Pythagoras and its converse

Leaving Certificate · Ordinary Level

Understand the idea

How to start

Pythagoras applies to a right-angled triangle. The hypotenuse is the side opposite the right angle.

1. Label the hypotenuse c and the shorter sides a and b.
2. Write $a^2 + b^2 = c^2$, then put the known lengths in their places.
3. After finding the missing square, take the positive square root to find a length.

Key terms & definitions

Hypotenuse
The side opposite the right angle in a right-angled triangle.

Converse of Pythagoras
If the square of the longest side equals the sum of the other two squares, the triangle is right-angled.

Key ideas

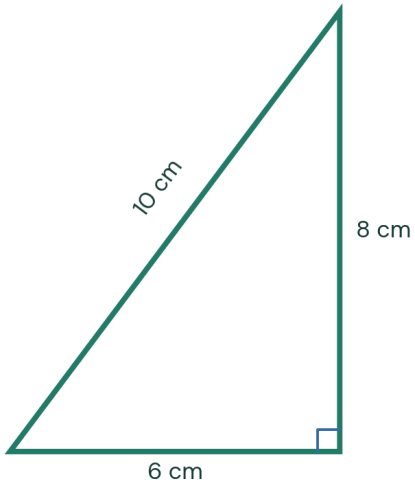
• In a right-angled triangle, $a^2 + b^2 = c^2$, where c is the hypotenuse.

• The hypotenuse is opposite the right angle and is the longest side.

• To find a shorter side, subtract the known shorter side squared from the hypotenuse squared.

• The converse checks whether a triangle is right-angled: square the longest side and compare it with the sum of the other squares.

• Keep exact roots if requested; round only after finding the square root.



Right triangle : $6^2 + 8^2 = 10^2$. The 10 cm side is opposite the right angle.

Quick reminder

• Right triangle only: $a^2 + b^2 = c^2$.

• c is the hypotenuse, opposite the right angle.

• Square first; take the positive square root for a length.

Worked examples

Example 01 · Find the hypotenuse

A right triangle has shorter sides 6 cm and 8 cm. Find the hypotenuse.

Blue follows the first shorter side and purple the second. The hypotenuse remains c.

Why this method?

Identify the right angle and the longest side. The longest side has its square alone on one side of the equation.

$a = 6$, $b = 8$	**Step 1** The given sides are the shorter sides. The missing hypotenuse is c.
$a^2 + b^2 = c^2$	**Step 2** The triangle is right-angled, so Pythagoras applies.
$6^2 + 8^2 = c^2$	**Step 3** Substitute the two known lengths.

$36 + 64 = c^2$	**Step 4** Square each length separately.
$100 = c^2$	**Step 5** Add the two squares. This is c squared, not c.
$c = \sqrt{100} = 10\text{cm}$	**Step 6** Take the positive square root. Ten is longer than either shorter side.

Example 02 · Find a shorter side

A right triangle has hypotenuse 13 cm and one shorter side 5 cm. Find the other side.

Why this method?

Identify the right angle and the longest side. The longest side has its square alone on one side of the equation.

$a^2 + 5^2 = 13^2$	**Step 1** Write the equation
$a^2 = 169 - 25 = 144$	**Step 2** Subtract the square of the known shorter side from the square of the hypotenuse.
$a = 12\text{cm}$	**Step 3** Take the square root to undo squaring. Use the positive root because this value is a length.

Example 03 · Test the converse

Does a triangle with sides 7 cm, 9 cm and 12 cm have a right angle?

Why this method?

Identify the right angle and the longest side. The longest side has its square alone on one side of the equation.

$12^2 = 144$	**Step 1** Square the longest side
$7^2 + 9^2 = 49 + 81 = 130$	**Step 2** Add the other squares

144 is not 130, so the triangle is not right-angled.	**Step 3** Compare the two calculated quantities. Equality or inequality determines which conclusion is justified.

Example 04 · Find the missing shorter side

A right triangle has hypotenuse 13 cm and one shorter side 5 cm. Find the other.

$x^2 + 5^2 = 13^2$	**Step 1** Put the hypotenuse by itself.
$x^2 = 169 - 25 = 144$	**Step 2** Subtract the known square.
$x = 12$ cm	**Final step** Take the positive square root for a length.

Common mistake

Using $a^2 + b^2 = c^2$ for a triangle that is not right-angled. It applies to right-angled triangles, and c must be the hypotenuse: the side opposite the right angle.

Exam technique

Mark the right angle and identify c before substituting.

Try it yourself

Work on paper before checking the answers at the end. These questions are for self-checking, not submitted homework.

Question 1

A right triangle has shorter sides 9 cm and 12 cm. Find the hypotenuse.

Question 2

A right triangle has hypotenuse 17 cm and one shorter side 8 cm. Find the other side.

Watch an explanation

Cognito — Pythagoras' Theorem

Corbettmaths — Pythagoras: show triangle is right angle

Open the website chapter to load the embedded players. Use the rates and rules in your question for financial examples.

Self-check answers

Question 1

$c^2 = 9^2 + 12^2 = 225$, so $c = 15\text{cm}$.

The hypotenuse is opposite the right angle and must be longer than 12 cm.

Question 2

$a^2 = 17^2 - 8^2 = 225$, so $a = 15\text{cm}$.

Subtract the square of the known shorter side. The unknown shorter side must be less than 17 cm.

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