

Practical Maths for Plumbing & Heating Students and Apprentices

Unit 10: Trigonometry, Geometry and Pythagoras for Plumbing and Heating Learners

Teacher Notes

Overview

These teacher notes are based on Unit 10: **Trigonometry, Geometry and Pythagoras for Plumbing and Heating Learners** and are designed for Level 2 and Level 3 plumbing and heating learners. The unit covers geometric shapes, rectangles, circles, triangles, Pythagoras' theorem, trigonometric ratios, inverse trigonometric functions, and practical plumbing and heating applications involving lengths, angles, areas, falls, and pipe routes.

Learning objectives

By the end of delivery, learners should be able to:

- Understand the properties of squares, rectangles, circles, and triangles.
- Apply Pythagoras' theorem to solve right-angled triangle problems.
- Use trigonometric ratios, sine, cosine, and tangent, to find unknown sides and angles.
- Apply trigonometry to plumbing and heating calculations.
- Solve practical trade problems involving pipe routes, roof work, flues, and falls.
- Use geometry to calculate area, perimeter, circumference, and volume-related dimensions.

Suggested lesson sequence

1. Start with the main geometric shapes used in plumbing and heating work: rectangles, circles, and triangles.
2. Teach area, perimeter, circumference, and circle area before moving into right-angled triangles.
3. Introduce Pythagoras' theorem for finding missing lengths in right-angled triangles.
4. Move into trigonometric ratios using SOHCAHTOA, with clear side-labelling practice.
5. Teach inverse trigonometric functions for finding unknown angles, making sure calculators are in degree mode.
6. Finish with practical plumbing and heating examples involving flues, roof runs, pipe falls, offsets, and circular openings.

Core teaching points

1. Geometric shapes in plumbing and heating work

The unit begins by showing that squares and rectangles are used for floor areas, panel sizes, trays, and workspaces, circles are used for pipes, cylinders, tanks, and cross-sections, and triangles are used for roof work, falls, offsets, and diagonal distances. This provides a very strong vocational context for the topic.

This section works well as a discussion starter, because learners can quickly identify where they have already seen these shapes on site or in workshop tasks.

2. Rectangles and circles

The unit gives rectangle formulae for perimeter $2(l + b)$ and area $l \times b$, with practical examples such as a bathroom floor of 3.2 m by 2.4 m giving a perimeter of 11.2 m and an area of 7.68 m², and a radiator wall space of 1.2 m by 1.8 m giving 2.16 m².

For circles, the unit covers radius, diameter, circumference, and area, using $d = 2r$, $C = \pi d$, $C = 2\pi r$, and $A = \pi r^2$. Worked examples include a 22 mm pipe circumference of 69.12 mm, a 28 mm opening area of 615.83 mm², and a 314.2 mm² opening giving a diameter of 20 mm.

3. Triangles and Pythagoras' theorem

The unit explains that the angles in a triangle always total 180° and that right-angled triangles are especially important because they allow Pythagoras' theorem and trigonometry to be used. It clearly identifies the hypotenuse as the side opposite the 90° angle and the longest side.

Pythagoras' theorem is given as $c^2 = a^2 + b^2$, with rearrangements to find shorter sides.

Practical examples include a 6 m horizontal run and 8 m rise giving a 10 m straight-line length, a 5 m ladder reaching 4 m high giving a 3 m base distance, and an offset of 0.3 m by 0.4 m giving a sloping length of 0.5 m.

4. Introducing trigonometry

The unit defines trigonometry as the study of relationships between sides and angles in triangles and links it directly to roof angles, pipe offsets, sloping waste pipes, support brackets, and layout problems. This keeps the topic rooted in trade use rather than pure mathematics.

The core side names are introduced as hypotenuse, opposite, and adjacent, with a reminder that opposite and adjacent depend on which angle is being used. This point should be reinforced often because it is one of the biggest learner stumbling blocks.

5. The three trigonometric ratios

The unit teaches:

- $\sin(\theta) = \text{opposite/hypotenuse}$.
- $\cos(\theta) = \text{adjacent/hypotenuse}$.
- $\tan(\theta) = \text{opposite/adjacent}$.

It also provides the memory aid SOHCAHTOA, which is very useful for Level 2 and Level 3 learners alike. This should be taught alongside a labelled triangle every time rather than as a memory trick on its own.

6. Finding sides and angles

The unit models finding sides using trig, such as a 100 mm hypotenuse and 30° angle giving an opposite side of 50 mm, a 50 mm hypotenuse with a 60° angle giving an adjacent side of 25 mm, and an adjacent side of 40 mm with 35° giving an opposite side of 28.01 mm.

It then moves into inverse trig for finding angles, including $\tan^{-1}(30/20) = 56.31^\circ$ and $\sin^{-1}(15/25) = 36.87^\circ$. The unit specifically warns learners to ensure calculators are in degree mode.

7. Practical plumbing and heating applications

The unit includes practical examples that make the topic highly teachable for trade learners. These include a flue rising 4 m and running 3 m horizontally to give a length of 5 m and an angle of 53.13° , a waste pipe drop of 0.18 m over 6 m giving an angle of about 1.72° , a roof rise of 2.5 m over 4 m giving a slope length of 4.72 m, and a 100 mm circular opening giving a circumference of 314.2 mm and an area of 7855 mm^2 .

These applications are ideal for linking workshop tasks, site set-out, and design checks with classroom mathematics.

Worked examples to emphasise in class

Recommended examples from the unit to model carefully:

- Bathroom floor 3.2 m by 2.4 m gives perimeter 11.2 m and area 7.68 m^2 .
- A 22 mm pipe gives circumference 69.12 mm.
- A 28 mm circular opening gives area 615.83 mm^2 .
- A circle area of 314.2 mm^2 gives diameter 20 mm.

- A 6 m horizontal run and 8 m rise gives a straight length of 10 m by Pythagoras.
- A 0.3 m rise and 0.4 m run gives an offset pipe length of 0.5 m.
- A 100 mm hypotenuse with angle 30° gives an opposite side of 50 mm.
- A flue with 3 m horizontal run and 4 m rise gives length 5 m and angle 53.13° .

Common learner mistakes

The unit highlights several common issues that should be addressed directly:

- Calculator set to radians instead of degrees.
- Mixing up opposite and adjacent sides.
- Using sin, cos, or tan instead of inverse functions when finding angles.
- Using Pythagoras on a triangle that is not right-angled.
- Mixing millimetres, centimetres, and metres in one calculation.
- Failing to identify the hypotenuse correctly.

Teaching tips

- Always draw and label the triangle before choosing a method.
- Teach learners to decide first whether they need geometry, Pythagoras, trig, or inverse trig.
- Reinforce unit consistency before calculation, especially when switching between mm and m.
- Keep SOHCAHTOA visible, but always pair it with side-labelling practice.
- Use real plumbing and heating examples such as flues, waste pipe falls, roof runs, and pipe offsets to maintain relevance.
- Check calculator mode at the start of any lesson involving angles.

Assessment opportunities

The unit includes practice on:

- Basic trigonometry and right-angled triangles.
- Plumbing and heating applications involving flues, waste pipes, and openings.
- Perimeter, area, circumference, and circular area calculations.
- Mixed practical problems using geometry, Pythagoras, and trigonometry.

These can be separated by level. Level 2 learners can focus on shapes, area, perimeter, circumference, and straightforward Pythagoras problems, while Level 3 learners can extend into trig ratios, inverse trig, proof of right-angled triangles, and multi-step trade applications.

Classroom emphasis

For Level 2 learners, focus on shape properties, area, perimeter, circle basics, and simple right-angled triangle work. For Level 3 learners, place more emphasis on trig ratios, inverse trig, angle calculation, and selecting the correct method for practical plumbing and heating scenarios.

Quick reference rules

- Use rectangle formulae for perimeter and area.
- Use $C = \pi d$ and $A = \pi r^2$ for circles.
- Pythagoras only works in right-angled triangles.
- The hypotenuse is opposite the 90° angle and is the longest side.
- Use sine, cosine, and tangent to find sides in right-angled triangles.
- Use inverse trig functions to find angles.
- Keep the calculator in degree mode.
- Keep units consistent throughout the calculation.

Summary for delivery

This unit is highly valuable because it brings together geometry, Pythagoras, and trigonometry in ways that directly support plumbing and heating installation and design work. The most effective delivery approach is to move from familiar shapes into right-angled triangles and then into trig methods, using realistic trade examples throughout so learners see exactly why the mathematics matters.