

Problem 2.7.2

Sarvesh Tamgade

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Question: The area of a triangle with vertices $A(-1,1)$, $B(0,5)$ and $C(3,2)$ is?

Solution

Given: $A(-1, 1)$, $B(0, 5)$, $C(3, 2)$.

$$\mathbf{B} - \mathbf{A} = \begin{pmatrix} 0 - (-1) \\ 5 - 1 \end{pmatrix} = \begin{pmatrix} 1 \\ 4 \end{pmatrix}, \quad \mathbf{C} - \mathbf{A} = \begin{pmatrix} 3 - (-1) \\ 2 - 1 \end{pmatrix} = \begin{pmatrix} 4 \\ 1 \end{pmatrix}.$$

$$\|(\mathbf{B} - \mathbf{A}) \times (\mathbf{C} - \mathbf{A})\| = \left\| \begin{pmatrix} |\mathbf{A}_{23} & \mathbf{B}_{23}| \\ |\mathbf{A}_{31} & \mathbf{B}_{31}| \\ |\mathbf{A}_{12} & \mathbf{B}_{12}| \end{pmatrix} \right\| = 7.5$$

$$\text{Area} = \frac{1}{2} \|(\mathbf{B} - \mathbf{A}) \times (\mathbf{C} - \mathbf{A})\| = 7.5 \text{ Answer:}$$

$$\boxed{\text{Area of Triangle } ABC = 7.5 \text{ sq. units}}$$

$$(3.1)$$

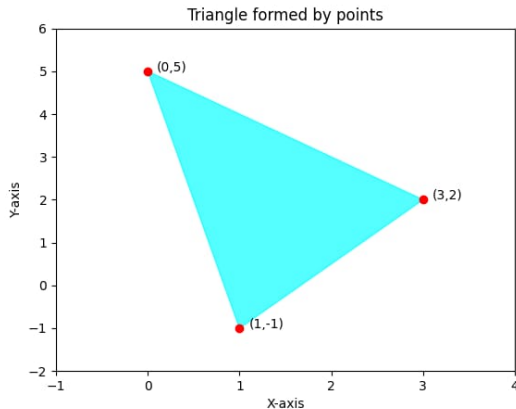


Figure: Vector Representation

C Code

```
#include <stdio.h>
#include <stdlib.h>
#include <math.h>
#ifndef M_PI
#define M_PI 3.14159265358979323846
#endif
#include "matfun.h"

int main(void) {
    // Allocate 2x1 matrices for points
    double **A = createMat(2,1);
    double **B = createMat(2,1);
    double **C = createMat(2,1);

    // Set points: A(-1,1), B(0,5), C(3,2)
    A[0][0] = -1.0; A[1][0] = 1.0;
    B[0][0] = 0.0; B[1][0] = 5.0;
    C[0][0] = 3.0; C[1][0] = 2.0;
```

```
// Vectors B-A and C-A
double **BA = Matsub(B, A, 2, 1);
double **CA = Matsub(C, A, 2, 1);

// Extract components
double BAx = BA[0][0], BAy = BA[1][0];
double CAx = CA[0][0], CAy = CA[1][0];

// Cross product magnitude  $|(B-A) \times (C-A)| = |BAx*CAy - BAy*CAx|$ 
double cp = fabs(BAx*CAy - BAy*CAx);
double area = 0.5 * cp; // Triangle area

// Save to points.dat
FILE *fp = fopen("points.dat", "w");
if (!fp) {
    perror("points.dat");
    freeMat(BA, 2); freeMat(CA, 2);
}
```

```
    freeMat(A, 2); freeMat(B, 2); freeMat(C, 2);
    return 1;
}
fprintf(fp, "# Point_Name X Y\n");
fprintf(fp, "A %.1f %.1f\n", A[0][0], A[1][0]);
fprintf(fp, "B %.1f %.1f\n", B[0][0], B[1][0]);
fprintf(fp, "C %.1f %.1f\n", C[0][0], C[1][0]);
fclose(fp);
printf("Wrote points.dat\n");
printf("Triangle area = %.2f\n", area);

// Clean-up
freeMat(BA, 2); freeMat(CA, 2);
freeMat(A, 2); freeMat(B, 2); freeMat(C, 2);
return 0;
}
```


Python Code for Plotting

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

# Define the three points
points = np.array([[1, -1], [0, 5], [3, 2]])

# Extract x and y coordinates
x = points[:, 0]
y = points[:, 1]

# Plot the points
plt.plot(x, y, 'ro')

# Annotate the points
for i, (xi, yi) in enumerate(points):
    plt.text(xi + 0.1, yi, f'({xi},{yi})')
```


Python Code for Plotting

```
# Draw the triangle by connecting points and closing the loop
triangle = plt.Polygon(points, closed=True, fill=True, color='
cyan', alpha=0.3)
plt.gca().add_patch(triangle)

# Set limits
plt.xlim(min(x)-1, max(x)+1)
plt.ylim(min(y)-1, max(y)+1)

# Title and labels
plt.title('Triangle formed by points')
plt.xlabel('X-axis')
plt.ylabel('Y-axis')

# Save the figure
plt.savefig('triangle_area.png')

plt.show()
```