5.2.29

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Question

Solve for the system of linear equations:

$$\begin{aligned} x + 3y &= 6 \\ 2x - 3y &= 12 \end{aligned}$$

Theoretical Solution

According to the question,
The equation of lines given,

$$\begin{pmatrix} 1 & 3 \end{pmatrix} \mathbf{x} = 6 \quad \begin{pmatrix} 2 & -3 \end{pmatrix} \mathbf{x} = 12 \tag{1}$$

$$\therefore \begin{pmatrix} 1 & 3 \\ 2 & -3 \end{pmatrix} \mathbf{x} = \begin{pmatrix} 6 \\ 12 \end{pmatrix} \tag{2}$$

Theoretical Solution

Forming an augmented matrix,

$$\left(\begin{array}{cc|c} 1 & 3 & 6 \\ 2 & -3 & 12 \end{array}\right) \tag{3}$$

Upon doing row reduction,

$$\left(\begin{array}{cc|c} 1 & 3 & 6 \\ 2 & -3 & 12 \end{array}\right) \xleftrightarrow{R_2 \leftarrow R_2 - 2 \times R_1} \left(\begin{array}{cc|c} 1 & 3 & 6 \\ 0 & -9 & 0 \end{array}\right) \xleftrightarrow{R_1 \leftarrow R_1 + \frac{1}{3} \times R_2} \left(\begin{array}{cc|c} 1 & 0 & 6 \\ 0 & -9 & 0 \end{array}\right) \tag{4}$$

$$\implies \mathbf{x} = \begin{pmatrix} 6 \\ 0 \end{pmatrix} \tag{5}$$

C Code -Finding Solution for the system of Equations

```c
#include <stdio.h>

void rref_solver(double aug[2][3], double solution[2]) {
    // Normalize first row (pivot = aug[0][0])
    double pivot = aug[0][0];
    for (int j = 0; j < 3; j++) {
        aug[0][j] /= pivot;
    }
    // Eliminate below pivot
    double factor = aug[1][0];
    for (int j = 0; j < 3; j++) {
        aug[1][j] -= factor * aug[0][j];
    }
```

C Code -Finding Solution for the system of Equations

```c
    // Normalize second row (pivot = aug[1][1])
    pivot = aug[1][1];
    for (int j = 0; j < 3; j++) {
        aug[1][j] /= pivot;
    }
    // Eliminate above pivot
    factor = aug[0][1];
    for (int j = 0; j < 3; j++) {
        aug[0][j] -= factor * aug[1][j];
    }
    // Extract solution
    solution[0] = aug[0][2]; // x
    solution[1] = aug[1][2]; // y
}
```

Python+C code

```python
import ctypes
import numpy as np
import matplotlib.pyplot as plt
import matplotlib as mp
mp.use("TkAgg")
# Load the shared C library
lib = ctypes.CDLL("./liblineq_solver.so")
# Define argument and return types
lib.rref_solver.argtypes = [ctypes.c_double * 6, ctypes.c_double
    * 2]
# Create augmented matrix for system:
aug = (ctypes.c_double * 6)(1, 3, 6, 2, -3, 12) # Flattened 2x3
solution = (ctypes.c_double * 2)()
lib.rref_solver(aug, solution)
# Convert result to numpy vector (ensure flat)
x_sol = np.array([solution[0], solution[1]], dtype=float).flatten
    ()
print("Solution vector from C:", x_sol)
```

Python+C code

```
# plot
x_vals = np.linspace(-2, 10, 400)
y1 = (6 - x_vals) / 3
y2 = (12 - 2*x_vals) / -3

plt.plot(x_vals, y1, label=r"$x+3y=6$")
plt.plot(x_vals, y2, label=r"$2x-3y=12$")

plt.scatter(x_sol[0], x_sol[1], color="red", zorder=5)
plt.text(float(x_sol[0])+0.2, float(x_sol[1]), f"({x_sol[0]:.1f},
    {x_sol[1]:.1f})", color="red")
```

Python+C code

```
plt.xlabel("x")
plt.ylabel("y")
plt.title("Garphical solution of the Linear system")
plt.axhline(0, color="black", linewidth=0.8)
plt.axvline(0, color="black", linewidth=0.8)
plt.legend()
plt.grid(True)
plt.savefig("/home/user/Matrix/Matgeo_assignments/5.2.29/figs/
    Figure_1.png")
plt.show()
```

Python code

```
import numpy as np
import matplotlib.pyplot as plt
import matplotlib as mp
mp.use("TkAgg")

A=np.array([[1,3],[2,-3]],dtype=float)
b=np.array([6,12], dtype=float)

x=np.linalg.solve(A,b)
print("Solution vector for the system of equations:",x)
```

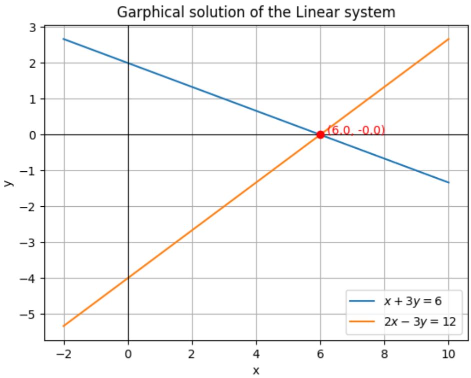
Python code

```
# Making a plot
x_vals = np.linspace(-2, 10, 400)

# Rearranged equations to express y in terms of x
y1 = (6 - x_vals) / 3 # from x + 3y = 6
y2 = (12 - 2*x_vals) / -3 # from 2x - 3y = 12

# Plot lines
plt.plot(x_vals, y1, label=r"$x + 3y = 6$")
plt.plot(x_vals, y2, label=r"$2x - 3y = 12$")

# Mark solution
plt.scatter(x[0], x[1], color="red", zorder=5)
plt.text(x[0]+0.2, x[1], f"({x[0]:.1f}, {x[1]:.1f})", color="red"
    )
```

Python code

```
# Formatting
plt.xlabel("x")
plt.ylabel("y")
plt.title("Graphical Solution of the Linear System")
plt.axhline(0, color='black', linewidth=0.8)
plt.axvline(0, color='black', linewidth=0.8)
plt.legend()
plt.grid(True)
plt.savefig("/home/user/Matrix/Matgeo_assignments/5.2.29/figs/
    Figure_1")
plt.show()
```

Plot



Garphical solution of the Linear system
(6.0, -0.0)
$x + 3y = 6$
$2x - 3y = 12$
x
y