# Electro Critical Skills Resource Suite

# Entry Level Literacy and Numeracy Assessment for the Electrotechnology Trades

## Enrichment Resource

### UNIT 13: Pythagoras' Theorem

energise oz
managing apprentice progression

An E-Oz Energy Skills Australia project.

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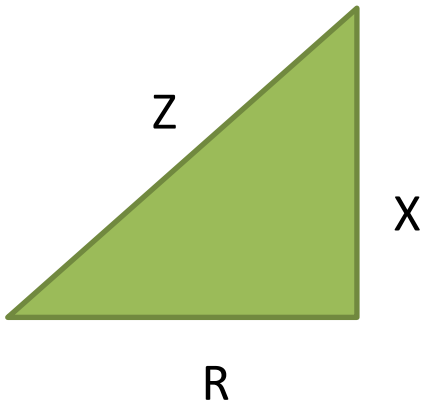
# PYTHAGORGAS' THEOREM

Pythagoras' theorem states the relationship between the lengths of the sides of any right-angles triangle. The equation which describes this relationship ($Z^2=R^2+X^2$) is used when solving problems related to alternating current theory. For example power factor, resistance and impedance can be calculated using this Theorem.




$$Z^2 = R^2 + X^2$$

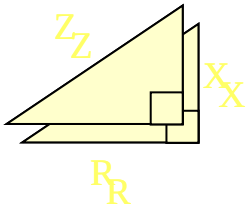
$$Z = \sqrt{R^2 + X^2}$$

# LEARNING OUTCOME

- Can use Pythagoras' theorem to calculate an unknown side of a right-angled triangle.

# PERFORMANCE CRITERIA

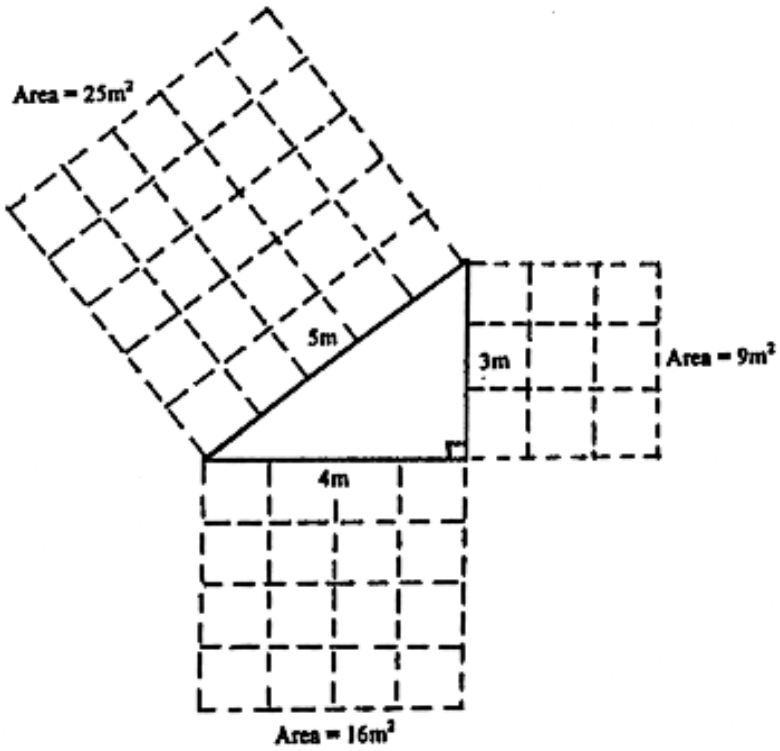
- Understands when to apply Pythagoras' theorem.
- Uses the calculator to solve problems involving Pythagoras' theorem.
- Calculates the length of an unknown side of a right-angled triangle using Pythagoras' theorem.
- Uses the calculator to solve electrical problems involving Pythagoras' theorem.



# PYTHAGORAS' THEOREM

Pythagoras was a Greek mathematician who found **that in any right-angled triangle the square on the hypotenuse is equal to the sum of the squares on the other two sides.**

**The hypotenuse being the longest side**

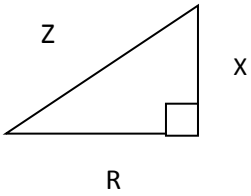



NOTE:

$5^2 = 4^2 + 3^2$

Answer: $25m^2 = 16m^2 + 9m^2$

# PYTHAGORAS AND ELECTRICAL THEORY




A right-angled triangle labelled with the symbols used in electrical problems.

Z = hypotenuse
X = altitude
R = base

Pythagoras' theorem states: $Z^2 = R^2 + X^2$

therefore: $Z = \sqrt{R^2 + X^2}$

The above theorem can be used to calculate any of the three sides of a right-angled triangle when the other two sides are known.

This can be done by transposing (changing) the formula to make the subject of the equation the side you want to know.

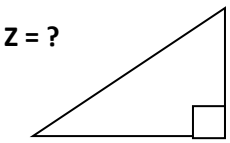
$Z^2 = R^2 + X^2$ or $Z = \sqrt{R^2 + X^2}$

$R^2 = Z^2 - X^2$ or $R = \sqrt{Z^2 - X^2}$

$X^2 = Z^2 - R^2$ or $X = \sqrt{Z^2 - R^2}$

**Example 2**

Find the length of the hypotenuse (Z)




$$Z = \sqrt{R^2 + X^2}$$
$$Z = \sqrt{3^2 + 2^2}$$
$$Z = \sqrt{9 + 4}$$
$$Z = \sqrt{13}$$
$$Z = 3.61$$

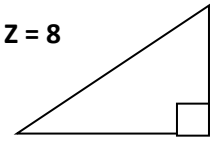
**Using the calculator**

Note: Steps on some calculators may differ. Refer to calculator guide.

| 3 | $X^2$ | + | 2 | $X^2$ | = | √ | = |
|---|---|---|---|---|---|---|---|

Answer: 3.61

Find the length of side R.



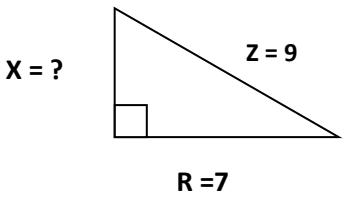

$$R = \sqrt{Z^2 - X^2}$$
$$R = \sqrt{8^2 - 3^2}$$
$$R = \sqrt{64 - 9}$$
$$R = \sqrt{55}$$
$$R = 7.42$$

**Using the calculator**

| 8 | $X^2$ | - | 3 | $X^2$ | = | √ | = |
|---|---|---|---|---|---|---|---|

Answer: 7.42

Find the length of side X.




$$X = \sqrt{Z^2 - R^2}$$
$$X = \sqrt{9^2 - 7^2}$$
$$X = \sqrt{81 - 49}$$
$$X = \sqrt{32}$$
$$X = 5.66$$

**Using the calculator**

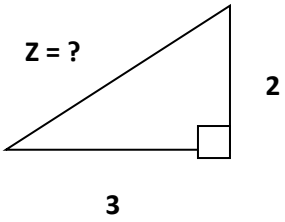
| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **9** | **$X^2$** | **-** | **7** | **$X^2$** | **=** | **√** | **=** |

Answer: 5.66

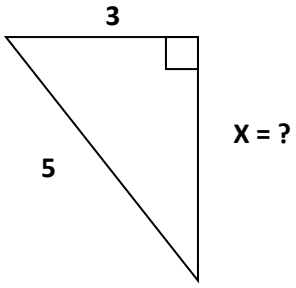
## EXERCISE 1

Use Pythagoras' Theorem to find the lengths of the unknown sides of the following right-angled triangles.

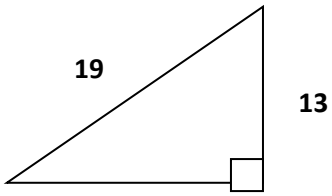
a)




b)

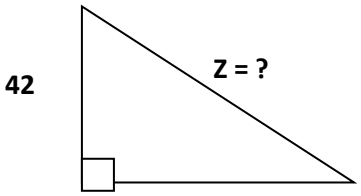


c)




**R = ?**

d)




**56**

## EXERCISE 2

Use Pythagoras' Theorem to solve for the length of the missing sides of each triangle.

a) X=8, R = 13, Z = ?

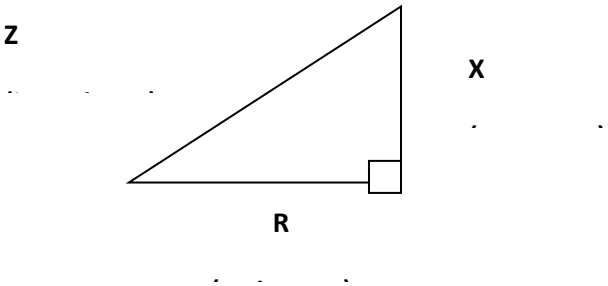
b) Z = 20, R = 8, X = ?

c) X = 12, Z = 24, R = ?

☑ **Use the answer sheet to check your work.**

# PYTHAGORAS AND ELECTRICAL THEORY

The right angled triangle below shows the relationship between:
impedance (Z)
reactance (X)
resistance (R)




Note: Impedance, reactance and resistance are measured in ohms (Ω).

## EXERCISE 3

Use the above diagram to find the impedance (Z) of a circuit with a resistance (R) of 8 ohms and reactance (X) of 12 ohms.

Answer: The impedance of the circuit is……..ohms.

## EXERCISE 4

Use the diagram in Exercise 3 to help solve the following problems where the values of the impedance, reactance and/or resistance are known.

a) Reactance (R) = 40 ohms

Resistance (X) = 30 ohms

Impedance (Z) = ….. ohms

b) Reactance (R) = 38.7Ω

Resistance (X) =…….Ω

Impedance (Z) = 43.6 Ω

☑ **Use the answer sheet to check your work.**

# ANSWERS:

## EXERCISE 1

a) $$Z = \sqrt{R^2 + X^2}$$
$$= \sqrt{2^2 + 3^2}$$
$$= \sqrt{4 + 9}$$
$$Z = \sqrt{13} = 3.61$$

b) $$X = \sqrt{Z^2 - R^2}$$
$$= \sqrt{5^2 - 3^2}$$
$$= \sqrt{25 - 9}$$
$$X = \sqrt{16} = 4$$

c) $$R = \sqrt{Z^2 - X^2}$$
$$= \sqrt{19^2 - 13^2}$$
$$= \sqrt{361 - 169}$$
$$R = \sqrt{192} = 13.86$$

d) $$Z = \sqrt{R^2 + X^2}$$
$$= \sqrt{56^2 + 42^2}$$
$$= \sqrt{3136 + 1764}$$
$$Z = \sqrt{4900} = 70$$

## EXERCISE 2

a)

$$Z = \sqrt{13^2 + 8^2}$$
$$= \sqrt{169 = 64}$$
$$Z = \sqrt{233} = 15.26$$

b)

$$X = \sqrt{20^2 - 8^2}$$
$$= \sqrt{400 - 64}$$
$$X = \sqrt{336} = 18.33$$

c)

$$R = \sqrt{24^2 - 12^2}$$
$$= \sqrt{576 - 144}$$
$$= \sqrt{432} = 20.78$$

## EXERCISE 3

$$Z = \sqrt{R^2 + X^2}$$
$$= \sqrt{8^2 + 12^2}$$
$$= \sqrt{64 + 144}$$
$$Z = \sqrt{208} = 14.42\Omega$$

## EXERCISE 4

a)

$$Z = \sqrt{40^2 + 30^2}$$
$$= \sqrt{1600 + 900}$$
$$Z = \sqrt{2500} = 50\Omega$$

b)

$$X = \sqrt{43.6^2 - 38.7^2}$$
$$= \sqrt{1900.96 - 1497.69}$$
$$X = \sqrt{403.27} = 20.08\Omega$$