1.4.17

EE25BTECH11002 - Achat Parth Kalpesh

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Question

Find the coordinates of the points of trisection
(i.e. points dividing to three equal parts) of the line segment joining the points **A** $(2, -2)$ and **B** $(-7, 4)$.

Theoretical Solution

Let the vectors for the given points **A** and **B** be

$$\mathbf{A} = \begin{pmatrix} 2 \\ -2 \end{pmatrix}, \mathbf{B} = \begin{pmatrix} -7 \\ 4 \end{pmatrix} \tag{1}$$

Let the points of trisection be **P** and **Q**. Point **P** divides the line segment AB in the ratio 1 : 2, and point **Q** divides it in the ratio 2 : 1.
We can use the internal division formula to find the coordinates of **P** and **Q**

Equation

The internal division formula for a vector **R** that divides the line segment formed by vectors **A** and **B** in the ratio m:n is given by:

$$\mathbf{R} = \frac{m\mathbf{B} + n\mathbf{A}}{m + n} \tag{2}$$

Theoretical Solution

For the first point of trisection, **P** (ratio 1:2)
Here, m=1 and n=2.

$$\mathbf{P} = \frac{1 \times \begin{pmatrix} -7 \\ 4 \end{pmatrix} + 2 \times \begin{pmatrix} 2 \\ -2 \end{pmatrix}}{1+2} \tag{3}$$

$$\mathbf{P} = \frac{1}{3}\begin{pmatrix} -7+4 \\ 4-4 \end{pmatrix} = \frac{1}{3}\begin{pmatrix} -3 \\ 0 \end{pmatrix} = \begin{pmatrix} -1 \\ 0 \end{pmatrix} \tag{4}$$

So, the coordinates of **P** are $(-1, 0)$.

Theoretical Solution

For the second point of trisection, $\mathbf{Q}$ (ratio 2:1)
Here, m=2 and n=1.

$$\mathbf{Q} = \frac{2 \times \begin{pmatrix} -7 \\ 4 \end{pmatrix} + 1 \times \begin{pmatrix} 2 \\ -2 \end{pmatrix}}{2+1} \tag{5}$$

$$\mathbf{Q} = \frac{1}{3} \begin{pmatrix} -14+2 \\ 8-2 \end{pmatrix} = \frac{1}{3} \begin{pmatrix} -12 \\ 6 \end{pmatrix} = \begin{pmatrix} -4 \\ 2 \end{pmatrix} \tag{6}$$

So, the coordinates of $\mathbf{Q}$ are $(-4, 2)$.

C code

```
#include <stdio.h>
void section_formula(float *P, float *A, float *B, int m, int n,
    int k){
for (int i = 0; i < k ; i++) {
    P[i] = (m*B[i]+n*A[i])/(m+n);
}
}
```

Python Code

```
import sys
import ctypes
import numpy as np
import matplotlib.pyplot as plt
c_lib = ctypes.CDLL('./formula.so')

c_lib.section_formula.argtypes = [
    ctypes.POINTER(ctypes.c_float),
    ctypes.POINTER(ctypes.c_float),
    ctypes.POINTER(ctypes.c_float),
    ctypes.c_int,
    ctypes.c_int,
    ctypes.c_int
]
c_lib.section_formula.restype = None
k = 2
A = np.array([2, -2], dtype=np.float32)
B = np.array([-7, 4], dtype=np.float32)
```

Python Code

```
P = np.zeros(k, dtype=np.float32)
Q = np.zeros(k, dtype=np.float32)

m = 1
n = 2
c_lib.section_formula(
    P.ctypes.data_as(ctypes.POINTER(ctypes.c_float)),
    A.ctypes.data_as(ctypes.POINTER(ctypes.c_float)),
    B.ctypes.data_as(ctypes.POINTER(ctypes.c_float)),
    m,
    n,
    k
)
m = 2
n = 1
```

Python Code

```python
c_lib.section_formula(
    Q.ctypes.data_as(ctypes.POINTER(ctypes.c_float)),
    A.ctypes.data_as(ctypes.POINTER(ctypes.c_float)),
    B.ctypes.data_as(ctypes.POINTER(ctypes.c_float)),
    m,
    n,
    k
)
plt.plot([A[0], B[0]], [A[1], B[1]], label='Line AB', zorder=1)
all_points = np.vstack([A, B, P, Q])
plt.scatter(all_points[:, 0], all_points[:, 1], color='red', zorder=2)
vert_labels = ['A', 'B', 'P', 'Q']
for i, txt in enumerate(vert_labels):
    plt.annotate(f'{txt}\n({all_points[i, 0]:.1f}, {all_points[i, 1]:.1f})',
                 (all_points[i, 0], all_points[i, 1]),
```

Python Code

```
                textcoords="offset points", xytext=(0,10), ha='
                    center')
ax = plt.gca()
ax.spines['left'].set_position('zero')
ax.spines['bottom'].set_position('zero')
ax.spines['right'].set_color('none')
ax.spines['top'].set_color('none')
plt.xlabel('$x$')
plt.ylabel('$y$')
plt.legend(loc='upper right')
plt.grid(True)
plt.axis('equal')
plt.savefig('plot_from_c_corrected.png')
plt.show()
```

Plot

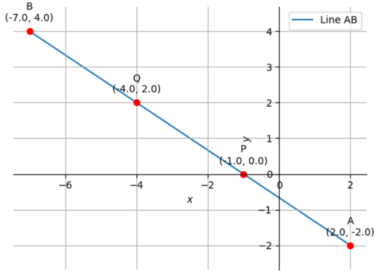

Figure: Trisection of the line segment joining **A** $(2, -2)$ and **B** $(-7, 4)$