4.3.12

Vishwambhar - EE25BTECH11025

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Question

Check which of the following are solutions of the equation $x - 2y = 4$ and which are not

1. $(0, 2)$
2. $(2, 0)$
3. $(4, 0)$
4. $\left(\sqrt{2}, 4\sqrt{2}\right)$
5. $(1, 1)$

Given

Given line equation can be written as:

$$\mathbf{n}^\top \mathbf{x} = c \tag{1}$$

where $\mathbf{n} = \begin{pmatrix} 1 \\ -2 \end{pmatrix}$, $\mathbf{x} = \begin{pmatrix} x \\ y \end{pmatrix}$ and $c = 4$.

Checking

Checking whether a point lies on the line or not by substituting given vectors in (1):

$$\mathbf{x}_1 = \begin{pmatrix} 0 \\ 2 \end{pmatrix}, \mathbf{x}_2 = \begin{pmatrix} 2 \\ 0 \end{pmatrix}, \mathbf{x}_3 = \begin{pmatrix} 4 \\ 0 \end{pmatrix}, \mathbf{x}_4 = \begin{pmatrix} \sqrt{2} \\ 4\sqrt{2} \end{pmatrix}, \mathbf{x}_5 = \begin{pmatrix} 1 \\ 1 \end{pmatrix} \tag{2}$$

$$\mathbf{n}^\top \begin{pmatrix} \mathbf{x}_1 & \mathbf{x}_2 & \mathbf{x}_3 & \mathbf{x}_4 & \mathbf{x}_5 \end{pmatrix} = \begin{pmatrix} c_1 & c_2 & c_3 & c_4 & c_5 \end{pmatrix} \tag{3}$$

$$\begin{pmatrix} 1 & -2 \end{pmatrix} \begin{pmatrix} 0 & 2 & 4 & \sqrt{2} & 1 \\ 2 & 0 & 0 & 4\sqrt{2} & 1 \end{pmatrix} = \begin{pmatrix} -4 & 2 & 4 & -7\sqrt{2} & -1 \end{pmatrix} \tag{4}$$

$$\tag{5}$$

Conclusion

Conclusion:

The point which lies on the line is only option (3).

C Code

```c
#include <stdio.h>

#define size 2

double n[size], v1[size], v2[size], v3[size], v4[size], v5[size];

void insert_vector(int index, double vec[size]){
    double *target;
    switch (index){
        case 0: target = n; break;
        case 1: target = v1; break;
        case 2: target = v2; break;
        case 3: target = v3; break;
        case 4: target = v4; break;
        case 5: target = v5; break;
    }
    for (int i=0; i<size; i++){
        target[i] = vec[i];
    }
```

C Code

```c
double* get_vector(int index){
    switch (index){
        case 0: return n;
        case 1: return v1;
        case 2: return v2;
        case 3: return v3;
        case 4: return v4;
        case 5: return v5;
        default: return NULL;
    }
}
```

Python Code 1

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

x = np.linspace(-6, 10, 100)
y = x/2 - 2
X = [0, 2, 4, 1, math.sqrt(2) ]
Y = [2, 0, 0, 1, 4*math.sqrt(2)]

plt.plot(x, y, 'r-', label="x-2y=4")
plt.plot(X, Y, 'ko')

plt.text(8.17, 1.76, "x-2y=4", fontsize=12, color='black')

for i in range(len(X)-1):
    plt.text(X[i]+0.1, Y[i]+0.1, f"({X[i]},{Y[i]})", fontsize=10,
         color='black')
```

Python Code 1

```
plt.axvline(x=0, color='k', linewidth=1.5)

plt.axhline(y=0, color='k', linewidth=1.5)
plt.title("Plot of the given line and points")
plt.xlabel("X-axis")
plt.ylabel("Y-axis")
plt.axis('equal')
plt.grid(True)
plt.savefig("../figs/plot.png")
plt.show()
```

Python Code 2

```
import ctypes
import numpy as np
import math

lib = ctypes.CDLL("./problem.so")

lib.insert_vector.argtypes = (ctypes.c_int, ctypes.POINTER(ctypes
    .c_double))
lib.insert_vector.restype = None

lib.get_vector.argtypes = (ctypes.c_int,)
lib.get_vector.restype = ctypes.POINTER(ctypes.c_double)
```

Python Code 2

```
    vectors = [
    [1, -2],
    [0, 2],
    [2, 0],
    [4, 0],
    [math.sqrt(2), 4*math.sqrt(2)],
    [1, 1],
]
for i, vec in enumerate(vectors):
    arr = (ctypes.c_double * 2)(*vec)
    lib.insert_vector(i, arr)

def get_vector(i):
    ptr = lib.get_vector(i)
    return np.ctypeslib.as_array(ptr, shape=(2, ))

all_vectors = [get_vector(i) for i in range(0, 6)]
```

Python Code 2

```
n = get_vector(0)

for i in range(1, 6):
    v = get_vector(i)
    v_T = v.T
    res = n@v_T
    if(res==4):
        print(f"option ({i}) lies on the given line.")
    else:
        print(f"option ({i}) does not lie on the given line.")
```

Plot

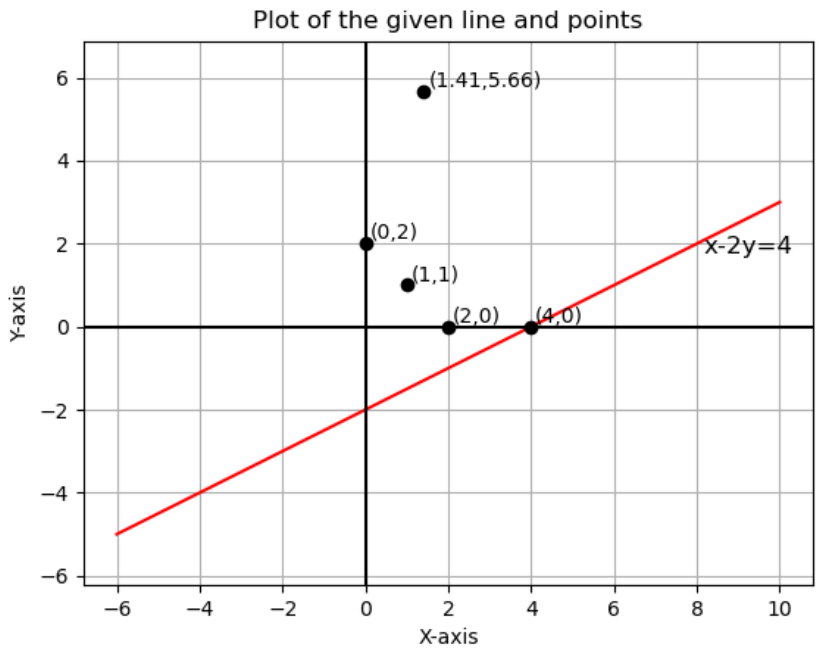

Figure: Plot of given line and points