1.5.20

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Question

The midpoint of the line segment joining $\mathbf{A}\,(2a, 4)$ and $\mathbf{B}\,(-2, 3b)$ is $(1, 2a + 1)$. Find the values of a and b.

Equation

The midpoint M of line segment AB, with $\mathbf{A}\,(x_1, y_1)$ and $\mathbf{B}\,(x_2, y_2)$, is:

$$\mathbf{M} = \frac{\mathbf{A} + \mathbf{B}}{2} = \frac{\begin{pmatrix} x_1 \\ y_1 \end{pmatrix} + \begin{pmatrix} x_2 \\ y_2 \end{pmatrix}}{2} \tag{1}$$

Theoretical Solution

Given details:

$$\mathbf{A} = \begin{pmatrix} 2a \\ 4 \end{pmatrix} \mathbf{B} = \begin{pmatrix} -2 \\ 3b \end{pmatrix} \mathbf{M} = \begin{pmatrix} 1 \\ 2a+1 \end{pmatrix} \tag{2}$$

Theoretical Solution

Substituting the points:

$$\frac{\begin{pmatrix} 2a \\ 4 \end{pmatrix} + \begin{pmatrix} -2 \\ 3b \end{pmatrix}}{2} = \begin{pmatrix} \frac{2a-2}{2} \\ \frac{(4+3b)}{2} \end{pmatrix} \tag{3}$$

Theoretical Solution

Equating coordinates, we get two equations:

$$\frac{2a-2}{2} = 1 \tag{4}$$

$$\frac{4+3b}{2} = 2a+1 \tag{5}$$

Theoretical Solution

Using (3)

$$a = 2 \tag{6}$$

Using (3) and (6)

$$b = 2 \tag{7}$$

Therefore Values of a and b are both 2

C Code (1) - Function to generate a line segment

```c
#include <stdio.h>

void line_segment_gen(double *X, double *Y, double *A, double *B,
     int n)
{
    double dx = (B[0] - A[0]) / (double)n;
    double dy = (B[1] - A[1]) / (double)n;

    for (int i = 0; i <= n; i++)
    {
        X[i] = A[0] + dx * i;
        Y[i] = A[1] + dy * i;
    }
}
```

Python Code - Using Shared Object

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

# Load shared library
lib = ctypes.CDLL("./line_segment.so")

# Define argument types for the C function
lib.line_segment_gen.argtypes = [
    np.ctypeslib.ndpointer(dtype=np.double, ndim=1, flags="
        C_CONTIGUOUS"), # X
    np.ctypeslib.ndpointer(dtype=np.double, ndim=1, flags="
        C_CONTIGUOUS"), # Y
    np.ctypeslib.ndpointer(dtype=np.double, ndim=1, flags="
        C_CONTIGUOUS"), # A
```

Python Code - Using Shared Object

```
 np.ctypeslib.ndpointer(dtype=np.double, ndim=1, flags="
     C_CONTIGUOUS"), # B
    ctypes.c_int
]
# Define start & end points
A = np.array([4.0, 4.0], dtype=np.double) # Point (4,4)
B = np.array([-2.0, 6.0], dtype=np.double) # Point (-2,6)
n = 20 # number of segments

# Allocate space for results
X = np.zeros(n+1, dtype=np.double)
Y = np.zeros(n+1, dtype=np.double)

# Call the C function
lib.line_segment_gen(X, Y, A, B, n)

# Compute midpoint
midpoint = np.array([(A[0] + B[0]) / 2, (A[1] + B[1]) / 2])
```

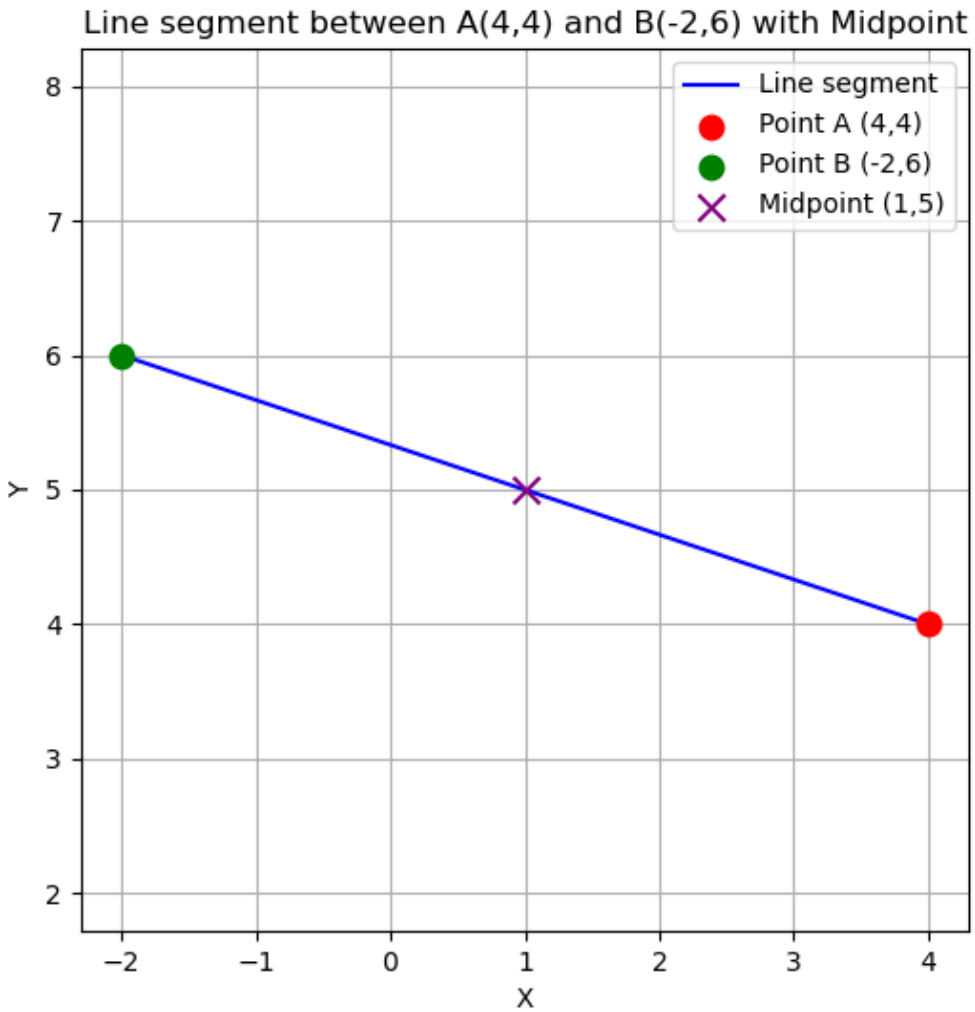
Python Code - Using Shared Object

```
# --------- Plotting ---------
plt.figure(figsize=(6,6))

# Draw line segment
plt.plot(X, Y, 'b-', label="Line segment")

# Mark endpoints
plt.scatter(A[0], A[1], color='red', s=80, zorder=3, label="Point
    A (4,4)")
plt.scatter(B[0], B[1], color='green', s=80, zorder=3, label="
    Point B (-2,6)")

# Mark midpoint
plt.scatter(midpoint[0], midpoint[1], color='purple', s=100,
    marker='x', zorder=4, label="Midpoint (1,5)")
```

Python Code - Using Shared Object

```
# Labels & grid
plt.xlabel("X")
plt.ylabel("Y")
plt.title("Line segment between A(4,4) and B(-2,6) with Midpoint"
    )
plt.legend()
plt.grid(True)
plt.axis("equal")
plt.savefig('figs/line_segment.png')
subprocess.run(shlex.split("termux-open figs/line_segment.png"))
```

Plot-Using Both C and Python



Python Code

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

# Define points
A = np.array([4.0, 4.0])
B = np.array([-2.0, 6.0])

# Generate line segment points
n = 20
X = np.linspace(A[0], B[0], n+1)
Y = np.linspace(A[1], B[1], n+1)
```

Python Code

```
# --------- Plotting ---------
plt.figure(figsize=(6,6))

# Line
plt.plot(X, Y, 'b-', label="Line segment")

# Endpoints
plt.scatter(A[0], A[1], color='red', s=80, zorder=3, label="Point
    A (4,4)")
plt.scatter(B[0], B[1], color='green', s=80, zorder=3, label="
    Point B (-2,6)")

# Midpoint
plt.scatter(midpoint[0], midpoint[1], color='purple', s=100,
    marker='x', zorder=4, label="Midpoint (1,5)")
```

Python Code

```
    # Midpoint
midpoint = (A + B) / 2


# Labels & grid
plt.xlabel("X")
plt.ylabel("Y")
plt.title("Line segment between A(4,4) and B(-2,6) with Midpoint"
    )
plt.legend()
plt.grid(True)
plt.axis("equal")
plt.savefig('figs/line_segment2.png')
subprocess.run(shlex.split("termux-open figs/line_segment2.png"))
```

Plot-Using only Python