

Programming Assignment #1

Triangle Solver

Write a C++ program to analyze a variety of triangles. The program should determine all angles and all sides for a triangle for three different options (give the user a menu of choices):

- 1) Given two sides and the angle between
- 2) Given two angles and one side
- 3) Given three sides

More details for each option is provided below.

Option 1: Given two sides and the angle between

First check to be sure that the three values entered are valid. In particular, the following conditions must be met:

- Both sides > 0
- If angle is in degrees, then $0 < \text{angle} < 180$ (if angle is in radians, convert it to degrees first and then check)

Example 1:

If $a = 20$, $b = 15$, $C = 35^\circ$, then

Find side c using the law of cosines :

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

$$c^2 = 20^2 + 15^2 - 2 \cdot (20) \cdot (15) \cdot \cos(35^\circ)$$

$$c = 11.55$$

Find angle B using the law of cosines again :

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

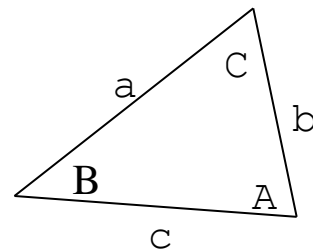
$$15^2 = 20^2 + 11.55^2 - 2 \cdot (20) \cdot (11.55) \cdot \cos(B)$$

$$B = \cos^{-1} \left(\frac{20^2 + 11.55^2 - 15^2}{2 \cdot (20) \cdot (11.55)} \right)$$

$$B = 48.12^\circ$$

Find angle A :

$$A = 180 - B - C = 180 - 48.12 - 35 = 96.88^\circ$$



Option 2: Given two angles and one side

First check to be sure that the three values entered are valid. In particular, the following conditions must be met:

- Side > 0
- For each angle: $0 < \text{angle} < 180$ (if angle is in radians, convert it to degrees first and then check)
- For the sum of the two angles entered: $0 < \text{Sum} < 180$ (if angles are in radians, convert them to degrees first and then check)

Example 2 :

If $A = 30^\circ$, $B = 100^\circ$, and $a = 20$, then

Find the remaining angle :

$$C = 180 - 30 - 100 = 50^\circ$$

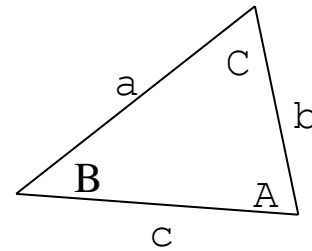
Find the two remaining sides using the law of sines :

$$\frac{\sin(A)}{a} = \frac{\sin(B)}{b} = \frac{\sin(C)}{c}$$

$$\frac{\sin(30^\circ)}{20} = \frac{\sin(100^\circ)}{b} = \frac{\sin(50^\circ)}{c}$$

$$\text{so } b = \frac{a \cdot \sin(B)}{\sin(A)} = \frac{20 \sin(100^\circ)}{\sin(30^\circ)} = 39.39$$

$$\text{and } c = \frac{a \cdot \sin(C)}{\sin(A)} = \frac{20 \sin(50^\circ)}{\sin(30^\circ)} = 30.64$$



Option 3: Given three sides

First check to be sure that the three sides entered form a valid triangle. For the triangle to be valid, 6 conditions must be met:

- $a > 0$, $b > 0$, $c > 0$
- $a < b + c$, $b < a + c$, $c < a + b$

Example 3 :

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

Find angle A using the law of cosines :

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

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

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

$$A = 104.48^\circ$$

Find angle B using the law of cosines :

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

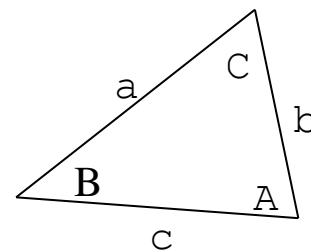
$$15^2 = 20^2 + 10^2 - 2 \cdot (20) \cdot (10) \cdot \cos(B)$$

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

$$B = 46.57^\circ$$

Find angle C :

$$C = 180 - A - B = 180 - 104.48 - 46.57 = 28.95^\circ$$



Other program requirements:

- The user should be able to indicate whether an angle is being entered in degrees or in radians by entering either d or D for degrees or entering r or R for radians. Examples:
 - Please enter the angle: 30 d
 - Please enter the angle: 30 D
 - Please enter the angle: 1.5 r
 - Please enter the angle: 1.5 R
- If any bad inputs are entered, print out an appropriate error message and terminate the program using the command: ***return 1;***
Bad inputs include invalid triangles, invalid menu choices, and invalid units for angles.
 - Example:

```
if (Side < 0)
{
    cout << "Error. Negative value for side not allowed. Program terminated.";
    Return 1;
}
```
- After performing the calculations for any of the three menu choices, display the values for all three sides and all three angles (in degrees).
 - Use 2 digits after the decimal point for all angles.
 - Use 3 digits after the decimal point for all sides.
 - Include the unit ***degrees*** after all angles.
 - No units are required for the sides.
- Note that for option 2, the calculations are different based on which side is entered. Ask the user to enter angles A and B, and then ask the user which side that they would like to enter (a, b, or c). Perform the appropriate calculations in each case.
- Run the program for the following 7 test cases:
 - Option 1: a = 20, b = 15, C = 35° (see Example 1)
 - Option 1: a = 20, b = 15, C = 0.5 radians
 - Option 2: A = 30°, B = 100°, and a = 20 (see Example 2)
 - Option 2: A = 30°, B = 100°, and b = 20
 - Option 2: A = 30°, B = 100°, and c = 20
 - Option 3: a = 20, b = 15, c = 10 (see Example 3)
 - Option 3: a = 5, b = 12, c = 13

Report:

Follow all guidelines in the document [Format for Programming Projects](#) (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, display an error message and request that the user re-enter the information. This can be done fairly easily using a **do while loop** (covered in Ch. 6).
2. Display a diagram of the triangle with A, B, C, 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 with the results.
4. 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 are generally not accepted more than two weeks late.