EGR 125 Due date: See course outline
Introduction to Engineering Methods (C++)
File: N125P1E

Programming Assignment #1

Triangle – Circle Geometry

Create a **flowchart** and write a **C++ program** to analyze a triangle along with its inscribed and circumscribed circles. The program should do the following:

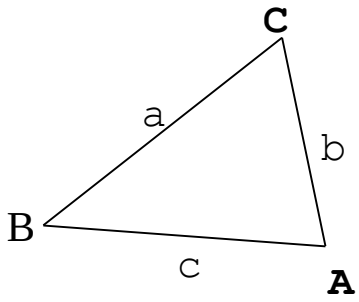
- prompt for the length of the 3 sides of a triangle, and then…
- check to be sure that the three sides entered form a valid triangle.
  For the triangle to be valid, 6 conditions must be met:
  - a > 0, b > 0, c > 0
  - a < b+c, b < a+c, c < a+b
- If any bad inputs are entered, print out an appropriate descriptive error message and terminate the program using the command: ***return 1;*** Bad inputs include invalid triangles, sides, or menu choices.

  For Example:

```
if (Side < 0)
{   cout << "Error.  Negative value for side not allowed.  Program terminated.";
    Return 1;  }
```

- If inputs are valid, the program should provide a menu and prompt for user preference (indicated by a single number or character) of the following options:

Option 1: Find the 3 angles of the triangle, and the triangle area.



Example 1a :

If $a = 20,\ b = 15, c = 10$, then

Find angle A using the law of cosines :

$$a^2 = b^2 + c^2 - 2 \cdot b \cdot c \cdot \cos(A)$$

$$20^2 = 15^2 + 10^2 - 2 \cdot (15) \cdot (10) \cdot \cos(A)$$

$$A = \cos^{-1}\left(\frac{15^2 + 10^2 - 20^2}{2 \cdot (15) \cdot (10)}\right)$$

$$A = 104.48°$$

Find angle B using the law of cosines :

$$b^2 = a^2 + c^2 - 2 \cdot a \cdot c \cdot \cos(B)$$

$$15^2 = 20^2 + 10^2 - 2 \cdot (20) \cdot (10) \cdot \cos(B)$$

$$B = \cos^{-1}\left(\frac{20^2 + 10^2 - 15^2}{2 \cdot (20) \cdot (10)}\right)$$

$$B = 46.57°$$

Find angle C :

$$C = 180 - A - B = 180 - 104.48 - 46.57 = 28.95°$$

Example 1b :

If $a = 20,\ b = 15, c = 10$, then

Find area inside the ΔABC using Heron's Formula :

Where the semi-perimeter, $s = \frac{1}{2}(a + b + c)$

And then triangle Area $= \sqrt{s(s-a)(s-b)(s-c)}$

$$s = \frac{1}{2}(20 + 15 + 10) = 22.5 \quad \text{and then}$$

$$\Delta ABC \text{ Area} = \sqrt{22.5(22.5 - 20)(22.5 - 15)(22.5 - 10)}$$

$$= 72.6184$$

Include the unit ***degrees*** after all angles, but leave the area dimensionless.

Option 2: Find the largest 'incircle' radius, and the remaining interior area of the triangle.

Note: The largest circle inscribed inside a triangle is called an 'incircle', and is tangent to all three sides.

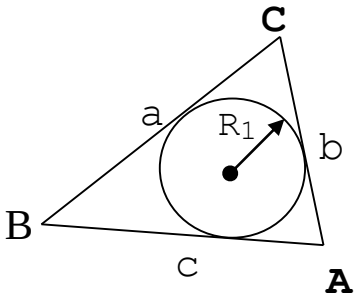
Example 2:

If $a = 20,\ b = 15, c = 10$, then

$$R_1 = \frac{2 * \Delta ABC\ Area}{\Delta ABC\ perimeter} = \frac{2 * 72.6184}{20 + 15 + 10} = 3.2275$$

The area inside the ΔABC, but not inside the incircle is:

$$\text{Remaining Interior Area} = \Delta ABC\ \text{Area} - \text{incircle Area}$$
$$= 72.6184 - \pi (R_1)^2$$
$$= 72.6184 - \pi (3.2275)^2$$
$$= 39.8932$$



Option 3: Find the 'circumcircle' radius, and the remaining interior area of the circumcircle.

Note: The unique circle circumscribed on the outside of a triangle that includes all 3 triangle corners is called a 'circumcircle'.

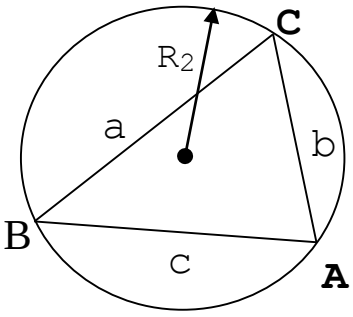
Example 3:

If $a = 20, b = 15, c = 10$, then

$$R_2 = \frac{a \cdot b \cdot c}{\sqrt{(a+b+c)(b+c-a)(c+a-b)(a+b-c)}}$$
$$= \frac{20 \cdot 15 \cdot 10}{\sqrt{(20+15+10)(15+10-20)(10+20-15)(20+15-10)}}$$
$$= 10.328$$

And the area inside the circumcircle, but not inside the triangle is:

$$\text{Remaining Interior Area} = \text{circumcircle area} - \text{triangle area}$$
$$= \pi \cdot (R_2)^2 - 72.6184$$
$$= \pi \cdot (10.328)^2 - 72.6184$$
$$= 262.405$$



Other program requirements:

- Run the program for the following 10 test cases:
  - Option 1: $a = 20,\ b = 15, c = 10$ (correct results shown in examples)
  - Option 2: $a = 20,\ b = 15, c = 10$ (correct results shown in examples)
  - Option 3: $a = 20,\ b = 15, c = 10$ (correct results shown in examples)
  - Option 1: $a = 20,\ b = 15, c = 25$
  - Option 2: $a = 20,\ b = 15, c = 25$
  - Option 3: $a = 20,\ b = 15, c = 25$
  - Option 1: $a = 14,\ b = 15, c = 16$
  - Option 2: $a = 14,\ b = 15, c = 16$
  - Option 3: $a = 14,\ b = 15, c = 16$
  - Enter a bad set of sides, see if error message is produced.

Report:

Follow all guidelines in the document **Format for Programming Projects**, including the flowchart (see Blackboard site).

Extra Credit Suggestions:

You can earn up to 10 additional points on this program's grade. The number of points awarded depends on the complexity or creativity of the feature. Here are a few ideas:

1. If an incorrect entry is made by the user and an error message is displayed, instead of ending the program request that the user re-enter the information. This can be done fairly easily using a ***do while*** loop (covered in Ch. 5).
2. Display a **diagram** of the triangle with angles A, B, C, sides a, b, and c labeled so that it is clearer to the user what should be entered.
3. Include **units** with the sides of the triangle. Allow the user to enter m, ft, or in after the values for sides. Display the same units for the radius, and same units squared for area results.
4. Let the user request either degrees or radians for the angle units.
5. Use your imagination!

Late Assignments:

It is better to turn in an assignment late than to turn it in on time if it isn't working correctly. 10 points are deducted for late assignments. Assignments that are not working have greater penalties.