**Requirements**

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Purpose

The purpose of this program is to receive the required input for sides or angles of a triangle and solves the rest of the triangle.

First the user will be prompted to enter information about the triangle. Once the program has determined that it has the required amount of information, it will stop prompting and solve the rest of the triangle.

In order to solve for the third angle given two angles:



In order to solve for an angle given three sides:



In order to solve for a side, given 2 sides and the angle in between:



In order to solve for an angle given its opposite side, another angle and the opposite side to that angle:



In order to solve for a side given its opposite angle, another side and the opposite angle to that side:



The program then offers the user with the options to calculate and output perimeter and area as well as to enter a completely new triangle with new specifications should the user choose to do so.

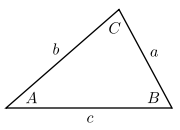
Requirements List:

1. An Object called Triangle which defines the triangles through double side lengths and integer angles
2. The object’s instance fields are encapsulated
3. Accessor and Mutator Methods for each instance field
4. Constructors to create an object of type triangle according to what combination of sides and angles the user enters
5. Object will also contain instance methods to calculate other side lengths and angles, and class methods to calculate area and perimeter
6. A main program which will prompt the user to enter values for fields of a triangle
   1. The user has the ability to choose which field they can enter in any order they choose
7. The main program will use the object to determine if it has received enough information
8. Once enough information has been entered, the program will run the required instance methods to determine the rest of the triangle.
9. The user must have enough general knowledge about the properties of a triangle (i.e. the largest angle is opposite to the largest side, the ambiguous case, sine and cosine law, etc.).

Measurable Goals and Test Cases:

**Prototypes and Mock-Ups:**

In order to create a triangle to match the user’s specifications, several combinations of information can be entered.



For all cases use the following triangle as a visual:

In order to solve the triangle to the user’s specifications, the user needs to enter some information about the triangle. There are several combinations of fields the user can enter. The following are the different combinations:

1. SSS

* Inputs:
  + a, b, c
  + b, c, a
  + c, a, b
  + c, b, a
  + b, a, c
  + a, c, b

1. SAS

* Inputs:
  + a, B, c
  + b, A, c
  + a, C, b
  + etc.

1. ASA

* Inputs:
  + A, b, C
  + B, a, C
  + A, c, B
  + etc.

1. ASS/SSA

* Inputs:
  + a, b, A
  + b, a, B
  + b, c, B
  + c, b, C
  + a, c, A
  + c, a, C
  + etc.

1. AAS/SAA

* Inputs:
  + A, B, a
  + B, A, b
  + B, C, b
  + C, B, c
  + A, C, a
  + C, A, c
  + etc.

**User Interface:**

**Step 1:**

The user will be asked what they would like to enter with the following prompt:

What would you like to enter, side or angle? (S for side and A for angle):

**Step 2:**

The user will then be prompted which side or angle they would like to enter. The prompt will appear as such:

**Case 1 (User chooses side):**

Which side would you like to enter? (Enter a, b, or c):

**Case 2 (User chooses angle):**

Which angle would you like to enter? (Enter A, B, or C):

**Step 3:**

The user will be further prompted for the value:

**Case 1 (User chooses side):**

Enter length of side:

**Case 2 (User chooses angle):**

Enter size of angle:

**Step 4:**

Steps 1, 2 and 3 will now repeat until one of the conditions listed in *Prototypes and Mock-Ups*  is met.

The above method of prompting the user will be successful because by first choosing whether the user wants to enter a side or angle, and then entering a specific side or angle, the variability within cases is eliminated. For example, if the user chooses to enter side *a* first, and angle *C* as the second input, then *case 1* is eliminated. Furthermore, if the user enters an angle as the third input then *case 2* and *case 4* are eliminated. Depending on which angle the user now enters, will determine whether how this scenario is treated. For example, if the user enters angle *B*, then the problem will be treated as a side between two angle case, and its respective instance method will run. If the user enters angle *A,* then the problem will be categorized into *case 5* and its respective instance method will run.

**Step 5:**

A menu will now be displayed to the user. This menu will appear as such:

MENU

1) Return specifications

2) Output perimeter

3) Output area

4) Change attributes

Enter an option:

**Step 5:**

In the case where the user enters option 1, the following information will be displayed:

Triangle ABC:

Side a: a units

Side b: b units

Side c: c units

Angle A: A degrees

Angle B: B degrees

Angle C: C degrees

**Step 6:**

In the case where the user enters option 2, the following information will be displayed:

The perimeter of triangle ABC is p units.

**Step 7:**

In the case where the user enters option 3, the following information will be displayed:

The area of triangle ABC is area units squared.

**Step 8:**

In the case where the user enters option 4, the current attributes will be eliminated (by being set to **null)and s**teps 1 – 3 will repeat.

**Ambiguous Case:**

Should the user enter data that results in an ambiguity, the prompts from *Steps 5* – 8 will appear as such:

**Step 4:**

A menu will be displayed to the user. This menu will appear as such:

MENU

1) Return specifications

2) Output perimeter

3) Output area

4) Change attributes

\*WARNING\*

Ambiguous Case

Enter an option:

**Step 5:**

In the case where the user enters option 1, the following information will be displayed:

\*Note: There are two separate solutions for the two different triangles.

Triangle ABC:

Solution 1:

Side a: a units

Side b: b units

Side c: c units

Angle A: A degrees

Angle B: B degrees

Angle C: C degrees

Solution 2:

Side a: a units

Side b: b units

Side c: c units

Angle A: A degrees

Angle B: B degrees

Angle C: C degrees

**Step 6:**

In the case where the user enters option 2, the following information will be displayed:

\*Note: Solution 1 will be the larger triangle and Solution 2 will be the smaller triangle.

The perimeter of the larger triangle ABC is p units.

The perimeter of the smaller triangle ABC is p units.

**Step 7:**

In the case where the user enters option 3, the following information will be displayed:

\*Note: Solution 1 will be the larger triangle and Solution 2 will be the smaller triangle.

The area of the larger triangle ABC is a units squared.

The area of the smaller triangle ABC is a units squared.

**Step 8:**

In the case where the user enters option 4, the current attributes will be eliminated (by being set to **null)and s**teps 1 – 3 will repeat.

**Error/Restart Program:**

As soon as the user enters incorrect data, an error message will be outputted according to the type of error, there are three cases.

**Case 1 (Negative Side Length)**

**Case 2 (Angle Out of Range)**

**Case 3 (The Sum of Two Side Lengths is Less Than or equal to the length of the Third Side)**

**Case 4 (Ambiguous Case of Sine Law where there are no solutions)**

* a<bsinA

**Case 5 (The Sum of Three Angles are greater than 180o)**

For all above cases, the program will output:

A triangle cannot be constructed based on these specifications.

Reinitializing...Complete

**Error/Restart Program:**

Should the user enter option 4 from the menu, the program will reset all fields and then output:

Reinitializing...Complete

Quality Standards and Constraints:

**Error Checking:**

When the user enters data, error checks will be run throughout the program to ensure the triangle entered is constructible. There are two types of errors to check, one involving sides and the other involving angles.

**Case 1: Sides**

In the case that all three sides are entered, an error check will be made to ensure that the sum of any two sides is greater than the third. If this were to the case, then the input process will reset and the user will be prompted to re-enter the data.

**Case 2: Angle**

There are two different error checks that need to be made in the case of an incompatible angle being entered.

If the user enters an angle that is greater the 179˚, an error will occur because such a triangle is impossible to construct due to the limitation of the type variable used to hold angles, which is an integer. If such a case were to arise, then the user will be re-prompted to enter a more logical angle.

If the user enters two angle and they are both greater than 90˚, an error will occur because it is impossible for a triangle to have two obtuse angles. If such a case were to arise, then the user will be re-prompted to enter a different pair of angles.

Test Cases:

|  |  |  |
| --- | --- | --- |
| Case # | Input | Output |
| 1(SSS) | S  a  5  S  b  10  S  c  7  1  2  3 | What would you like to enter, side or angle? (S for side and A for angle):  Which side would you like to enter? (Enter a, b, or c):  Enter length of side:  What would you like to enter, side or angle? (S for side and A for angle):  Which side would you like to enter? (Enter a, b, or c):  Enter length of side:  What would you like to enter, side or angle? (S for side and A for angle):  Which side would you like to enter? (Enter a, b, or c):  Enter length of side:  MENU  1) Return specifications  2) Output perimeter  3) Output area  4) Change attributes  Enter an option:  Triangle ABC:  Side a: 5.0 units  Side b: 10.0 units  Side c: 7.0 units  Angle A: 28 degrees  Angle B: 112 degrees  Angle C: 40 degrees  Enter an option:  The perimeter of triangle ABC is 22.0 units.  Enter an option:  The area of triangle ABC is 16.24 units squared. |
| 2 (SSS where sum of two sides equals the third) | S  a  17  S  b  10  S  c  7 | What would you like to enter, side or angle? (S for side and A for angle):  Which side would you like to enter? (Enter a, b, or c):  Enter length of side:  What would you like to enter, side or angle? (S for side and A for angle):  Which side would you like to enter? (Enter a, b, or c):  Enter length of side:  What would you like to enter, side or angle? (S for side and A for angle):  Which side would you like to enter? (Enter a, b, or c):  Enter length of side:  A triangle cannot be constructed based on these specifications.  Reinitializing...Complete  What would you like to enter, side or angle? (S for side and A for angle): |
| 3 (SAA) | A  A  67  A  C  72  S  c  7  1  2  3 | What would you like to enter, side or angle? (S for side and A for angle):  Which angle would you like to enter? (Enter A, B, or C):    Enter size of angle:  What would you like to enter, side or angle? (S for side and A for angle):  Which angle would you like to enter? (Enter A, B, or C):  Enter size of angle:  What would you like to enter, side or angle? (S for side and A for angle):  Which side would you like to enter? (Enter a, b, or c):  Enter length of side:  MENU  1) Return specifications  2) Output perimeter  3) Output area  4) Change attributes  Enter an option:  Triangle ABC:  Side a: 6.8 units  Side b: 4.8 units  Side c: 7 units  Angle A: 67 degrees  Angle B: 41 degrees  Angle C: 72 degrees  Enter an option:  The perimeter of triangle ABC is 18.6 units.  Enter an option:  The area of triangle ABC is 15.6 units squared. |
| 4 (ASA) | A  B  59  S  A  13  A  C  43  1  2  3 | What would you like to enter, side or angle? (S for side and A for angle):  Which angle would you like to enter? (Enter A, B, or C):    Enter size of angle:  What would you like to enter, side or angle? (S for side and A for angle):  Which side would you like to enter? (Enter a, b, or c):  Enter length of side:  What would you like to enter, side or angle? (S for side and A for angle):  Which angle would you like to enter? (Enter A, B, or C):  Enter size of angle:  MENU  1) Return specifications  2) Output perimeter  3) Output area  4) Change attributes  Enter an option:  Triangle ABC:  Side a: 13.0 units  Side b: 11.4 units  Side c: 9.1 units  Angle A: 78 degrees  Angle B: 59 degrees  Angle C: 43 degrees  Enter an option:  The perimeter of triangle ABC is 33.5 units.  Enter an option:  The area of triangle ABC is 50.5 units squared. |
| 5 (SAS) | S  a  18  A  B  49  S  c  4  1  2  3 | What would you like to enter, side or angle? (S for side and A for angle):  Which side would you like to enter? (Enter a, b, or c):  Enter length of side:  What would you like to enter, side or angle? (S for side and A for angle):  Which angle would you like to enter? (Enter A, B, or C):    Enter size of angle:  What would you like to enter, side or angle? (S for side and A for angle):  Which side would you like to enter? (Enter a, b, or c):  Enter length of side:  MENU  1) Return specifications  2) Output perimeter  3) Output area  4) Change attributes  Enter an option:  Triangle ABC:  Side a: 18 units  Side b: 15.7 units  Side c: 4 units  Angle A: 120 degrees  Angle B: 49 degrees  Angle C: 11 degrees  Enter an option:  The perimeter of triangle ABC is 37.7 units.  Enter an option:  The area of triangle ABC is 27.2 units squared. |
| 6 (SSA) (1 solution) | S  a  20  S  c  16  A  A  30  1  2  3 | What would you like to enter, side or angle? (S for side and A for angle):  Which side would you like to enter? (Enter a, b, or c):  Enter length of side:  What would you like to enter, side or angle? (S for side and A for angle):  Which side would you like to enter? (Enter a, b, or c):  Enter length of side:  What would you like to enter, side or angle? (S for side and A for angle):  Which angle would you like to enter? (Enter A, B, or C):    Enter size of angle:  MENU  1) Return specifications  2) Output perimeter  3) Output area  4) Change attributes  Enter an option:  Triangle ABC:  Side a: 20 units  Side b: 32.2 units  Side c: 16 units  Angle A: 30 degrees  Angle B: 126 degrees  Angle C: 24 degrees  Enter an option:  The perimeter of triangle ABC is 68.4 units.  Enter an option:  The area of triangle ABC is 128.7 units squared. |
| 7 (SSA) (2 solution and re-entering values) | S  a  10  S  b  16  A  A  30  1  2  3  4  S  a  20  S  c  16  A  A  30  1  2  3 | What would you like to enter, side or angle? (S for side and A for angle):  Which side would you like to enter? (Enter a, b, or c):  Enter length of side:  What would you like to enter, side or angle? (S for side and A for angle):  Which side would you like to enter? (Enter a, b, or c):  Enter length of side:  What would you like to enter, side or angle? (S for side and A for angle):  Which angle would you like to enter? (Enter A, B, or C):    Enter size of angle:  MENU  1) Return specifications  2) Output perimeter  3) Output area  4) Change attributes  \*WARNING\*  Ambiguous Case  Enter an option:  Triangle ABC:  Solution 1:  Side a: 10.0 units  Side b: 16.0 units  Side c: 19.9 units  Angle A: 30 degrees  Angle B: 53 degrees  Angle C: 97 degrees  Solution 2:  Side a: 10.0 units  Side b: 16.0 units  Side c: 7.9 units  Angle A: 30 degrees  Angle B: 127 degrees  Angle C: 23 degrees  Enter an option:  The perimeter of the larger triangle ABC is 45.9 units.  The perimeter of the smaller triangle ABC is 33.9 units.  Enter an option:  The area of the larger triangle ABC is 79.4 units squared.  The area of the smaller triangle ABC is 31.4 units squared.  Enter an option:  Reinitializing...Complete  What would you like to enter, side or angle? (S for side and A for angle):  Which side would you like to enter? (Enter a, b, or c):  Enter length of side:  What would you like to enter, side or angle? (S for side and A for angle):  Which side would you like to enter? (Enter a, b, or c):  Enter length of side:  What would you like to enter, side or angle? (S for side and A for angle):  Which angle would you like to enter? (Enter A, B, or C):    Enter size of angle:  MENU  1) Return specifications  2) Output perimeter  3) Output area  4) Change attributes  Enter an option:  Triangle ABC:  Side a: 20 units  Side b: 32.2 units  Side c: 16 units  Angle A: 30 degrees  Angle B: 126 degrees  Angle C: 24 degrees  Enter an option:  The perimeter of triangle ABC is 68.4 units.  Enter an option:  The area of triangle ABC is 128.7 units squared. |
| 8 (Right Angle Triangle) | S  a  7  S  c  3  A  B  90  1  2  3 | What would you like to enter, side or angle? (S for side and A for angle):  Which side would you like to enter? (Enter a, b, or c):  Enter length of side:  What would you like to enter, side or angle? (S for side and A for angle):  Which side would you like to enter? (Enter a, b, or c):  Enter length of side:  What would you like to enter, side or angle? (S for side and A for angle):  Which angle would you like to enter? (Enter A, B, or C):    Enter size of angle:  MENU  1) Return specifications  2) Output perimeter  3) Output area  4) Change attributes  Enter an option:  Triangle ABC:  Side a: 7 units  Side b: 7.6 units  Side c: 3 units  Angle A: 67 degrees  Angle B: 90 degrees  Angle C: 23 degrees  Enter an option:  The perimeter of triangle ABC is 17.6 units.  Enter an option:  The area of triangle ABC is 10.5 units squared. |
| 9 (ASA with 2 90o angles) | S  a  7  A  C  90  A  B  90 | What would you like to enter, side or angle? (S for side and A for angle):  Which side would you like to enter? (Enter a, b, or c):  Enter length of side:  What would you like to enter, side or angle? (S for side and A for angle):  Which angle would you like to enter? (Enter A, B, or C):    Enter size of angle:  What would you like to enter, side or angle? (S for side and A for angle):  Which angle would you like to enter? (Enter A, B, or C):    Enter size of angle:  A triangle cannot be constructed based on these specifications.  Reinitializing...Complete  What would you like to enter, side or angle? (S for side and A for angle): |
| 10 (ASA with 2 Obtuse Angles) | S  a  8  A  C  102  A  B  112 | What would you like to enter, side or angle? (S for side and A for angle):  Which side would you like to enter? (Enter a, b, or c):  Enter length of side:  What would you like to enter, side or angle? (S for side and A for angle):  Which angle would you like to enter? (Enter A, B, or C):    Enter size of angle:  What would you like to enter, side or angle? (S for side and A for angle):  Which angle would you like to enter? (Enter A, B, or C):    Enter size of angle:  A triangle cannot be constructed based on these specifications.  Reinitializing...Complete  What would you like to enter, side or angle? (S for side and A for angle): |
| 11 (Negative Side) | S  a  -7  S  c  3  A  B  90 | What would you like to enter, side or angle? (S for side and A for angle):  Which side would you like to enter? (Enter a, b, or c):  Enter length of side:  What would you like to enter, side or angle? (S for side and A for angle):  Which side would you like to enter? (Enter a, b, or c):  Enter length of side:  What would you like to enter, side or angle? (S for side and A for angle):  Which angle would you like to enter? (Enter A, B, or C):    Enter size of angle:  A triangle cannot be constructed based on these specifications.  Reinitializing...Complete  What would you like to enter, side or angle? (S for side and A for angle): |
| 12 (Angle out of Range) | S  a  7  S  c  3  A  B  185 | What would you like to enter, side or angle? (S for side and A for angle):  Which side would you like to enter? (Enter a, b, or c):  Enter length of side:  What would you like to enter, side or angle? (S for side and A for angle):  Which side would you like to enter? (Enter a, b, or c):  Enter length of side:  What would you like to enter, side or angle? (S for side and A for angle):  Which angle would you like to enter? (Enter A, B, or C):    Enter size of angle:  A triangle cannot be constructed based on these specifications.  Reinitializing...Complete  What would you like to enter, side or angle? (S for side and A for angle): |
| 13 (SSA with no solutions) | S  a  7  S  c  3  A  A  30 | What would you like to enter, side or angle? (S for side and A for angle):  Which side would you like to enter? (Enter a, b, or c):  Enter length of side:  What would you like to enter, side or angle? (S for side and A for angle):  Which side would you like to enter? (Enter a, b, or c):  Enter length of side:  What would you like to enter, side or angle? (S for side and A for angle):  Which angle would you like to enter? (Enter A, B, or C):    Enter size of angle:  A triangle cannot be constructed based on these specifications.  Reinitializing...Complete  What would you like to enter, side or angle? (S for side and A for angle): |

Questions:

1. **How many different ways can a user enter information?**

The user can enter information in any combination of three values, so as long as they are valid and meet the specifications of any of the 5 cases , and are error-free. Also, in order to broaden the range of user input, the user will be asked exactly which side or angle they would like to enter.

1. **What fields should be created? Why should they be private? How do we access them?**

According to constructs of what defines a triangle, and the purposes of this assignment, only six fields must be created. Three of these fields are created in order to store the length of the three sides of a triangle, of type *double*, and will be represented by the names: *a*, *b*, and *c*. The other three fields are created in order to store the value of the three angles of a triangle, of type *integer*, and will be represented by the names: *A*, *B*, and *C*. The fields must be private, so that the user cannot access them directly. By encapsulating the fields, the user will not have the ability to input illogical data, and this will ensure that the fields remain a certain way. For example, the user will not be able to store a value of zero for any of the side lengths. Lastly, the fields will be accessed through *accessor* methods and can be changed through *mutator* methods, which will contain an error check before the value of the field is changed.

1. **How many constructor methods will you need?**

One constructor method will be needed for each case, hence a total of 5 constructor methods (SSS, SAS, ASA, AAS/SAA, or SSA/ASS).

1. **What instance methods should be created? What purpose will these serve?**

Instance methods should be created for each case, because they involve slightly different approaches to solving the triangle. Other instance methods must be created in order to calculate area, calculate perimeter and display the contents of each field in the class. The main purpose that most of these instance methods is to perform the many trigonometric calculations needed to solve the triangle.

1. **Why should error checking be done using instance methods and not the main program?**

Error checking must be done using instance methods and not in the main program because the error checking must be done at the object level. This is because the error check is done only to the information that is stored in the fields within the class method, and therefore only applies to the class, not the main program.