1.5.4

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Question

A circle has its center at $(4, 4)$. If one end of a diameter is $(4, 0)$, then find the coordinates of the other end.

Theoretical Solution

Let the position vectors for the center, the known end, and the unknown end of the diameter be **C**, **B**, and **A** respectively. Let the coordinates of the unknown end **A** be (a, b).
The given vectors are:

$$\mathbf{A} = \begin{pmatrix} a \\ b \end{pmatrix}, \quad \mathbf{B} = \begin{pmatrix} 4 \\ 0 \end{pmatrix}, \quad \mathbf{C} = \begin{pmatrix} 4 \\ 4 \end{pmatrix} \tag{1}$$

The center of the circle is the midpoint of the diameter. Therefore, the center vector is the average of the endpoint vectors.

$$\mathbf{C} = \frac{\mathbf{A} + \mathbf{B}}{2} \tag{2}$$

To find the unknown vector **A**, we rearrange the equation:

$$2\mathbf{C} = \mathbf{A} + \mathbf{B} \tag{3}$$

$$\mathbf{A} = 2\mathbf{C} - \mathbf{B} \tag{4}$$

Theoretical Solution

Substituting the given vector values:

$$\begin{aligned}\begin{pmatrix} a \\ b \end{pmatrix} &= 2\begin{pmatrix} 4 \\ 4 \end{pmatrix} - \begin{pmatrix} 4 \\ 0 \end{pmatrix} \\ &= \begin{pmatrix} 8 \\ 8 \end{pmatrix} - \begin{pmatrix} 4 \\ 0 \end{pmatrix} && (5) \\ &= \begin{pmatrix} 4 \\ 8 \end{pmatrix} && (6)\end{aligned}$$

$\therefore$ The other end of the diameter is $(4, 8)$.

C Code - Finding the other endpoint

```c
#include <stdio.h>

void other_end(double cx, double cy, double x1, double y1, double *x2, double *y2) {
    *x2 = 2*cx - x1;
    *y2 = 2*cy - y1;
}
```

Python + C Code

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

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

# Define function prototype
lib.other_end.argtypes = [ctypes.c_double, ctypes.c_double,
                      ctypes.c_double, ctypes.c_double,
                      ctypes.POINTER(ctypes.c_double),
                      ctypes.POINTER(ctypes.c_double)]

# Inputs
cx, cy = 4.0, 4.0 # centre
x1, y1 = 4.0, 0.0 # one endpoint
```

Python + C Code

```
# Prepare outputs
x2_ptr = ctypes.c_double()
y2_ptr = ctypes.c_double()

# Call C function
lib.other_end(cx, cy, x1, y1, ctypes.byref(x2_ptr), ctypes.byref(
    y2_ptr))

# Extract other endpoint
x2, y2 = x2_ptr.value, y2_ptr.value
print("Other end of diameter:", (x2, y2))

# Radius = distance from centre to endpoint
r = np.sqrt((x1 - cx)**2 + (y1 - cy)**2)

# Generate circle points
theta = np.linspace(0, 2*np.pi, 500)
x_circle = cx + r * np.cos(theta)
y_circle = cy + r * np.sin(theta)
```

Python + C Code

```python
# Plot
plt.figure(figsize=(6,6))
plt.plot(x_circle, y_circle, label="Circle")

plt.scatter([x1, x2], [y1, y2], color="red", s=80, label="Endpoints")
plt.text(x1 + 0.2, y1 - 0.5, f"A({x1:.0f}, {y1:.0f})")
plt.text(x2 + 0.2, y2 + 0.2, f"B({x2:.0f}, {y2:.0f})")

plt.scatter(cx, cy, color="blue", marker="x", s=200, label="Centre")
plt.text(cx - 1.2, cy - 0.5, f"C({cx:.0f}, {cy:.0f})")

plt.plot([x1, x2], [y1, y2], 'g--', label="Diameter")
plt.axis("equal")
plt.legend()
plt.title("Circle with Given Centre and Diameter")
plt.savefig("figs/Figure_1.png")
plt.show()
```

Python Code

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

# Inputs
cx, cy = 4.0, 4.0 # centre
x1, y1 = 4.0, 0.0 # one endpoint

# Other endpoint using symmetry
x2 = 2*cx - x1
y2 = 2*cy - y1
print("Other end of diameter:", (x2, y2))

# Radius = distance from centre to endpoint
r = np.sqrt((x1 - cx)**2 + (y1 - cy)**2)
```

Python Code

```python
# Generate circle points
theta = np.linspace(0, 2*np.pi, 500)
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```
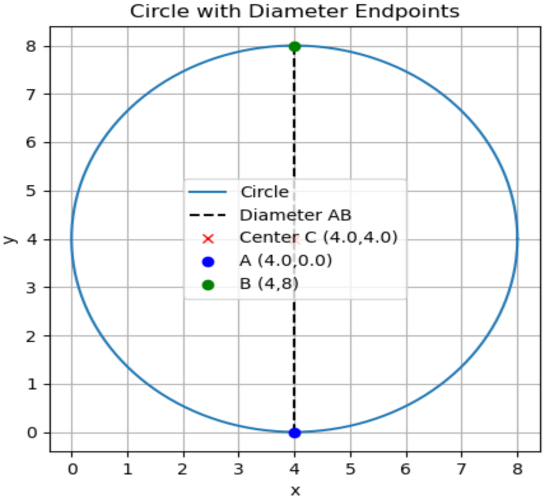

Plot


Circle with Diameter Endpoints
Circle
Diameter AB
Center C (4.0,4.0)
A (4.0,0.0)
B (4,8)
0
1
2
3
4
5
6
7
8
x
y