1.6.12

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Question

Show that point $\begin{pmatrix} -4 \\ 2 \end{pmatrix}$ lies on the line segment joining the points **A** $\begin{pmatrix} -4 \\ 6 \end{pmatrix}$ and **B** $\begin{pmatrix} -4 \\ -6 \end{pmatrix}$.

Variables used

Name	Point
A	$\begin{pmatrix} -4 \\ 6 \end{pmatrix}$
B	$\begin{pmatrix} -4 \\ -6 \end{pmatrix}$
C	$\begin{pmatrix} -4 \\ 2 \end{pmatrix}$

Table: Variables Used

Solution

The Collinearity matrix is given by

$$\begin{pmatrix} \mathbf{B}-\mathbf{A} & \mathbf{C}-\mathbf{A} \end{pmatrix}^{T} = \begin{pmatrix} 0 & -12 \\ 0 & -4 \end{pmatrix} \tag{1}$$

$$\xleftrightarrow{R_2 \to R_2 - \frac{1}{3}R_1} \begin{pmatrix} 0 & -12 \\ 0 & 0 \end{pmatrix} \tag{2}$$

Since the rank of the Collinearity matrix is 1, the points are collinear

Python - Importing libraries and checking system

```
import sys
import numpy as np
import numpy.linalg as LA
import matplotlib.pyplot as plt
import matplotlib.image as mpimg

from libs.line.funcs import *
from libs.triangle.funcs import *
from libs.conics.funcs import circ_gen

import subprocess
import shlex

print('Using termux?(y/n)')
y = input()
```

Python - Checking collinearity

```
A = np.array([-4, 6]).reshape(-1, 1)
B = np.array([-4, -6]).reshape(-1, 1)
C = np.array([-4, 2]).reshape(-1, 1)

collinearity_matrix = np.column_stack([B-A, C-A]).T
rank = LA.matrix_rank(collinearity_matrix)

if(rank == 1):
    print('The given points are collinear as the rank of the
        collinearity matrix is 1')
else:
    print('The given points are not collinear as the rank of the
        collinearity matrix is not 1')
```

Python - Generating points and plotting

```
p_AB = line_gen(A, B)
p_AC = line_gen(A, C)
p_CB = line_gen(C, B)

plt.plot(p_AB[0, :], p_AB[1, :], label = 'Line through AB')
plt.plot(p_AC[0, :], p_AC[1, :], label = 'Line through AC')
plt.plot(p_CB[0, :], p_CB[1, :], label = 'Line through CB')
```

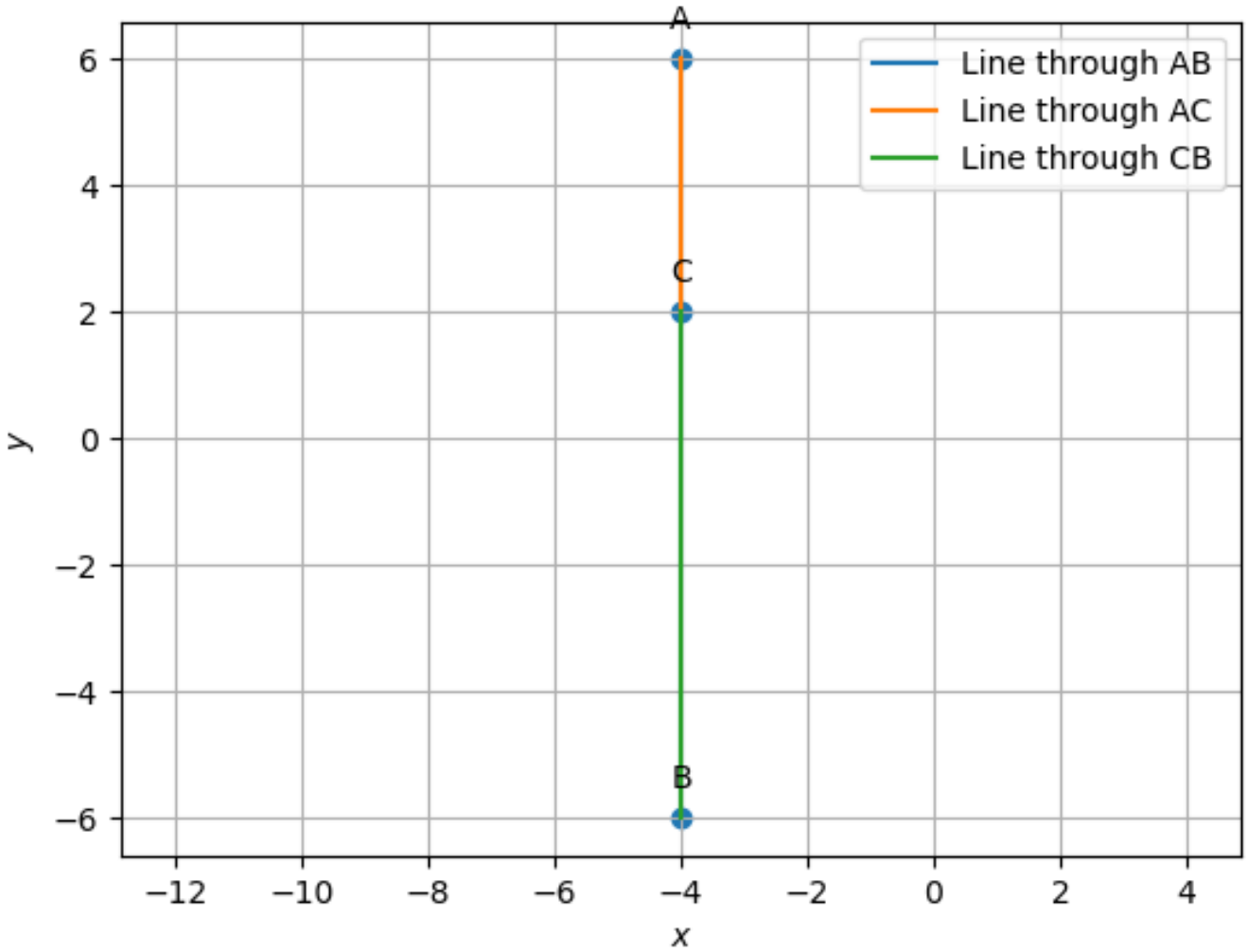
Python - Labelling points

```
line_coords = np.block([[A,B,C]])
plt.scatter(line_coords[0,:], line_coords[1,:])
vert_labels = ['A','B','C']
for i, txt in enumerate(vert_labels):
    plt.annotate(txt,
                 (line_coords[0,i], line_coords[1,i]),
                 textcoords="offset points",
                 xytext=(0,10),
                 ha='center')

plt.xlabel('$x$')
plt.ylabel('$y$')
plt.legend(loc='best')
plt.grid()
plt.axis('equal')
```

Python - Saving figure and opening it

```
plt.savefig('../figs/fig.png')
print('Saved figure to ../figs/fig.png')

if(y == 'y'):
    subprocess.run(shlex.split('termux-open ../figs/fig.
        png'))
else:
    subprocess.run(["open", "../figs/fig.png"])
```

Plot-Using only Python



C Code (0) - Importing libraries

```c
#include <stdio.h>
#include <stdlib.h>
#include <string.h>
#include <math.h>
#include <sys/socket.h>
#include <netinet/in.h>
#include <unistd.h>
#include "libs/matfun.h"
#include "libs/geofun.h"
```

C Code (1) - Function to Generate Points on a Line

```c
void point_gen(FILE *p_file, double **A, double **B, int rows,
    int cols, int npts){
    for(int i = 0; i <= npts; i++){
     double **output = Matadd(A, Matscale(Matsub(B, A, rows, cols
         ), rows, cols, (double)i/npts), rows, cols);
     fprintf(p_file, "%lf, %lf\n", output[0][0], output[1][0]);
     freeMat(output, rows);
    }
}
```

C Code (2) - Function to write points b/w given points to a file

```c
void write_points(double x1, double y1, double x2, double y2, int
     npts){
    int m = 2;
    int n = 1;

    double **A = createMat(m, n);
    double **B = createMat(m, n);

    A[0][0] = x1;
    A[1][0] = y1;

    B[0][0] = x2;
    B[1][0] = y2;
```

C Code (2) - Function to write points b/w given points to a file

```
    FILE *p_file;
    p_file = fopen("plot.dat", "w");
    if(p_file == NULL){
        printf("Error opening data file\n");
    }

    point_gen(p_file, A, B, m, n, npts);

    freeMat(A, m);
    freeMat(B, m);

    fclose(p_file);
}
```

C Code (3) - Checking if points are collinear

```
int check_collinearity(double x1, double y1, double x2, double y2
    , double x3, double y3){
    int m = 2;
    int n = 1;

    double **A = createMat(m, n);
    double **B = createMat(m, n);
    double **C = createMat(m, n);

    A[0][0] = x1;
    A[1][0] = y1;

    B[0][0] = x2;
    B[1][0] = y2;

    C[0][0] = x3;
    C[1][0] = y3;
```

C Code (3) - Checking if points are collinear

```
double **collinearity_matrix = transposeMat(Mathstack(Matsub
    (B, A, m, n), Matsub(C, A, m, n), m, n , n), m, n*2);
double **eigvals = Mateigval(collinearity_matrix);


int rank = 0;
for (int i = 0; i < 2; i++) {
   if (fabs(eigvals[i][0]) > 1e-9) rank++;
}

freeMat(A, m);
freeMat(B, m);
freeMat(C, m);
freeMat(collinearity_matrix, m);
freeMat(eigvals, m);
```

C Code (3) - Checking if points are collinear

```
    if(rank == 1){
        return 1;
    }
    else{
        return 0;
    }
}
```

Python Code (0) - Importing libraries and checking system

```
import numpy as np
import matplotlib.pyplot as plt
import ctypes
import os
import sys
import subprocess

print('Using termux? (y/n)')
termux = input()
```

Python Code (1) - Using Shared Object

```
lib_path = os.path.join(os.path.dirname(__file__), 'plot.so')
my_lib = ctypes.CDLL(lib_path)

my_lib.write_points.argtypes = [ctypes.c_double, ctypes.c_double,
     ctypes.c_double, ctypes.c_double, ctypes.c_int]
my_lib.write_points.restype = None
my_lib.write_points(-4, 6, -4, -6, 20000)

my_lib.check_collinearity.argtypes = [ctypes.c_double, ctypes.
    c_double, ctypes.c_double, ctypes.c_double, ctypes.c_double,
    ctypes.c_double]
my_lib.check_collinearity.restype = ctypes.c_int
collinearity = my_lib.check_collinearity(-4, 6, -4, -6, -4, 2)
```

Python Code (2) - Handling collinearity

```
if (collinearity == 1):
    print('The given points are collinear and the rank of the
        collinearity matrix is 1')
else:
    print('The given points are not collinear and the rank of the
         collinearity matrix is not 1')
```

Python Code (3) - Loading and plotting points

```
points = np.loadtxt('plot.dat', delimiter=',', usecols = (0,1))

x = points[:, 0]
y = points[:, 1]

plt.plot(x, y, label = 'Line through AB')

plt.xlabel('$x$')
plt.ylabel('$y$')
plt.legend(loc='best')
plt.grid()
plt.axis('equal')
```

Python Code (4) - Saving plot and opening it

```
plt.savefig('../figs/fig2.png')
print('Saved figure to ../figs/fig2.png')

if(termux == 'y'):
    subprocess.run(shlex.split('termux-open ../figs/fig2.png'))
else:
    subprocess.run(["open", "../figs/fig2.png"])
```

Plot-Using Both C and Python