5.2.34

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Question

Solve the given system of linear equations

$$x + y = 5$$
$$2x - 3y = 4$$

Theoretical Solution

Given lines can be represented as

$$\begin{pmatrix} 1 & 1 \end{pmatrix} \mathbf{x} = 5 \tag{1}$$

$$\begin{pmatrix} 2 & -3 \end{pmatrix} \mathbf{x} = 4 \tag{2}$$

Expressing the above as an augmented matrix

$$\left(\begin{array}{cc|c} 1 & 1 & 5 \\ 2 & -3 & 4 \end{array}\right) \tag{3}$$

Theoretical Solution

Converting into Reduced Row Echelon form using row operations

$$\left(\begin{array}{cc|c} 1 & 1 & 5 \\ 2 & -3 & 4 \end{array}\right) \xleftrightarrow{R_2 \to R_2 - 2R_1} \left(\begin{array}{cc|c} 1 & 1 & 5 \\ 0 & -5 & -6 \end{array}\right) \tag{4}$$

$$\left(\begin{array}{cc|c} 1 & 1 & 5 \\ 0 & -5 & -6 \end{array}\right) \xleftrightarrow{R_2 \to \frac{-1}{5} R_2} \left(\begin{array}{cc|c} 1 & 1 & 5 \\ 0 & 1 & \frac{6}{5} \end{array}\right) \tag{5}$$

Theoretical Solution

$$\left(\begin{array}{cc|c} 1 & 1 & 5 \\ 0 & 1 & \frac{6}{5} \end{array}\right) \xleftrightarrow{R_1 \rightarrow R_1 - R_2} \left(\begin{array}{cc|c} 1 & 0 & \frac{19}{5} \\ 0 & 1 & \frac{6}{5} \end{array}\right) \tag{6}$$

$$\mathbf{x} = \begin{pmatrix} \frac{19}{5} \\ \frac{6}{5} \end{pmatrix} \tag{7}$$

The solution of the given system of linear equations is $\begin{pmatrix} \frac{19}{5} \\ \frac{6}{5} \end{pmatrix}$

C Code - Solving Using Gaussian Elimination

```c
#include <stdio.h>

void Solve_Gaussian(double A[3], double B[3], double sol[2]) {
    // If A[0] == 0, swap rows to avoid division by zero
    //Also covers the case where the matrix is diagonal.
    if (A[0] == 0) {
        for (int i = 0; i < 3; i++) {
            double temp = A[i];
            A[i] = B[i];
            B[i] = temp;
        }
    }
```

C Code - Solving Using Gaussian Elimination

```c

    double factor = B[0] / A[0];
    for (int i = 0; i < 3; i++) {
        B[i] = B[i] - factor * A[i];
    }

    sol[1] = B[2] / B[1];
    sol[0] = (A[2] - A[1] * sol[1]) / A[0];
}
```

Python Code - Using Shared Object

```
import ctypes
import numpy as np
import matplotlib.pyplot as plt

c_lib = ctypes.CDLL("./code.so")

c_lib.Gaussian.argtypes = [ctypes.c_double*3, ctypes.c_double*3,
    ctypes.c_double*2]


A = (ctypes.c_double*3)(1,1,5)
B = (ctypes.c_double*3)(2,-3,4)

sols = (ctypes.c_double*2)(0.0,0.0)

c_lib.Gaussian(A,B,sols)
```

Python Code - Using Shared Object

```
plt.plot([-1,5.5], [6,-0.5], c='green', label = "$x+y=5$")
plt.plot([-1,5], [-2,2], c='blue', label = "$2x-3y=4$")

plt.scatter(sols[0],sols[1])

plt.annotate(
        f"{sols[0],sols[1]}",
        xy=(sols[0],sols[1]),
        xytext = (-15,-15),
        textcoords = "offset points"
        )
```

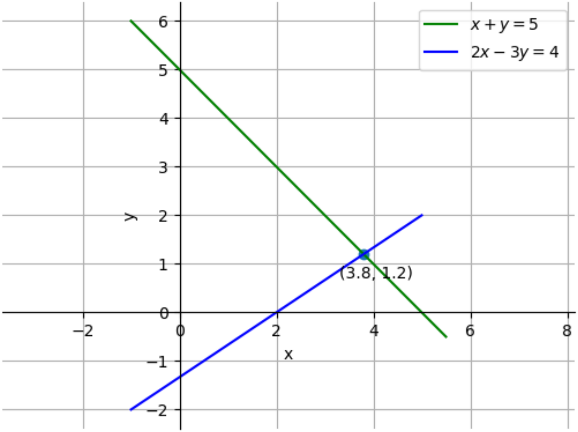
Python Code - Using Shared Object

```python

ax = plt.gca()
ax.spines['top'].set_color('none')
ax.spines['bottom'].set_position('zero')
ax.spines['right'].set_color('none')
ax.spines['left'].set_position('zero')
plt.xlabel('x')
plt.ylabel('y')
plt.legend(loc='best')
plt.grid()
plt.axis('equal')

plt.savefig("../Figs/plot(py+C).png")
plt.show()
```

Plot-Using Both C and Python



Python Code

```
import numpy as np
import matplotlib.pyplot as plt
import numpy.linalg as LA


M = np.array([[1, 1],
             [2,-3]])
b = np.array([5,4])
x = LA.solve(M, b)


plt.scatter(x[0],x[1])
```

Python Code

```
plt.plot([-1,5.5], [6,-0.5], c='red', label = '$x+y=5$')
plt.plot([-1,5], [-2,2], c='blue', label = '$2x-3y=4$')

plt.annotate(
        f'{x[0],x[1]}',
        xy=(x[0],x[1]),
        xytext = (-15,-15),
        textcoords = "offset points"
        )
```

Python Code

```python

ax = plt.gca()
ax.spines['top'].set_color('none')
ax.spines['bottom'].set_position('zero')
ax.spines['right'].set_color('none')
ax.spines['left'].set_position('zero')
plt.xlabel('x')
plt.ylabel('y')
plt.legend(loc='best')
plt.grid()
plt.axis('equal')

plt.savefig("../Figs/plot(py).png")
plt.show()
```

Plot-Using Python only