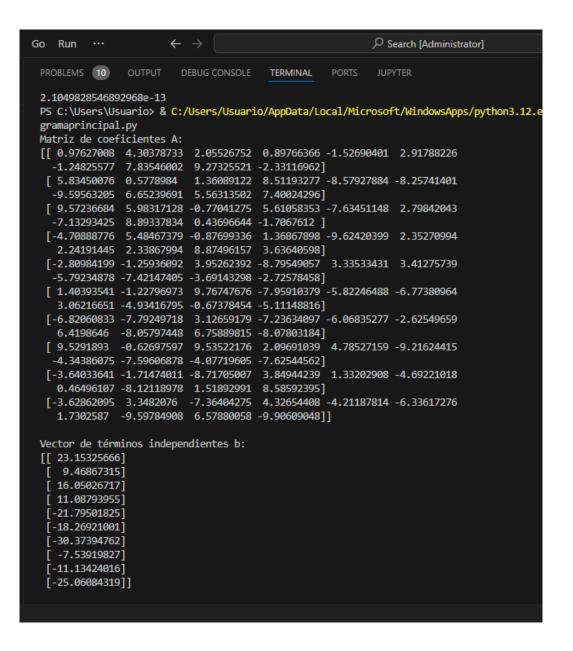**Con np.random.seed(0), A y b tendremos los mismos valores en cada ejecución del script.**
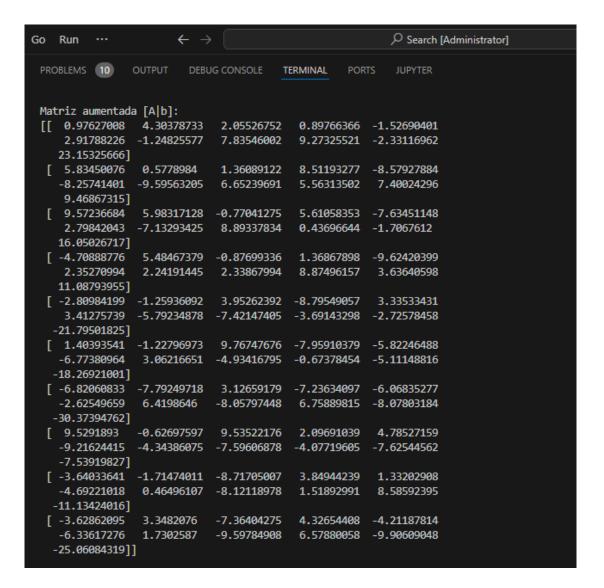
Como se observa en el siguiente programa trabajado en clase mibilioteca1.py y miprogramaprincipal.py

```python
54    import numpy as np
55    import mibiblioteca1 as bib
56    #import time
57
58    # Paso 1: Generar una matriz aleatoria A y el vector b
59    np.random.seed(0)  # Para reproducibilidad
60    A = np.random.uniform(-10, 10, (10, 10))
61    x_exacta = np.ones((10, 1))  # Solución exacta x = [1, 1, ..., 1]
62    b = np.dot(A, x_exacta)
63
64    # Paso 2: Imprimir la matriz de coeficientes y el vector de términos independientes
65    print("Matriz de coeficientes A:")
66    print(A)
67    print("\nVector de términos independientes b:")
68    print(b)
69
70    # Paso 3: Resolución por eliminación gaussiana simple
71    # Matriz aumentada
72    Ab = np.append(A, b, axis=1)
73    print("\nMatriz aumentada [A|b]:")
74    print(Ab)
75
76    # Escalonar la matriz aumentada
77    bib.escalonaSimple(Ab)
78    print("\nMatriz aumentada escalonada:")
79    print(Ab)
80
81    # Resolver el sistema
82    A1 = Ab[:, :10]
83    b1 = Ab[:, 10]
84    b1 = b1.reshape(b1.shape[0], 1)
85    x = bib.sustRegresiva(A1, b1)

86
87    print("\nSolución del sistema:")
88    print(x)
89
90    # Calcular la norma suma del residuo
91    residuo = b - np.dot(A, x)
92    norma_suma_residuo = np.sum(np.abs(residuo))
93
94    print("\nNorma suma del residuo:")
95    print(norma_suma_residuo)
```

```
2.1049828546892968e-13
PS C:\Users\Usuario> & C:/Users/Usuario/AppData/Local/Microsoft/WindowsApps/python3.12.e
gramaprincipal.py
Matriz de coeficientes A:
[[ 0.97627008  4.30378733  2.05526752  0.89766366 -1.52690401  2.91788226
  -1.24825577  7.83546002  9.27325521 -2.33116962]
 [ 5.83450076  0.5778984   1.36089122  8.51193277 -8.57927884 -8.25741401
  -9.59563205  6.65239691  5.56313502  7.40024296]
 [ 9.57236684  5.98317128 -0.77041275  5.61058353 -7.63451148  2.79842043
  -7.13293425  8.89337834  0.43696644 -1.7067612 ]
 [-4.70888776  5.48467379 -0.87699336  1.36867898 -9.62420399  2.35270994
   2.24191445  2.33867994  8.87496157  3.63640598]
 [-2.80984199 -1.25936092  3.95262392 -8.79549057  3.33533431  3.41275739
  -5.79234878 -7.42147405 -3.69143298 -2.72578458]
 [ 1.40393541 -1.22796973  9.76747676 -7.95910379 -5.82246488 -6.77380964
   3.06216651 -4.93416795 -0.67378454 -5.11148816]
 [-6.82060833 -7.79249718  3.12659179 -7.23634097 -6.06835277 -2.62549659
   6.4198646  -8.05797448  6.75889815 -8.07803184]
 [ 9.5291893  -0.62697597  9.53522176  2.09691039  4.78527159 -9.21624415
  -4.34386075 -7.59606878 -4.07719605 -7.62544562]
 [-3.64033641 -1.71474011 -8.71705007  3.84944239  1.33202908 -4.69221018
   0.46496107 -8.12118978  1.51892991  8.58592395]
 [-3.62862095  3.3482076  -7.36404275  4.32654408 -4.21187814 -6.33617276
   1.7302587  -9.59784908  6.57880058 -9.90609048]]

Vector de términos independientes b:
[[ 23.15325666]
 [  9.46867315]
 [ 16.05026717]
 [ 11.08793955]
 [-21.79501825]
 [-18.26921001]
 [-30.37394762]
 [ -7.53919827]
 [-11.13424016]
 [-25.06084319]]
```

```
Matriz aumentada [A|b]:
[[  0.97627008    4.30378733    2.05526752    0.89766366   -1.52690401
    2.91788226   -1.24825577    7.83546002    9.27325521   -2.33116962
   23.15325666]
 [  5.83450076    0.5778984     1.36089122    8.51193277   -8.57927884
   -8.25741401   -9.59563205    6.65239691    5.56313502    7.40024296
    9.46867315]
 [  9.57236684    5.98317128   -0.77041275    5.61058353   -7.63451148
    2.79842043   -7.13293425    8.89337834    0.43696644   -1.7067612
   16.05026717]
 [ -4.70888776    5.48467379   -0.87699336    1.36867898   -9.62420399
    2.35270994    2.24191445    2.33867994    8.87496157    3.63640598
   11.08793955]
 [ -2.80984199   -1.25936092    3.95262392   -8.79549057    3.33533431
    3.41275739   -5.79234878   -7.42147405   -3.69143298   -2.72578458
  -21.79501825]
 [  1.40393541   -1.22796973    9.76747676   -7.95910379   -5.82246488
   -6.77380964    3.06216651   -4.93416795   -0.67378454   -5.11148816
  -18.26921001]
 [ -6.82060833   -7.79249718    3.12659179   -7.23634097   -6.06835277
   -2.62549659    6.4198646    -8.05797448    6.75889815   -8.07803184
  -30.37394762]
 [  9.5291893    -0.62697597    9.53522176    2.09691039    4.78527159
   -9.21624415   -4.34386075   -7.59606878   -4.07719605   -7.62544562
   -7.53919827]
 [ -3.64033641   -1.71474011   -8.71705007    3.84944239    1.33202908
   -4.69221018    0.46496107   -8.12118978    1.51892991    8.58592395
  -11.13424016]
 [ -3.62862095    3.3482076    -7.36404275    4.32654408   -4.21187814
   -6.33617276    1.7302587    -9.59784908    6.57880058   -9.90609048
  -25.06084319]]
```

```
Matriz aumentada escalonada:
[[ 9.76270079e-01  4.30378733e+00  2.05526752e+00  8.97663660e-01
  -1.52690401e+00  2.91788226e+00 -1.24825577e+00  7.83546002e+00
   9.27325521e+00 -2.33116962e+00  2.31532567e+01]
 [ 0.00000000e+00 -2.51429047e+01 -1.09220417e+01  3.14720898e+00
   5.45985600e-01 -2.56956072e+01 -2.13565819e+00 -4.01748064e+01
  -4.98567900e+01  2.13320547e+01 -1.28902559e+02]
 [ 0.00000000e+00  0.00000000e+00 -5.19037278e+00 -7.72425834e+00
   6.55040974e+00  1.12002115e+01  8.18244771e+00 -1.00661555e+01
  -1.86743563e+01 -9.57606763e+00 -2.52981416e+01]
 [ 0.00000000e+00  0.00000000e+00  0.00000000e+00  1.25011427e+01
  -1.94022854e+01 -1.54943384e+01 -9.73442098e+00  2.78299812e+00
   1.00688641e+01  1.90191761e+01 -2.58863761e-01]
 [ 0.00000000e+00  0.00000000e+00  0.00000000e+00  0.00000000e+00
  -1.35713081e+01 -3.95662073e+00 -1.19802024e+01 -9.67277123e+00
  -7.26373379e+00  9.44749940e+00 -3.69971368e+01]
 [ 0.00000000e+00  0.00000000e+00  0.00000000e+00  0.00000000e+00
   0.00000000e+00 -4.08622288e+00  2.83209013e+01  3.23161391e+00
   9.31750513e-01 -9.31289295e+00  1.90851499e+01]
 [ 0.00000000e+00  0.00000000e+00  0.00000000e+00  0.00000000e+00
   0.00000000e+00  0.00000000e+00  6.11466556e+01  1.82702541e+01
   2.01013805e+01 -3.36807688e+01  6.58375215e+01]
 [ 0.00000000e+00  0.00000000e+00  0.00000000e+00  0.00000000e+00
   0.00000000e+00  0.00000000e+00 -1.77635684e-15 -1.88279571e+01
  -1.09468932e+01 -4.45483594e+00 -3.42296862e+01]
 [ 0.00000000e+00 -1.77635684e-15  0.00000000e+00  0.00000000e+00
   0.00000000e+00  0.00000000e+00 -6.12040388e-16  0.00000000e+00
   1.99631398e+01 -1.05726222e+01  9.39051762e+00]
 [ 0.00000000e+00  2.41794748e-15  0.00000000e+00  0.00000000e+00
   0.00000000e+00  0.00000000e+00  3.47124519e-16  0.00000000e+00
   3.55271368e-15 -1.94633229e+01 -1.94633229e+01]]
```

```
Solución del sistema:
[[1.]
 [1.]
 [1.]
 [1.]
 [1.]
 [1.]
 [1.]
 [1.]
 [1.]
 [1.]]

Norma suma del residuo:
1.971756091734278e-13
```

Para visualizar mejor importamos labulate

```python
 96    ###############################3
 97    import numpy as np
 98    import mibiblioteca1 as bib
 99    #import time
100    from tabulate import tabulate
101
102    # Paso 1: Generar una matriz aleatoria A y el vector b
103    np.random.seed(0)  # Para reproducibilidad
104    A = np.random.uniform(-10, 10, (10, 10))
105    x_exacta = np.ones((10, 1))  # Solución exacta x = [1, 1, ..., 1]
106    b = np.dot(A, x_exacta)
107
108    # Paso 2: Imprimir la matriz de coeficientes y el vector de términos independientes
109    print("Matriz de coeficientes A:")
110    print(tabulate(A, tablefmt="fancy_grid"))
111
112    print("\nVector de términos independientes b:")
113    print(tabulate(b, tablefmt="fancy_grid"))
114
115    # Paso 3: Resolución por eliminación gaussiana simple
116    # Matriz aumentada
117    Ab = np.append(A, b, axis=1)
118    print("\nMatriz aumentada [A|b]:")
119    print(tabulate(Ab, tablefmt="fancy_grid"))
120
121    # Escalonar la matriz aumentada
122    bib.escalonaSimple(Ab)
123    print("\nMatriz aumentada escalonada:")
124    print(tabulate(Ab, tablefmt="fancy_grid"))
125
126    # Resolver el sistema
127    A1 = Ab[:, :10]
```

Ln 103, Col 1   Spaces: 4   UTF-8   CRLF

```python
128    b1 = b1.reshape(b1.shape[0], 1)
129    x = bib.sustRegresiva(A1, b1)
130
131    print("\nSolución del sistema:")
132    print(tabulate(x, tablefmt="fancy_grid"))
133
134    # Calcular la norma suma del residuo
135    residuo = b - np.dot(A, x)
136    norma_suma_residuo = np.sum(np.abs(residuo))
137
138    print("\nNorma suma del residuo:")
139    print(norma_suma_residuo)
140
```

Matriz de coeficientes A:

0.97627	4.30379	2.05527	0.897664	-1.5269	2.91788	-1.24826	7.83546	9.27326	-2.33117
5.8345	0.577898	1.36089	8.51193	-8.57928	-8.25741	-9.59563	6.6524	5.56314	7.40024
9.57237	5.98317	-0.770413	5.61058	-7.63451	2.79842	-7.13293	8.89338	0.436966	-1.70676
-4.70889	5.48467	-0.876993	1.36868	-9.6242	2.35271	2.24191	2.33868	8.87496	3.63641
-2.80984	-1.25936	3.95262	-8.79549	3.33533	3.41276	-5.79235	-7.42147	-3.69143	-2.72578
1.40394	-1.22797	9.76748	-7.9591	-5.82246	-6.77381	3.06217	-4.93417	-0.673785	-5.11149
-6.82061	-7.7925	3.12659	-7.23634	-6.06835	-2.6255	6.41986	-8.05797	6.7589	-8.07803
9.52919	-0.626976	9.53522	2.09691	4.78527	-9.21624	-4.34386	-7.59607	-4.0772	-7.62545
-3.64034	-1.71474	-8.71705	3.84944	1.33203	-4.69221	0.464961	-8.12119	1.51893	8.58592
-3.62862	3.34821	-7.36404	4.32654	-4.21188	-6.33617	1.73026	-9.59785	6.5788	-9.90609

Vector de términos independientes b:

23.1533
9.46867
16.0503
11.0879
-21.795
-18.2692
-30.3739
-7.5392
-11.1342
-25.0608

Matriz aumentada [A|b]:

0.97627	4.30379	2.05527	0.897664	-1.5269	2.91788	-1.24826	7.83546	9.27326	-2.33117	23.1533
5.8345	0.577898	1.36089	8.51193	-8.57928	-8.25741	-9.59563	6.6524	5.56314	7.40024	9.46867
9.57237	5.98317	-0.770413	5.61058	-7.63451	2.79842	-7.13293	8.89338	0.436966	-1.70676	16.0503
-4.70889	5.48467	-0.876993	1.36868	-9.6242	2.35271	2.24191	2.33868	8.87496	3.63641	11.0879
-2.80984	-1.25936	3.95262	-8.79549	3.33533	3.41276	-5.79235	-7.42147	-3.69143	-2.72578	-21.795
1.40394	-1.22797	9.76748	-7.9591	-5.82246	-6.77381	3.06217	-4.93417	-0.673785	-5.11149	-18.2692
-6.82061	-7.7925	3.12659	-7.23634	-6.06835	-2.6255	6.41986	-8.05797	6.7589	-8.07803	-30.3739
9.52919	-0.626976	9.53522	2.09691	4.78527	-9.21624	-4.34386	-7.59607	-4.0772	-7.62545	-7.5392
-3.64034	-1.71474	-8.71705	3.84944	1.33203	-4.69221	0.464961	-8.12119	1.51893	8.58592	-11.1342
-3.62862	3.34821	-7.36404	4.32654	-4.21188	-6.33617	1.73026	-9.59785	6.5788	-9.90609	-25.0608

Matriz aumentada escalonada:

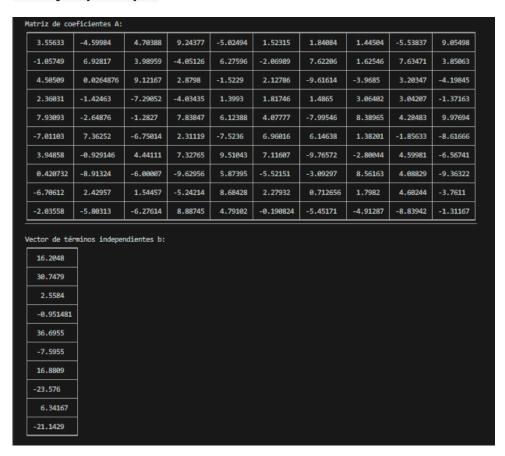| 0.97627	4.30379	2.05527	0.897664	-1.5269	2.91788	-1.24826	7.83546	9.27326	-2.33117	23.1533
0	-25.1429	-10.922	3.14721	0.545986	-25.6956	-2.13566	-40.1748	-49.8568	21.3321	-128.903
0	0	-5.19037	-7.72426	6.55041	11.2002	8.18245	-10.0662	-18.6744	-9.57607	-25.2981
0	0	0	12.5011	-19.4023	-15.4943	-9.73442	2.783	10.0689	19.0192	-0.258864
0	0	0	0	-13.5713	-3.95662	-11.9802	-9.67277	-7.26373	9.4475	-36.9971
0	0	0	0	0	-4.08622	28.3209	3.23161	0.931751	-9.31289	19.0851
0	0	0	0	0	0	61.1467	18.2703	20.1014	-33.6808	65.8375
0	0	0	0	0	0	-1.77636e-15	-18.828	-10.9469	-4.45484	-34.2297
0	-1.77636e-15	0	0	0	0	-6.1204e-16	0	19.9631	-10.5726	9.39052
0	2.41795e-15	0	0	0	0	3.47125e-16	0	3.55271e-15	-19.4633	-19.4633

Solución del sistema:

1
1
1
1
1
1
1
1
1
1

Norma suma del residuo:
1.971756091734278e-13
PS C:\Users\Usuario>

Comentario

Si no ponemos np.random.seed(0), cada vez que ejecutemos nuestro script, la matriz A generada y el vector b serán diferentes debido a la naturaleza aleatoria del generador de números. Esto significa que no obtendremos resultados reproducibles.

Caso contrario podemos omitir y generara matrices diferentes en cada iteración que hagamos correr.

Por ejemplo aquí:

Matriz de coeficientes A:

3.55633	-4.59984	4.70388	9.24377	-5.02494	1.52315	1.84084	1.44504	-5.53837	9.05498
-1.05749	6.92817	3.98959	-4.05126	6.27596	-2.06989	7.62206	1.62546	7.63471	3.85063
4.50509	0.0264876	9.12167	2.8798	-1.5229	2.12786	-9.61614	-3.9685	3.20347	-4.19845
2.36031	-1.42463	-7.29052	-4.03435	1.3993	1.81746	1.4865	3.06402	3.04207	-1.37163
7.93093	-2.64876	-1.2827	7.83847	6.12388	4.07777	-7.99546	8.38965	4.28483	9.97694
-7.01103	7.36252	-6.75014	2.31119	-7.5236	6.96016	6.14638	1.38201	-1.85633	-8.61666
3.94858	-0.929146	4.44111	7.32765	9.51043	7.11607	-9.76572	-2.80044	4.59981	-6.56741
0.420732	-8.91324	-6.00007	-9.62956	5.87395	-5.52151	-3.09297	8.56163	4.08829	-9.36322
-6.70612	2.42957	1.54457	-5.24214	8.68428	2.27932	0.712656	1.7982	4.60244	-3.7611
-2.03558	-5.80313	-6.27614	8.88745	4.79102	-0.190824	-5.45171	-4.91287	-8.83942	-1.31167

Vector de términos independientes b:

16.2048
30.7479
2.5584
-0.951481
36.6955
-7.5955
16.8809
-23.576
6.34167
-21.1429

Matriz aumentada [A|b]:

3.55633	-4.59984	4.70388	9.24377	-5.02494	1.52315	1.84084	1.44504	-5.53837	9.05498	16.2048
-1.05749	6.92817	3.98959	-4.05126	6.27596	-2.06989	7.62206	1.62546	7.63471	3.85063	30.7479
4.50509	0.0264876	9.12167	2.8798	-1.5229	2.12786	-9.61614	-3.9685	3.20347	-4.19845	2.5584
2.36031	-1.42463	-7.29052	-4.03435	1.3993	1.81746	1.4865	3.06402	3.04207	-1.37163	-0.951481
7.93093	-2.64876	-1.2827	7.83847	6.12388	4.07777	-7.99546	8.38965	4.28483	9.97694	36.6955
-7.01103	7.36252	-6.75014	2.31119	-7.5236	6.96016	6.14638	1.38201	-1.85633	-8.61666	-7.5955
3.94858	-0.929146	4.44111	7.32765	9.51043	7.11607	-9.76572	-2.80044	4.59981	-6.56741	16.8809
0.420732	-8.91324	-6.00007	-9.62956	5.87395	-5.52151	-3.09297	8.56163	4.08829	-9.36322	-23.576
-6.70612	2.42957	1.54457	-5.24214	8.68428	2.27932	0.712656	1.7982	4.60244	-3.7611	6.34167
-2.03558	-5.80313	-6.27614	8.88745	4.79102	-0.190824	-5.45171	-4.91287	-8.83942	-1.31167	-21.1429

Matriz aumentada escalonada:

3.55633	-4.59984	4.70388	9.24377	-5.02494	1.52315	1.84084	1.44504	-5.53837	9.05498	16.2048
0	5.56039	5.38831	-1.30258	4.78177	-1.61697	8.16945	2.05515	5.98785	6.54317	35.5665
0	0	-2.50942	-7.45877	-0.191221	1.90057	-20.5481	-7.96252	3.9159	-22.5572	-55.4108
0	0	1.77636e-15	25.8509	4.24774	-7.8011	96.0537	39.549	-13.7462	98.4833	242.637
-8.88178e-16	0	-3.15514e-15	0	4.70039	2.2489	-37.1103	-7.13869	2.97963	-21.9871	-56.3072
-3.31625e-15	0	-1.23112e-14	0	0	23.357	-189.169	-46.8581	10.8103	-137.811	-339.671
1.69989e-15	0	6.81005e-15	0	-1.77636e-15	0	69.4904	9.38777	-1.85924	32.539	109.558
-4.25614e-16	0	-8.64472e-16	0	7.10547e-16	0	0	13.9936	6.60077	-3.11871	17.4757
-8.84651e-17	0	6.00853e-16	0	1.66904e-15	0	0	0	-3.93198	20.5633	16.6313
3.73534e-16	0	2.41466e-15	0	2.66446e-15	0	0	0	0	10.1297	10.1297

Solución del sistema:

1
1
1
1
1
1
1
1
1
1

Norma suma del residuo:
2.1049828546892968e-13
PS C:\Users\Usuario>