1.5.13

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Find the ratio in which the Y-axis divides the line segment joining the points **A**$(5, -6)$ and **B**$(-1, -4)$. Also find the coordinates of the point of intersection.

Let the Y-axis divide the line segment **AB** at point **C** in the ratio $m : 1$.
Since **C** lies on Y-axis, let

$$\mathbf{C} = \begin{pmatrix} 0 \\ y \end{pmatrix}$$

The point **A**, **B**, **C** are collinear.

$$\implies \operatorname{rank} \begin{pmatrix} \mathbf{B} - \mathbf{A} & \mathbf{C} - \mathbf{A} \end{pmatrix} = 1 \tag{1}$$

$$\begin{pmatrix} -6 & -5 \\ 2 & a+6 \end{pmatrix} [] R_2 \to \frac{1}{3} R_1 + R_2 \begin{pmatrix} -6 & -5 \\ 0 & a+\frac{13}{3} \end{pmatrix} \tag{2}$$

The number of nonzero rows in the row reduced matrix (also known as *echelon form*) is defined as the rank. For above matrix to be of rank 1,

$$a + \frac{13}{3} = 0 \tag{3}$$

$$a = \frac{-13}{3} \tag{4}$$

$\therefore$ The coordinates of the point of intersection are

$$\mathbf{C} = \begin{pmatrix} 0 \\ \frac{-13}{3} \end{pmatrix}$$

Substituting the values of **A**, **B** and **C**,

$$k = \frac{\begin{pmatrix} 5 & \frac{-5}{3} \end{pmatrix} \begin{pmatrix} 1 \\ \frac{-1}{3} \end{pmatrix}}{\left\| \begin{pmatrix} 1 \\ \frac{-1}{3} \end{pmatrix} \right\|^2} = 5 \tag{5}$$

Thus, the ratio in which the point **C** divides the line segment **AB** is **5:1**.

C Code

```c
#include <stdio.h>
#include <math.h>
void function(double *P, double *B, double *A , int m, int k) {
    for ( int i = 0 ; i < m ; i++ ) {
        P[i] = (1*A[i] + k*B[i])/(k+1) ;
    }
}
```

Python Code

```python
import sys
import math
import numpy as np
import matplotlib.pyplot as plt
import ctypes

problem = ctypes.CDLL('/home/ganachari-vishwmabhar/ee1030-2025/
    EE25BTECH11025/ASSIGNMENTS/matgeo/1.5.13/codes/problem.so')
```

Python Code

```python
problem.argtypes = [
    ctypes.POINTER(ctypes.c_double),
    ctypes.POINTER(ctypes.c_double),
    ctypes.POINTER(ctypes.c_double),
    ctypes.c_int,
    ctypes.c_int,
]
problem.restype = None # void function

m = 2
k = 5

A = np.array([[5, -6]], dtype=np.float64)
B = np.array([[-1, -4]], dtype=np.float64)
P = np.zeros(m, dtype=np.float64)
```

Python Code

```
problem.function(
    P.ctypes.data_as(ctypes.POINTER(ctypes.c_double)),
    B.ctypes.data_as(ctypes.POINTER(ctypes.c_double)),
    A.ctypes.data_as(ctypes.POINTER(ctypes.c_double)),
    m, #len(P) alternate
    k
)

A = np.array([5, -6]).reshape(-1,1)
B = np.array([-1, -4]).reshape(-1,1)
P = P.reshape(-1,1)
```

```python
plt.plot([A[0,0], B[0,0]], [A[1,0], B[1,0]], 'g--', label="Line
    Segment AB")

plot_coords = np.block([[A, B, P]])
plt.scatter(plot_coords[0,:], plot_coords[1,:], color='blue')

vert_labels = [
    f'A({A[0,0]}, {A[1,0]})',
    f'B({B[0,0]}, {B[1,0]})',
    f'P({P[0,0]}, {P[1,0]:.2f})'
]
```

Python Code

```python
for i, txt in enumerate(vert_labels):
    plt.annotate(txt,
             (plot_coords[0,i],plot_coords[1,i]),
             textcoords="offset points",
             xytext=(0,10),
             ha='center')

plt.xlabel('$x$')
plt.ylabel('$y$')
plt.title("Line Segment AB Divided by Y-axis")
plt.legend(loc='best')
plt.grid()
plt.axis('equal')

plt.savefig("../figs/plot.png")
plt.show()
```
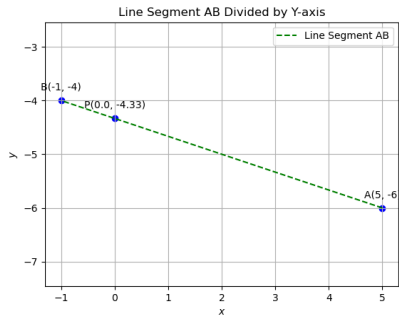
Plot

Figure: Plot of Intersection of AB by Y-axis