1.9.29

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Question

Find the value of y for which the distance between the points $\mathbf{A}\,(3,-1)$ and $\mathbf{B}\,(11,y)$ is 10 units.

Equation Used

$$\text{Distance} \; = \|\mathbf{A}-\mathbf{B}\| = \sqrt{(\mathbf{A}-\mathbf{B})^T(\mathbf{A}-\mathbf{B})} \tag{1}$$

Solution

$$\mathbf{A} - \mathbf{B} = \begin{pmatrix} 3 - 11 \\ -1 - y \end{pmatrix} \tag{2}$$

Next

$$(\mathbf{A} - \mathbf{B})^T(\mathbf{A} - \mathbf{B}) = \begin{pmatrix} 3 - 11 & -1 - y \end{pmatrix} \begin{pmatrix} 3 - 11 \\ -1 - y \end{pmatrix} \tag{3}$$

Putting values in equation (1)

$$\sqrt{(3-11)^2+(-1-y)^2}=10 \tag{4}$$

$$(3-11)^2+(-1-y)^2=100 \tag{5}$$

$$64+1+y^2+2y=100 \tag{6}$$

$$y^2+2y-35=0 \tag{7}$$

$$(y+7)(y-5)=0 \tag{8}$$

$$y=-7 \text{ or } 5 \tag{9}$$

Therefore, there are two possible values of $\mathbf{B}\,(11,5)$ or $\mathbf{B}\,(11,-7)$

C code

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

// Function to compute dot product
void dot_product(double vector1[], double vector2[], int size,
    double* result) {
    *result = 0.0;
    for (int i = 0; i < size; i++) {
        *result += vector1[i] * vector2[i];
    }
}
```

C code

```c


// Function to compute squared distance between two 2D points
    using dot product
void distance_squared(double A[2], double B[2], double* result) {
    double AB[2];
    AB[0] = B[0] - A[0]; // x2 - x1
    AB[1] = B[1] - A[1]; // y2 - y1
    dot_product(AB, AB, 2, result); // AB  AB
}
```

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

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

# Define signatures
lib.distance_squared.argtypes = [
    np.ctypeslib.ndpointer(dtype=np.float64, flags="C_CONTIGUOUS"
        ),
    np.ctypeslib.ndpointer(dtype=np.float64, flags="C_CONTIGUOUS"
        ),
    ctypes.POINTER(ctypes.c_double)
]
```

Python Code through Shared obejct

```
lib.distance_squared.restype = None

def distance_squared(A, B):
    res = ctypes.c_double()
    lib.distance_squared(A, B, ctypes.byref(res))
    return res.value

# Point A
A = np.array([3.0, -1.0], dtype=np.float64)

# B points from solving equation (y = 5 or y = -7)
solutions = [5.0, -7.0]
points = []

for yB in solutions:
    B = np.array([11.0, yB], dtype=np.float64)
    d2 = distance_squared(A, B)
    d = math.sqrt(d2)
```

```python
    print(f"For y = {yB}, distance AB = {d}")
    points.append(B)
# --- Plot ---
plt.figure(figsize=(6,6))
plt.scatter(A[0], A[1], color="red")
plt.text(A[0]+0.2, A[1]+0.2, "A(3, -1)", color="red", fontsize=10)

for i, B in enumerate(points, start=1):
    plt.scatter(B[0], B[1], color="blue")
    plt.text(B[0]+0.2, B[1]+0.2, f"B{ i }(11, {int(B[1])})", color="blue", fontsize=10)
    plt.plot([A[0], B[0]], [A[1], B[1]], linestyle="--")
```

Python Code through Shared obejct

```
plt.xlabel("X-axis")
plt.ylabel("Y-axis")
plt.title("Points A and B with distance 10 (using C
    distance_squared)")
plt.grid(True)
plt.axis("equal")
plt.show()
```

Direct python Code

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

# --- 1. Define the given points and distance ---
p_a = np.array([3, -1])
x_b = 11
distance = 10

# --- 2. Solve for y ---
# We have the equation: distance^2 = (x_b - p_a[0])^2 + (y - p_a
    [1])^2
# 10^2 = (11 - 3)^2 + (y - (-1))^2
# 100 = 8^2 + (y + 1)^2
# 100 = 64 + (y + 1)^2
# 36 = (y + 1)^2
# So, y + 1 = +/- 6

# First solution for y
```

```python
# Second solution for y
y2 = -6 - 1
p_b1 = np.array([x_b, y1])
p_b2 = np.array([x_b, y2])

# --- 3. Plot the results ---
# Create a figure and axis for the plot
fig, ax = plt.subplots(figsize=(10, 10))

# Plot the points A, B1, and B2
ax.scatter(p_a[0], p_a[1], color='red', s=100, zorder=5)
ax.scatter(p_b1[0], p_b1[1], color='blue', s=100, zorder=5)
ax.scatter(p_b2[0], p_b2[1], color='green', s=100, zorder=5)
```

Direct python Code

```python
# Annotate the points directly on the graph
ax.text(p_a[0] + 0.3, p_a[1], f'A ({p_a[0]}, {p_a[1]})', fontsize
    =12, verticalalignment='center', color='red')
ax.text(p_b1[0] + 0.3, p_b1[1], f'B1 ({p_b1[0]}, {p_b1[1]})',
    fontsize=12, verticalalignment='center', color='blue')
ax.text(p_b2[0] + 0.3, p_b2[1], f'B2 ({p_b2[0]}, {p_b2[1]})',
    fontsize=12, verticalalignment='center', color='green')

# Draw the lines representing the distance
ax.plot([p_a[0], p_b1[0]], [p_a[1], p_b1[1]], 'b--', label=f'
    Distance = {distance} units')
```

Direct python Code

```
ax.plot([p_a[0], p_b2[0]], [p_a[1], p_b2[1]], 'g--')

# --- Visualization Aid: Draw a circle centered at A with radius
    10 ---
# The solution points B1 and B2 must lie on this circle.
circle = plt.Circle(p_a, distance, color='red', fill=False,
    linestyle=':', alpha=0.5)
ax.add_artist(circle)

# --- Visualization Aid: Draw the vertical line x = 11 ---
```

Direct python Code

```
# Point B must lie on this line.
ax.axvline(x=x_b, color='purple', linestyle='-.', alpha=0.5)

# --- 4. Formatting the plot ---
ax.set_title('Geometric Solution for the Distance Problem',
    fontsize=16)
ax.set_xlabel('X-axis', fontsize=12)
ax.set_ylabel('Y-axis', fontsize=12)

# Set equal aspect ratio to ensure the circle is not distorted
ax.set_aspect('equal', adjustable='box')

# Add grid and legend
ax.grid(True, which='both', linestyle='--', linewidth=0.5)
ax.legend(fontsize=10)
```

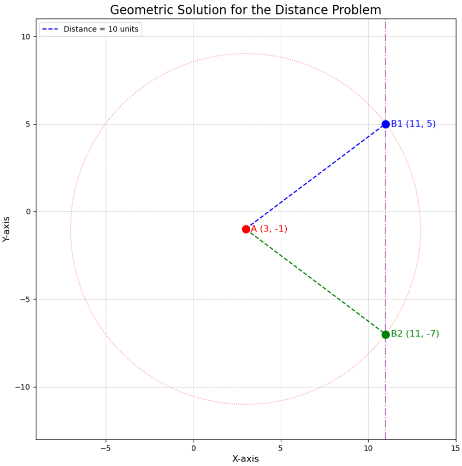
Direct python Code

```
# Set axis limits to give some padding around the points
plt.xlim(p_a[0] - distance - 2, p_a[0] + distance + 2)
plt.ylim(p_a[1] - distance - 2, p_a[1] + distance + 2)

# Save the plot as a PNG file
plt.savefig('distance_plot.png')

# Show the plot
plt.show()
```

Figure



Geometric Solution for the Distance Problem
Distance = 10 units
B1 (11, 5)
A (3, -1)
B2 (11, -7)
X-axis
Y-axis
−5
0
5
10
15
10
5
0
−5
−10