

1.9.16

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Agust, 2025

Question

Find the distance between the points (a, b) and $(-a, -b)$.

Let the given two points be P and Q, where,

$$\mathbf{P} = \begin{pmatrix} a \\ b \end{pmatrix} \text{ and } \mathbf{Q} = \begin{pmatrix} -a \\ -b \end{pmatrix} \quad (1)$$

Let D be a vector defined as:

$$\mathbf{D} = \mathbf{P} - \mathbf{Q} \quad (2)$$

Theoretical Solution

Now,

$$\mathbf{D} = \begin{pmatrix} a \\ b \end{pmatrix} - \begin{pmatrix} -a \\ -b \end{pmatrix} \quad (3)$$

$$\mathbf{D} = \begin{pmatrix} 2a \\ 2b \end{pmatrix} \quad (4)$$

The distance between the point P and Q = Norm of the vector D
Norm of the vector D is defined as:

$$||D|| \triangleq \sqrt{D^T D} \quad (5)$$

$$D^T D = \begin{pmatrix} 2a & 2b \end{pmatrix} \begin{pmatrix} 2a \\ 2b \end{pmatrix} \quad (6)$$

$$D^T D = 4a^2 + 4b^2 \quad (7)$$

Theoretical Solution

Now substitute in Eq.5:

$$||D|| = \sqrt{4a^2 + 4b^2} \quad (8)$$

$$||D|| = 2\sqrt{a^2 + b^2} \quad (9)$$

Therefore the distance between the two points is: $2\sqrt{a^2 + b^2}$

For verification let us assume $a = 4$ and $b = 4$

C Code - Midpoint formula

```
#include <stdio.h>
#include <math.h>

// Function to calculate distance
float distance(float a, float b) {
    float x1 = a, y1 = b;
    float x2 = -a, y2 = -b;

    float dist = sqrt((x2 - x1)*(x2 - x1) + (y2 - y1)*(y2 - y1));
    return dist;
}
```

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

# Load the shared library
lib = ctypes.CDLL(./midpoint.so) # use midpoint.dll on Windows

# Define function signature
lib.midpoint.argtypes = [
    ctypes.c_float, ctypes.c_float, # x1, y1
    ctypes.c_float, ctypes.c_float, # x2, y2
    ctypes.POINTER(ctypes.c_float), # mx
    ctypes.POINTER(ctypes.c_float) # my
]
```

Python Code

```
import ctypes
import matplotlib.pyplot as plt

# Load shared C library
lib = ctypes.CDLL('./c.so')
lib.distance.argtypes = [ctypes.c_float, ctypes.c_float]
lib.distance.restype = ctypes.c_float

# Example values
a, b = 4, 4 # change as needed

# Call C function
dist = lib.distance(a, b)
print(fDistance between ({a},{b}) and (-{a},-{b}) = {dist})

# Coordinates
x1, y1 = a, b
x2, y2 = -a, -b
```



```
# Plot
plt.figure(figsize=(6,6))

# Line between points
plt.plot([x1, x2], [y1, y2], b-, label=fDistance = {dist:.2f})

# Points
plt.scatter(x1, y1, color=red, s=100, label=fA({x1}, {y1}))
plt.scatter(x2, y2, color=green, s=100, label=fB({x2}, {y2}))

# Labels near points
plt.text(x1+0.2, y1, fA({x1}, {y1}), fontsize=10, color=red)
plt.text(x2-1.5, y2, fB({x2}, {y2}), fontsize=10, color=green)
```

```
# Axes + Grid
plt.axhline(0, color=black, linewidth=0.7)
plt.axvline(0, color=black, linewidth=0.7)
plt.xlabel(X-axis)
plt.ylabel(Y-axis)
plt.title(Distance using C + Python)
plt.grid(True)
plt.legend()
plt.show()
```

Plot

