

1.5.20

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# Question

The midpoint of the line segment joining **A**  $(2a, 4)$  and **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:

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

# Theoretical Solution

Given details:

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

# Theoretical Solution

Substituting the points:

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

# Theoretical Solution

Equating coordinates, we get two equations:

$$\frac{2a - 2}{2} = 1 \quad (4)$$

$$\frac{4 + 3b}{2} = 2a + 1 \quad (5)$$

# Theoretical Solution

Using (3)

$$a = 2 \quad (6)$$

Using (3) and (6)

$$b = 2 \quad (7)$$

Therefore Values of a and b are both 2

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

```
#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])
```

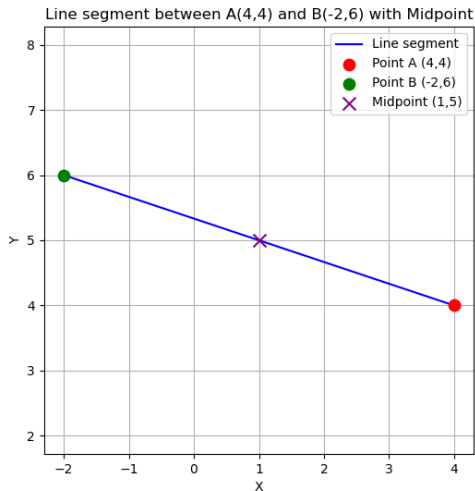
# Python Code - Using Shared Object

```
# ----- 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)")
```

```
# 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

