Problem 12.661

ee25btech11023-Venkata Sai

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Problem

Let $\mathbf{A} = \begin{pmatrix} 1 & 2 \\ 2 & 1 \end{pmatrix}$, $\mathbf{X} = \begin{pmatrix} 1 & a \\ b & 0 \end{pmatrix}$ and $\mathbf{Y} = \begin{pmatrix} 3 & 1 \\ 3 & 2 \end{pmatrix}$.If $\mathbf{AX} = \mathbf{Y}$.Then $a + b$ equals

Inverse

Given

$$\mathbf{A} = \begin{pmatrix} 1 & 2 \\ 2 & 1 \end{pmatrix}, \mathbf{X} = \begin{pmatrix} 1 & a \\ b & 0 \end{pmatrix} \text{ and } \mathbf{Y} = \begin{pmatrix} 3 & 1 \\ 3 & 2 \end{pmatrix} \tag{3.1}$$

$$\mathbf{AX} = \mathbf{Y} \tag{3.2}$$

$$\mathbf{X} = \mathbf{A}^{-1}\mathbf{Y} \tag{3.3}$$

Augmented matrix of $\left(\mathbf{A} \mid \mathbf{I}\right)$ is Inverse by

$$\left(\begin{array}{cc|cc} 1 & 2 & 1 & 0 \\ 2 & 1 & 0 & 1 \end{array}\right) \xrightarrow{R_2 \to R_2 - 2R_1} \left(\begin{array}{cc|cc} 1 & 2 & 1 & 0 \\ 0 & -3 & -2 & 1 \end{array}\right) \tag{3.4}$$

$$\left(\begin{array}{cc|cc} 1 & 2 & 1 & 0 \\ 0 & -3 & -2 & 1 \end{array}\right) \xrightarrow{R_2 \to \frac{2}{3} R_2} \left(\begin{array}{cc|cc} 1 & 2 & 1 & 0 \\ 0 & \frac{2}{3}(-3) & \frac{2}{3}(-2) & \frac{2}{3}(1) \end{array}\right) \tag{3.5}$$

$$\left(\begin{array}{cc|cc} 1 & 2 & 1 & 0 \\ 0 & -2 & -\frac{4}{3} & \frac{2}{3} \end{array}\right) \xrightarrow{R_1 \to R_1 + R_2} \left(\begin{array}{cc|cc} 1 & 0 & 1 - \frac{4}{3} & \frac{2}{3} \\ 0 & -2 & -\frac{4}{3} & \frac{2}{3} \end{array}\right) \tag{3.6}$$

Conclusion

$$\left(\begin{array}{cc|cc} 1 & 0 & 1-\frac{4}{3} & \frac{2}{3} \\ 0 & -2 & -\frac{4}{3} & \frac{2}{3} \end{array}\right) \xrightarrow{R_2 \to -\frac{1}{2}R_2} \left(\begin{array}{cc|cc} 1 & 0 & -\frac{1}{3} & \frac{2}{3} \\ 0 & 1 & \frac{2}{3} & -\frac{1}{3} \end{array}\right) \tag{3.7}$$

$$\mathbf{A}^{-1} = \begin{pmatrix} -\frac{1}{3} & \frac{2}{3} \\ \frac{2}{3} & -\frac{1}{3} \end{pmatrix} \tag{3.8}$$

$$\mathbf{X} = \begin{pmatrix} -\frac{1}{3} & \frac{2}{3} \\ \frac{2}{3} & -\frac{1}{3} \end{pmatrix} \begin{pmatrix} 3 & 1 \\ 3 & 2 \end{pmatrix} = \begin{pmatrix} -\frac{1}{3}(3) + \frac{2}{3}(3) & -\frac{1}{3}(1) + \frac{2}{3}(2) \\ \frac{2}{3}(3) - \frac{1}{3}(3) & \frac{2}{3}(1) - \frac{1}{3}(2) \end{pmatrix} \tag{3.9}$$

$$\begin{pmatrix} 1 & a \\ b & 0 \end{pmatrix} = \begin{pmatrix} 1 & 1 \\ 1 & 0 \end{pmatrix} \tag{3.10}$$

Hence $a = 1, b = 1 \implies a + b = 1 + 1 = 2$

C code

```c
void get_matrices_data(double* out_data) {
    out_data[0] = 1.0;
    out_data[1] = 2.0;
    out_data[2] = 2.0;
    out_data[3] = 1.0;
    out_data[4] = 3.0;
    out_data[5] = 1.0;
    out_data[6] = 3.0;
    out_data[7] = 2.0;
}
```

Python Code for Solving

```
 fontsize=12)
  import ctypes
import numpy as np

def solve_matrix_equation():

    lib = ctypes.CDLL('./code.so')
    double_array_8 = ctypes.c_double * 8
    lib.get_matrices_data.argtypes = [ctypes.POINTER(ctypes.
        c_double)]

    out_data_c = double_array_8()
    lib.get_matrices_data(out_data_c)
    raw_data = np.array(list(out_data_c))

    A = raw_data[0:4].reshape((2, 2))
    Y = raw_data[4:8].reshape((2, 2))
```

Python Code for Solving

```
  X = np.linalg.solve(A, Y)

   return X
if __name__ == '__main__':
   solution_X = solve_matrix_equation()

   a = solution_X[0, 1]
   b = solution_X[1,0]

   print(f\nThis corresponds to: a={a:.2f}, b={b:.2f})
```