2.6.18

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Question

Find the area of the region bounded by the triangle whose vertices are $(1, 0)$, $(2, 2)$ and $(3, 1)$.

Variables Used

Variable	Formula
A	$A = \begin{pmatrix} 1 \\ 0 \end{pmatrix}$
B	$B = \begin{pmatrix} 2 \\ 2 \end{pmatrix}$
C	$C = \begin{pmatrix} 3 \\ 1 \end{pmatrix}$

Table: Variables Used

Solution

$$\text{Area of triangle ABC} = \frac{1}{2}\left|(\mathbf{A}-\mathbf{B})\times(\mathbf{A}-\mathbf{C})\right| \tag{1}$$

$$\mathbf{A}-\mathbf{B} = \begin{pmatrix}-1\\0\end{pmatrix} - \begin{pmatrix}1\\3\end{pmatrix} = \begin{pmatrix}-2\\-3\end{pmatrix} \tag{2}$$

$$\mathbf{A}-\mathbf{C} = \begin{pmatrix}-1\\0\end{pmatrix} - \begin{pmatrix}3\\2\end{pmatrix} = \begin{pmatrix}-4\\-2\end{pmatrix} \tag{3}$$

$$(\mathbf{A}-\mathbf{B})\times(\mathbf{A}-\mathbf{C}) = (-2)(-2)-(-3)(-4) = 4-12 = -8 \tag{4}$$

$$\text{Area} = \frac{1}{2}\left|-8\right| = 4 \tag{5}$$

Thus, the area of the triangle is 4.

Python code - Calculating the area of triangle

```
# Triangle Plotting Script
# Author: Dhanush (based on GVV Sharma)
# September 13, 2025
# Draw a triangle, calculate area, and save figure

import sys
import os
import numpy as np
import numpy.linalg as LA
import matplotlib.pyplot as plt

# Add parent folder of 'triangle' and 'line' to Python path
sys.path.insert(0, '/home/harshith-kumar-a/code/CoordGeo')

# Local imports
from triangle.funcs import tri_sides, tri_mid_pt
from line.funcs import dir_vec, norm_vec, line_gen
```

Python code - Calculating the area of triangle

```
# ------------------------
# Triangle vertices (column vectors)
A = np.array([-1, 0]).reshape(-1,1)
B = np.array([1, 3]).reshape(-1,1)
C = np.array([3, 2]).reshape(-1,1)
m1 = dir_vec(A,B)
m2 = dir_vec(B,C)
m3 = dir_vec(C,A)

# Area using cross product
arvec = np.cross(m1[:,0], m3[:,0])
area = 0.5 * LA.norm(arvec)
print(fArea of the triangle: {area:.3f})
```

Python code - Plotting the triangle

```
# Generate points for triangle sides
x_AB = line_gen(A,B)
x_BC = line_gen(B,C)
x_CA = line_gen(C,A)

# Plot triangle sides
plt.plot(x_AB[0,:], x_AB[1,:], 'b', label='AB')
plt.plot(x_BC[0,:], x_BC[1,:], 'g', label='BC')
plt.plot(x_CA[0,:], x_CA[1,:], 'r', label='CA')

# Plot vertices
tri_coords = np.block([[A,B,C]])
plt.scatter(tri_coords[0,:], tri_coords[1,:], color='red')
```

Python code - Plotting the triangle

```
# Annotate vertices
vert_labels = ['A','B','C']
for i, txt in enumerate(vert_labels):
    plt.annotate(txt,
                 (tri_coords[0,i], tri_coords[1,i]),
                 textcoords=offset points,
                 xytext=(0,10),
                 ha='center',
                 fontsize=12, color='blue')
```

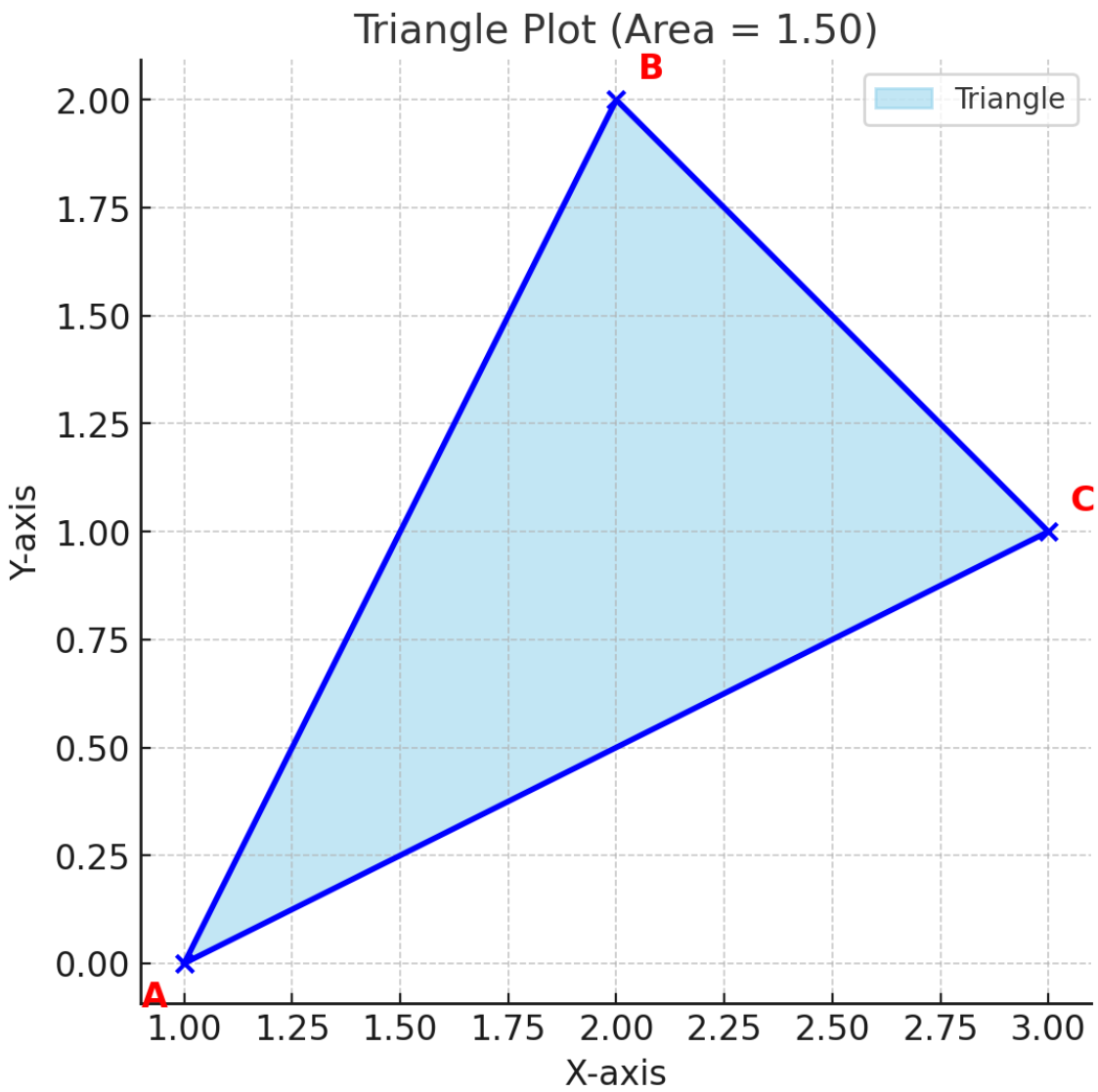
Python code - Plotting the triangle

```
plt.xlabel('X-axis')
plt.ylabel('Y-axis')
plt.title('Triangle Plot')
plt.grid(True)
plt.axis('equal')
plt.legend()

# Save the figure
plt.savefig('../figs/triangle_plot.png', dpi=300)
print(Figure saved as figs/triangle_plot.png)

plt.show()
```

Plot-Using Python



C code - To calculate the area of triangle and Save points

```c
#include <stdio.h>
#include <stdlib.h>
#include <math.h>
#include /home/harshith-kumar-a/ee1030-2025/ai25btech11010/matgeo
    /1.11.12/codes/libs/matfun.h

int main() {
    // Step 1: Create triangle vertices as 2x1 matrices
    double **A = createMat(2,1);
    double **B = createMat(2,1);
    double **C = createMat(2,1);

    A[0][0] = -1; A[1][0] = 0;
    B[0][0] = 1; B[1][0] = 3;
    C[0][0] = 3; C[1][0] = 2;
```

C code - To calculate the area of triangle and Save points

```c
// Step 2: Compute vectors AB and AC using matrix subtraction
double **AB = Matsub(B, A, 2, 1);
double **AC = Matsub(C, A, 2, 1);

// Step 3: Create rotated row vector [AB_y, -AB_x] for cross
    product
double **rotAB = createMat(1,2);
rotAB[0][0] = AB[1][0]; // AB_y
rotAB[0][1] = -AB[0][0]; // -AB_x

// Step 4: Area = 0.5 * |rotAB * AC|
double **prod = Matmul(rotAB, AC, 1, 2, 1); // 1x1 matrix
double area = 0.5 * fabs(prod[0][0]);
```

C code - To calculate the area of triangle and Save points

```c
// Step 5: Save results to files
FILE *fp_points = fopen(points.dat, w);
if(fp_points != NULL){
    fprintf(fp_points, Vertex\tX\tY\n);
    fprintf(fp_points, A\t%.2f\t%.2f\n, A[0][0], A[1][0]);
    fprintf(fp_points, B\t%.2f\t%.2f\n, B[0][0], B[1][0]);
    fprintf(fp_points, C\t%.2f\t%.2f\n, C[0][0], C[1][0]);
    fclose(fp_points);
}

FILE *fp_area = fopen(area.dat, w);
if(fp_area != NULL){
    fprintf(fp_area, %.2f\n, area);
    fclose(fp_area);
}
```

C code - To calculate the area of triangle and Save points

```
    // Step 6: Free memory
    for(int i=0;i<2;i++){
        free(A[i]); free(B[i]); free(C[i]);
        free(AB[i]); free(AC[i]);
    }
    free(A); free(B); free(C);
    free(AB); free(AC);
    free(rotAB[0]); free(rotAB);
    free(prod[0]); free(prod);

    return 0;
}
```

Python code -Ploting the points using c function

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

# Step 1: Compile the C program
os.system(gcc c.c -o triangle -lm)

# Step 2: Run the compiled C program
os.system(./triangle)

# Step 3: Load points data
points_data = np.genfromtxt(points.dat, skip_header=1, dtype=None
    , encoding=utf-8)
labels = [row[0] for row in points_data]
x_vals = np.array([float(row[1]) for row in points_data])
y_vals = np.array([float(row[2]) for row in points_data])
```

Python code -Ploting the points using c function

```
# Step 4: Load area
with open(area.dat) as f:
    area = float(f.read().strip())

# Step 5: Prepare triangle coordinates
triangle_coords = [(x_vals[i], y_vals[i]) for i in range(3)]
triangle_coords.append(triangle_coords[0]) # close the triangle
tx, ty = zip(*triangle_coords)

# Step 6: Plot the triangle
fig, ax = plt.subplots(figsize=(6,6))
ax.plot(tx, ty, 'b-o', label='Triangle')
ax.fill(tx, ty, 'skyblue', alpha=0.3)
```

Python code -Ploting the points using c function

```
# Label points
for i in range(3):
    ax.text(x_vals[i], y_vals[i], f{labels[i]}, fontsize=12,
        color='red')

# Axes formatting
ax.axhline(0, color=black, linewidth=1.0, linestyle=--)
ax.axvline(0, color=black, linewidth=1.0, linestyle=--)
ax.set_aspect(equal)
ax.grid(True)
ax.set_title(fTriangle Plot (Area = {area:.2f}))
plt.legend()
```

Python code -Ploting the points using c function

```
# Step 7: Save and show plot
os.makedirs(../figs, exist_ok=True)
plt.savefig(../figs/triangle_plot.png, dpi=300, bbox_inches=tight
    )
plt.show()
```

Plot-Using Python and C