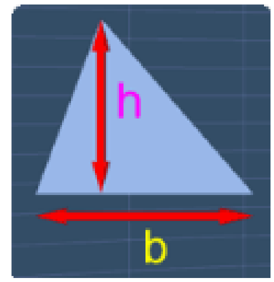
Elgienbert Rafferty A. Corey
BS-CpE/2A

Initial Requirements for CpE1130 Mini-Project

General Formula for the Area of a Triangle

The area of a triangle, when the height is perpendicular to the base, is:



$$A = \frac{1}{2}bh$$

Where:
A = Area of a triangle (in units squared)
b = Base of the triangle
h = Height of the triangle

Sample Problems:

1. Find the area of the triangle when its base is 5 cm and the height is 3 cm.

Given:
b = 5 cm
h = 3 cm

Required:
Area of the triangle.

Solution:

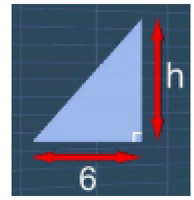
$$A = \frac{1}{2}bh$$

$$A = \frac{1}{2}(5)(4)$$

$$A = \frac{1}{2}(20)$$

$$A = 10\ cm^2$$

2. The area of this triangle is 24 ft^2 and the base is 6 ft. Find the height.



Given:
b = 5 cm
h = 3 cm

Required:
Height of the triangle.

Solution:

$$A = \frac{1}{2}bh$$

$$24 = \frac{1}{\cancel{2}}(\overset{3}{\cancel{6}})h$$

$$\frac{24}{3} = \frac{\cancel{3}h}{\cancel{3}}$$

$$8\,ft = h$$

3. Find the area of the triangle when its base is 5 cm and the height is 3 cm.

Given:
b = 3 cm
h = 4 cm

Required:
Area of the triangle.

Solution:

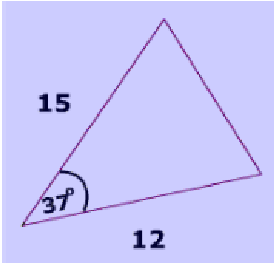
$$A = \frac{1}{2}bh$$

$$A = \frac{1}{2}(3)(4)$$
$$A = \frac{1}{2}(12)$$
$$A = 6\ cm^2$$

Side-Angle-Side (SAS) Formula

It is another way of finding the area of the triangle when an angle and two sides are known. Unlike the general formula for the area of the triangle, it is not limited to the height being perpendicular to the base. Make sure your calculator is in degree mode.

The area of the triangle using the SAS formula is:

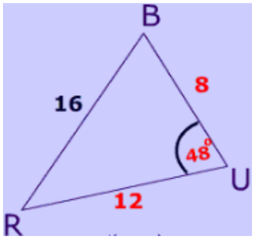


$$A = \frac{1}{2}cb\ sin\ \theta$$

Where:
A = Area of a triangle (in units squared)
b = Base/Side №1 of the triangle, at the bottom of the angle
c = Side №2 of the triangle, at the top of the angle
θ= Angle/Included Angle/Angle sandwiched between two given sides

Sample Problems:

1. Find the area of the triangle when it has an angle of 48^o sandwiched between the sides of 8 and 12.



Given:
b = 12
c = 8
θ= 48^o

Required:
Area of the triangle.

Solution:

$$A = \frac{1}{2} cb \sin \theta$$

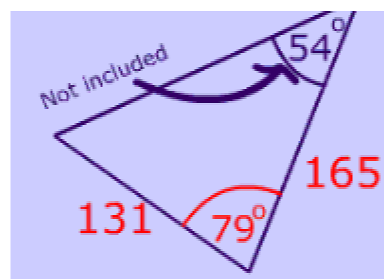
$$A = \frac{1}{2}(8)(12) \sin 48^o$$

$$A = \frac{1}{\cancel{2}}(\cancelto{48}{96}) \sin 48^o$$

$$A = 48 \sin 48^o$$

$$A = 3.567$$

2. Find the area of the triangle.



Given:
b = 131
c = 165
θ= 79°

54° is not used because it is not sandwiched between the known two sides. We only need the included angle.

Required:
Area of the triangle.

Solution:

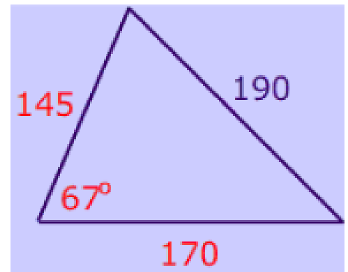
$$A = \frac{1}{2} cb \sin \theta$$

$$A = \frac{1}{2}(131)(165) \sin 79^o$$

$$A = \frac{1}{2}(21615)\ sin\ 79^o$$

$$A = 10{,}608.9$$

3. Find the area of the triangle.



Given:
b = 145
c = 170
θ= 67°

190 is not used because we only need the sides that has the included angle.

Required:
Area of the triangle.

Solution:

$$A = \frac{1}{2}cb\ sin\ \theta$$

$$A = \frac{1}{2}(145)(170)\ sin\ 67^o$$

12325

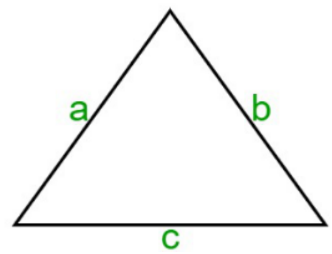
$$A = \frac{1}{\cancel{2}}(\cancel{24650})\ sin\ 67^o$$

$$A = 12325\ sin\ 67^o$$

$$A = 11{,}411.96$$

Heron's Formula

It is another way of calculating the area of the triangle where the length of all three sides is known. There is no need to find the angle nor other distances.



The area of the triangle using Heron's Formula is:

$$A = \sqrt{s(s-a)(s-b)(s-c)}$$

Where:

A = Area of a triangle (in units squared)

a = Side №1 of the triangle

b = Side №2 of the triangle

c = Side №3 of the triangle

s = semi-perimeter of the triangle, equivalent to:

$$s = \frac{a+b+c}{2}$$

Sample Problems:

1. Let ΔABC be the triangle with sides a = 4, b = 13, and c = 15. Find the area of the triangle.

Given:

a = 4

b = 13

c = 15

Required:

Area of the triangle.

Solution:

Find the semi-perimeter first.

$$s = \frac{a + b + c}{2}$$

$$s = \frac{4 + 13 + 15}{2}$$

$$s = \frac{32}{2}$$

$$s = 16$$

Now solving for the area:

$$A = \sqrt{s(s-a)(s-b)(s-c)}$$

$$A = \sqrt{16\,(16-4)(16-13)(16-15)}$$

$$A = \sqrt{16\,(12)(3)(1)}$$

$$A = \sqrt{576}$$

$$A = 24$$

2. Use Heron's formula to find the area of a triangle of lengths 2, 3, and 3.

Given:
a = 2
b = 3
c = 3

Required:
Area of the triangle.

Solution:
Find the semi-perimeter first.

$$s = \frac{a+b+c}{2}$$

$$s = \frac{2+3+3}{2}$$

$$s = \frac{8}{2}$$
$$s = 4$$

Now solving for the area:

$$A = \sqrt{s(s-a)(s-b)(s-c)}$$
$$A = \sqrt{4\ (4-2)(4-3)(4-3)}$$
$$A = \sqrt{4\ (2)(1)(1)}$$
$$A = \sqrt{8}$$
$$A = 2\sqrt{2}$$
$$A = 2.83$$

3. Let ΔABCbe the triangle with sides a = 7, b = 8, and c = 9. Find the area of the triangle.

Given:
a = 7
b = 8
c = 9

Required:
Area of the triangle.

Solution:
Find the semi-perimeter first.

$$s = \frac{a+b+c}{2}$$

$$s = \frac{7 + 8 + 9}{2}$$

$$s = \frac{24}{2}$$

$$s = 12$$

Now solving for the area:

$$A = \sqrt{s(s - a)(s - b)(s - c)}$$

$$A = \sqrt{12\,(12 - 7)(12 - 8)(12 - 9)}$$

$$A = \sqrt{12\,(5)(4)(3)}$$

$$A = \sqrt{720}$$

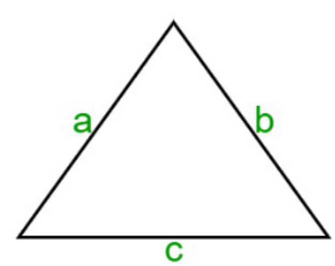
$$A = 12\sqrt{5}$$

$$A = 26.83$$

The formula for the Perimeter of a Triangle
The summation of the three sides of a triangle is the perimeter of the triangle..

The perimeter of a triangle is:

$$P = a + b + c$$



Where:
P = Perimeter of the triangle
a = Side №1 of the triangle
b = Side №2 of the triangle

c = Side №3 of the triangle

Sample Problems:

1. Find the perimeter of a 3-gon whose sides are 5 cm, 4 cm, and 2 cm.

Given:
a = 5 cm
b = 4 cm
c = 2 cm

Required:
Perimeter of a 3-gon (triangle).

Solution:

$$P = a + b + c$$

$$P = 5 + 4 + 2$$

$$P = 11\ cm$$

2. All three sides of the triangle are 5 cm, what is its perimeter?

Given:
a = 5 cm
b = 5 cm
c = 5 cm

Required:
Perimeter of triangle

Solution:

$$P = a + b + c$$

$$P = 5 + 5 + 5$$

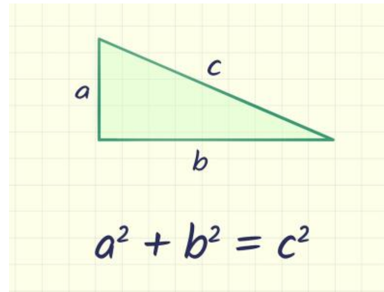
$$P = 15\ cm$$

Other Formulas Related to the Triangle

Pythagorean Theorem

The hypotenuse of a right triangle is equal to the sum of the squares of the two sides.

The formula for the Pythagorean theorem is:

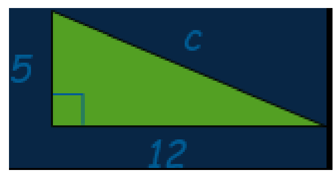


$$c^2 = a^2 + b^2$$

Where:
a = Height/Side №1 of a triangle
b = Base/Side №2 of a triangle
c = Hypotenuse

Sample Problems:

1. Solve this triangle:



Given:
a = 5
b = 12

Required:
Hypotenuse of the right triangle

Solution:

$$c^2 = a^2 + b^2$$

$$c^2 = (5)^2 + (12)^2$$

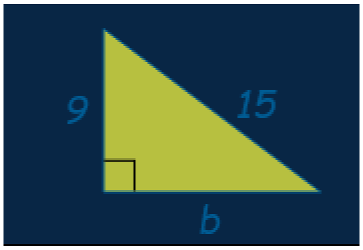
$$c^2 = 25 + 144$$

$$c^2 = 169$$

$$\sqrt{c^2} = \sqrt{169}$$

$$c = 13$$

2. Solve this triangle:



Given:
a = 9
c = 15

Required:
b = ?

Solution:

$$c^2 = a^2 + b^2$$

$$(15)^2 = (9)^2 + b^2$$

$$225 = 81 + b^2$$

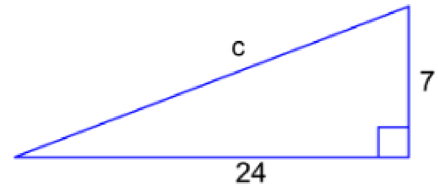
$$225 - 81 = b^2$$

$$144 = b^2$$

$$\sqrt{144} = \sqrt{b^2}$$

$$12 = \mathrm{b}$$

3. Solve this triangle:



Find c.

Given:
a = 7
b = 24

Required:
Hypotenuse of the right triangle

Solution:

$$c^2 = a^2 + b^2$$

$$c^2 = (7)^2 + (25)^2$$

$$c^2 = 49 + 576$$

$$c^2 = 625$$

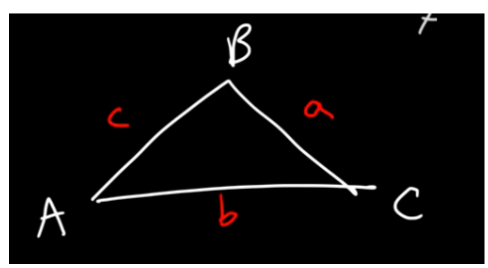
$$\sqrt{c^2} = \sqrt{625}$$

$$c = 25$$

Law of Sines
It shows the relationship between the sides and angles of oblique triangles. To use the Law of Sines, the values of the triangle given must be an AAS (Angle-Angle-Side) or SSA (Side-Side-Angle). Make sure your calculator is in degree mode.

The formula for the Law of Sines is

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

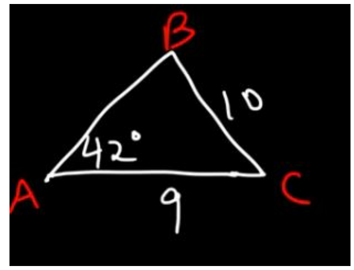


Where:
A = First Angle/Angle of a/Angle that is opposite to a
B = Second Angle/Angle of b/Angle that is opposite to b

C = Third Angle/Angle of c/Angle that is opposite to c
a = First Side/Side (a) that is opposite to angle A
b = Second Side/Side (b) that is opposite to angle B
c = Third Side/Side (c) that is opposite to angle C

Sample Problems:

1. Given A = 42^0, a = 10, and b = 9, find angle B.



Given:
a = 10
b = 9
A = 42^0

Required:
Angle B

Solution:
It is an SSA triangle because the given are 2 sides and one angle.

Use this portion of the Law of Sines:

$$\frac{a}{sin\ A} = \frac{b}{sin\ B}$$

Actual solving:

$$\frac{10}{sin\ 42} = \frac{9}{sin\ B}$$

$$10\ sin\ B = 6.022$$

$$\frac{\cancel{10}\ sin\ B}{\cancel{10}} = \frac{6.022}{10}$$

$$sin\ B = 0.6022$$

$$\cancel{sin}^{-1}(\cancel{sin}\ B) = sin^{-1}(0.6022)$$

$$B = sin^{-1}(0.6022)$$

$$B = 37.03^o$$

Sometimes you may get two solutions/two triangles when you are taking arcsines. This is the formula for the second solution.

$$B_2 = 180 - B$$

Solving for B_2.

$$B_2 = 180 - B$$

$$B_2 = 180 - 37.03$$

$$B_2 = 142.97^o$$

After taking the second solution, let us test if it makes sense if we are going to get two triangles or just one. Note that B will always work, so we will focus on B_2.

The formula for checking if the second solution is valid is:

$$180^o < given\ angle\ in\ the\ problem + B_2$$

Checking:

$$180^o < given\ angle\ in\ the\ problem + B_2$$

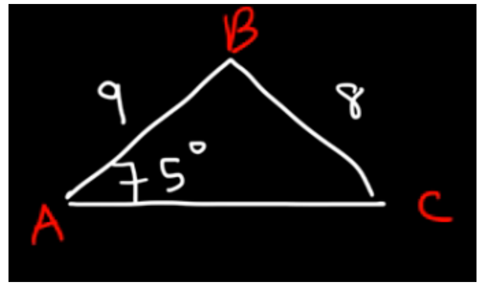
$$180^o < 42^o + 142.97^o$$

$$180^o < 184.97^o$$

Therefore, B_2 is invalid because it exceeds 180^o. The final answer is:

$$B = 37.03^o$$

2. Given A = 75^0, a = 8, and c = 9, find angle C.



Given:
a = 8
c = 9
A = 75^0

Required:
Angle C

Solution:
It is an SSA triangle because the given are 2 sides and one angle.

Use this portion of the Law of Sines:

$$\frac{a}{\sin A} = \frac{c}{\sin C}$$

Actual solving:

$$\frac{9}{\sin C} = \frac{8}{\sin 75}$$

$$8.693 = 8 \sin C$$

$$\frac{8.693}{8} = \frac{\cancel{8} \sin C}{\cancel{8}}$$

$$1.089 = \sin C$$

$$\sin^{-1}(1.089) = \cancel{\sin}^{-1}(\cancel{\sin} C)$$

$$\sin^{-1}(1.089) = C$$

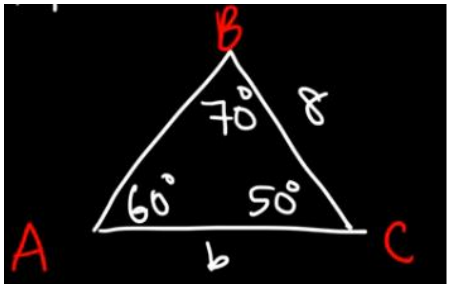
$$Math\ Error \ = \ C$$

Typing arcsin(1.089) into the calculator yields a math error because it is outside the range of arcsin that it can evaluate. The range of arcsin is from -1 to +1. Anything greater than 1 or lesser than -1 is outside of the capabilities of arcsin.

Therefore, there is no answer/solution, thus the final answer is:

$$No\ triangle$$

3. Given A = 60^0, B = 70^0, and a = 8, find b.



Given:
A = 60^0
B = 70^0
a = 8

Required:
b = ?

Solution:
It is an AAS triangle because the given are 2 angles and one side.

Use this portion of the Law of Sines:

$$\frac{a}{sin\ A} = \frac{b}{sin\ B}$$

Actual solving:

$$\frac{8}{sin\ 60} = \frac{b}{sin\ 70}$$

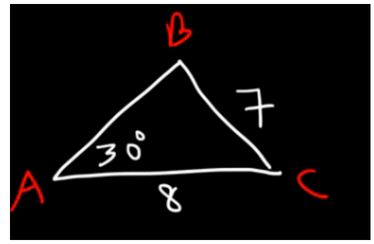
$$8\ sin\ 70 = b\ sin\ 60$$

$$\frac{8\ sin\ 70}{sin\ 60} = \frac{b\ \cancel{sin\ 60}}{\cancel{sin\ 60}}$$

$$\frac{8\ sin\ 70}{sin\ 60} = b$$

$$8.68 = b$$

4. Given A = 30^0, a = 7, and b = 8, find angle B.



Given:
a = 7
b = 8
A = 30^0

Required:
Angle B

Solution:
It is an SSA triangle because the given are 2 sides and one angle.

Use this portion of the Law of Sines:

$$\frac{a}{\sin A} = \frac{b}{\sin B}$$

Actual solving:

$$\frac{7}{\sin 30} = \frac{8}{\sin B}$$

$$7 \sin B = 4$$

$$\frac{\cancel{7} \sin B}{\cancel{7}} = \frac{4}{7}$$

$$\sin B = \frac{4}{7}$$

$$\cancel{\sin^{-1}}(\cancel{\sin} B) = \sin^{-1}(\frac{4}{7})$$

$$B = \sin^{-1}(\frac{4}{7})$$

$$B = 34.85^o$$

Sometimes you may get two solutions/two triangles when you are taking arcsines. This is the formula for the second solution.

$$B_2 = 180 - B$$

Solving for B_2.

$$B_2 = 180 - B$$

$$B_2 = 180 - 34.85$$

$$B_2 = 145.15^o$$

After taking the second solution, let us test if it makes sense if we are going to get two triangles or just one. Note that B will always work, so we will focus on B_2.

The formula for checking if the second solution is valid is:

$$180^o < given\ angle\ in\ the\ problem + B_2$$

Checking:

$$180^o < given\ angle\ in\ the\ problem + B_2$$

$$180^o < 30^o + 145.15^o$$

$$180^o < 175.15^o$$

Therefore, B_2 is valid because it is less than 180^o. The final answer is either:

$$B = 34.85^o$$

or

$$B_2 = 145.15^o$$

5. Using the given and the answers in №4, get the other angles and the side.

Required:
C = ?
c = ?

Solution for the angles:
The angles of the triangle must add up to 180. Since we are dealing with two angles from B, there are two angles when we are solving for C in the two triangles.

For 34.85º:

$$180^o = given\ angle\ in\ the\ problem + B + C$$

$$180^o = 30^o + 34.85^o + C$$

$$180^o = 64.85^o + C$$

$$180^o - 64.85^o = C$$

$$115.15^o = C$$

For 175.15º:

$$180^o = given\ angle\ in\ the\ problem + B_2 + C$$

$$180^o = 30^o + 145.15^o + C$$

$$180^o = 175.15^o + C$$

$$180^o - 175.15^o = C$$

$$4.85^o = C$$

Solution for c:
Since we are dealing with two angles from C, there are two sides when we are solving for c for the two triangles.

For c from 115.15º:
Use this portion of the Law of Sines:

$$\frac{a}{sin\ A} = \frac{c}{sin\ B}$$

And solve.

$$\frac{7}{sin\ 30} = \frac{c}{sin\ 115.15}$$

$$7\ sin\ 115.15 = c\ sin\ 30$$

$$\frac{7\ sin\ 115.15}{sin\ 30} = \frac{c\ \cancel{sin\ 30}}{\cancel{sin\ 30}}$$

$$\frac{7\ sin\ 115.15}{sin\ 30} = c$$

$$12.7 = c$$

For c from 4.85^o:
Use this portion of the Law of Sines:

$$\frac{a}{\sin A} = \frac{c}{\sin B}$$

And solve.

$$\frac{7}{\sin 30} = \frac{c}{\sin 4.85}$$

$$7 \sin 4.85 = c \sin 30$$

$$\frac{7 \sin 4.85}{\sin 30} = \frac{c \cancel{\sin 30}}{\cancel{\sin 30}}$$

$$\frac{7 \sin 4.85}{\sin 30} = c$$

$$1.20 = c$$

Therefore the final answer:
First triangle:

$$115.15^o = C$$

$$12.7 = c$$

Second triangle:

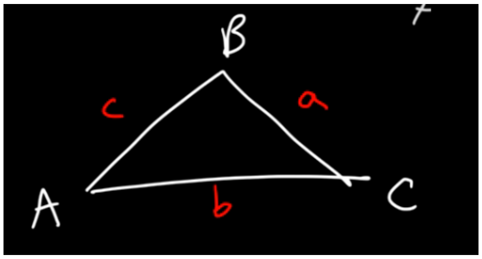
$$4.85^o = C$$

$$1.20 = c$$

Law of Cosines

It is used to find the remaining parts of an oblique triangle. To use the Law of Sines, the values of the triangle given must be an SAS (Side-Angle-Side) or SSS (Side-Side-Side). Make sure your calculator is in degree mode. Note that to find the remaining angles after doing Law of Cosines for finding the missing side, it is easiest to use the Law of Sines rather than sticking to Law of Cosines.

The formula for the Law of Cosines is either:



$$c^2 = a^2 + b^2 - 2ab\cos C$$

or

$$b^2 = a^2 + c^2 - 2ac\cos B$$

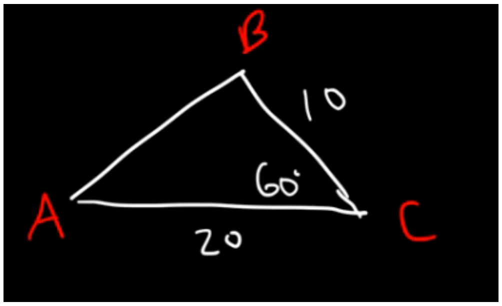
or

$$a^2 = b^2 + c^2 - 2ab\cos A$$

Where:
A = First Angle/Angle of a/Angle that is opposite to a
B = Second Angle/Angle of b/Angle that is opposite to b
C = Third Angle/Angle of c/Angle that is opposite to c
a = First Side/Side (a) that is opposite to angle A
b = Second Side/Side (b) that is opposite to angle B
c = Third Side/Side (c) that is opposite to angle C

Sample Problems:

1. Given C = 60^0, a = 10, and b = 20, find c.



Given:
a = 10
b = 20
A = 42^0

Required:
Angle B

Solution:
It is an SAS triangle because the given are 2 sides and one angle.

Use this portion of the Law of Sines:

$$c^2 = a^2 + b^2 - 2ab\ cos\ C$$

Actual solving:

$$c^2 = (10)^2 + (20)^2 - 2(10)(20)\ cos\ 60$$

$$c^2 = 100 + 400 - 400\ (0.5)$$

$$c^2 = 500 - 200$$

$$c^2 = 300$$

$$\sqrt{c^2} = \sqrt{300}$$

$$c = 17.32$$

2. Given a = 7, and b = 8, and c = 9, find C without using Law of Sines.

Given:
a = 7
b = 8
c = 9

Required:
Angle C without using the Law of Sines.

Solution:
It is an SSS triangle because there are 3 given sides. Note that you cannot use Law of Sines because aside from the instructions stated, the given are all sides and the Law of Sines needs two angles and one side, or two sides and one angle.

Use this portion of the Law of Sines:

$$c^2 = a^2 + b^2 - 2ab\ cos\ C$$

Actual solving:

$$(9)^2 = (7)^2 + (8)^2 - 2(7)(8)\ cos\ C$$

$$81 = 49 + 64 - 112\ cos\ C$$

$$81 = 113 - 112\ cos\ C$$

$$81 - 113 = -112\ cos\ C$$

$$-32 = -112\ cos\ C$$

$$\frac{-32}{-112} = \frac{-\cancel{112}\ cos\ C}{-\cancel{112}}$$

$$0.2857 = cos\ C$$

$$cos^{-1}(0.2857) = \cancel{cos}^{-1}(\cancel{cos}\ C)$$

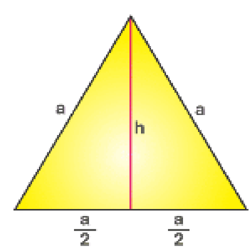
$$73.40 = C$$

Area of an Equilateral Triangle

An equilateral triangle is a kind of triangle where all sides are equal and the measure of all the angles in the triangle is 60º.

The area of an equilateral triangle, when the length of the side is known, is:

$$A = \frac{\sqrt{3}}{4}a^2$$



Where:
A = Area of a triangle (in units squared)
a = Side of a triangle

Sample Problems:

1. What is the area of an equilateral triangle whose side is 8 cm?

Given:
s = 8 cm

Required:
Area of an equilateral triangle.

Solution:

$$A = \frac{\sqrt{3}}{4}a^2$$

$$A = \frac{\sqrt{3}}{4}(8)^2$$

$$A = \frac{\sqrt{3}}{\cancel{4}}(\overset{16}{\cancel{64}})$$

$$A = 16\sqrt{3}\ cm^2$$

$$A = 27.71\ cm^2$$

2. What is the area of an equilateral triangle whose side is 28 cm?

Given:
s = 28 cm

Required:
Area of an equilateral triangle.

Solution:

$$A = \frac{\sqrt{3}}{4}a^2$$

$$A = \frac{\sqrt{3}}{4}(28)^2$$

$$A = \frac{\sqrt{3}}{\cancel{4}}(\cancel{784})$$

196

$$A = 196\sqrt{3}\ cm^2$$

$$A = 339.48\ cm^2$$

3. What is the area of an equilateral triangle whose side is 7 cm?

Given:
s = 7 cm

Required:
Area of an equilateral triangle.

Solution:

$$A = \frac{\sqrt{3}}{4}a^2$$

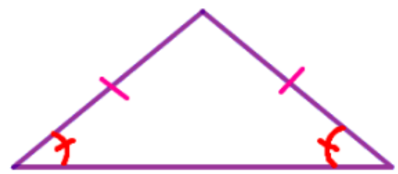
$$A = \frac{\sqrt{3}}{4}(7)^2$$

$$A = \frac{\sqrt{3}}{4}(49)$$

$$A = 21.22\ cm^2$$

Area of an Isosceles Triangle without Given Height
An isosceles triangle has at least two sides and angles of equal length. The area of an isosceles triangle is half of the product of the base and height. This variation accounts for when the height is not given.

The area of an equilateral triangle, when the height is unknown, is:



$$A = \frac{1}{2} b \sqrt{a^2 - \frac{b^2}{4}}$$

Where:
A = Area of a triangle (in units squared)
a = Length of two equal sides
b = Base of the triangle

Sample Problems:

1. Find the area of an isosceles triangle given a = 5 cm (length of two equal sides), b = 9 cm (base).

Given:
a = 5 cm
b = 9 cm

Required:
Area of an isosceles triangle

Solution:

$$A = \frac{1}{2} b \sqrt{a^2 - \frac{b^2}{4}}$$

$$A = \frac{1}{2}(9)\ \sqrt{(5)^2 - \frac{(9)^2}{4}}$$

$$A = \frac{9}{2}\ \sqrt{25 - \frac{81}{4}}$$

$$A = \frac{9}{2}\ \sqrt{25 - 20.25}$$

$$A = \frac{9}{2}\ \sqrt{4.75}$$

$$A = \frac{9}{2}\ (2.179)$$

$$A = 9.81\ cm$$

2. Find the area of an isosceles triangle given a = 12 cm, b = 7 cm.

Given:
a = 12 cm
b = 7 cm

Required:
Area of an isosceles triangle

Solution:

$$A = \frac{1}{2} b \sqrt{a^2 - \frac{b^2}{4}}$$

$$A = \frac{1}{2} (7) \sqrt{(12)^2 - \frac{(7)^2}{4}}$$

$$A = \frac{7}{2} \sqrt{144 - \frac{49}{4}}$$

$$A = \frac{9}{2} \sqrt{144 - 12.25}$$

$$A = \frac{9}{2} \sqrt{131.75}$$

$$A = \frac{9}{2} (11.478)$$

$$A = 40.173\ cm$$

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