -x_1 - 3x_2 + x_3 + x_4 &= 6, \\ 2x_1 + x_2 + 5x_3 - x_4 - x_5 &= 6, \\ -x_1 - x_2 - x_3 + 4x_4 &= 6, \\ 2x_2 - x_3 + x_4 + 4x_5 &= 6. \end{aligned}$$

```
A4 = np.array(
    [
        [4, 1, 1, 0, 1],
        [-1, -3, 1, 1, 0],
        [2, 1, 5, -1, -1],
        [-1, -1, -1, 4, 0],
        [0, 2, -1, 1, 4],
    ]
)
b4 = np.array([6, 6, 6, 6, 6])
x0_4 = np.zeros(len(b4))
```

```
print("Resultado tras 2 primeras iteraciones:")
sol4, tray4 = gauss_jacobi(A=A4, b=b4, x0=x0_4, tol=1e-6, max_iter=3)
```

```
Resultado tras 2 primeras iteraciones:
[02-03 19:19:17][INFO] i= 0 x: [0. 0. 0. 0. 0.]
[02-03 19:19:17][INFO] i= 1 x: [[ 1.5 -2.   1.2  1.5  1.5]]
[02-03 19:19:17][INFO] i= 2 x: [[ 1.325 -1.6    1.6    1.675  2.425]]
```

1.2 Ejercicio 2

Repita el ejercicio 1 usando el método de Gauss-Siedel.

a.

```
print("Resultado tras 2 primeras iteraciones:")
sol1, tray1 = gauss_seidel(A=A1, b=b1, x0=x0_1, tol=1e-6, max_iter=3)
```

```
Resultado tras 2 primeras iteraciones:
[02-03 19:19:20][INFO] i= 0 x: [0. 0. 0.]
[02-03 19:19:20][INFO] i= 1 x: [[ 0.33333333 -0.16666667  0.5       ]]
[02-03 19:19:20][INFO] i= 2 x: [[ 0.11111111 -0.22222222  0.61904762]]
```

b.

```
print("Resultado tras 2 primeras iteraciones:")
sol2, tray2 = gauss_seidel(A=A2, b=b2, x0=x0_2, tol=1e-6, max_iter=3)
```

```
Resultado tras 2 primeras iteraciones:
[02-03 19:19:21][INFO] i= 0 x: [0. 0. 0.]
[02-03 19:19:21][INFO] i= 1 x: [[0.9   0.79  0.758]]
[02-03 19:19:21][INFO] i= 2 x: [[0.979  0.9495 0.7899]]
```

c.

```
print("Resultado tras 2 primeras iteraciones:")
sol3, tray3 = gauss_seidel(A=A3, b=b3, x0=x0_3, tol=1e-6, max_iter=3)
```

```
Resultado tras 2 primeras iteraciones:
[02-03 19:19:23][INFO] i= 0 x: [0. 0. 0. 0.]
[02-03 19:19:23][INFO] i= 1 x: [[ 0.6    2.2   -0.275 -2.255]]
[02-03 19:19:23][INFO] i= 2 x: [[-0.5       2.64     -0.336875 -2.267375]]
```

d.

```
print("Resultado tras 2 primeras iteraciones:")
sol4, tray4 = gauss_seidel(A=A4, b=b4, x0=x0_4, tol=1e-6, max_iter=3)
```

```
Resultado tras 2 primeras iteraciones:
[02-03 19:19:26][INFO] i= 0 x: [0. 0. 0. 0. 0.]
[02-03 19:19:26][INFO] i= 1 x: [[ 1.5     -2.5      1.1      1.525    2.64375]]
[02-03 19:19:26][INFO] i= 2 x: [[ 1.1890625  -1.52135417  1.86239583  1.88252604  2.25564453]
```

1.3 Ejercicio 3

Utilice el método de Jacobi para resolver los sistemas lineales en el ejercicio 1, con $TOL = 10^{-3}$

a.

```
print('Solución con Gauss-Jacobi')
sol1, tray1 = gauss_jacobi(A=A1, b=b1, x0=x0_1, tol=1e-3, max_iter=100)

print('\nSolución del sistema:')
print(f'i= {len(tray1)} x: {np.squeeze(sol1)}')
```

```
Solución con Gauss-Jacobi
[02-03 19:19:30][INFO] i= 0 x: [0. 0. 0.]
[02-03 19:19:30][INFO] i= 1 x: [[0.33333333 0.         0.57142857]]
[02-03 19:19:30][INFO] i= 2 x: [[ 0.14285714 -0.35714286  0.42857143]]
[02-03 19:19:30][INFO] i= 3 x: [[ 0.07142857 -0.21428571  0.66326531]]
[02-03 19:19:30][INFO] i= 4 x: [[ 0.04081633 -0.25680272  0.63265306]]
[02-03 19:19:30][INFO] i= 5 x: [[ 0.03684807 -0.23129252  0.66399417]]
[02-03 19:19:30][INFO] i= 6 x: [[ 0.03490444 -0.23975543  0.6547619 ]]
[02-03 19:19:30][INFO] i= 7 x: [[ 0.03516089 -0.23570619  0.65922185]]
[02-03 19:19:30][INFO] i= 8 x: [[ 0.03502399 -0.23732106  0.65737656]]
[02-03 19:19:30][INFO] i= 9 x: [[ 0.03510079 -0.23663751  0.65812732]]

Solución del sistema:
i= 10 x: [ 0.03507839 -0.23692617  0.65780145]
```

b.

```
print("Solución con Gauss-Jacobi")
sol2, tray2 = gauss_jacobi(A=A2, b=b2, x0=x0_2, tol=1e-3, max_iter=100)

print("\nSolución del sistema:")
print(f"i= {len(tray2)} x: {np.squeeze(sol2)}")
```

```
Solución con Gauss-Jacobi
[02-03 19:19:34][INFO] i= 0 x: [0. 0. 0.]
[02-03 19:19:34][INFO] i= 1 x: [[0.9 0.7 0.6]]
[02-03 19:19:34][INFO] i= 2 x: [[0.97 0.91 0.74]]
[02-03 19:19:34][INFO] i= 3 x: [[0.991 0.945 0.782]]
[02-03 19:19:34][INFO] i= 4 x: [[0.9945 0.9555 0.789 ]]
[02-03 19:19:34][INFO] i= 5 x: [[0.99555 0.95725 0.7911 ]]

Solución del sistema:
i= 6 x: [0.995725 0.957775 0.79145 ]
```

c.

```
print("Solución con Gauss-Jacobi")
sol3, tray3 = gauss_jacobi(A=A3, b=b3, x0=x0_3, tol=1e-3, max_iter=100)

print("\nSolución del sistema:")
print(f"i= {len(tray3)} x: {np.squeeze(sol3)}")
```

```
Solución con Gauss-Jacobi
[02-03 19:19:39][INFO] i= 0 x: [0. 0. 0. 0.]
[02-03 19:19:39][INFO] i= 1 x: [[ 0.6    2.5   -1.375 -2.2  ]]
[02-03 19:19:39][INFO] i= 2 x: [[-0.65   1.65  -0.4   -2.475]]
[02-03 19:19:39][INFO] i= 3 x: [[-0.225     2.665    -0.859375 -2.28    ]]
[02-03 19:19:39][INFO] i= 4 x: [[-0.7325    2.26875  -0.3275   -2.371875]]
[02-03 19:19:39][INFO] i= 5 x: [[-0.534375    2.73525    -0.53710938 -2.2655    ]]
[02-03 19:19:39][INFO] i= 6 x: [[-0.767625    2.55234375 -0.2905625  -2.30742188]]
[02-03 19:19:39][INFO] i= 7 x: [[-0.67617187  2.7675875  -0.38725586 -2.2581125 ]]
[02-03 19:19:39][INFO] i= 8 x: [[-0.78379375  2.68318359 -0.27347031 -2.27745117]]
[02-03 19:19:39][INFO] i= 9 x: [[-0.7415918   2.78250875 -0.3180896  -2.25469406]]
[02-03 19:19:39][INFO] i= 10 x: [[-0.79125437  2.74356006 -0.26558238 -2.26361792]]
[02-03 19:19:39][INFO] i= 11 x: [[-0.77178003  2.78939423 -0.28617221 -2.25311648]]
[02-03 19:19:39][INFO] i= 12 x: [[-0.79469712  2.77142113 -0.26194244 -2.25723444]]
```

```
[02-03 19:19:39][INFO] i= 13 x: [[-0.78571057  2.79257158 -0.27144374 -2.25238849]]
[02-03 19:19:39][INFO] i= 14 x: [[-0.79628579  2.78427779 -0.26026277 -2.25428875]]
[02-03 19:19:39][INFO] i= 15 x: [[-0.79213889  2.79403779 -0.2646472  -2.25205255]]
[02-03 19:19:39][INFO] i= 16 x: [[-0.79701889  2.79021057 -0.25948768 -2.25292944]]
[02-03 19:19:39][INFO] i= 17 x: [[-0.79510528  2.79471438 -0.2615109  -2.25189754]]
[02-03 19:19:39][INFO] i= 18 x: [[-0.79735719  2.79294828 -0.25913    -2.25230218]]
[02-03 19:19:39][INFO] i= 19 x: [[-0.79647414  2.79502659 -0.26006363 -2.251826  ]]
[02-03 19:19:39][INFO] i= 20 x: [[-0.7975133   2.79421162 -0.25896495 -2.25201273]]
[02-03 19:19:39][INFO] i= 21 x: [[-0.79710581  2.79517067 -0.25939578 -2.25179299]]

Solución del sistema:
i= 22 x: [-0.79758533  2.79479459 -0.25888879 -2.25187916]
```

d.

```python
print("Solución con Gauss-Jacobi")
sol4, tray4 = gauss_jacobi(A=A4, b=b4, x0=x0_4, tol=1e-3, max_iter=100)

print("\nSolución del sistema:")
print(f"i= {len(tray4)} x: {np.squeeze(sol4)}")
```

```
Solución con Gauss-Jacobi
[02-03 19:19:41][INFO] i= 0 x: [0. 0. 0. 0. 0.]
[02-03 19:19:41][INFO] i= 1 x: [[ 1.5 -2.   1.2  1.5  1.5]]
[02-03 19:19:41][INFO] i= 2 x: [[ 1.325 -1.6    1.6    1.675  2.425]]
[02-03 19:19:41][INFO] i= 3 x: [[ 0.89375 -1.35     1.81     1.83125  2.28125]]
[02-03 19:19:41][INFO] i= 4 x: [[ 0.8146875  -1.08416667  1.935       1.8384375   2.1696875 ]
[02-03 19:19:41][INFO] i= 5 x: [[ 0.74486979 -1.01375     1.89258333  1.91638021  2.06622396]
[02-03 19:19:41][INFO] i= 6 x: [[ 0.76373568 -0.97863542  1.90132292  1.90592578  2.00092578]
[02-03 19:19:41][INFO] i= 7 x: [[ 0.76909668 -0.98549566  1.87160313  1.92160579  1.98816699]
[02-03 19:19:41][INFO] i= 8 x: [[ 0.78143139 -0.99196259  1.87141502  1.91380104  1.98024716]
[02-03 19:19:41][INFO] i= 9 x: [[ 0.7850751  -0.99873844  1.8646296   1.91522095  1.98538479]
[02-03 19:19:41][INFO] i= 10 x: [[ 0.78718101 -1.00174151  1.8658388   1.91274157  1.98672138
[02-03 19:19:41][INFO] i= 11 x: [[ 0.78729533 -1.00286688  1.86536849  1.91281957  1.98914507

Solución del sistema:
i= 12 x: [ 0.78708833 -1.00303576  1.86604817  1.91244923  1.98957067]
```

1.4 Ejercicio 4

Utilice el método de Gauss-Siedel para resolver los sistemas lineales en el ejercicio 1, con $TOL = 10^{-3}$.

a.

```
print("Solución con Gauss-Seidel")
sol1, tray1 = gauss_seidel(A=A1, b=b1, x0=x0_1, tol=1e-3, max_iter=100)

print("\nSolución del sistema:")
print(f"i= {len(tray1)} x: {np.squeeze(sol1)}")
```

```
Solución con Gauss-Seidel
[02-03 19:19:49][INFO] i= 0 x: [0. 0. 0.]
[02-03 19:19:49][INFO] i= 1 x: [[ 0.33333333 -0.16666667  0.5       ]]
[02-03 19:19:49][INFO] i= 2 x: [[ 0.11111111 -0.22222222  0.61904762]]
[02-03 19:19:49][INFO] i= 3 x: [[ 0.05291005 -0.23280423  0.64852608]]
[02-03 19:19:49][INFO] i= 4 x: [[ 0.03955656 -0.23595364  0.65559875]]
[02-03 19:19:49][INFO] i= 5 x: [[ 0.0361492  -0.23660752  0.65733928]]

Solución del sistema:
i= 6 x: [ 0.03535107 -0.23678863  0.65775895]
```

b.

```
print("Solución con Gauss-Seidel")
sol2, tray2 = gauss_seidel(A=A2, b=b2, x0=x0_2, tol=1e-3, max_iter=100)

print("\nSolución del sistema:")
print(f"i= {len(tray2)} x: {np.squeeze(sol2)}")
```

```
Solución con Gauss-Seidel
[02-03 19:19:51][INFO] i= 0 x: [0. 0. 0.]
[02-03 19:19:51][INFO] i= 1 x: [[0.9   0.79  0.758]]
[02-03 19:19:51][INFO] i= 2 x: [[0.979  0.9495 0.7899]]
[02-03 19:19:51][INFO] i= 3 x: [[0.99495  0.957475 0.791495]]

Solución del sistema:
i= 4 x: [0.9957475  0.95787375 0.79157475]
```

c.

```python
print("Solución con Gauss-Seidel")
sol3, tray3 = gauss_seidel(A=A3, b=b3, x0=x0_3, tol=1e-3, max_iter=100)

print("\nSolución del sistema:")
print(f"i= {len(tray3)} x: {np.squeeze(sol3)}")
```

```
Solución con Gauss-Seidel
[02-03 19:19:54][INFO] i= 0 x: [0. 0. 0. 0.]
[02-03 19:19:54][INFO] i= 1 x: [[ 0.6    2.2   -0.275 -2.255]]
[02-03 19:19:54][INFO] i= 2 x: [[-0.5       2.64     -0.336875 -2.267375]]
[02-03 19:19:54][INFO] i= 3 x: [[-0.72        2.72525    -0.29579687 -2.25915938]]
[02-03 19:19:54][INFO] i= 4 x: [[-0.762625    2.76299375 -0.27589805 -2.25517961]]
[02-03 19:19:54][INFO] i= 5 x: [[-0.78149687  2.78038922 -0.26670284 -2.25334057]]
[02-03 19:19:54][INFO] i= 6 x: [[-0.79019461  2.78841617 -0.26245949 -2.2524919 ]]
[02-03 19:19:54][INFO] i= 7 x: [[-0.79420808  2.79212025 -0.26050136 -2.25210027]]
[02-03 19:19:54][INFO] i= 8 x: [[-0.79606012  2.79382952 -0.25959778 -2.25191956]]
[02-03 19:19:54][INFO] i= 9 x: [[-0.79691476  2.79461827 -0.25918081 -2.25183616]]

Solución del sistema:
i= 10 x: [-0.79730913  2.79498224 -0.2589884  -2.25179768]
```

d.

```python
print("Solución con Gauss-Seidel")
sol4, tray4 = gauss_seidel(A=A4, b=b4, x0=x0_4, tol=1e-3, max_iter=100)

print("\nSolución del sistema:")
print(f"i= {len(tray4)} x: {np.squeeze(sol4)}")
```

```
Solución con Gauss-Seidel
[02-03 19:19:58][INFO] i= 0 x: [0. 0. 0. 0. 0.]
[02-03 19:19:58][INFO] i= 1 x: [[ 1.5     -2.5      1.1      1.525    2.64375]]
[02-03 19:19:58][INFO] i= 2 x: [[ 1.1890625  -1.52135417  1.86239583  1.88252604  2.25564453]
[02-03 19:19:58][INFO] i= 3 x: [[ 0.85082845 -1.03530219  1.89436317  1.92747236  2.0093738 ]
[02-03 19:19:58][INFO] i= 4 x: [[ 0.7828913  -0.98701859  1.87161643  1.91687229  1.98219533]
[02-03 19:19:58][INFO] i= 5 x: [[ 0.78330171 -0.998271    1.86614704  1.91279444  1.98747365]
[02-03 19:19:58][INFO] i= 6 x: [[ 0.78616258 -1.00240703  1.86606999  1.91245638  1.98960692]

Solución del sistema:
i= 7 x: [ 0.78668253 -1.00271872  1.86628339  1.9125618   1.98978976]
```

1.5 Ejercicio 5

El sistema lineal

$$\begin{aligned} 2x_1 - x_2 + x_3 &= -1, \\ 2x_1 + 2x_2 + 2x_3 &= 4, \\ -x_1 - x_2 + 2x_3 &= -5. \end{aligned}$$

tiene la solución $(1, 2, -1)^t$ **.**

```
A = np.array([[2, -1, 1], [2, 2, 2], [-1, -1, 2]])
b = np.array([-1, 4, -5])
x0 = np.zeros(len(b2))
```

a. Muestre que el método de Jacobi con $x^{(0)} = 0$ **falla al proporcionar una buena aproximación después de 25 iteraciones.**

```
print("Solución con Gauss-Jacobi")
sol, tray = gauss_jacobi(A=A, b=b, x0=x0, tol=1e-3, max_iter=25)

print("\nEl método de Gauss-Jacobi no converge")
```

```
Solución con Gauss-Jacobi
[02-03 19:20:05][INFO] i= 0 x: [0. 0. 0.]
[02-03 19:20:05][INFO] i= 1 x: [[-0.5  2.  -2.5]]
[02-03 19:20:05][INFO] i= 2 x: [[ 1.75  5.   -1.75]]
[02-03 19:20:05][INFO] i= 3 x: [[2.875 2.    0.875]]
[02-03 19:20:05][INFO] i= 4 x: [[ 0.0625 -1.75   -0.0625]]
[02-03 19:20:05][INFO] i= 5 x: [[-1.34375  2.      -3.34375]]
[02-03 19:20:05][INFO] i= 6 x: [[ 2.171875  6.6875   -2.171875]]
[02-03 19:20:05][INFO] i= 7 x: [[3.9296875 2.        1.9296875]]
[02-03 19:20:05][INFO] i= 8 x: [[-0.46484375 -3.859375    0.46484375]]
[02-03 19:20:05][INFO] i= 9 x: [[-2.66210938  2.         -4.66210938]]
[02-03 19:20:05][INFO] i= 10 x: [[ 2.83105469  9.32421875 -2.83105469]]
[02-03 19:20:05][INFO] i= 11 x: [[5.57763672 2.         3.57763672]]
[02-03 19:20:05][INFO] i= 12 x: [[-1.28881836 -7.15527344  1.28881836]]
[02-03 19:20:05][INFO] i= 13 x: [[-4.7220459  2.        -6.7220459]]
[02-03 19:20:05][INFO] i= 14 x: [[ 3.86102295 13.4440918  -3.86102295]]
[02-03 19:20:05][INFO] i= 15 x: [[8.15255737 2.         6.15255737]]
[02-03 19:20:05][INFO] i= 16 x: [[ -2.57627869 -12.30511475   2.57627869]]
[02-03 19:20:05][INFO] i= 17 x: [[-7.94069672  2.         -9.94069672]]
```

```
[02-03 19:20:05][INFO] i= 18 x: [[ 5.47034836 19.88139343 -5.47034836]]
[02-03 19:20:05][INFO] i= 19 x: [[12.1758709  2.         10.1758709]]
[02-03 19:20:05][INFO] i= 20 x: [[ -4.58793545 -20.35174179   4.58793545]]
[02-03 19:20:05][INFO] i= 21 x: [[-12.96983862   2.         -14.96983862]]
[02-03 19:20:05][INFO] i= 22 x: [[ 7.98491931 29.93967724 -7.98491931]]
[02-03 19:20:05][INFO] i= 23 x: [[18.46229827  2.         16.46229827]]
[02-03 19:20:05][INFO] i= 24 x: [[ -7.73114914 -32.92459655   7.73114914]]

El método de Gauss-Jacobi no converge
```

Al observar las iteraciones, se aprecia que los valores de x no tienden a una solución estable, ergo, no converge.

b. Utilice el método de Gauss-Siedel con $x(0) = 0$ para aproximar la solución para el sistema lineal dentro de 10^{-5}.

```python
print("Solución con Gauss-Seidel")
sol, tray = gauss_seidel(A=A, b=b, x0=x0, tol=1e-5, max_iter=100)

print("\nSolución del sistema:")
print(f"i= {len(tray)}: x: {np.squeeze(sol)}")
```

```
Solución con Gauss-Seidel
[02-03 19:20:15][INFO] i= 0 x: [0. 0. 0.]
[02-03 19:20:15][INFO] i= 1 x: [[-0.5  2.5 -1.5]]
[02-03 19:20:15][INFO] i= 2 x: [[ 1.5   2.   -0.75]]
[02-03 19:20:15][INFO] i= 3 x: [[ 0.875  1.875 -1.125]]
[02-03 19:20:15][INFO] i= 4 x: [[ 1.      2.125  -0.9375]]
[02-03 19:20:15][INFO] i= 5 x: [[ 1.03125  1.90625 -1.03125]]
[02-03 19:20:15][INFO] i= 6 x: [[ 0.96875   2.0625   -0.984375]]
[02-03 19:20:15][INFO] i= 7 x: [[ 1.0234375  1.9609375 -1.0078125]]
[02-03 19:20:15][INFO] i= 8 x: [[ 0.984375    2.0234375  -0.99609375]]
[02-03 19:20:15][INFO] i= 9 x: [[ 1.00976562  1.98632812 -1.00195312]]
[02-03 19:20:15][INFO] i= 10 x: [[ 0.99414062  2.0078125  -0.99902344]]
[02-03 19:20:15][INFO] i= 11 x: [[ 1.00341797  1.99560547 -1.00048828]]
[02-03 19:20:15][INFO] i= 12 x: [[ 0.99804688  2.00244141 -0.99975586]]
[02-03 19:20:15][INFO] i= 13 x: [[ 1.00109863  1.99865723 -1.00012207]]
[02-03 19:20:15][INFO] i= 14 x: [[ 0.99938965  2.00073242 -0.99993896]]
[02-03 19:20:15][INFO] i= 15 x: [[ 1.00033569  1.99960327 -1.00003052]]
[02-03 19:20:15][INFO] i= 16 x: [[ 0.99981689  2.00021362 -0.99998474]]
[02-03 19:20:15][INFO] i= 17 x: [[ 1.00009918  1.99988556 -1.00000763]]
[02-03 19:20:15][INFO] i= 18 x: [[ 0.99994659  2.00006104 -0.99999619]]
[02-03 19:20:15][INFO] i= 19 x: [[ 1.00002861  1.99996758 -1.00000191]]
```

```
[02-03 19:20:15][INFO] i= 20 x: [[ 0.99998474  2.00001717 -0.99999905]]
[02-03 19:20:15][INFO] i= 21 x: [[ 1.00000811  1.99999094 -1.00000048]]
[02-03 19:20:15][INFO] i= 22 x: [[ 0.99999571  2.00000477 -0.99999976]]

Solución del sistema:
i= 23: x: [ 1.00000226  1.9999975  -1.00000012]
```

1.6 Ejercicio 6

El sistema lineal

$$\begin{aligned} x_1 - x_3 &= 0.2, \\ -\frac{1}{2}x_1 + x_2 - \frac{1}{4}x_3 &= -1.425, \\ x_1 - \frac{1}{2}x_2 + x_3 &= 2. \end{aligned}$$

tiene la solución $(0.9, -0.8, 0.7)^t$ **.**

a. ¿La matriz de coeficientes

$$A = \begin{bmatrix} 1 & 0 & -1 \\ -\frac{1}{2} & 1 & -\frac{1}{4} \\ 1 & -\frac{1}{2} & 1 \end{bmatrix}$$

tiene diagonal estrictamente dominante?

```python
def diagonal_estrictamente_dominante(A):
    n = A.shape[0]

    for i in range(n):
        suma = sum(abs(A[i, j]) for j in range(n) if j != i)
        if abs(A[i, i]) <= suma:
            return False

    return True
```

```python
A = np.array([[1, 0, -1], [-1 / 2, 1, -1 / 4], [1, -1 / 2, 1]])

is_diagonal = diagonal_estrictamente_dominante(A)

if is_diagonal:
```

```
    print('La matriz tiene dominancia diagonal estricta.')
else:
    print('La matriz no tiene dominancia diagonal estricta.')
```

```
La matriz no tiene dominancia diagonal estricta.
```

b. Utilice el método iterativo Gauss-Seidel para aproximar la solución para el sistema lineal con una tolerancia de 10^{-2} y un máximo de 300 iteraciones.

```
b = np.array([0.2, -1.425, 2])
x0 = np.zeros(len(b))
```

```
print("Solución con Gauss-Seidel")
sol, tray = gauss_seidel(A=A, b=b, x0=x0, tol=1e-2, max_iter=300)

print("\nSolución del sistema:")
print(f"i= {len(tray)}: x: {np.squeeze(sol)}")
```

```
Solución con Gauss-Seidel
[02-03 19:20:53][INFO] i= 0 x: [0. 0. 0.]
[02-03 19:20:53][INFO] i= 1 x: [[ 0.2    -1.325   1.1375]]
[02-03 19:20:53][INFO] i= 2 x: [[ 1.3375    -0.471875   0.4265625]]
[02-03 19:20:53][INFO] i= 3 x: [[ 0.6265625  -1.00507812  0.87089844]]
[02-03 19:20:53][INFO] i= 4 x: [[ 1.07089844 -0.67182617  0.59318848]]
[02-03 19:20:53][INFO] i= 5 x: [[ 0.79318848 -0.88010864  0.7667572 ]]
[02-03 19:20:53][INFO] i= 6 x: [[ 0.9667572  -0.7499321   0.65827675]]
[02-03 19:20:53][INFO] i= 7 x: [[ 0.85827675 -0.83129244  0.72607703]]
[02-03 19:20:53][INFO] i= 8 x: [[ 0.92607703 -0.78044223  0.68370185]]
[02-03 19:20:53][INFO] i= 9 x: [[ 0.88370185 -0.81222361  0.71018634]]
[02-03 19:20:53][INFO] i= 10 x: [[ 0.91018634 -0.79236024  0.69363354]]
[02-03 19:20:53][INFO] i= 11 x: [[ 0.89363354 -0.80477485  0.70397904]]
[02-03 19:20:53][INFO] i= 12 x: [[ 0.90397904 -0.79701572  0.6975131 ]]

Solución del sistema:
i= 13: x: [ 0.8975131  -0.80186517  0.70155431]
```

c. ¿Qué pasa en la parte b) cuando el sistema cambia por el siguiente?

$$
\begin{aligned}
x_1 - 2x_3 &= 0.2, \\
-\frac{1}{2}x_1 + x_2 - \frac{1}{4}x_3 &= -1.425, \\
x_1 - \frac{1}{2}x_2 + x_3 &= 2.
\end{aligned}
$$

```
A1 = np.array([[1, 0, -2], [-1 / 2, 1, -1 / 4], [1, -1 / 2, 1]])
b1 = np.array([0.2, -1.425, 2])
x0_1 = np.zeros(len(b1))
```

```
print("Solución con Gauss-Seidel")
sol1, tray1 = gauss_seidel(A=A1, b=b1, x0=x0_1, tol=1e-2, max_iter=300)

print('\nEl método Gauss-Seidel no converge.')
```

```
Solución con Gauss-Seidel
[02-03 19:21:12][INFO] i= 0 x: [0. 0. 0.]
[02-03 19:21:12][INFO] i= 1 x: [[ 0.2    -1.325   1.1375]]
[02-03 19:21:12][INFO] i= 2 x: [[ 2.475      0.096875  -0.4265625]]
[02-03 19:21:12][INFO] i= 3 x: [[-0.653125   -1.85820313  1.72402344]]
[02-03 19:21:12][INFO] i= 4 x: [[ 3.64804688  0.8300293  -1.23303223]]
[02-03 19:21:12][INFO] i= 5 x: [[-2.26606445 -2.86629028  2.83291931]]
[02-03 19:21:12][INFO] i= 6 x: [[ 5.86583862  2.21614914 -2.75776405]]
[02-03 19:21:12][INFO] i= 7 x: [[-5.31552811 -4.77220507  4.92942557]]
[02-03 19:21:12][INFO] i= 8 x: [[10.05885115  4.83678197 -5.64046016]]
[02-03 19:21:12][INFO] i= 9 x: [[-11.08092033  -8.3755752    8.89313272]]
[02-03 19:21:12][INFO] i= 10 x: [[ 17.98626545   9.79141591 -11.0905575 ]]
[02-03 19:21:12][INFO] i= 11 x: [[-21.98111499 -15.18819687  16.38701656]]
[02-03 19:21:12][INFO] i= 12 x: [[ 32.97403311  19.1587707  -21.39464777]]
[02-03 19:21:12][INFO] i= 13 x: [[-42.58929553 -28.06830971  30.55514068]]
[02-03 19:21:12][INFO] i= 14 x: [[ 61.31028136  36.86892585 -40.87581843]]
[02-03 19:21:12][INFO] i= 15 x: [[-81.55163687 -52.41977304  57.34175035]]
[02-03 19:21:12][INFO] i= 16 x: [[114.88350069  70.35218793 -77.70740673]]
[02-03 19:21:12][INFO] i= 17 x: [[-155.21481345  -98.45925841  107.98518425]]
[02-03 19:21:12][INFO] i= 18 x: [[ 216.1703685   133.65648031 -147.34212834]]
[02-03 19:21:12][INFO] i= 19 x: [[-294.48425668 -185.50266043  203.73292647]]
[02-03 19:21:12][INFO] i= 20 x: [[ 407.66585294  253.34115809 -278.9952739 ]]
[02-03 19:21:12][INFO] i= 21 x: [[-557.79054779 -350.06909237  384.75600161]]
[02-03 19:21:12][INFO] i= 22 x: [[ 769.71200321  479.62000201 -527.90200221]]
[02-03 19:21:12][INFO] i= 23 x: [[-1055.60400442  -661.20250276   727.00275304]]
[02-03 19:21:12][INFO] i= 24 x: [[1454.20550607  907.4284413  -998.49128543]]
```

```
[02-03 19:21:12][INFO] i= 25 x: [[-1996.78257085 -1249.43910678  1374.06301746]]
[02-03 19:21:12][INFO] i= 26 x: [[ 2748.32603492  1716.25377182 -1888.19914901]]
[02-03 19:21:12][INFO] i= 27 x: [[-3776.19829801 -2361.57393626  2597.41132988]]
[02-03 19:21:12][INFO] i= 28 x: [[ 5195.02265977  3245.43916236 -3570.30307859]]
[02-03 19:21:12][INFO] i= 29 x: [[-7140.40615718 -4464.20384824  4910.30423306]]
[02-03 19:21:12][INFO] i= 30 x: [[ 9820.80846613  6136.55529133 -6750.53082046]]
[02-03 19:21:12][INFO] i= 31 x: [[-13500.86164092  -8439.48852558   9283.11737813]]
[02-03 19:21:12][INFO] i= 32 x: [[ 18566.43475627  11602.57172267 -12763.14889494]]
[02-03 19:21:12][INFO] i= 33 x: [[-25526.09778987 -15955.26111867  17550.46723054]]
[02-03 19:21:12][INFO] i= 34 x: [[ 35101.13446107  21936.75903817 -24130.75494199]]
[02-03 19:21:12][INFO] i= 35 x: [[-48261.30988397 -30164.76867748  33180.92554523]]
[02-03 19:21:12][INFO] i= 36 x: [[ 66362.05109046  41474.83193154 -45622.63512469]]
[02-03 19:21:12][INFO] i= 37 x: [[-91245.07024939 -57029.61890587  62732.26079645]]
[02-03 19:21:12][INFO] i= 38 x: [[125464.72159291  78414.00099557 -86255.72109512]]
[02-03 19:21:12][INFO] i= 39 x: [[-172511.24219025 -107820.97636891  118602.7540058 ]]
[02-03 19:21:12][INFO] i= 40 x: [[ 237205.70801159  148252.11750725 -163077.64925797]]
[02-03 19:21:12][INFO] i= 41 x: [[-326155.09851594 -203848.38657246  224232.90522971]]
[02-03 19:21:12][INFO] i= 42 x: [[ 448466.01045942  280289.80653714 -308319.10719085]]
[02-03 19:21:12][INFO] i= 43 x: [[-616638.0143817  -385400.20898856  423939.90988742]]
[02-03 19:21:12][INFO] i= 44 x: [[ 847880.01977484  529923.56235927 -582916.2385952 ]]
[02-03 19:21:12][INFO] i= 45 x: [[-1165832.2771904  -728646.623244    801510.9655684]]
[02-03 19:21:12][INFO] i= 46 x: [[ 1603022.1311368   1001887.3819605  -1102076.44015655]]
[02-03 19:21:12][INFO] i= 47 x: [[-2204152.6803131  -1377596.87519569  1515356.24271526]]
[02-03 19:21:12][INFO] i= 48 x: [[ 3030712.68543051  1894193.97839407 -2083613.69623348]]
[02-03 19:21:12][INFO] i= 49 x: [[-4167227.19246695 -2604518.44529185  2864969.96982103]]
[02-03 19:21:12][INFO] i= 50 x: [[ 5729940.13964206  3581211.13727629 -3939332.57100392]]
[02-03 19:21:12][INFO] i= 51 x: [[-7878664.94200784 -4924167.0387549   5416583.42263039]]
[02-03 19:21:12][INFO] i= 52 x: [[10833167.04526077  6770727.95328798 -7447801.06861678]]
[02-03 19:21:12][INFO] i= 53 x: [[-14895601.93723356  -9309752.66077098  10240727.60684807]]
[02-03 19:21:12][INFO] i= 54 x: [[ 20481455.41369615  12800908.18356009 -14080999.3219161 ]]
[02-03 19:21:12][INFO] i= 55 x: [[-28161998.4438322  -17601250.47739513  19361375.20513464]]
[02-03 19:21:12][INFO] i= 56 x: [[ 38722750.61026928  24201717.6814183  -26621889.76956013]]
[02-03 19:21:12][INFO] i= 57 x: [[-53243779.33912025 -33277363.53695016  36605099.57064518]]
[02-03 19:21:12][INFO] i= 58 x: [[ 73210199.34129035  45756373.13830648 -50332010.77213712]]
[02-03 19:21:12][INFO] i= 59 x: [[-1.00664021e+08 -6.29150148e+07  6.92065159e+07]]
[02-03 19:21:12][INFO] i= 60 x: [[ 1.38413032e+08  8.65081436e+07 -9.51589583e+07]]
[02-03 19:21:12][INFO] i= 61 x: [[-1.90317916e+08 -1.18948699e+08  1.30843569e+08]]
[02-03 19:21:12][INFO] i= 62 x: [[ 2.61687138e+08  1.63554460e+08 -1.79909906e+08]]
[02-03 19:21:12][INFO] i= 63 x: [[-3.59819812e+08 -2.24887384e+08  2.47376122e+08]]
[02-03 19:21:12][INFO] i= 64 x: [[ 4.94752244e+08  3.09220151e+08 -3.40142166e+08]]
[02-03 19:21:12][INFO] i= 65 x: [[-6.80284333e+08 -4.25177709e+08  4.67695480e+08]]
[02-03 19:21:12][INFO] i= 66 x: [[ 9.35390960e+08  5.84619349e+08 -6.43081284e+08]]
[02-03 19:21:12][INFO] i= 67 x: [[-1.28616257e+09 -8.03851606e+08  8.84236766e+08]]
```

```
[02-03 19:21:12][INFO] i= 68 x: [[ 1.76847353e+09  1.10529596e+09 -1.21582555e+09]]
[02-03 19:21:12][INFO] i= 69 x: [[-2.43165110e+09 -1.51978194e+09  1.67176014e+09]]
[02-03 19:21:12][INFO] i= 70 x: [[ 3.34352027e+09  2.08970017e+09 -2.29867019e+09]]
[02-03 19:21:12][INFO] i= 71 x: [[-4.59734037e+09 -2.87333773e+09  3.16067151e+09]]
[02-03 19:21:12][INFO] i= 72 x: [[ 6.32134301e+09  3.95083938e+09 -4.34592332e+09]]
[02-03 19:21:12][INFO] i= 73 x: [[-8.69184664e+09 -5.43240415e+09  5.97564457e+09]]
[02-03 19:21:12][INFO] i= 74 x: [[ 1.19512891e+10  7.46955571e+09 -8.21651128e+09]]
[02-03 19:21:12][INFO] i= 75 x: [[-1.64330226e+10 -1.02706391e+10  1.12977030e+10]]
[02-03 19:21:12][INFO] i= 76 x: [[ 2.25954060e+10  1.41221288e+10 -1.55343416e+10]]
[02-03 19:21:12][INFO] i= 77 x: [[-3.10686833e+10 -1.94179270e+10  2.13597197e+10]]
[02-03 19:21:12][INFO] i= 78 x: [[ 4.27194395e+10  2.66996497e+10 -2.93696147e+10]]
[02-03 19:21:12][INFO] i= 79 x: [[-5.87392293e+10 -3.67120183e+10  4.03832201e+10]]
[02-03 19:21:12][INFO] i= 80 x: [[ 8.07664403e+10  5.04790252e+10 -5.55269277e+10]]
[02-03 19:21:12][INFO] i= 81 x: [[-1.11053855e+11 -6.94086596e+10  7.63495256e+10]]
[02-03 19:21:12][INFO] i= 82 x: [[ 1.52699051e+11  9.54369070e+10 -1.04980598e+11]]
[02-03 19:21:12][INFO] i= 83 x: [[-2.09961195e+11 -1.31225747e+11  1.44348322e+11]]
[02-03 19:21:12][INFO] i= 84 x: [[ 2.88696644e+11  1.80435402e+11 -1.98478942e+11]]
[02-03 19:21:12][INFO] i= 85 x: [[-3.96957885e+11 -2.48098678e+11  2.72908546e+11]]
[02-03 19:21:12][INFO] i= 86 x: [[ 5.45817092e+11  3.41135682e+11 -3.75249251e+11]]
[02-03 19:21:12][INFO] i= 87 x: [[-7.50498501e+11 -4.69061563e+11  5.15967720e+11]]
[02-03 19:21:12][INFO] i= 88 x: [[ 1.03193544e+12  6.44959650e+11 -7.09455615e+11]]
[02-03 19:21:12][INFO] i= 89 x: [[-1.41891123e+12 -8.86819518e+11  9.75501470e+11]]
[02-03 19:21:12][INFO] i= 90 x: [[ 1.95100294e+12  1.21937684e+12 -1.34131452e+12]]
[02-03 19:21:12][INFO] i= 91 x: [[-2.68262904e+12 -1.67664315e+12  1.84430747e+12]]
[02-03 19:21:12][INFO] i= 92 x: [[ 3.68861493e+12  2.30538433e+12 -2.53592277e+12]]
[02-03 19:21:12][INFO] i= 93 x: [[-5.07184553e+12 -3.16990346e+12  3.48689380e+12]]
[02-03 19:21:12][INFO] i= 94 x: [[ 6.97378761e+12  4.35861726e+12 -4.79447898e+12]]
[02-03 19:21:12][INFO] i= 95 x: [[-9.58895796e+12 -5.99309873e+12  6.59240860e+12]]
[02-03 19:21:12][INFO] i= 96 x: [[ 1.31848172e+13  8.24051075e+12 -9.06456182e+12]]
[02-03 19:21:12][INFO] i= 97 x: [[-1.81291236e+13 -1.13307023e+13  1.24637725e+13]]
[02-03 19:21:12][INFO] i= 98 x: [[ 2.49275450e+13  1.55797156e+13 -1.71376872e+13]]
[02-03 19:21:12][INFO] i= 99 x: [[-3.42753744e+13 -2.14221090e+13  2.35643199e+13]]
[02-03 19:21:12][INFO] i= 100 x: [[ 4.71286398e+13  2.94553999e+13 -3.24009399e+13]]
[02-03 19:21:12][INFO] i= 101 x: [[-6.48018797e+13 -4.05011748e+13  4.45512923e+13]]
[02-03 19:21:12][INFO] i= 102 x: [[ 8.91025846e+13  5.56891154e+13 -6.12580269e+13]]
[02-03 19:21:12][INFO] i= 103 x: [[-1.22516054e+14 -7.65725336e+13  8.42297870e+13]]
[02-03 19:21:12][INFO] i= 104 x: [[ 1.68459574e+14  1.05287234e+14 -1.15815957e+14]]
[02-03 19:21:12][INFO] i= 105 x: [[-2.31631914e+14 -1.44769946e+14  1.59246941e+14]]
[02-03 19:21:12][INFO] i= 106 x: [[ 3.18493882e+14  1.99058676e+14 -2.18964544e+14]]
[02-03 19:21:12][INFO] i= 107 x: [[-4.37929088e+14 -2.73705680e+14  3.01076248e+14]]
[02-03 19:21:12][INFO] i= 108 x: [[ 6.02152496e+14  3.76345310e+14 -4.13979841e+14]]
[02-03 19:21:12][INFO] i= 109 x: [[-8.27959682e+14 -5.17474801e+14  5.69222281e+14]]
[02-03 19:21:12][INFO] i= 110 x: [[ 1.13844456e+15  7.11527852e+14 -7.82680637e+14]]
```

```
[02-03 19:21:12][INFO] i= 111 x: [[-1.56536127e+15 -9.78350796e+14  1.07618588e+15]]
[02-03 19:21:12][INFO] i= 112 x: [[ 2.15237175e+15  1.34523234e+15 -1.47975558e+15]]
[02-03 19:21:12][INFO] i= 113 x: [[-2.95951116e+15 -1.84969447e+15  2.03466392e+15]]
[02-03 19:21:12][INFO] i= 114 x: [[ 4.06932784e+15  2.54332990e+15 -2.79766289e+15]]
[02-03 19:21:12][INFO] i= 115 x: [[-5.59532578e+15 -3.49707861e+15  3.84678648e+15]]
[02-03 19:21:12][INFO] i= 116 x: [[ 7.69357295e+15  4.80848309e+15 -5.28933140e+15]]
[02-03 19:21:12][INFO] i= 117 x: [[-1.05786628e+16 -6.61166425e+15  7.27283068e+15]]
[02-03 19:21:12][INFO] i= 118 x: [[ 1.45456614e+16  9.09103835e+15 -1.00001422e+16]]
[02-03 19:21:12][INFO] i= 119 x: [[-2.00002844e+16 -1.25001777e+16  1.37501955e+16]]
[02-03 19:21:12][INFO] i= 120 x: [[ 2.75003910e+16  1.71877444e+16 -1.89065188e+16]]
[02-03 19:21:12][INFO] i= 121 x: [[-3.78130376e+16 -2.36331485e+16  2.59964634e+16]]
[02-03 19:21:12][INFO] i= 122 x: [[ 5.19929268e+16  3.24955792e+16 -3.57451371e+16]]
[02-03 19:21:12][INFO] i= 123 x: [[-7.14902743e+16 -4.46814214e+16  4.91495636e+16]]
[02-03 19:21:12][INFO] i= 124 x: [[ 9.82991271e+16  6.14369545e+16 -6.75806499e+16]]
[02-03 19:21:12][INFO] i= 125 x: [[-1.35161300e+17 -8.44758124e+16  9.29233936e+16]]
[02-03 19:21:12][INFO] i= 126 x: [[ 1.85846787e+17  1.16154242e+17 -1.27769666e+17]]
[02-03 19:21:12][INFO] i= 127 x: [[-2.55539332e+17 -1.59712083e+17  1.75683291e+17]]
[02-03 19:21:12][INFO] i= 128 x: [[ 3.51366582e+17  2.19604114e+17 -2.41564525e+17]]
[02-03 19:21:12][INFO] i= 129 x: [[-4.83129050e+17 -3.01955657e+17  3.32151222e+17]]
[02-03 19:21:12][INFO] i= 130 x: [[ 6.64302444e+17  4.15189028e+17 -4.56707931e+17]]
[02-03 19:21:12][INFO] i= 131 x: [[-9.13415861e+17 -5.70884913e+17  6.27973404e+17]]
[02-03 19:21:12][INFO] i= 132 x: [[ 1.25594681e+18  7.84966756e+17 -8.63463431e+17]]
[02-03 19:21:12][INFO] i= 133 x: [[-1.72692686e+18 -1.07932929e+18  1.18726222e+18]]
[02-03 19:21:12][INFO] i= 134 x: [[ 2.37452444e+18  1.48407777e+18 -1.63248555e+18]]
[02-03 19:21:12][INFO] i= 135 x: [[-3.26497110e+18 -2.04060694e+18  2.24466763e+18]]
[02-03 19:21:12][INFO] i= 136 x: [[ 4.48933526e+18  2.80583454e+18 -3.08641799e+18]]
[02-03 19:21:12][INFO] i= 137 x: [[-6.17283598e+18 -3.85802249e+18  4.24382474e+18]]
[02-03 19:21:12][INFO] i= 138 x: [[ 8.48764948e+18  5.30478092e+18 -5.83525902e+18]]
[02-03 19:21:12][INFO] i= 139 x: [[-1.16705180e+19 -7.29407377e+18  8.02348115e+18]]
[02-03 19:21:12][INFO] i= 140 x: [[ 1.60469623e+19  1.00293514e+19 -1.10322866e+19]]
[02-03 19:21:12][INFO] i= 141 x: [[-2.20645732e+19 -1.37903582e+19  1.51693940e+19]]
[02-03 19:21:12][INFO] i= 142 x: [[ 3.03387881e+19  1.89617426e+19 -2.08579168e+19]]
[02-03 19:21:12][INFO] i= 143 x: [[-4.17158336e+19 -2.60723960e+19  2.86796356e+19]]
[02-03 19:21:12][INFO] i= 144 x: [[ 5.73592712e+19  3.58495445e+19 -3.94344990e+19]]
[02-03 19:21:12][INFO] i= 145 x: [[-7.88689979e+19 -4.92931237e+19  5.42224361e+19]]
[02-03 19:21:12][INFO] i= 146 x: [[ 1.08444872e+20  6.77780451e+19 -7.45558496e+19]]
[02-03 19:21:12][INFO] i= 147 x: [[-1.49111699e+20 -9.31948120e+19  1.02514293e+20]]
[02-03 19:21:12][INFO] i= 148 x: [[ 2.05028586e+20  1.28142867e+20 -1.40957153e+20]]
[02-03 19:21:12][INFO] i= 149 x: [[-2.81914306e+20 -1.76196441e+20  1.93816086e+20]]
[02-03 19:21:12][INFO] i= 150 x: [[ 3.87632171e+20  2.42270107e+20 -2.66497118e+20]]
[02-03 19:21:12][INFO] i= 151 x: [[-5.32994235e+20 -3.33121397e+20  3.66433537e+20]]
[02-03 19:21:12][INFO] i= 152 x: [[ 7.32867074e+20  4.58041921e+20 -5.03846113e+20]]
[02-03 19:21:12][INFO] i= 153 x: [[-1.00769223e+21 -6.29807641e+20  6.92788406e+20]]
```

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[02-03 19:21:12][INFO] i= 154 x: [[ 1.38557681e+21  8.65985507e+20 -9.52584058e+20]]
[02-03 19:21:12][INFO] i= 155 x: [[-1.90516812e+21 -1.19073007e+21  1.30980308e+21]]
[02-03 19:21:12][INFO] i= 156 x: [[ 2.61960616e+21  1.63725385e+21 -1.80097923e+21]]
[02-03 19:21:12][INFO] i= 157 x: [[-3.60195847e+21 -2.25122404e+21  2.47634645e+21]]
[02-03 19:21:12][INFO] i= 158 x: [[ 4.95269289e+21  3.09543306e+21 -3.40497636e+21]]
[02-03 19:21:12][INFO] i= 159 x: [[-6.80995273e+21 -4.25622046e+21  4.68184250e+21]]
[02-03 19:21:12][INFO] i= 160 x: [[ 9.36368500e+21  5.85230313e+21 -6.43753344e+21]]
[02-03 19:21:12][INFO] i= 161 x: [[-1.28750669e+22 -8.04691680e+21  8.85160848e+21]]
[02-03 19:21:12][INFO] i= 162 x: [[ 1.77032170e+22  1.10645106e+22 -1.21709617e+22]]
[02-03 19:21:12][INFO] i= 163 x: [[-2.43419233e+22 -1.52137021e+22  1.67350723e+22]]
[02-03 19:21:12][INFO] i= 164 x: [[ 3.34701446e+22  2.09188404e+22 -2.30107244e+22]]
[02-03 19:21:12][INFO] i= 165 x: [[-4.60214488e+22 -2.87634055e+22  3.16397460e+22]]
[02-03 19:21:12][INFO] i= 166 x: [[ 6.32794921e+22  3.95496825e+22 -4.35046508e+22]]
[02-03 19:21:12][INFO] i= 167 x: [[-8.70093016e+22 -5.43808135e+22  5.98188948e+22]]
[02-03 19:21:12][INFO] i= 168 x: [[ 1.19637790e+23  7.47736186e+22 -8.22509804e+22]]
[02-03 19:21:12][INFO] i= 169 x: [[-1.64501961e+23 -1.02813726e+23  1.13095098e+23]]
[02-03 19:21:12][INFO] i= 170 x: [[ 2.26190196e+23  1.41368873e+23 -1.55505760e+23]]
[02-03 19:21:12][INFO] i= 171 x: [[-3.1101152e+23 -1.9438220e+23  2.1382042e+23]]
[02-03 19:21:12][INFO] i= 172 x: [[ 4.27640840e+23  2.67275525e+23 -2.94003077e+23]]
[02-03 19:21:12][INFO] i= 173 x: [[-5.88006154e+23 -3.67503846e+23  4.04254231e+23]]
[02-03 19:21:12][INFO] i= 174 x: [[ 8.08508462e+23  5.05317789e+23 -5.55849568e+23]]
[02-03 19:21:12][INFO] i= 175 x: [[-1.11169914e+24 -6.94811960e+23  7.64293156e+23]]
[02-03 19:21:12][INFO] i= 176 x: [[ 1.52858631e+24  9.55366445e+23 -1.05090309e+24]]
[02-03 19:21:12][INFO] i= 177 x: [[-2.10180618e+24 -1.31362886e+24  1.44499175e+24]]
[02-03 19:21:12][INFO] i= 178 x: [[ 2.88998350e+24  1.80623968e+24 -1.98686365e+24]]
[02-03 19:21:12][INFO] i= 179 x: [[-3.97372731e+24 -2.48357957e+24  2.73193752e+24]]
[02-03 19:21:12][INFO] i= 180 x: [[ 5.46387505e+24  3.41492190e+24 -3.75641409e+24]]
[02-03 19:21:12][INFO] i= 181 x: [[-7.51282819e+24 -4.69551762e+24  5.16506938e+24]]
[02-03 19:21:12][INFO] i= 182 x: [[ 1.03301388e+25  6.45633672e+24 -7.10197040e+24]]
[02-03 19:21:12][INFO] i= 183 x: [[-1.42039408e+25 -8.87746299e+24  9.76520929e+24]]
[02-03 19:21:12][INFO] i= 184 x: [[ 1.95304186e+25  1.22065116e+25 -1.34271628e+25]]
[02-03 19:21:12][INFO] i= 185 x: [[-2.68543256e+25 -1.67839535e+25  1.84623488e+25]]
[02-03 19:21:12][INFO] i= 186 x: [[ 3.69246976e+25  2.30779360e+25 -2.53857296e+25]]
[02-03 19:21:12][INFO] i= 187 x: [[-5.07714593e+25 -3.17321620e+25  3.49053782e+25]]
[02-03 19:21:12][INFO] i= 188 x: [[ 6.98107565e+25  4.36317228e+25 -4.79948951e+25]]
[02-03 19:21:12][INFO] i= 189 x: [[-9.59897902e+25 -5.99936189e+25  6.59929807e+25]]
[02-03 19:21:12][INFO] i= 190 x: [[ 1.31985961e+26  8.24912259e+25 -9.07403485e+25]]
[02-03 19:21:12][INFO] i= 191 x: [[-1.81480697e+26 -1.13425436e+26  1.24767979e+26]]
[02-03 19:21:12][INFO] i= 192 x: [[ 2.49535958e+26  1.55959974e+26 -1.71555971e+26]]
[02-03 19:21:12][INFO] i= 193 x: [[-3.43111943e+26 -2.14444964e+26  2.35889461e+26]]
[02-03 19:21:12][INFO] i= 194 x: [[ 4.71778921e+26  2.94861826e+26 -3.24348008e+26]]
[02-03 19:21:12][INFO] i= 195 x: [[-6.48696017e+26 -4.05435011e+26  4.45978512e+26]]
[02-03 19:21:12][INFO] i= 196 x: [[ 8.91957023e+26  5.57473140e+26 -6.13220453e+26]]
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[02-03 19:21:12][INFO] i= 197 x: [[-1.22644091e+27 -7.66525567e+26  8.43178124e+26]]
[02-03 19:21:12][INFO] i= 198 x: [[ 1.68635625e+27  1.05397265e+27 -1.15936992e+27]]
[02-03 19:21:12][INFO] i= 199 x: [[-2.31873984e+27 -1.44921240e+27  1.59413364e+27]]
[02-03 19:21:12][INFO] i= 200 x: [[ 3.18826728e+27  1.99266705e+27 -2.19193375e+27]]
[02-03 19:21:12][INFO] i= 201 x: [[-4.38386751e+27 -2.73991719e+27  3.01390891e+27]]
[02-03 19:21:12][INFO] i= 202 x: [[ 6.02781783e+27  3.76738614e+27 -4.14412475e+27]]
[02-03 19:21:12][INFO] i= 203 x: [[-8.28824951e+27 -5.18015594e+27  5.69817154e+27]]
[02-03 19:21:12][INFO] i= 204 x: [[ 1.13963431e+28  7.12271442e+27 -7.83498586e+27]]
[02-03 19:21:12][INFO] i= 205 x: [[-1.56699717e+28 -9.79373233e+27  1.07731056e+28]]
[02-03 19:21:12][INFO] i= 206 x: [[ 2.15462111e+28  1.34663820e+28 -1.48130202e+28]]
[02-03 19:21:12][INFO] i= 207 x: [[-2.96260403e+28 -1.85162752e+28  2.03679027e+28]]
[02-03 19:21:12][INFO] i= 208 x: [[ 4.07358054e+28  2.54598784e+28 -2.80058662e+28]]
[02-03 19:21:12][INFO] i= 209 x: [[-5.60117324e+28 -3.50073328e+28  3.85080661e+28]]
[02-03 19:21:12][INFO] i= 210 x: [[ 7.70161321e+28  4.81350826e+28 -5.29485908e+28]]
[02-03 19:21:12][INFO] i= 211 x: [[-1.05897182e+29 -6.61857385e+28  7.28043124e+28]]
[02-03 19:21:12][INFO] i= 212 x: [[ 1.45608625e+29  9.10053905e+28 -1.00105930e+29]]
[02-03 19:21:12][INFO] i= 213 x: [[-2.00211859e+29 -1.25132412e+29  1.37645653e+29]]
[02-03 19:21:12][INFO] i= 214 x: [[ 2.75291306e+29  1.72057066e+29 -1.89262773e+29]]
[02-03 19:21:12][INFO] i= 215 x: [[-3.78525546e+29 -2.36578466e+29  2.60236313e+29]]
[02-03 19:21:12][INFO] i= 216 x: [[ 5.20472626e+29  3.25295391e+29 -3.57824930e+29]]
[02-03 19:21:12][INFO] i= 217 x: [[-7.15649860e+29 -4.47281163e+29  4.92009279e+29]]
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[02-03 19:21:12][INFO] i= 219 x: [[-1.35302552e+30 -8.45640948e+29  9.30205043e+29]]
[02-03 19:21:12][INFO] i= 220 x: [[ 1.86041009e+30  1.16275630e+30 -1.27903193e+30]]
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[02-03 19:21:12][INFO] i= 222 x: [[ 3.51733782e+30  2.19833614e+30 -2.41816975e+30]]
[02-03 19:21:12][INFO] i= 223 x: [[-4.83633950e+30 -3.02271219e+30  3.32498341e+30]]
[02-03 19:21:12][INFO] i= 224 x: [[ 6.64996682e+30  4.15622926e+30 -4.57185219e+30]]
[02-03 19:21:12][INFO] i= 225 x: [[-9.14370437e+30 -5.71481523e+30  6.28629676e+30]]
[02-03 19:21:12][INFO] i= 226 x: [[ 1.25725935e+31  7.85787094e+30 -8.64365804e+30]]
[02-03 19:21:12][INFO] i= 227 x: [[-1.72873161e+31 -1.08045725e+31  1.18850298e+31]]
[02-03 19:21:12][INFO] i= 228 x: [[ 2.37700596e+31  1.48562873e+31 -1.63419160e+31]]
[02-03 19:21:12][INFO] i= 229 x: [[-3.26838320e+31 -2.04273950e+31  2.24701345e+31]]
[02-03 19:21:12][INFO] i= 230 x: [[ 4.49402689e+31  2.80876681e+31 -3.08964349e+31]]
[02-03 19:21:12][INFO] i= 231 x: [[-6.17928698e+31 -3.86205436e+31  4.24825980e+31]]
[02-03 19:21:12][INFO] i= 232 x: [[ 8.49651960e+31  5.31032475e+31 -5.84135722e+31]]
[02-03 19:21:12][INFO] i= 233 x: [[-1.16827144e+32 -7.30169653e+31  8.03186618e+31]]
[02-03 19:21:12][INFO] i= 234 x: [[ 1.60637324e+32  1.00398327e+32 -1.10438160e+32]]
[02-03 19:21:12][INFO] i= 235 x: [[-2.2087632e+32 -1.3804770e+32  1.5185247e+32]]
[02-03 19:21:12][INFO] i= 236 x: [[ 3.03704940e+32  1.89815587e+32 -2.08797146e+32]]
[02-03 19:21:12][INFO] i= 237 x: [[-4.17594292e+32 -2.60996433e+32  2.87096076e+32]]
[02-03 19:21:12][INFO] i= 238 x: [[ 5.74192152e+32  3.58870095e+32 -3.94757105e+32]]
[02-03 19:21:12][INFO] i= 239 x: [[-7.89514209e+32 -4.93446381e+32  5.42791019e+32]]
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[02-03 19:21:12][INFO] i= 240 x: [[ 1.08558204e+33  6.78488774e+32 -7.46337651e+32]]
[02-03 19:21:12][INFO] i= 241 x: [[-1.49267530e+33 -9.32922064e+32  1.02621427e+33]]
[02-03 19:21:12][INFO] i= 242 x: [[ 2.05242854e+33  1.28276784e+33 -1.41104462e+33]]
[02-03 19:21:12][INFO] i= 243 x: [[-2.82208924e+33 -1.76380578e+33  1.94018635e+33]]
[02-03 19:21:12][INFO] i= 244 x: [[ 3.88037271e+33  2.42523294e+33 -2.66775624e+33]]
[02-03 19:21:12][INFO] i= 245 x: [[-5.33551247e+33 -3.33469530e+33  3.66816483e+33]]
[02-03 19:21:12][INFO] i= 246 x: [[ 7.33632965e+33  4.58520603e+33 -5.04372664e+33]]
[02-03 19:21:12][INFO] i= 247 x: [[-1.00874533e+34 -6.30465829e+33  6.93512412e+33]]
[02-03 19:21:12][INFO] i= 248 x: [[ 1.38702482e+34  8.66890516e+33 -9.53579567e+33]]
[02-03 19:21:12][INFO] i= 249 x: [[-1.90715913e+34 -1.19197446e+34  1.31117190e+34]]
[02-03 19:21:12][INFO] i= 250 x: [[ 2.62234381e+34  1.63896488e+34 -1.80286137e+34]]
[02-03 19:21:12][INFO] i= 251 x: [[-3.60572274e+34 -2.25357671e+34  2.47893438e+34]]
[02-03 19:21:12][INFO] i= 252 x: [[ 4.95786876e+34  3.09866798e+34 -3.40853478e+34]]
[02-03 19:21:12][INFO] i= 253 x: [[-6.81706955e+34 -4.26066847e+34  4.68673532e+34]]
[02-03 19:21:12][INFO] i= 254 x: [[ 9.37347063e+34  5.85841915e+34 -6.44426106e+34]]
[02-03 19:21:12][INFO] i= 255 x: [[-1.28885221e+35 -8.05532633e+34  8.86085896e+34]]
[02-03 19:21:12][INFO] i= 256 x: [[ 1.77217179e+35  1.10760737e+35 -1.21836811e+35]]
[02-03 19:21:12][INFO] i= 257 x: [[-2.43673621e+35 -1.52296013e+35  1.67525615e+35]]
[02-03 19:21:12][INFO] i= 258 x: [[ 3.35051229e+35  2.09407018e+35 -2.30347720e+35]]
[02-03 19:21:12][INFO] i= 259 x: [[-4.60695440e+35 -2.87934650e+35  3.16728115e+35]]
[02-03 19:21:12][INFO] i= 260 x: [[ 6.33456230e+35  3.95910144e+35 -4.35501158e+35]]
[02-03 19:21:12][INFO] i= 261 x: [[-8.71002317e+35 -5.44376448e+35  5.98814093e+35]]
[02-03 19:21:12][INFO] i= 262 x: [[ 1.19762819e+36  7.48517616e+35 -8.23369378e+35]]
[02-03 19:21:12][INFO] i= 263 x: [[-1.64673876e+36 -1.02921172e+36  1.13213289e+36]]
[02-03 19:21:12][INFO] i= 264 x: [[ 2.26426579e+36  1.41516612e+36 -1.55668273e+36]]
[02-03 19:21:12][INFO] i= 265 x: [[-3.11336546e+36 -1.94585341e+36  2.14043875e+36]]
[02-03 19:21:12][INFO] i= 266 x: [[ 4.28087751e+36  2.67554844e+36 -2.94310329e+36]]
[02-03 19:21:12][INFO] i= 267 x: [[-5.88620657e+36 -3.67887911e+36  4.04676702e+36]]
[02-03 19:21:12][INFO] i= 268 x: [[ 8.09353404e+36  5.05845877e+36 -5.56430465e+36]]
[02-03 19:21:12][INFO] i= 269 x: [[-1.11286093e+37 -6.95538081e+36  7.65091889e+36]]
[02-03 19:21:12][INFO] i= 270 x: [[ 1.53018378e+37  9.56364862e+36 -1.05200135e+37]]
[02-03 19:21:12][INFO] i= 271 x: [[-2.10400270e+37 -1.31500168e+37  1.44650185e+37]]
[02-03 19:21:12][INFO] i= 272 x: [[ 2.89300371e+37  1.80812732e+37 -1.98894005e+37]]
[02-03 19:21:12][INFO] i= 273 x: [[-3.97788010e+37 -2.48617506e+37  2.73479257e+37]]
[02-03 19:21:12][INFO] i= 274 x: [[ 5.46958513e+37  3.41849071e+37 -3.76033978e+37]]
[02-03 19:21:12][INFO] i= 275 x: [[-7.52067956e+37 -4.70042472e+37  5.17046720e+37]]
[02-03 19:21:12][INFO] i= 276 x: [[ 1.03409344e+38  6.46308400e+37 -7.10939239e+37]]
[02-03 19:21:12][INFO] i= 277 x: [[-1.42187848e+38 -8.88674049e+37  9.77541454e+37]]
[02-03 19:21:12][INFO] i= 278 x: [[ 1.95508291e+38  1.22192682e+38 -1.34411950e+38]]
[02-03 19:21:12][INFO] i= 279 x: [[-2.68823900e+38 -1.68014937e+38  1.84816431e+38]]
[02-03 19:21:12][INFO] i= 280 x: [[ 3.69632862e+38  2.31020539e+38 -2.54122593e+38]]
[02-03 19:21:12][INFO] i= 281 x: [[-5.08245186e+38 -3.17653241e+38  3.49418565e+38]]
[02-03 19:21:12][INFO] i= 282 x: [[ 6.98837130e+38  4.36773207e+38 -4.80450527e+38]]
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[02-03 19:21:12][INFO] i= 283 x: [[-9.60901054e+38 -6.00563159e+38  6.60619475e+38]]
[02-03 19:21:12][INFO] i= 284 x: [[ 1.32123895e+39  8.25774344e+38 -9.08351778e+38]]
[02-03 19:21:12][INFO] i= 285 x: [[-1.81670356e+39 -1.13543972e+39  1.24898369e+39]]
[02-03 19:21:12][INFO] i= 286 x: [[ 2.49796739e+39  1.56122962e+39 -1.71735258e+39]]
[02-03 19:21:12][INFO] i= 287 x: [[-3.43470516e+39 -2.14669073e+39  2.36135980e+39]]
[02-03 19:21:12][INFO] i= 288 x: [[ 4.72271960e+39  2.95169975e+39 -3.24686972e+39]]
[02-03 19:21:12][INFO] i= 289 x: [[-6.49373944e+39 -4.05858715e+39  4.46444587e+39]]
[02-03 19:21:12][INFO] i= 290 x: [[ 8.92889174e+39  5.58055733e+39 -6.13861307e+39]]
[02-03 19:21:12][INFO] i= 291 x: [[-1.22772261e+40 -7.67326634e+39  8.44059297e+39]]
[02-03 19:21:12][INFO] i= 292 x: [[ 1.68811859e+40  1.05507412e+40 -1.16058153e+40]]
[02-03 19:21:12][INFO] i= 293 x: [[-2.32116307e+40 -1.45072692e+40  1.59579961e+40]]
[02-03 19:21:12][INFO] i= 294 x: [[ 3.19159922e+40  1.99474951e+40 -2.19422446e+40]]
[02-03 19:21:12][INFO] i= 295 x: [[-4.38844892e+40 -2.74278058e+40  3.01705863e+40]]
[02-03 19:21:12][INFO] i= 296 x: [[ 6.03411727e+40  3.77132329e+40 -4.14845562e+40]]
[02-03 19:21:12][INFO] i= 297 x: [[-8.29691124e+40 -5.18556953e+40  5.70412648e+40]]
[02-03 19:21:12][INFO] i= 298 x: [[ 1.14082530e+41  7.13015810e+40 -7.84317391e+40]]
[02-03 19:21:12][INFO] i= 299 x: [[-1.56863478e+41 -9.80396739e+40  1.07843641e+41]]

El método Gauss-Seidel no converge.
```

1.7 Ejercicio 7

Repita el ejercicio 6 usando el método de Jacobi.

b.

```python
print("Solución con Gauss-Jacobi")
sol, tray = gauss_jacobi(A=A, b=b, x0=x0, tol=1e-2, max_iter=300)

print("\nSolución del sistema:")
print(f"i= {len(tray)}: x: {np.squeeze(sol)}")
```

```
Solución con Gauss-Jacobi
[02-03 19:21:19][INFO] i= 0 x: [0. 0. 0.]
[02-03 19:21:19][INFO] i= 1 x: [[ 0.2   -1.425  2.   ]]
[02-03 19:21:19][INFO] i= 2 x: [[ 2.2    -0.825   1.0875]]
[02-03 19:21:19][INFO] i= 3 x: [[ 1.2875   -0.053125 -0.6125  ]]
[02-03 19:21:19][INFO] i= 4 x: [[-0.4125    -0.934375   0.6859375]]
[02-03 19:21:19][INFO] i= 5 x: [[ 0.8859375  -1.45976563  1.9453125 ]]
[02-03 19:21:19][INFO] i= 6 x: [[ 2.1453125  -0.49570312  0.38417969]]
[02-03 19:21:19][INFO] i= 7 x: [[ 0.58417969 -0.25629883 -0.39316406]]
[02-03 19:21:19][INFO] i= 8 x: [[-0.19316406 -1.23120117  1.2876709 ]]
```

```
[02-03 19:21:19][INFO] i= 9 x: [[ 1.4876709  -1.19966431  1.57756348]]
[02-03 19:21:19][INFO] i= 10 x: [[ 1.77756348 -0.28677368 -0.08750305]]
[02-03 19:21:19][INFO] i= 11 x: [[ 0.11249695 -0.55809402  0.07904968]]
[02-03 19:21:19][INFO] i= 12 x: [[ 0.27904968 -1.34898911  1.60845604]]
[02-03 19:21:19][INFO] i= 13 x: [[ 1.80845604 -0.88336115  1.04645576]]
[02-03 19:21:19][INFO] i= 14 x: [[ 1.24645576 -0.25915804 -0.25013661]]
[02-03 19:21:19][INFO] i= 15 x: [[-0.05013661 -0.86430627  0.62396522]]
[02-03 19:21:19][INFO] i= 16 x: [[ 0.82396522 -1.294077    1.61798348]]
[02-03 19:21:19][INFO] i= 17 x: [[ 1.81798348 -0.60852152  0.52899628]]
[02-03 19:21:19][INFO] i= 18 x: [[ 0.72899628 -0.38375919 -0.12224424]]
[02-03 19:21:19][INFO] i= 19 x: [[ 0.07775576 -1.09106292  1.07912412]]
[02-03 19:21:19][INFO] i= 20 x: [[ 1.27912412 -1.11634109  1.37671278]]
[02-03 19:21:19][INFO] i= 21 x: [[ 1.57671278 -0.44125974  0.16270533]]
[02-03 19:21:19][INFO] i= 22 x: [[ 0.36270533 -0.59596728  0.20265735]]
[02-03 19:21:19][INFO] i= 23 x: [[ 0.40265735 -1.192983    1.33931103]]
[02-03 19:21:19][INFO] i= 24 x: [[ 1.53931103 -0.88884357  1.00085115]]
[02-03 19:21:19][INFO] i= 25 x: [[ 1.20085115 -0.4051317   0.01626719]]
[02-03 19:21:19][INFO] i= 26 x: [[ 0.21626719 -0.82050763  0.596583  ]]
[02-03 19:21:19][INFO] i= 27 x: [[ 0.796583   -1.16772066  1.373479  ]]
[02-03 19:21:19][INFO] i= 28 x: [[ 1.573479   -0.68333875  0.61955667]]
[02-03 19:21:19][INFO] i= 29 x: [[ 0.81955667 -0.48337133  0.08485162]]
[02-03 19:21:19][INFO] i= 30 x: [[ 0.28485162 -0.99400876  0.93875766]]
[02-03 19:21:19][INFO] i= 31 x: [[ 1.13875766 -1.04788477  1.218144  ]]
[02-03 19:21:19][INFO] i= 32 x: [[ 1.418144   -0.55108517  0.33729995]]
[02-03 19:21:19][INFO] i= 33 x: [[ 0.53729995 -0.63160301  0.30631342]]
[02-03 19:21:19][INFO] i= 34 x: [[ 0.50631342 -1.07977167  1.14689854]]
[02-03 19:21:19][INFO] i= 35 x: [[ 1.34689854 -0.88511866  0.95380075]]
[02-03 19:21:19][INFO] i= 36 x: [[ 1.15380075 -0.51310054  0.21054213]]
[02-03 19:21:19][INFO] i= 37 x: [[ 0.41054213 -0.79546409  0.58964898]]
[02-03 19:21:19][INFO] i= 38 x: [[ 0.78964898 -1.07231669  1.19172582]]
[02-03 19:21:19][INFO] i= 39 x: [[ 1.39172582 -0.73224405  0.67419268]]
[02-03 19:21:19][INFO] i= 40 x: [[ 0.87419268 -0.56058892  0.24215215]]
[02-03 19:21:19][INFO] i= 41 x: [[ 0.44215215 -0.92736562  0.84551286]]
[02-03 19:21:19][INFO] i= 42 x: [[ 1.04551286 -0.99254571  1.09416504]]
[02-03 19:21:19][INFO] i= 43 x: [[ 1.29416504 -0.62870231  0.45821428]]
[02-03 19:21:19][INFO] i= 44 x: [[ 0.65821428 -0.66336391  0.39148381]]
[02-03 19:21:19][INFO] i= 45 x: [[ 0.59148381 -0.99802191  1.01010376]]
[02-03 19:21:19][INFO] i= 46 x: [[ 1.21010376 -0.87673215  0.90950524]]
[02-03 19:21:19][INFO] i= 47 x: [[ 1.10950524 -0.59257181  0.35153016]]
[02-03 19:21:19][INFO] i= 48 x: [[ 0.55153016 -0.78236484  0.59420886]]
[02-03 19:21:19][INFO] i= 49 x: [[ 0.79420886 -1.00068271  1.05728742]]
[02-03 19:21:19][INFO] i= 50 x: [[ 1.25728742 -0.76357372  0.70544979]]
[02-03 19:21:19][INFO] i= 51 x: [[ 0.90544979 -0.61999384  0.36092572]]
```

```
[02-03 19:21:19][INFO] i= 52 x: [[ 0.56092572 -0.88204367  0.78455329]]
[02-03 19:21:19][INFO] i= 53 x: [[ 0.98455329 -0.94839882  0.99805244]]
[02-03 19:21:19][INFO] i= 54 x: [[ 1.19805244 -0.68321025  0.5412473 ]]
[02-03 19:21:19][INFO] i= 55 x: [[ 0.7412473  -0.69066195  0.46034244]]
[02-03 19:21:19][INFO] i= 56 x: [[ 0.66034244 -0.93929074  0.91342172]]
[02-03 19:21:19][INFO] i= 57 x: [[ 1.11342172 -0.86647335  0.87001219]]
[02-03 19:21:19][INFO] i= 58 x: [[ 1.07001219 -0.65078609  0.4533416 ]]
[02-03 19:21:19][INFO] i= 59 x: [[ 0.6533416  -0.7766585   0.60459476]]
[02-03 19:21:19][INFO] i= 60 x: [[ 0.80459476 -0.94718051  0.95832914]]
[02-03 19:21:19][INFO] i= 61 x: [[ 1.15832914 -0.78312033  0.72181498]]
[02-03 19:21:19][INFO] i= 62 x: [[ 0.92181498 -0.66538168  0.45011069]]
[02-03 19:21:19][INFO] i= 63 x: [[ 0.65011069 -0.85156484  0.74549417]]
[02-03 19:21:19][INFO] i= 64 x: [[ 0.94549417 -0.91357111  0.92410689]]
[02-03 19:21:19][INFO] i= 65 x: [[ 1.12410689 -0.72122619  0.59772027]]
[02-03 19:21:19][INFO] i= 66 x: [[ 0.79772027 -0.71351649  0.51528001]]
[02-03 19:21:19][INFO] i= 67 x: [[ 0.71528001 -0.89731986  0.84552149]]
[02-03 19:21:19][INFO] i= 68 x: [[ 1.04552149 -0.85597962  0.83606006]]
[02-03 19:21:19][INFO] i= 69 x: [[ 1.03606006 -0.69322424  0.5264887 ]]
[02-03 19:21:19][INFO] i= 70 x: [[ 0.7264887  -0.7753478   0.61732782]]
[02-03 19:21:19][INFO] i= 71 x: [[ 0.81732782 -0.90742369  0.8858374 ]]
[02-03 19:21:19][INFO] i= 72 x: [[ 1.0858374  -0.79487674  0.72896033]]
[02-03 19:21:19][INFO] i= 73 x: [[ 0.92896033 -0.69984122  0.51672423]]
[02-03 19:21:19][INFO] i= 74 x: [[ 0.71672423 -0.83133878  0.72111906]]
[02-03 19:21:19][INFO] i= 75 x: [[ 0.92111906 -0.88635812  0.86760638]]
[02-03 19:21:19][INFO] i= 76 x: [[ 1.06760638 -0.74753887  0.63570188]]
[02-03 19:21:19][INFO] i= 77 x: [[ 0.83570188 -0.73227134  0.55862418]]
[02-03 19:21:19][INFO] i= 78 x: [[ 0.75862418 -0.86749301  0.79816245]]
[02-03 19:21:19][INFO] i= 79 x: [[ 0.99816245 -0.8461473   0.80762931]]
[02-03 19:21:19][INFO] i= 80 x: [[ 1.00762931 -0.72401145  0.5787639 ]]
[02-03 19:21:19][INFO] i= 81 x: [[ 0.7787639  -0.77649437  0.63036497]]
[02-03 19:21:19][INFO] i= 82 x: [[ 0.83036497 -0.87802681  0.83298891]]
[02-03 19:21:19][INFO] i= 83 x: [[ 1.03298891 -0.80157029  0.73062163]]
[02-03 19:21:19][INFO] i= 84 x: [[ 0.93062163 -0.72585014  0.56622594]]
[02-03 19:21:19][INFO] i= 85 x: [[ 0.76622594 -0.8181327   0.7064533 ]]
[02-03 19:21:19][INFO] i= 86 x: [[ 0.9064533  -0.8652737   0.82470771]]
[02-03 19:21:19][INFO] i= 87 x: [[ 1.02470771 -0.76559642  0.66090985]]
[02-03 19:21:19][INFO] i= 88 x: [[ 0.86090985 -0.74741868  0.59249408]]
[02-03 19:21:19][INFO] i= 89 x: [[ 0.79249408 -0.84642156  0.76538081]]
[02-03 19:21:19][INFO] i= 90 x: [[ 0.96538081 -0.83740776  0.78429514]]
[02-03 19:21:19][INFO] i= 91 x: [[ 0.98429514 -0.74623581  0.61591531]]
[02-03 19:21:19][INFO] i= 92 x: [[ 0.81591531 -0.7788736   0.64258695]]
[02-03 19:21:19][INFO] i= 93 x: [[ 0.84258695 -0.85639561  0.79464789]]
[02-03 19:21:19][INFO] i= 94 x: [[ 0.99464789 -0.80504455  0.72921524]]
```

```
[02-03 19:21:19][INFO] i= 95 x: [[ 0.92921524 -0.74537224  0.60282984]]
[02-03 19:21:19][INFO] i= 96 x: [[ 0.80282984 -0.80968492  0.69809864]]
[02-03 19:21:19][INFO] i= 97 x: [[ 0.89809864 -0.84906042  0.7923277 ]]
[02-03 19:21:19][INFO] i= 98 x: [[ 0.9923277  -0.77786876  0.67737115]]
[02-03 19:21:19][INFO] i= 99 x: [[ 0.87737115 -0.75949336  0.61873792]]
[02-03 19:21:19][INFO] i= 100 x: [[ 0.81873792 -0.83162994  0.74288217]]
[02-03 19:21:19][INFO] i= 101 x: [[ 0.94288217 -0.8299105   0.76544711]]
[02-03 19:21:19][INFO] i= 102 x: [[ 0.96544711 -0.76219714  0.64216258]]
[02-03 19:21:19][INFO] i= 103 x: [[ 0.84216258 -0.7817358   0.65345432]]
[02-03 19:21:19][INFO] i= 104 x: [[ 0.85345432 -0.84055513  0.76696952]]
[02-03 19:21:19][INFO] i= 105 x: [[ 0.96696952 -0.80653046  0.72626812]]
[02-03 19:21:19][INFO] i= 106 x: [[ 0.92626812 -0.75994821  0.62976525]]
[02-03 19:21:19][INFO] i= 107 x: [[ 0.82976525 -0.80442463  0.69375778]]
[02-03 19:21:19][INFO] i= 108 x: [[ 0.89375778 -0.83667793  0.76802243]]
[02-03 19:21:19][INFO] i= 109 x: [[ 0.96802243 -0.7861155   0.68790326]]
[02-03 19:21:19][INFO] i= 110 x: [[ 0.88790326 -0.76901297  0.63891982]]
[02-03 19:21:19][INFO] i= 111 x: [[ 0.83891982 -0.82131842  0.72759026]]
[02-03 19:21:19][INFO] i= 112 x: [[ 0.92759026 -0.82364253  0.75042098]]
[02-03 19:21:19][INFO] i= 113 x: [[ 0.95042098 -0.77359963  0.66058848]]
[02-03 19:21:19][INFO] i= 114 x: [[ 0.86058848 -0.78464239  0.66277921]]
[02-03 19:21:19][INFO] i= 115 x: [[ 0.86277921 -0.82901096  0.74709033]]
[02-03 19:21:19][INFO] i= 116 x: [[ 0.94709033 -0.80683781  0.72271531]]
[02-03 19:21:19][INFO] i= 117 x: [[ 0.92271531 -0.77077601  0.64949077]]
[02-03 19:21:19][INFO] i= 118 x: [[ 0.84949077 -0.80126965  0.69189669]]
[02-03 19:21:19][INFO] i= 119 x: [[ 0.89189669 -0.82728045  0.74987441]]
[02-03 19:21:19][INFO] i= 120 x: [[ 0.94987441 -0.79158306  0.69446309]]
[02-03 19:21:19][INFO] i= 121 x: [[ 0.89446309 -0.77644702  0.65433407]]
[02-03 19:21:19][INFO] i= 122 x: [[ 0.85433407 -0.81418494  0.7173134 ]]
[02-03 19:21:19][INFO] i= 123 x: [[ 0.9173134  -0.81850462  0.73857347]]
[02-03 19:21:19][INFO] i= 124 x: [[ 0.93857347 -0.78169994  0.6734343 ]]
[02-03 19:21:19][INFO] i= 125 x: [[ 0.8734343  -0.78735469  0.67057657]]
[02-03 19:21:19][INFO] i= 126 x: [[ 0.87057657 -0.82063871  0.73288836]]
[02-03 19:21:19][INFO] i= 127 x: [[ 0.93288836 -0.80648963  0.71910408]]
[02-03 19:21:19][INFO] i= 128 x: [[ 0.91910408 -0.7787798   0.66386683]]
[02-03 19:21:19][INFO] i= 129 x: [[ 0.86386683 -0.79948125  0.69150602]]
[02-03 19:21:19][INFO] i= 130 x: [[ 0.89150602 -0.82019008  0.73639254]]
[02-03 19:21:19][INFO] i= 131 x: [[ 0.93639254 -0.79514885  0.69839894]]
[02-03 19:21:19][INFO] i= 132 x: [[ 0.89839894 -0.78220399  0.66603303]]
[02-03 19:21:19][INFO] i= 133 x: [[ 0.86603303 -0.80929227  0.71049906]]
[02-03 19:21:19][INFO] i= 134 x: [[ 0.91049906 -0.81435872  0.72932083]]
[02-03 19:21:19][INFO] i= 135 x: [[ 0.92932083 -0.78742026  0.68232158]]
[02-03 19:21:19][INFO] i= 136 x: [[ 0.88232158 -0.78975919  0.67696904]]
[02-03 19:21:19][INFO] i= 137 x: [[ 0.87696904 -0.81459695  0.72279883]]
```

```
[02-03 19:21:19][INFO] i= 138 x: [[ 0.92279883 -0.80581577  0.71573249]]
[02-03 19:21:19][INFO] i= 139 x: [[ 0.91573249 -0.78466746  0.67429328]]
[02-03 19:21:19][INFO] i= 140 x: [[ 0.87429328 -0.79856044  0.69193378]]
[02-03 19:21:19][INFO] i= 141 x: [[ 0.89193378 -0.81486991  0.7264265 ]]
[02-03 19:21:19][INFO] i= 142 x: [[ 0.9264265  -0.79742648  0.70063126]]
[02-03 19:21:19][INFO] i= 143 x: [[ 0.90063126 -0.78662893  0.67486026]]
[02-03 19:21:19][INFO] i= 144 x: [[ 0.87486026 -0.8059693   0.70605427]]
[02-03 19:21:19][INFO] i= 145 x: [[ 0.90605427 -0.8110563   0.72215509]]
[02-03 19:21:19][INFO] i= 146 x: [[ 0.92215509 -0.79143409  0.68841758]]
[02-03 19:21:19][INFO] i= 147 x: [[ 0.88841758 -0.79181806  0.68212786]]
[02-03 19:21:19][INFO] i= 148 x: [[ 0.88212786 -0.81025925  0.71567339]]
[02-03 19:21:19][INFO] i= 149 x: [[ 0.91567339 -0.80501772  0.71274251]]
[02-03 19:21:19][INFO] i= 150 x: [[ 0.91274251 -0.78897768  0.68181775]]
[02-03 19:21:19][INFO] i= 151 x: [[ 0.88181775 -0.79817431  0.69276865]]
[02-03 19:21:19][INFO] i= 152 x: [[ 0.89276865 -0.81089896  0.7190951 ]]
[02-03 19:21:19][INFO] i= 153 x: [[ 0.9190951  -0.7988419   0.70178187]]
[02-03 19:21:19][INFO] i= 154 x: [[ 0.90178187 -0.79000698  0.68148395]]
[02-03 19:21:19][INFO] i= 155 x: [[ 0.88148395 -0.80373808  0.70321464]]
[02-03 19:21:19][INFO] i= 156 x: [[ 0.90321464 -0.80845436  0.71664701]]
[02-03 19:21:19][INFO] i= 157 x: [[ 0.91664701 -0.79423093  0.69255818]]
[02-03 19:21:19][INFO] i= 158 x: [[ 0.89255818 -0.79353695  0.68623753]]
[02-03 19:21:19][INFO] i= 159 x: [[ 0.88623753 -0.80716153  0.71067335]]
[02-03 19:21:19][INFO] i= 160 x: [[ 0.91067335 -0.8042129   0.71018171]]
[02-03 19:21:19][INFO] i= 161 x: [[ 0.91018171 -0.7921179   0.6872202 ]]
[02-03 19:21:19][INFO] i= 162 x: [[ 0.8872202  -0.79810409  0.69375934]]
[02-03 19:21:19][INFO] i= 163 x: [[ 0.89375934 -0.80795006  0.71372775]]
[02-03 19:21:19][INFO] i= 164 x: [[ 0.91372775 -0.79968839  0.70226563]]
[02-03 19:21:19][INFO] i= 165 x: [[ 0.90226563 -0.79256972  0.68642805]]
[02-03 19:21:19][INFO] i= 166 x: [[ 0.88642805 -0.80226017  0.70144951]]
[02-03 19:21:19][INFO] i= 167 x: [[ 0.90144951 -0.80642359  0.71244186]]
[02-03 19:21:19][INFO] i= 168 x: [[ 0.91244186 -0.79616478  0.69533869]]
[02-03 19:21:19][INFO] i= 169 x: [[ 0.89533869 -0.7949444   0.68947575]]
[02-03 19:21:19][INFO] i= 170 x: [[ 0.88947575 -0.80496172  0.70718911]]
[02-03 19:21:19][INFO] i= 171 x: [[ 0.90718911 -0.80346485  0.70804339]]
[02-03 19:21:19][INFO] i= 172 x: [[ 0.90804339 -0.7943946   0.69107847]]
[02-03 19:21:19][INFO] i= 173 x: [[ 0.89107847 -0.79820869  0.69475931]]
[02-03 19:21:19][INFO] i= 174 x: [[ 0.89475931 -0.80577094  0.70981719]]
[02-03 19:21:19][INFO] i= 175 x: [[ 0.90981719 -0.80016605  0.70235522]]
[02-03 19:21:19][INFO] i= 176 x: [[ 0.90235522 -0.7945026   0.69009979]]
[02-03 19:21:19][INFO] i= 177 x: [[ 0.89009979 -0.80129744  0.70039348]]
[02-03 19:21:19][INFO] i= 178 x: [[ 0.90039348 -0.80485174  0.70925149]]
[02-03 19:21:19][INFO] i= 179 x: [[ 0.90925149 -0.79749039  0.69718065]]
[02-03 19:21:19][INFO] i= 180 x: [[ 0.89718065 -0.79607909  0.69200332]]
```

```
[02-03 19:21:19][INFO] i= 181 x: [[ 0.89200332 -0.80340885  0.7047798 ]]
[02-03 19:21:19][INFO] i= 182 x: [[ 0.9047798  -0.80280339  0.70629226]]
[02-03 19:21:19][INFO] i= 183 x: [[ 0.90629226 -0.79603703  0.6938185 ]]
[02-03 19:21:19][INFO] i= 184 x: [[ 0.8938185  -0.79839924  0.69568922]]
[02-03 19:21:19][INFO] i= 185 x: [[ 0.89568922 -0.80416844  0.70698188]]
[02-03 19:21:19][INFO] i= 186 x: [[ 0.90698188 -0.80040992  0.70222656]]
[02-03 19:21:19][INFO] i= 187 x: [[ 0.90222656 -0.79595242  0.69281316]]
[02-03 19:21:19][INFO] i= 188 x: [[ 0.89281316 -0.80068343  0.69979723]]
[02-03 19:21:19][INFO] i= 189 x: [[ 0.89979723 -0.80364411  0.70684512]]
[02-03 19:21:19][INFO] i= 190 x: [[ 0.90684512 -0.7983901   0.69838071]]

Solución del sistema:
i= 191: x: [ 0.89838071 -0.79698226  0.69395983]
```

c.

```
print("Solución con Gauss-Jacobi")
sol1, tray1 = gauss_jacobi(A=A1, b=b1, x0=x0_1, tol=1e-2, max_iter=300)

print("\nEl método de Gauss-Jacobi no converge")
```

```
Solución con Gauss-Jacobi
[02-03 19:21:25][INFO] i= 0 x: [0. 0. 0.]
[02-03 19:21:25][INFO] i= 1 x: [[ 0.2   -1.425  2.   ]]
[02-03 19:21:25][INFO] i= 2 x: [[ 4.2    -0.825   1.0875]]
[02-03 19:21:25][INFO] i= 3 x: [[ 2.375     0.946875 -2.6125  ]]
[02-03 19:21:25][INFO] i= 4 x: [[-5.025     -0.890625   0.0984375]]
[02-03 19:21:25][INFO] i= 5 x: [[ 0.396875   -3.91289062  6.5796875 ]]
[02-03 19:21:25][INFO] i= 6 x: [[13.359375    0.41835938 -0.35332031]]
[02-03 19:21:25][INFO] i= 7 x: [[ -0.50664063   5.16635742 -11.15019531]]
[02-03 19:21:25][INFO] i= 8 x: [[-22.10039062  -4.46586914   5.08981934]]
[02-03 19:21:25][INFO] i= 9 x: [[ 10.37963867 -11.20274048  21.86745605]]
[02-03 19:21:25][INFO] i= 10 x: [[ 43.93491211   9.23168335 -13.98100891]]
[02-03 19:21:25][INFO] i= 11 x: [[-27.76201782  17.04720383 -37.31907043]]
[02-03 19:21:25][INFO] i= 12 x: [[-74.43814087 -24.63577652  38.28561974]]
[02-03 19:21:25][INFO] i= 13 x: [[ 76.77123947 -29.0726655   64.12025261]]
[02-03 19:21:25][INFO] i= 14 x: [[128.44050522  52.99068289 -89.30757222]]
[02-03 19:21:25][INFO] i= 15 x: [[-178.41514444   40.46835955  -99.94516377]]
[02-03 19:21:25][INFO] i= 16 x: [[-199.69032755 -115.61886317  200.64932422]]
[02-03 19:21:25][INFO] i= 17 x: [[401.49864844 -51.10783272 143.88089597]]
[02-03 19:21:25][INFO] i= 18 x: [[ 287.96179193  235.29454821 -425.0525648 ]]
[02-03 19:21:25][INFO] i= 19 x: [[-849.9051296    36.29275477 -168.31451783]]
```

```
[02-03 19:21:25][INFO] i= 20 x: [[-336.42903565 -468.45619426  870.05150698]]
[02-03 19:21:25][INFO] i= 21 x: [[1740.30301397   47.87335892  104.20093852]]
[02-03 19:21:25][INFO] i= 22 x: [[  208.60187705   894.77674162 -1714.36633451]]
[02-03 19:21:25][INFO] i= 23 x: [[-3428.53266902  -325.7156451    240.78649376]]
[02-03 19:21:25][INFO] i= 24 x: [[  481.77298752 -1655.49471107  3267.67484647]]
[02-03 19:21:25][INFO] i= 25 x: [[ 6535.54969293  1056.38020537 -1307.52034305]]
[02-03 19:21:25][INFO] i= 26 x: [[-2614.8406861   2939.4697607  -6005.35959024]]
[02-03 19:21:25][INFO] i= 27 x: [[-12010.51918049  -2810.18524061   4086.57556645]]
[02-03 19:21:25][INFO] i= 28 x: [[ 8173.35113291 -4985.04069863 10607.42656018]]
[02-03 19:21:25][INFO] i= 29 x: [[ 21215.05312036   6737.1072065  -10663.87148222]]
[02-03 19:21:25][INFO] i= 30 x: [[-21327.54296445   7940.13368963 -17844.49951711]]
[02-03 19:21:25][INFO] i= 31 x: [[-35688.79903423 -15126.3213615   25299.60980926]]
[02-03 19:21:25][INFO] i= 32 x: [[ 50599.41961852 -11520.9220648   28127.63835348]]
[02-03 19:21:25][INFO] i= 33 x: [[ 56255.47670696  32330.19439763 -56357.88065092]]
[02-03 19:21:25][INFO] i= 34 x: [[-112715.56130184   14036.84319075  -40088.37950814]]
[02-03 19:21:25][INFO] i= 35 x: [[-80176.55901628 -66381.30052796 119735.98289722]]
[02-03 19:21:25][INFO] i= 36 x: [[239472.16579443 -10155.70878384  46987.9087523 ]]
[02-03 19:21:25][INFO] i= 37 x: [[  93976.0175046   131481.63508529 -244548.02018635]]
[02-03 19:21:25][INFO] i= 38 x: [[-489095.8403727   -14150.42129429  -28233.19996196]]
[02-03 19:21:25][INFO] i= 39 x: [[ -56466.19992391 -251607.64517684  482022.62972556]]
[02-03 19:21:25][INFO] i= 40 x: [[964045.45945112  92271.13246943 -69335.62266451]]
[02-03 19:21:25][INFO] i= 41 x: [[-138671.04532901  464687.39905943 -917907.8932164 ]]
[02-03 19:21:25][INFO] i= 42 x: [[-1835815.58643281  -298813.92096861   371016.74485873]]
[02-03 19:21:25][INFO] i= 43 x: [[ 742033.68971746 -825155.03200172 1686410.6259485 ]]
[02-03 19:21:25][INFO] i= 44 x: [[ 3372821.45189701   792618.07634585 -1154609.20571832]]
[02-03 19:21:25][INFO] i= 45 x: [[-2309218.21143664  1397756.99951892 -2976510.41372408]]
[02-03 19:21:25][INFO] i= 46 x: [[-5953020.62744816 -1898738.13414934  3008098.7111961 ]]
[02-03 19:21:25][INFO] i= 47 x: [[ 6016197.6223922  -2224487.06092505  5003653.56037349]]
[02-03 19:21:25][INFO] i= 48 x: [[10007307.32074698  4259010.77628947 -7128439.15285472]]
[02-03 19:21:25][INFO] i= 49 x: [[-14256878.10570945   3221542.44715981  -7877799.93260224]]
[02-03 19:21:25][INFO] i= 50 x: [[-15755599.66520448  -9097890.46100529  15867651.32928935]]
[02-03 19:21:25][INFO] i= 51 x: [[31735302.8585787  -3910888.4252799  11206656.43470184]]
[02-03 19:21:25][INFO] i= 52 x: [[ 22413313.06940368  18669314.11296481 -33690745.07121865]]
[02-03 19:21:25][INFO] i= 53 x: [[-67381489.9424373    2783968.84189718 -13078654.01292128]]
[02-03 19:21:25][INFO] i= 54 x: [[-26157307.82584255 -36960409.89944897  68773476.3633859 ]]
[02-03 19:21:25][INFO] i= 55 x: [[1.37546953e+08 4.11471375e+06 7.67710488e+06]]
[02-03 19:21:25][INFO] i= 56 x: [[ 1.53542100e+07  7.06927513e+07 -1.35489594e+08]]
[02-03 19:21:25][INFO] i= 57 x: [[-2.70979188e+08 -2.61952950e+07  1.99921677e+07]]
[02-03 19:21:25][INFO] i= 58 x: [[ 3.99843356e+07 -1.30491553e+08  2.57881542e+08]]
[02-03 19:21:25][INFO] i= 59 x: [[ 5.15763085e+08  8.44625520e+07 -1.05230110e+08]]
[02-03 19:21:25][INFO] i= 60 x: [[-2.10460220e+08  2.31574014e+08 -4.73531807e+08]]
[02-03 19:21:25][INFO] i= 61 x: [[-9.47063614e+08 -2.23613063e+08  3.26247229e+08]]
[02-03 19:21:25][INFO] i= 62 x: [[ 6.52494458e+08 -3.91970001e+08  8.35257084e+08]]
```

```
[02-03 19:21:25][INFO] i= 63 x: [[ 1.67051417e+09  5.35061499e+08 -8.48479457e+08]]
[02-03 19:21:25][INFO] i= 64 x: [[-1.69695891e+09  6.23137219e+08 -1.40298342e+09]]
[02-03 19:21:25][INFO] i= 65 x: [[-2.80596683e+09 -1.19922531e+09  2.00852753e+09]]
[02-03 19:21:25][INFO] i= 66 x: [[ 4.01705505e+09 -9.00851537e+08  2.20635418e+09]]
[02-03 19:21:25][INFO] i= 67 x: [[ 4.41270836e+09  2.56011607e+09 -4.46748082e+09]]
[02-03 19:21:25][INFO] i= 68 x: [[-8.93496163e+09  1.08948397e+09 -3.13265032e+09]]
[02-03 19:21:25][INFO] i= 69 x: [[-6.26530065e+09 -5.25064340e+09  9.47970362e+09]]
[02-03 19:21:25][INFO] i= 70 x: [[ 1.89594072e+10 -7.62724419e+08  3.63997895e+09]]
[02-03 19:21:25][INFO] i= 71 x: [[ 7.27995790e+09  1.03896984e+10 -1.93407695e+10]]
[02-03 19:21:25][INFO] i= 72 x: [[-3.86815389e+10 -1.19521342e+09 -2.08510872e+09]]
[02-03 19:21:25][INFO] i= 73 x: [[-4.17021744e+09 -1.98620466e+10  3.80839322e+10]]
[02-03 19:21:25][INFO] i= 74 x: [[ 7.61678644e+10  7.43587433e+09 -5.76080588e+09]]
[02-03 19:21:25][INFO] i= 75 x: [[-1.15216118e+10  3.66437307e+10 -7.24499272e+10]]
[02-03 19:21:25][INFO] i= 76 x: [[-1.44899854e+11 -2.38732877e+10  2.98434771e+10]]
[02-03 19:21:25][INFO] i= 77 x: [[ 5.96869543e+10 -6.49890580e+10  1.32963211e+11]]
[02-03 19:21:25][INFO] i= 78 x: [[ 2.65926421e+11  6.30842798e+10 -9.21814832e+10]]
[02-03 19:21:25][INFO] i= 79 x: [[-1.84362966e+11  1.09917840e+11 -2.34384281e+11]]
[02-03 19:21:25][INFO] i= 80 x: [[-4.68768563e+11 -1.50777554e+11  2.39321886e+11]]
[02-03 19:21:25][INFO] i= 81 x: [[ 4.78643773e+11 -1.74553810e+11  3.93379786e+11]]
[02-03 19:21:25][INFO] i= 82 x: [[ 7.86759572e+11  3.37666833e+11 -5.65920678e+11]]
[02-03 19:21:25][INFO] i= 83 x: [[-1.13184136e+12  2.51899617e+11 -6.17926155e+11]]
[02-03 19:21:25][INFO] i= 84 x: [[-1.23585231e+12 -7.20402217e+11  1.25779116e+12]]
[02-03 19:21:25][INFO] i= 85 x: [[ 2.51558233e+12 -3.03478365e+11  8.75651203e+11]]
[02-03 19:21:25][INFO] i= 86 x: [[ 1.75130241e+12  1.47670396e+12 -2.66732151e+12]]
[02-03 19:21:25][INFO] i= 87 x: [[-5.33464302e+12  2.08820825e+11 -1.01295042e+12]]
[02-03 19:21:25][INFO] i= 88 x: [[-2.02590085e+12 -2.92055912e+12  5.43905343e+12]]
[02-03 19:21:25][INFO] i= 89 x: [[1.08781069e+13 3.46812935e+11 5.65621289e+11]]
[02-03 19:21:25][INFO] i= 90 x: [[ 1.13124258e+12  5.58045875e+12 -1.07047004e+13]]
[02-03 19:21:25][INFO] i= 91 x: [[-2.14094008e+13 -2.11055381e+12  1.65898680e+12]]
[02-03 19:21:25][INFO] i= 92 x: [[ 3.31797360e+12 -1.02899537e+13  2.03541239e+13]]
[02-03 19:21:25][INFO] i= 93 x: [[ 4.07082478e+13  6.74751777e+12 -8.46295045e+12]]
[02-03 19:21:25][INFO] i= 94 x: [[-1.69259009e+13  1.82383863e+13 -3.73344889e+13]]
[02-03 19:21:25][INFO] i= 95 x: [[-7.46689778e+13 -1.77965727e+13  2.60450940e+13]]
[02-03 19:21:25][INFO] i= 96 x: [[ 5.20901881e+13 -3.08232154e+13  6.57706914e+13]]
[02-03 19:21:25][INFO] i= 97 x: [[ 1.31541383e+14  4.24877669e+13 -6.75017957e+13]]
[02-03 19:21:25][INFO] i= 98 x: [[-1.35003591e+14  4.88952425e+13 -1.10297499e+14]]
[02-03 19:21:25][INFO] i= 99 x: [[-2.20594999e+14 -9.50761706e+13  1.59451213e+14]]
[02-03 19:21:25][INFO] i= 100 x: [[ 3.18902425e+14 -7.04346962e+13  1.73056914e+14]]
[02-03 19:21:25][INFO] i= 101 x: [[ 3.46113827e+14  2.02715441e+14 -3.54119774e+14]]
[02-03 19:21:25][INFO] i= 102 x: [[-7.08239547e+14  8.45269702e+13 -2.44756107e+14]]
[02-03 19:21:25][INFO] i= 103 x: [[-4.89512213e+14 -4.15308800e+14  7.50503032e+14]]
[02-03 19:21:25][INFO] i= 104 x: [[ 1.50100606e+15 -5.71303485e+13  2.81857813e+14]]
[02-03 19:21:25][INFO] i= 105 x: [[ 5.63715626e+14  8.20967486e+14 -1.52957124e+15]]
```

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[02-03 19:21:25][INFO] i= 106 x: [[-3.05914248e+15 -1.00534997e+14 -1.53231883e+14]]
[02-03 19:21:25][INFO] i= 107 x: [[-3.06463766e+14 -1.56787921e+15  3.00887498e+15]]
[02-03 19:21:25][INFO] i= 108 x: [[ 6.01774996e+15  5.98986862e+14 -4.77475838e+14]]
[02-03 19:21:25][INFO] i= 109 x: [[-9.54951677e+14  2.88950602e+15 -5.71825653e+15]]
[02-03 19:21:25][INFO] i= 110 x: [[-1.14365131e+16 -1.90703997e+15  2.39970469e+15]]
[02-03 19:21:25][INFO] i= 111 x: [[ 4.79940937e+15 -5.11833036e+15  1.04829931e+16]]
[02-03 19:21:26][INFO] i= 112 x: [[ 2.09659861e+16  5.02045295e+15 -7.35857455e+15]]
[02-03 19:21:26][INFO] i= 113 x: [[-1.47171491e+16  8.64334943e+15 -1.84557597e+16]]
[02-03 19:21:26][INFO] i= 114 x: [[-3.69115193e+16 -1.19725145e+16  1.90388238e+16]]
[02-03 19:21:26][INFO] i= 115 x: [[ 3.80776476e+16 -1.36960537e+16  3.09252621e+16]]
[02-03 19:21:26][INFO] i= 116 x: [[ 6.18505242e+16  2.67701393e+16 -4.49256745e+16]]
[02-03 19:21:26][INFO] i= 117 x: [[-8.98513490e+16  1.96938435e+16 -4.84654545e+16]]
[02-03 19:21:26][INFO] i= 118 x: [[-9.69309090e+16 -5.70420381e+16  9.96982707e+16]]
[02-03 19:21:26][INFO] i= 119 x: [[ 1.99396541e+17 -2.35408868e+16  6.84098900e+16]]
[02-03 19:21:26][INFO] i= 120 x: [[ 1.36819780e+17  1.16800743e+17 -2.11166985e+17]]
[02-03 19:21:26][INFO] i= 121 x: [[-4.22333970e+17  1.56181438e+16 -7.84194083e+16]]
[02-03 19:21:26][INFO] i= 122 x: [[-1.56838817e+17 -2.30771837e+17  4.30143042e+17]]
[02-03 19:21:26][INFO] i= 123 x: [[8.60286083e+17 2.91163521e+16 4.14528982e+16]]
[02-03 19:21:26][INFO] i= 124 x: [[ 8.29057964e+16  4.40506266e+17 -8.45727907e+17]]
[02-03 19:21:26][INFO] i= 125 x: [[-1.69145581e+18 -1.69979079e+17  1.37347337e+17]]
[02-03 19:21:26][INFO] i= 126 x: [[ 2.74694673e+17 -8.11391073e+17  1.60646628e+18]]
[02-03 19:21:26][INFO] i= 127 x: [[ 3.21293255e+18  5.38963905e+17 -6.80390210e+17]]
[02-03 19:21:26][INFO] i= 128 x: [[-1.36078042e+18  1.43636872e+18 -2.94345060e+18]]
[02-03 19:21:26][INFO] i= 129 x: [[-5.88690119e+18 -1.41625286e+18  2.07896478e+18]]
[02-03 19:21:26][INFO] i= 130 x: [[ 4.15792956e+18 -2.42370940e+18  5.17877477e+18]]
[02-03 19:21:26][INFO] i= 131 x: [[ 1.03575495e+19  3.37365847e+18 -5.36978426e+18]]
[02-03 19:21:26][INFO] i= 132 x: [[-1.07395685e+19  3.83632870e+18 -8.67072029e+18]]
[02-03 19:21:26][INFO] i= 133 x: [[-1.73414406e+19 -7.53746434e+18  1.26577329e+19]]
[02-03 19:21:26][INFO] i= 134 x: [[ 2.53154658e+19 -5.50628708e+18  1.35727084e+19]]
[02-03 19:21:26][INFO] i= 135 x: [[ 2.71454168e+19  1.60509100e+19 -2.80686093e+19]]
[02-03 19:21:26][INFO] i= 136 x: [[-5.61372186e+19  6.55555610e+18 -1.91199619e+19]]
[02-03 19:21:26][INFO] i= 137 x: [[-3.82399237e+19 -3.28485998e+19  5.94149966e+19]]
[02-03 19:21:26][INFO] i= 138 x: [[ 1.18829993e+20 -4.26621269e+18  2.18156238e+19]]
[02-03 19:21:26][INFO] i= 139 x: [[ 4.36312476e+19  6.48689026e+19 -1.20963100e+20]]
[02-03 19:21:26][INFO] i= 140 x: [[-2.41926199e+20 -8.42515108e+18 -1.11967964e+19]]
[02-03 19:21:26][INFO] i= 141 x: [[-2.23935927e+19 -1.23762299e+20  2.37713624e+20]]
[02-03 19:21:26][INFO] i= 142 x: [[ 4.75427247e+20  4.82316096e+19 -3.94875566e+19]]
[02-03 19:21:26][INFO] i= 143 x: [[-7.89751133e+19  2.27841735e+20 -4.51311443e+20]]
[02-03 19:21:26][INFO] i= 144 x: [[-9.02622885e+20 -1.52315417e+20  1.92895981e+20]]
[02-03 19:21:26][INFO] i= 145 x: [[ 3.85791961e+20 -4.03087447e+20  8.26465176e+20]]
[02-03 19:21:26][INFO] i= 146 x: [[ 1.65293035e+21  3.99512275e+20 -5.87335685e+20]]
[02-03 19:21:26][INFO] i= 147 x: [[-1.17467137e+21  6.79631255e+20 -1.45317422e+21]]
[02-03 19:21:26][INFO] i= 148 x: [[-2.90634843e+21 -9.50629239e+20  1.51448700e+21]]
```

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[02-03 19:21:26][INFO] i= 149 x: [[ 3.02897399e+21 -1.07455247e+21  2.43103381e+21]]
[02-03 19:21:26][INFO] i= 150 x: [[ 4.86206762e+21  2.12224545e+21 -3.56625023e+21]]
[02-03 19:21:26][INFO] i= 151 x: [[-7.13250046e+21  1.53947126e+21 -3.80094490e+21]]
[02-03 19:21:26][INFO] i= 152 x: [[-7.60188980e+21 -4.51648645e+21  7.90223608e+21]]
[02-03 19:21:26][INFO] i= 153 x: [[ 1.58044722e+22 -1.82538588e+21  5.34364657e+21]]
[02-03 19:21:26][INFO] i= 154 x: [[ 1.06872931e+22  9.23814773e+21 -1.67171651e+22]]
[02-03 19:21:26][INFO] i= 155 x: [[-3.34343302e+22  1.16435530e+21 -6.06821928e+21]]
[02-03 19:21:26][INFO] i= 156 x: [[-1.21364386e+22 -1.82342199e+22  3.40165079e+22]]
[02-03 19:21:26][INFO] i= 157 x: [[6.80330157e+22 2.43590768e+21 3.01932860e+21]]
[02-03 19:21:26][INFO] i= 158 x: [[ 6.03865720e+21  3.47713400e+22 -6.68150619e+22]]
[02-03 19:21:26][INFO] i= 159 x: [[-1.33630124e+23 -1.36844369e+22  1.13470128e+22]]
[02-03 19:21:26][INFO] i= 160 x: [[ 2.26940256e+22 -6.39783087e+22  1.26787905e+23]]
[02-03 19:21:26][INFO] i= 161 x: [[ 2.53575811e+23  4.30439891e+22 -5.46831799e+22]]
[02-03 19:21:26][INFO] i= 162 x: [[-1.09366360e+23  1.13117110e+23 -2.32053816e+23]]
[02-03 19:21:26][INFO] i= 163 x: [[-4.64107632e+23 -1.12696634e+23  1.65924915e+23]]
[02-03 19:21:26][INFO] i= 164 x: [[ 3.31849830e+23 -1.90572587e+23  4.07759315e+23]]
[02-03 19:21:26][INFO] i= 165 x: [[ 8.15518630e+23  2.67864744e+23 -4.27136124e+23]]
[02-03 19:21:26][INFO] i= 166 x: [[-8.54272247e+23  3.00975284e+23 -6.81586258e+23]]
[02-03 19:21:26][INFO] i= 167 x: [[-1.36317252e+24 -5.97532688e+23  1.00475989e+24]]
[02-03 19:21:26][INFO] i= 168 x: [[ 2.00951978e+24 -4.30396286e+23  1.06440617e+24]]
[02-03 19:21:26][INFO] i= 169 x: [[ 2.12881234e+24  1.27086143e+24 -2.22471792e+24]]
[02-03 19:21:26][INFO] i= 170 x: [[-4.44943584e+24  5.08226692e+23 -1.49338163e+24]]
[02-03 19:21:26][INFO] i= 171 x: [[-2.98676326e+24 -2.59806333e+24  4.70354919e+24]]
[02-03 19:21:26][INFO] i= 172 x: [[ 9.40709838e+24 -3.17494331e+23  1.68773159e+24]]
[02-03 19:21:26][INFO] i= 173 x: [[ 3.37546319e+24  5.12548209e+24 -9.56584555e+24]]
[02-03 19:21:26][INFO] i= 174 x: [[-1.91316911e+25 -7.03729794e+23 -8.12722141e+23]]
[02-03 19:21:26][INFO] i= 175 x: [[-1.62544428e+24 -9.76902608e+24  1.87798262e+25]]
[02-03 19:21:26][INFO] i= 176 x: [[ 3.75596524e+25  3.88223441e+24 -3.25906876e+24]]
[02-03 19:21:26][INFO] i= 177 x: [[-6.51813752e+24  1.79650590e+25 -3.56185352e+25]]
[02-03 19:21:26][INFO] i= 178 x: [[-7.12370704e+25 -1.21637026e+25  1.55006670e+25]]
[02-03 19:21:26][INFO] i= 179 x: [[ 3.10013340e+25 -3.17433684e+25  6.51552191e+25]]
[02-03 19:21:26][INFO] i= 180 x: [[ 1.30310438e+26  3.17894718e+25 -4.68730183e+25]]
[02-03 19:21:26][INFO] i= 181 x: [[-9.37460365e+25  5.34369645e+25 -1.14415702e+26]]
[02-03 19:21:26][INFO] i= 182 x: [[-2.28831405e+26 -7.54769438e+25  1.20464519e+26]]
[02-03 19:21:26][INFO] i= 183 x: [[ 2.40929038e+26 -8.42995726e+25  1.91092933e+26]]
[02-03 19:21:26][INFO] i= 184 x: [[ 3.82185865e+26  1.68237752e+26 -2.83078824e+26]]
[02-03 19:21:26][INFO] i= 185 x: [[-5.66157648e+26  1.20323227e+26 -2.98066989e+26]]
[02-03 19:21:26][INFO] i= 186 x: [[-5.96133979e+26 -3.57595571e+26  6.26319261e+26]]
[02-03 19:21:26][INFO] i= 187 x: [[ 1.25263852e+27 -1.41487174e+26  4.17336193e+26]]
[02-03 19:21:26][INFO] i= 188 x: [[ 8.34672386e+26  7.30653309e+26 -1.32338211e+27]]
[02-03 19:21:26][INFO] i= 189 x: [[-2.64676422e+27  8.64906658e+25 -4.69345732e+26]]
[02-03 19:21:26][INFO] i= 190 x: [[-9.38691463e+26 -1.44071854e+27  2.69000955e+27]]
[02-03 19:21:26][INFO] i= 191 x: [[5.38001910e+27 2.03156656e+26 2.18332192e+26]]
```

```
[02-03 19:21:26][INFO] i= 192 x: [[ 4.36664384e+26  2.74459260e+27 -5.27844077e+27]]
[02-03 19:21:26][INFO] i= 193 x: [[-1.05568815e+28 -1.10127800e+27  9.35631915e+26]]
[02-03 19:21:26][INFO] i= 194 x: [[ 1.87126383e+27 -5.04453280e+27  1.00062425e+28]]
[02-03 19:21:26][INFO] i= 195 x: [[ 2.00124851e+28  3.43719255e+27 -4.39353023e+27]]
[02-03 19:21:26][INFO] i= 196 x: [[-8.78706046e+27  8.90785999e+27 -1.82938888e+28]]
[02-03 19:21:26][INFO] i= 197 x: [[-3.65877776e+28 -8.96700243e+27  1.32409905e+28]]
[02-03 19:21:26][INFO] i= 198 x: [[ 2.64819809e+28 -1.49836412e+28  3.21042764e+28]]
[02-03 19:21:26][INFO] i= 199 x: [[ 6.42085528e+28  2.12670596e+28 -3.39738015e+28]]
[02-03 19:21:26][INFO] i= 200 x: [[-6.79476030e+28  2.36108260e+28 -5.35750231e+28]]
[02-03 19:21:26][INFO] i= 201 x: [[-1.07150046e+29 -4.73675573e+28  7.97530160e+28]]
[02-03 19:21:26][INFO] i= 202 x: [[ 1.59506032e+29 -3.36367691e+28  8.34662675e+28]]
[02-03 19:21:26][INFO] i= 203 x: [[ 1.66932535e+29  1.00619583e+29 -1.76324417e+29]]
[02-03 19:21:26][INFO] i= 204 x: [[-3.52648833e+29  3.93851633e+28 -1.16622744e+29]]
[02-03 19:21:26][INFO] i= 205 x: [[-2.33245487e+29 -2.05480102e+29  3.72341415e+29]]
[02-03 19:21:26][INFO] i= 206 x: [[ 7.44682830e+29 -2.35373898e+28  1.30505436e+29]]
[02-03 19:21:26][INFO] i= 207 x: [[ 2.61010872e+29  4.04967774e+29 -7.56451525e+29]]
[02-03 19:21:26][INFO] i= 208 x: [[-1.51290305e+30 -5.86074453e+28 -5.85269847e+28]]
[02-03 19:21:26][INFO] i= 209 x: [[-1.17053969e+29 -7.71083271e+29  1.48359933e+30]]
[02-03 19:21:26][INFO] i= 210 x: [[ 2.96719865e+30  3.12372847e+29 -2.68487666e+29]]
[02-03 19:21:26][INFO] i= 211 x: [[-5.36975332e+29  1.41647741e+30 -2.81101223e+30]]
[02-03 19:21:26][INFO] i= 212 x: [[-5.62202446e+30 -9.71240723e+29  1.24521404e+30]]
[02-03 19:21:26][INFO] i= 213 x: [[ 2.49042807e+30 -2.49970872e+30  5.13640410e+30]]
[02-03 19:21:26][INFO] i= 214 x: [[ 1.02728082e+31  2.52931506e+30 -3.74028243e+30]]
[02-03 19:21:26][INFO] i= 215 x: [[-7.48056487e+30  4.20133349e+30 -9.00815067e+30]]
[02-03 19:21:26][INFO] i= 216 x: [[-1.80163013e+31 -5.99232010e+30  9.58123161e+30]]
[02-03 19:21:26][INFO] i= 217 x: [[ 1.91624632e+31 -6.61284276e+30  1.50201413e+31]]
[02-03 19:21:26][INFO] i= 218 x: [[ 3.00402826e+31  1.33362669e+31 -2.24688846e+31]]
[02-03 19:21:26][INFO] i= 219 x: [[-4.49377692e+31  9.40292013e+30 -2.33721491e+31]]
[02-03 19:21:26][INFO] i= 220 x: [[-4.67442982e+31 -2.83119219e+31  4.96392293e+31]]
[02-03 19:21:26][INFO] i= 221 x: [[ 9.92784586e+31 -1.09623418e+31  3.25883372e+31]]
[02-03 19:21:26][INFO] i= 222 x: [[ 6.51766745e+31  5.77863136e+31 -1.04759629e+32]]
[02-03 19:21:26][INFO] i= 223 x: [[-2.09519259e+32  6.39842989e+30 -3.62835177e+31]]
[02-03 19:21:26][INFO] i= 224 x: [[-7.25670354e+31 -1.13830509e+32  2.12718474e+32]]
[02-03 19:21:26][INFO] i= 225 x: [[4.25436948e+32 1.68961008e+31 1.56517810e+31]]
[02-03 19:21:26][INFO] i= 226 x: [[ 3.13035619e+31  2.16631419e+32 -4.16988897e+32]]
[02-03 19:21:26][INFO] i= 227 x: [[-8.33977795e+32 -8.85954434e+31  7.70121476e+31]]
[02-03 19:21:26][INFO] i= 228 x: [[ 1.54024295e+32 -3.97735860e+32  7.89680073e+32]]
[02-03 19:21:26][INFO] i= 229 x: [[ 1.57936015e+33  2.74432166e+32 -3.52892225e+32]]
[02-03 19:21:26][INFO] i= 230 x: [[-7.05784451e+32  7.01457017e+32 -1.44214406e+33]]
[02-03 19:21:26][INFO] i= 231 x: [[-2.88428813e+33 -7.13428241e+32  1.05651296e+33]]
[02-03 19:21:26][INFO] i= 232 x: [[ 2.11302592e+33 -1.17801582e+33  2.52757401e+33]]
[02-03 19:21:26][INFO] i= 233 x: [[ 5.05514801e+33  1.68840646e+33 -2.70203383e+33]]
[02-03 19:21:26][INFO] i= 234 x: [[-5.40406766e+33  1.85206555e+33 -4.21094478e+33]]
```

```
[02-03 19:21:26][INFO] i= 235 x: [[-8.42188956e+33 -3.75477002e+33  6.33010043e+33]]
[02-03 19:21:26][INFO] i= 236 x: [[ 1.26602009e+34 -2.62841967e+33  6.54450455e+33]]
[02-03 19:21:26][INFO] i= 237 x: [[ 1.30890091e+34  7.96622657e+33 -1.39744107e+34]]
[02-03 19:21:26][INFO] i= 238 x: [[-2.79488214e+34  3.05090187e+33 -9.10589581e+33]]
[02-03 19:21:26][INFO] i= 239 x: [[-1.82117916e+34 -1.62508847e+34  2.94742723e+34]]
[02-03 19:21:26][INFO] i= 240 x: [[ 5.89485447e+34 -1.73732773e+33  1.00863493e+34]]
[02-03 19:21:26][INFO] i= 241 x: [[ 2.01726986e+34  3.19958597e+34 -5.98172085e+34]]
[02-03 19:21:26][INFO] i= 242 x: [[-1.19634417e+35 -4.86795284e+33 -4.17476875e+33]]
[02-03 19:21:26][INFO] i= 243 x: [[-8.34953751e+33 -6.08609007e+34  1.17200441e+35]]
[02-03 19:21:26][INFO] i= 244 x: [[ 2.34400881e+35  2.51253414e+34 -2.20809129e+34]]
[02-03 19:21:26][INFO] i= 245 x: [[-4.41618257e+34  1.11680212e+35 -2.21838211e+35]]
[02-03 19:21:26][INFO] i= 246 x: [[-4.43676421e+35 -7.75404655e+34  1.00001932e+35]]
[02-03 19:21:26][INFO] i= 247 x: [[ 2.00003864e+35 -1.96837728e+35  4.04906189e+35]]
[02-03 19:21:26][INFO] i= 248 x: [[ 8.09812377e+35  2.01228479e+35 -2.98422728e+35]]
[02-03 19:21:26][INFO] i= 249 x: [[-5.96845455e+35  3.30300507e+35 -7.09198138e+35]]
[02-03 19:21:26][INFO] i= 250 x: [[-1.41839628e+36 -4.75722262e+35  7.61995709e+35]]
[02-03 19:21:26][INFO] i= 251 x: [[ 1.52399142e+36 -5.18699210e+35  1.18053514e+36]]
[02-03 19:21:26][INFO] i= 252 x: [[ 2.36107029e+36  1.05712949e+36 -1.78334102e+36]]
[02-03 19:21:26][INFO] i= 253 x: [[-3.56668205e+36  7.34699888e+35 -1.83250554e+36]]
[02-03 19:21:26][INFO] i= 254 x: [[-3.66501108e+36 -2.24146741e+36  3.93403199e+36]]
[02-03 19:21:26][INFO] i= 255 x: [[ 7.86806398e+36 -8.48997543e+35  2.54427738e+36]]
[02-03 19:21:26][INFO] i= 256 x: [[ 5.08855475e+36  4.57010133e+36 -8.29256275e+36]]
[02-03 19:21:26][INFO] i= 257 x: [[-1.65851255e+37  4.71136690e+35 -2.80350409e+36]]
[02-03 19:21:26][INFO] i= 258 x: [[-5.60700818e+36 -8.99343877e+36  1.68206938e+37]]
[02-03 19:21:26][INFO] i= 259 x: [[3.36413877e+37 1.40166937e+36 1.11028879e+36]]
[02-03 19:21:26][INFO] i= 260 x: [[ 2.22057758e+36  1.70982660e+37 -3.29405530e+37]]
[02-03 19:21:26][INFO] i= 261 x: [[-6.58811060e+37 -7.12484946e+36  6.32855544e+36]]
[02-03 19:21:26][INFO] i= 262 x: [[ 1.26571109e+37 -3.13584141e+37  6.23186813e+37]]
[02-03 19:21:26][INFO] i= 263 x: [[ 1.24637363e+38  2.19082258e+37 -2.83363180e+37]]
[02-03 19:21:26][INFO] i= 264 x: [[-5.66726359e+37  5.52346018e+37 -1.13683250e+38]]
[02-03 19:21:26][INFO] i= 265 x: [[-2.27366499e+38 -5.67571304e+37  8.42899368e+37]]
[02-03 19:21:26][INFO] i= 266 x: [[ 1.68579874e+38 -9.26107655e+37  1.98987934e+38]]
[02-03 19:21:26][INFO] i= 267 x: [[ 3.97975868e+38  1.34036920e+38 -2.14885256e+38]]
[02-03 19:21:26][INFO] i= 268 x: [[-4.29770513e+38  1.45266620e+38 -3.30957408e+38]]
[02-03 19:21:26][INFO] i= 269 x: [[-6.61914816e+38 -2.97624608e+38  5.02403823e+38]]
[02-03 19:21:26][INFO] i= 270 x: [[ 1.00480765e+39 -2.05356452e+38  5.13102512e+38]]
[02-03 19:21:26][INFO] i= 271 x: [[ 1.02620502e+39  6.30679451e+38 -1.10748587e+39]]
[02-03 19:21:26][INFO] i= 272 x: [[-2.21497174e+39  2.36231044e+38 -7.10865299e+38]]
[02-03 19:21:26][INFO] i= 273 x: [[-1.42173060e+39 -1.28520220e+39  2.33308727e+39]]
[02-03 19:21:26][INFO] i= 274 x: [[ 4.66617453e+39 -1.27593482e+38  7.79129499e+38]]
[02-03 19:21:26][INFO] i= 275 x: [[ 1.55825900e+39  2.52786964e+39 -4.72997127e+39]]
[02-03 19:21:26][INFO] i= 276 x: [[-9.45994254e+39 -4.03363319e+38 -2.94324179e+38]]
[02-03 19:21:26][INFO] i= 277 x: [[-5.88648357e+38 -4.80355232e+39  9.25826089e+39]]
```

```
[02-03 19:21:26][INFO] i= 278 x: [[ 1.85165218e+40  2.02024104e+39 -1.81312780e+39]]
[02-03 19:21:26][INFO] i= 279 x: [[-3.62625560e+39  8.80497893e+39 -1.75064012e+40]]
[02-03 19:21:26][INFO] i= 280 x: [[-3.50128025e+40 -6.18972811e+39  8.02874507e+39]]
[02-03 19:21:26][INFO] i= 281 x: [[ 1.60574901e+40 -1.54992150e+40  3.19179384e+40]]
[02-03 19:21:26][INFO] i= 282 x: [[ 6.38358769e+40  1.60082297e+40 -2.38070976e+40]]
[02-03 19:21:26][INFO] i= 283 x: [[-4.76141953e+40  2.59661640e+40 -5.58317620e+40]]
[02-03 19:21:26][INFO] i= 284 x: [[-1.11663524e+41 -3.77650381e+40  6.05972773e+40]]
[02-03 19:21:26][INFO] i= 285 x: [[ 1.21194555e+41 -4.06824427e+40  9.27810050e+40]]
[02-03 19:21:26][INFO] i= 286 x: [[ 1.85562010e+41  8.37925285e+40 -1.41535776e+41]]
[02-03 19:21:26][INFO] i= 287 x: [[-2.83071552e+41  5.73970610e+40 -1.43665746e+41]]
[02-03 19:21:26][INFO] i= 288 x: [[-2.87331492e+41 -1.77452212e+41  3.11770082e+41]]
[02-03 19:21:26][INFO] i= 289 x: [[ 6.23540165e+41 -6.57232252e+40  1.98605385e+41]]
[02-03 19:21:26][INFO] i= 290 x: [[ 3.97210771e+41  3.61421429e+41 -6.56401777e+41]]
[02-03 19:21:26][INFO] i= 291 x: [[-1.31280355e+42  3.45049410e+40 -2.16500056e+41]]
[02-03 19:21:26][INFO] i= 292 x: [[-4.33000113e+41 -7.10526791e+41  1.33005603e+42]]
[02-03 19:21:26][INFO] i= 293 x: [[2.66011205e+42 1.16013950e+41 7.77367170e+40]]
[02-03 19:21:26][INFO] i= 294 x: [[ 1.55473434e+41  1.34949020e+42 -2.60210508e+42]]
[02-03 19:21:26][INFO] i= 295 x: [[-5.20421015e+42 -5.72789552e+41  5.19271668e+41]]
[02-03 19:21:26][INFO] i= 296 x: [[ 1.03854334e+42 -2.47228716e+42  4.91781537e+42]]
[02-03 19:21:26][INFO] i= 297 x: [[ 9.83563075e+42  1.74872551e+42 -2.27468692e+42]]
[02-03 19:21:26][INFO] i= 298 x: [[-4.54937383e+42  4.34914365e+42 -8.96126799e+42]]
[02-03 19:21:26][INFO] i= 299 x: [[-1.79225360e+43 -4.51500391e+42  6.72394565e+42]]

El método de Gauss-Jacobi no converge
```

1.8 Ejercicio 8

Un cable coaxial está formado por un conductor interno de 0.1 pulgadas cuadradas y un conductor externo de 0.5 pulgadas cuadradas. El potencial en un punto en la sección transversal del cable se describe mediante la ecuación de Laplace.

Suponga que el conductor interno se mantiene en 0 volts y el conductor externo se mantiene en 110 volts. Aproximar el potencial entre los dos conductores requiere resolver el siguiente sistema lineal.

$$\begin{bmatrix} 4 & -1 & 0 & 0 & -1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ -1 & 4 & -1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & -1 & 4 & -1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & -1 & 4 & 0 & -1 & 0 & 0 & 0 & 0 & 0 & 0 \\ -1 & 0 & 0 & 0 & 4 & 0 & -1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & -1 & 0 & 4 & 0 & -1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & -1 & 0 & 4 & 0 & -1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & -1 & 0 & 4 & 0 & 0 & 0 & -1 \\ 0 & 0 & 0 & 0 & 0 & 0 & -1 & 0 & 4 & -1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -1 & 4 & -1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -1 & 4 & -1 \\ 0 & 0 & 0 & 0 & 0 & -1 & 0 & 0 & 0 & 0 & -1 & 4 \end{bmatrix} \begin{bmatrix} w_1 \\ w_2 \\ w_3 \\ w_4 \\ w_5 \\ w_6 \\ w_7 \\ w_8 \\ w_9 \\ w_{10} \\ w_{11} \\ w_{12} \end{bmatrix} = \begin{bmatrix} 220 \\ 110 \\ 110 \\ 220 \\ 110 \\ 110 \\ 110 \\ 110 \\ 220 \\ 110 \\ 110 \\ 220 \end{bmatrix}.$$

Figura 1: Ejercicio 8 - Sistema de ecuaciones

a. ¿La matriz es estrictamente diagonalmente dominante?

```
A = np.array(
    [
        [4, -1, 0, 0, 0, -1, 0, 0, 0, 0, 0, 0],
        [-1, 4, -1, 0, 0, 0, 0, 0, 0, 0, 0, 0],
        [0, -1, 4, -1, 0, 0, 0, 0, 0, 0, 0, 0],
        [0, 0, -1, 4, 0, -1, 0, 0, 0, 0, 0, 0],
        [-1, 0, 0, 0, 4, -1, 0, 0, 0, 0, 0, 0],
        [0, 0, 0, -1, -1, 4, -1, 0, 0, 0, 0, 0],
        [0, 0, 0, 0, 0, -1, 4, -1, 0, 0, 0, 0],
        [0, 0, 0, 0, 0, 0, -1, 4, -1, 0, 0, 0],
        [0, 0, 0, 0, 0, 0, 0, -1, 4, -1, 0, 0],
        [0, 0, 0, 0, 0, 0, 0, 0, -1, 4, -1, 0],
        [0, 0, 0, 0, 0, 0, 0, 0, 0, -1, 4, -1],
        [0, 0, 0, 0, 0, -1, 0, 0, 0, 0, -1, 4],
    ]
)

is_diagonal = diagonal_estrictamente_dominante(A)

if is_diagonal:
    print("La matriz tiene dominancia diagonal estricta.")
```

```
else:
    print("La matriz no tiene dominancia diagonal estricta.")
```

```
La matriz tiene dominancia diagonal estricta.
```

b. Resuelva el sistema lineal usando el método de Jacobi con $x^{(0)} = 0$ y $TOL = 10 - 2$.

```
b = np.array([220, 110, 110, 220, 110, 110, 110, 110, 220, 110, 110, 220])
x0 = np.zeros(len(b))
```

```
print("Solución con Gauss-Jacobi")
sol, tray = gauss_jacobi(A=A, b=b, x0=x0, tol=1e-2, max_iter=100)

print("\nSolución del sistema:")
print(f"i= {len(tray)}: x: {np.squeeze(sol)}")
```

```
Solución con Gauss-Jacobi
[02-03 19:17:46][INFO] i= 0 x: [0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.]
[02-03 19:17:46][INFO] i= 1 x: [[55.  27.5 27.5 55.  27.5 27.5 27.5 27.5 55.  27.5 27.5 55. ]
[02-03 19:17:46][INFO] i= 2 x: [[68.75  48.125 48.125 68.75  48.125 55.    41.25  48.125 68.7
  48.125 61.875]]
[02-03 19:17:46][INFO] i= 3 x: [[80.78125 56.71875 56.71875 80.78125 58.4375  67.03125 53.281
  79.0625  56.71875 55.      67.03125]]
[02-03 19:17:47][INFO] i= 4 x: [[85.9375    61.875     61.875     85.9375    64.453125  75.62
  58.0078125 60.5859375 82.9296875 61.015625  58.4375    68.75     ]]
[02-03 19:17:47][INFO] i= 5 x: [[89.375      64.453125   64.453125   89.375      67.890625
  61.55273438 62.734375   85.40039062 62.84179688 59.94140625 69.609375  ]]
[02-03 19:17:47][INFO] i= 6 x: [[91.01318359 65.95703125 65.95703125 91.01318359 69.74365234
  63.08349609 64.23828125 86.39404297 63.83544922 60.61279297 69.98535156]]
[02-03 19:17:47][INFO] i= 7 x: [[92.04040527 66.74255371 66.74255371 92.04040527 70.80444336
  64.11071777 64.86938477 87.01843262 64.25170898 60.9552002  70.15319824]]
[02-03 19:17:47][INFO] i= 8 x: [[92.55065918 67.19573975 67.19573975 92.55065918 71.37512207
  64.58236694 65.2822876  87.28027344 64.4934082  61.10122681 70.23880005]]
[02-03 19:17:47][INFO] i= 9 x: [[92.85865784 67.43659973 67.43659973 92.85865784 71.6973877
  64.8802948  65.4656601  87.44392395 64.59537506 61.18305206 70.2753067 ]]
[02-03 19:17:47][INFO] i= 10 x: [[93.01590919 67.57381439 67.57381439 93.01590919 71.8714237
  65.02317429 65.58105469 87.51525879 64.656744   61.21767044 70.29576302]]
[02-03 19:17:47][INFO] i= 11 x: [[93.10822487 67.6474309  67.6474309  93.10822487 71.9687485
  65.11003494 65.63460827 87.55944967 64.68323231 61.23812675 70.30441761]]
```

```
[02-03 19:17:47][INFO] i= 12 x: [[93.15626442 67.68891394 67.68891394 93.15626442 72.0214629
  65.15305877 65.66737115 87.57946014 64.69939411 61.24691248 70.30953169]]
[02-03 19:17:47][INFO] i= 13 x: [[93.18391651 67.71129459 67.71129459 93.18391651 72.0507541
  65.17853081 65.68312973 87.59169132 64.70659316 61.25223145 70.31172812]]
[02-03 19:17:47][INFO] i= 14 x: [[93.19849778 67.72380278 67.72380278 93.19849778 72.0666532
  65.19145656 65.69255553 87.59743072 64.71098069 61.25458032 70.31305786]]
[02-03 19:17:47][INFO] i= 15 x: [[93.20677578 67.73057514 67.73057514 93.20677578 72.0754495
  65.19896397 65.69722182 87.60088406 64.71300276 61.25600964 70.31364508]]
[02-03 19:17:47][INFO] i= 16 x: [[93.21118176 67.73433773 67.73433773 93.21118176 72.0802319
  65.20284343 65.69996201 87.60255615 64.71422342 61.25666196 70.31400241]]

Solución del sistema:
i= 17: x: [93.21365876 67.73637987 67.73637987 93.21365876 72.08286977 85.12356428
 65.20506483 65.70134989 87.60354636 64.71480453 61.25705646 70.31416549]
```

c. Repita la parte b) mediante el método de Gauss-Siedel.

```python
print("Solución con Gauss-Seidel")
sol, tray = gauss_seidel(A=A, b=b, x0=x0, tol=1e-2, max_iter=100)

print("\nSolución del sistema:")
print(f"i= {len(tray)}: x: {np.squeeze(sol)}")
```

```
Solución con Gauss-Seidel
[02-03 19:18:46][INFO] i= 0 x: [0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.]
[02-03 19:18:46][INFO] i= 1 x: [[55.         41.25       37.8125     64.453125   41.25
  40.98144531 37.74536133 64.43634033 43.60908508 38.40227127 64.60056782]]
[02-03 19:18:46][INFO] i= 2 x: [[78.79394531 56.65161133 57.77618408 82.92549133 60.67993164
  55.3480196  57.44608998 80.26379377 57.16651626 57.94177102 69.48544275]]
[02-03 19:18:46][INFO] i= 3 x: [[87.5745821  63.83769155 64.19079572 89.4593782  67.80532479
  62.02481766 63.07215286 85.05966728 63.25035957 60.68395058 70.17098765]]
[02-03 19:18:46][INFO] i= 4 x: [[91.12271805 66.32837844 66.44693916 91.77502995 70.44397467
  64.15827711 64.8044861  87.01371142 64.4244155  61.14885079 70.2872127 ]]
[02-03 19:18:46][INFO] i= 5 x: [[92.4723335  67.22981817 67.25121203 92.7030419  71.50832227
  64.8492241  65.46573388 87.47253735 64.65534703 61.23563993 70.30890998]]
[02-03 19:18:46][INFO] i= 6 x: [[92.95555712 67.55169229 67.56368355 93.03902347 71.88699186
  65.10238593 65.64373082 87.57476946 64.70260235 61.25287808 70.31321952]]
[02-03 19:18:46][INFO] i= 7 x: [[93.12387554 67.67188977 67.67772831 93.15538454 72.01692135
  65.17810094 65.6882176  87.59770499 64.71264577 61.25646632 70.31411658]]
[02-03 19:18:46][INFO] i= 8 x: [[93.18514068 67.71571725 67.71777545 93.1966121  72.06345341
  65.1994398  65.6992862  87.60298299 64.71486233 61.25724473 70.31431118]]
[02-03 19:18:46][INFO] i= 9 x: [[93.20631472 67.73102254 67.73190866 93.21036257 72.07896408
```

```
  65.20536945 65.70208811 87.60423761 64.71537058 61.25742044 70.31435511]]
[02-03 19:18:46][INFO] i= 10 x: [[93.21330354 67.73630305 67.7366664  93.2147145  72.0838737
  65.20701939 65.70281425 87.60454621 64.71549166 61.25746169 70.31436542]]

Solución del sistema:
i= 11: x: [93.21557312 67.73805988 67.7381936  93.21604576 72.08539064 85.12711395
 65.20748205 65.70300706 87.60462468 64.71552159 61.25747175 70.31436794]
```

GitHub: Tarea11 - @mateobtw18