1.3.4

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Question

If $A(1,3), B(-1,2), C(2,5)$ and $D(x,4)$ are the vertices of a parallelogram $ABCD$, then the value of x is _____(10, 2012)

Theoretical Solution

In a parallelogram, the diagonals bisect each other. Therefore, the midpoint of diagonal AC equals the midpoint of diagonal BD:

$$\frac{\mathbf{A}+\mathbf{C}}{2} = \frac{\mathbf{B}+\mathbf{D}}{2} \tag{1}$$

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

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

Substituting the coordinates:

$$\begin{pmatrix} x \\ 4 \end{pmatrix} = \begin{pmatrix} 1 \\ 3 \end{pmatrix} + \begin{pmatrix} 2 \\ 5 \end{pmatrix} - \begin{pmatrix} -1 \\ 2 \end{pmatrix} \tag{4}$$

$$= \begin{pmatrix} 1+2-(-1) \\ 3+5-2 \end{pmatrix} \tag{5}$$

$$= \begin{pmatrix} 4 \\ 6 \end{pmatrix} \tag{6}$$

Theoretical Solution

This gives us the equations:

$$x = 4 \tag{7}$$

$$4 = 6 \tag{8}$$

this indicates that the assumption ABCD is a parallelogram with the given order might be incorrect. Perhaps the vertices are not in order A,B,C,DA,B,C,D. Let's try a different pairing.

$$\frac{\mathbf{A}+\mathbf{D}}{2} = \frac{\mathbf{B}+\mathbf{C}}{2} \tag{9}$$

$$\mathbf{A}+\mathbf{D} = \mathbf{B}+\mathbf{C} \tag{10}$$

$$\mathbf{D} = \mathbf{B}+\mathbf{C}-\mathbf{A} \tag{11}$$

Theoretical Solution

Substituting the coordinates:

$$\begin{pmatrix} x \\ 4 \end{pmatrix} = \begin{pmatrix} -1 \\ 2 \end{pmatrix} + \begin{pmatrix} 2 \\ 5 \end{pmatrix} - \begin{pmatrix} 1 \\ 3 \end{pmatrix} \tag{12}$$

$$= \begin{pmatrix} -1+2-(-1) \\ 2+5-3 \end{pmatrix} \tag{13}$$

$$= \begin{pmatrix} 0 \\ 4 \end{pmatrix} \tag{14}$$

This gives us the equations:

$$x = 0 \tag{15}$$

$$4 = 4 \tag{16}$$

Answer: x=0

Main C Code

```c
// main.c
#include <stdio.h>

// function declaration
int find_x(int Ax, int Ay, int Bx, int By, int Cx, int Cy, int Dy
    );

int main() {
    int Ax=1, Ay=3, Bx=-1, By=2, Cx=2, Cy=5, Dy=4;
    int x = find_x(Ax, Ay, Bx, By, Cx, Cy, Dy);

    printf("The value of x is: %d\n", x);
```

Main C Code

```c
// save coordinates to file for Python
    FILE *fp = fopen("coords.dat","w");
    fprintf(fp,"%d %d\n",Ax,Ay);
    fprintf(fp,"%d %d\n",Bx,By);
    fprintf(fp,"%d %d\n",x,Dy);
    fprintf(fp,"%d %d\n",Cx,Cy);
    fclose(fp);

    return 0;
}
```

C Function

```c
// parallelogram.c
#include <stdio.h>

int find_x(int Ax, int Ay, int Bx, int By, int Cx, int Cy, int Dy
    ){
int Dx=Bx+Cx-Ax;

    return Dx;
}
```

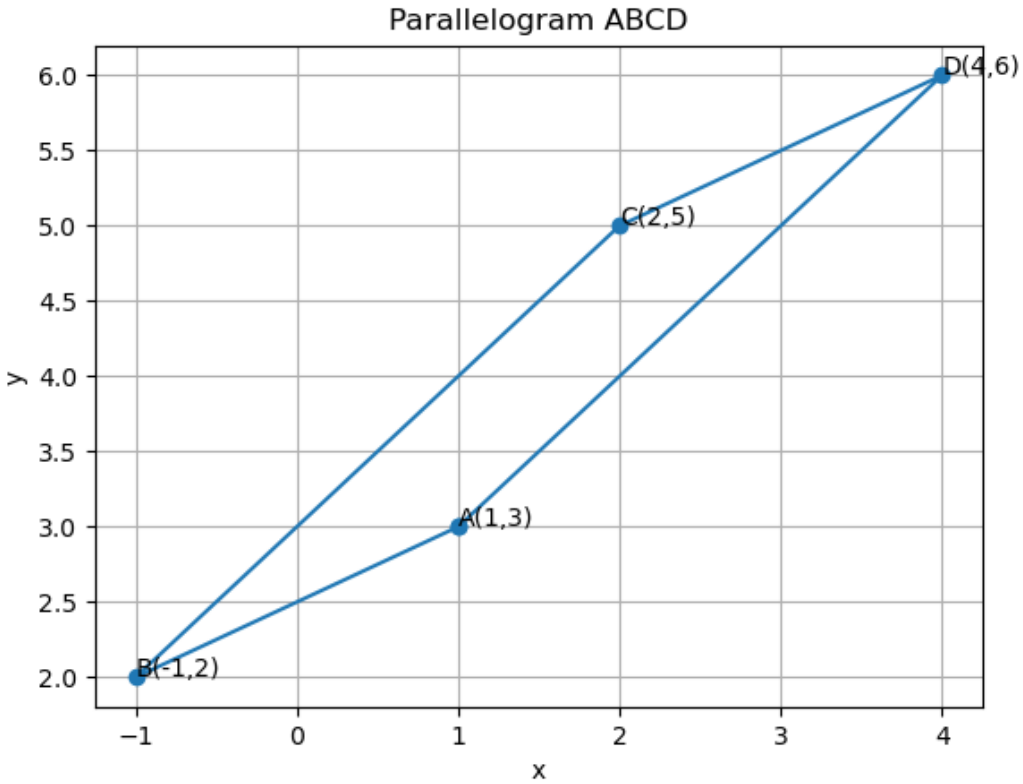
Python Code

```
from ctypes import CDLL
import matplotlib.pyplot as plt

# load shared library
lib = CDLL("./libparallelogram.so")

# run C main program to generate coords.dat
import os
os.system("./main")
# read coords
coords = []
with open("coords.dat") as f:
    for line in f:
        x,y = map(int,line.split())
        coords.append((x,y))

# close polygon
coords.append(coords[0])
```

Python Code

```
# plot
xs, ys = zip(*coords)
plt.plot(xs, ys, marker='o')
plt.text(1,3,"A(1,3)")
plt.text(-1,2,"B(-1,2)")
plt.text(0,4,"D(0,4)")
plt.text(2,5,"C(2,5)")
plt.title("Parallelogram ABCD")
plt.grid(True)
plt.savefig("/home/r-nikhil/ee1030-2025/ai25btech11025/matgeo
    /1.3.4/figs/plotc.png")
plt.show()
```

Plot


Parallelogram ABCD
D(4,6)
C(2,5)
A(1,3)
B(-1,2)
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
y
−1
0
1
2
3
4
x