System of Equations

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Problem Statement

Solve the following system of equations:

$$x - y = 8,$$
$$3x - 3y = 16$$

Solution

Each equation can be expressed in vector form as a dot product:

$$\begin{pmatrix} 1 & -1 \end{pmatrix} \begin{pmatrix} x \\ y \end{pmatrix} = 8, \tag{1}$$

$$\begin{pmatrix} 3 & -3 \end{pmatrix} \begin{pmatrix} x \\ y \end{pmatrix} = 16. \tag{2}$$

Stacking these gives the matrix equation

$$\begin{pmatrix} 1 & -1 \\ 3 & -3 \end{pmatrix} \begin{pmatrix} x \\ y \end{pmatrix} = \begin{pmatrix} 8 \\ 16 \end{pmatrix}. \tag{3}$$

Solution (cont..)

In augmented form,

$$\left(\begin{array}{cc|c} 1 & -1 & 8 \\ 3 & -3 & 16 \end{array}\right). \tag{4}$$

Applying the row operation $R_2 \to R_2 - 3R_1$,

$$\left(\begin{array}{cc|c} 1 & -1 & 8 \\ 0 & 0 & -8 \end{array}\right). \tag{5}$$

This yields the contradiction

$$0 = -8. \tag{6}$$

Hence the system is inconsistent,

$$\boxed{\text{No solution}}$$

Python Code (Plotting Line and Vectors)

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

x = np.linspace(−5, 15, 400)
y1 = x − 8
y2 = x − 16/3

plt.figure(figsize=(8, 6))
plt.plot(x, y1, color='blue')
plt.plot(x, y2, color='red')
plt.text(10, 2, r'$x - y = 8$', color='blue', fontsize=12)
plt.text(10, 7, r'$3x - 3y = 16$', color='red', fontsize=12)
```

Python Code (cont..)

```
plt.title("Plot of the system of equations")
plt.xlabel("x")
plt.ylabel("y")
plt.grid(True)
plt.axhline(0, color='black', linewidth=0.5)
plt.axvline(0, color='black', linewidth=0.5)

plt.show()
```

Plot

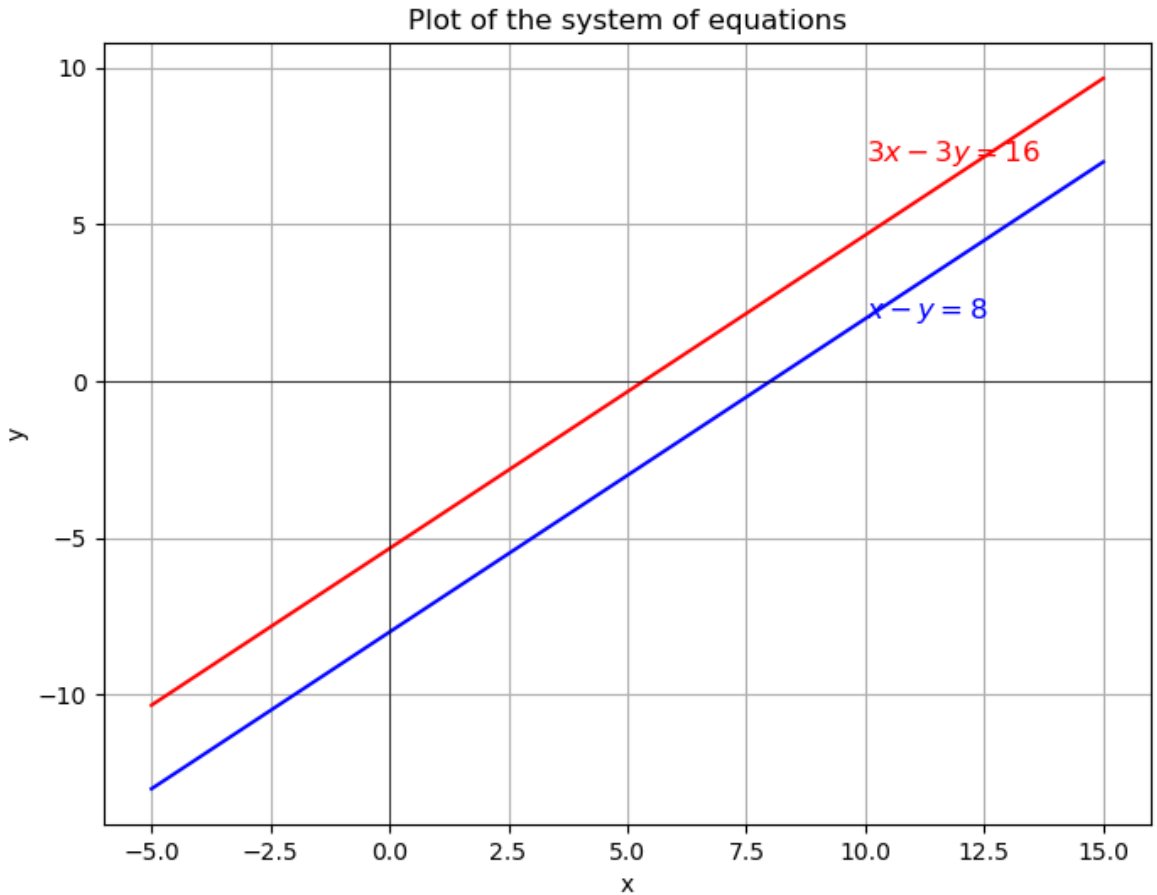

Figure: System of Equations

C Code (Computations)

```
#include <stdio.h>

void get_lines(double* x, double* y1, double* y2, int n) {
    for (int i = 0; i < n; i++) {
        y1[i] = x[i] - 8;
        y2[i] = x[i] - 16.0/3.0;
    }
}
```

Python Code (Using C)

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

lines_lib = ctypes.CDLL('./points.so')

n = 100
x = np.linspace(−5, 15, n)
y1 = np.zeros(n, dtype=np.float64)
y2 = np.zeros(n, dtype=np.float64)
```

Python Code (Cont..

```
lines_lib.get_lines.argtypes = [
    np.ctypeslib.ndpointer(dtype=np.float64, ndim=1, flags="
        C_CONTIGUOUS"),
    np.ctypeslib.ndpointer(dtype=np.float64, ndim=1, flags="
        C_CONTIGUOUS"),
    np.ctypeslib.ndpointer(dtype=np.float64, ndim=1, flags="
        C_CONTIGUOUS"),
    ctypes.c_int
]
lines_lib.get_lines(x, y1, y2, n)

plt.figure(figsize=(8, 6))
plt.plot(x, y1, color='blue')
plt.plot(x, y2, color='red')
```

Python Code (Cont..)

```
plt.text(10, 2, r'$x - y = 8$', color='blue', fontsize=12)
plt.text(10, 7, r'$3x - 3y = 16$', color='red', fontsize=12)

plt.title("System of Equations")
plt.xlabel("x")
plt.ylabel("y")
plt.grid(True)
plt.axhline(0, color='black', linewidth=0.5)
plt.axvline(0, color='black', linewidth=0.5)
plt.show()
```