# Problem 1.5.13

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## Problem Statement

The centroid of a triangle $ABC$ is at the point $\begin{pmatrix} 1 \\ 1 \\ 1 \end{pmatrix}$. If the coordinates of

$A$ and $B$ are $\begin{pmatrix} 3 \\ -5 \\ 7 \end{pmatrix}$ and $\begin{pmatrix} -1 \\ 7 \\ -6 \end{pmatrix}$ respectively, find the coordinates of the

point $C$.

## Vector Setup

Let the position vectors of points $A$, $B$, and $C$ be:

$$\mathbf{A} = \begin{pmatrix} 3 \\ -5 \\ 7 \end{pmatrix}, \quad \mathbf{B} = \begin{pmatrix} -1 \\ 7 \\ -6 \end{pmatrix}, \quad \mathbf{C} = \mathbf{C} \tag{1}$$

The centroid $\mathbf{G}$ of triangle $ABC$ is given by:

$$\mathbf{G} = \frac{1}{3}(\mathbf{A} + \mathbf{B} + \mathbf{C}) \tag{2}$$

## Solving for **C**

Given:

$$\mathbf{G} = \begin{pmatrix} 1 \\ 1 \\ 1 \end{pmatrix} \tag{3}$$

Substitute and solve:

$$\frac{1}{3} \left( \begin{pmatrix} 3 \\ -5 \\ 7 \end{pmatrix} + \begin{pmatrix} -1 \\ 7 \\ -6 \end{pmatrix} + \mathbf{C} \right) = \begin{pmatrix} 1 \\ 1 \\ 1 \end{pmatrix} \tag{4}$$

Add vectors:

$$\frac{1}{3} \left( \begin{pmatrix} 2 \\ 2 \\ 1 \end{pmatrix} + \mathbf{C} \right) = \begin{pmatrix} 1 \\ 1 \\ 1 \end{pmatrix} \tag{5}$$

Multiply both sides by 3:

$$\begin{pmatrix} 2 \\ 2 \\ 1 \end{pmatrix} + \mathbf{C} = \begin{pmatrix} 3 \\ 3 \\ 3 \end{pmatrix} \tag{6}$$

# Solving for **C**

Subtract:

$$\mathbf{C} = \begin{pmatrix} 1 \\ 1 \\ 2 \end{pmatrix} \tag{7}$$

**Therefore, the coordinates of point $C$ are $(1, 1, 2)$.**

# C Function - Centroid Calculation

```c
#include <stdio.h>

void centroid(double* A, double* B,
              double* G, double* C) {
    for (int i = 0; i < 3; i++) {
        C[i] = 3 * G[i] - A[i] - B[i];
    }
}
```

# Python Code - Setup

```python
import ctypes
import numpy as np

lib = ctypes.CDLL("./libcentroid.so")
lib.centroid.argtypes = [
    ctypes.POINTER(ctypes.c_double)
] * 4

A = np.array([3.0, -5.0, 7.0])
B = np.array([-1.0, 7.0, -6.0])
```

# Python Code - Conversion and Call

```python
G = np.array([1.0, 1.0, 1.0])
C = np.zeros(3)

A_ct = A.ctypes.data_as(
    ctypes.POINTER(ctypes.c_double))
B_ct = B.ctypes.data_as(
    ctypes.POINTER(ctypes.c_double))
G_ct = G.ctypes.data_as(
    ctypes.POINTER(ctypes.c_double))
C_ct = C.ctypes.data_as(
    ctypes.POINTER(ctypes.c_double))
```

# Python Code - Output

```
lib.centroid(A_ct, B_ct, G_ct, C_ct)

print("Coordinates of point C:")
print(C)
```
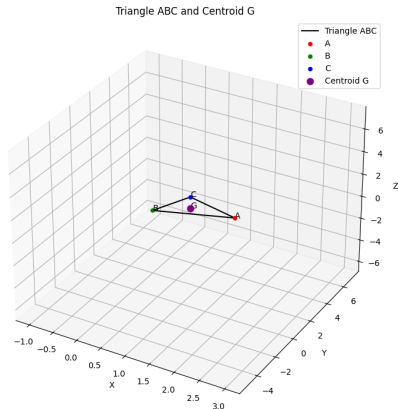
# Plot



Figure: 3D plot of triangle ABC and centroid G