



Cyfoeth Naturiol Cymru
Natural Resources Wales



Tree Measuring

Connecting Trees with the Curriculum for Wales



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Amended for Wales with thanks to the original author Penny Martin and Outdoor and Woodland Learning Scotland



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Introduction

Why use trees for measuring?

Trees can be found everywhere – in school grounds, local greenspace, park or woodland – in urban and rural settings alike. Trees can be found within walking distance of most schools, so it's easy to take learning outdoors.

From a child's point of view, trees can be large, tactile and sometimes charismatic, stimulating curiosity and imagination. With bark, leaves, seeds, twigs and branches, to growth, form and structure, any tree provides a wonderful free resource for learning and play outdoors, naturally supporting an interdisciplinary approach to learning.

This resource will focus on how the properties of trees can support progression in numeracy and mathematical skills in particular but can also support many other aspects of the curriculum and secure the added benefits associated with learning outside the classroom.

Measuring the properties of trees – their height, spread, girth and internal structure – provides a window into the world of work. In professional forestry and similar professions, these measurements carry real value and meaning.

Progression in numeracy and mathematical skills

This resource aims to provide activities to support delivery of the Wales Numeracy Framework.

Outdoor learning provides experiences in a real-world context, not in isolation. The activities contained in this resource can help to embed an understanding of mathematical concepts within the world outside the classroom.

The progression of these tree measuring activities with increasing challenge demands increasing sophistication in the learner's ability to:

- interpret questions
- select and communicate processes and solutions
- justify choice of strategy used
- link mathematical concepts
- use mathematical vocabulary and notation;
- use mental agility
- reason algebraically
- determine the reasonableness of a solution

These activities encourage the development of numeracy skills and support their use in other curriculum areas. For example, using trees as a context for learning outdoors supports health and wellbeing across the curriculum, in particular providing opportunities for planning for choices and changes.



How to use this resource

This booklet provides a selection of activities for use from Foundation Phase to Key Stage 4, providing different ways to estimate and then calculate various measurements. Key Stages are indicative and more able learners will be able to have a go at more complicated methods.

Tree Measuring Activities and Skills Progression

Foundation Phase and Key Stage 2

Aim: to help children learn about estimation, simple measurement and basic calculations, by measuring the height and girth of trees.

Before you start

Make sure that the children are familiar with the basic parts of a tree – roots, trunk, branches and leaves.

Estimating the girth of a tree	Working in groups using arm lengths or hand spans to measure the circumference of a tree.	Skills: estimation, measurement, data & analysis.
Measuring the girth of a tree	Working in pairs of small groups using a measuring tape to measure the circumference of a tree or several trees and charting the results.	Skills: estimating, measurement, data & analysis.
Estimating the height of a tree	Comparing the height of a tree by eye, to objects of a similar height to provide a sense of scale.	Skills: estimation, number processes, fractions, measurement, data & analysis.
Using a pencil to measure tree height	Working in pairs, using a pencil at a distance aligned to the tree height and partner, then pacing the distance between two points to estimate the height of the tree.	Skills: estimation, measurement, data & analysis.

To Key Stage 2 and 3

Key Stage 2 and 3

Aim: to develop children's skills in estimating and measurement (measuring to the nearest cm), carrying out calculations using decimals and introducing angles. The children look at two ways of measuring tree height and calculate a tree's age from its girth.

Before you start

Make sure that the children are familiar with the basic parts of a tree – roots, trunk, branches and leaves, and have experience of the Foundation Phase/KS2 Tree Measuring Activities.

These activities can also be used to support lower ability KS3 learners.

Measuring tree height looking through legs	Working in pairs to estimate the height of a tree using the concept of measuring using angles and triangles.	Skills: estimation, measurement, angles, data & analysis.
Measuring tree height with a metre stick	Working in pairs to calculate the height of a tree using a metre stick and the concept of angles and triangles.	Skills: measurement, numbers, multiples.
Estimating the age of a tree, measuring girth of tree and calculating rates of growth	Working in pairs, using a pencil at a distance aligned to the tree height and partner, then pacing the distance between two points to estimate the height of the tree.	Skills: estimation, measurement, data & analysis.

To Key Stage 3 and 4

Key Stage 3 and 4

Aim: To involve students in developing and using simple tools for measuring tree height, spread and density using angles and simple formulae. This creates opportunities for discussions on the accuracy of their measurements and how they might be used in real life situations. For example: surveying their school grounds or local community spaces and developing tree planting schemes, and considering the mathematical skills needed in professions like forestry.

Before you start

Make sure that the children are familiar with the basic parts of a tree – roots, trunk, branches and leaves.

Using a clinometer to measure tree height

Working in pairs to make a tool and use this to measure the height of a tree using trigonometry, working to scale.

Skills: measurement, angle, symmetry and transformation, data and analysis, impact of maths in the world, 2D shapes & 3D objects.

Measuring tree height using a hypsometer

Make a tool then working together use this to measure tree height.

Skills: Measurement, angle, symmetry and transformation, data analysis.

Measuring the diameter of a tree trunk

Calculating the diameter of a tree by measuring circumference, using different measuring tools.

Skills: Measurement, data & analysis, mathematics – its impact on the world.

Measuring tree spread & crown

Working in groups, using a compass to explore symmetry of spread, and measuring branch length to calculate the crown area.

Skills: Measurement, 2D shapes and 3D objects, angle, symmetry and transformation, data analysis, mathematics – its impact on the world.

Measuring the area of ground covered by tree stems (trunks) in a hectare

Make a simple tool then working individually use this to estimate tree density in an area.

Skills: Measurement, estimation and rounding, data & analysis, maths – its impact on the world.



Foundation Phase: Measuring tree girth

Hugging a tree

Use arm lengths or hand spans to measure the circumference of a tree.

Skills

Estimation, measurement, data & analysis.

Resources

Tree(s); enough children to encircle a tree;
Extension: paper/pens/cloth/clay.



ACTIVITY

1. Working in a group, ask the learners to choose a tree they like.

Explore

Ask the group - How can we work out how big it is all the way round (the tree's girth)?

2. Help the group decide how many people are needed to measure the tree's girth using outstretched arms, touching one another's fingertips, standing around the tree.
3. Experiment with different measures, like hand spans, around the tree.
4. Discuss and decide how to get consistency in measurements between different trees.

Explore

Ask the learners to describe the shape and girth of the chosen tree to someone else?

Choosing a site with a variety of trees will enable the group to discuss how the girths of different trees vary, and to choose the appropriate form of measurement whether it is arm lengths or hand spans (or something else!).



How many people?

Extension

Learners can make handprints on paper or cloth to show how many hand spans each tree required - hang these from your tree or make a picture washing line outdoors!

Learners can make up a name for the tree from the words used to describe it. Use ID sheets, books or apps to find out the real name of the tree? Try writing the name on a rolled-out piece of clay or mud and stick it on your tree.



Foundation Phase and KS2: Measuring tree girth

Measuring a tree

Working in pairs or small groups use a measuring tape to measure the circumference of a tree or several trees and chart the results.

Skills

Estimating, measurement, data & analysis.

Resources

Tree(s); a measuring tape (optional - a piece of string/rope)



ACTIVITY

1. Learners work in pairs to measure the girth of a tree
2. Each pair chooses a tree they like.

Explore

Look at the shape of a tree's trunk - is it the same size (girth) all the way up?

3. Girth is usually measured at 1.3 metres or chest height up from the ground.

Explore

Let each child measure each other up to their underarm to see if this is a good approximation for one metre.

This helps the learners to begin to understand how they can use their own body as a measuring tool and the importance of consistency in measurement. For foresters, diameter of trees at breast height (1.37m) is a commonly used measure.

4. If you are in school grounds, a park or woodland that has a number of different species, you can measure a few of each species. Identify your trees using ID sheets, books or apps.
5. Get the learners to draw a diagram or chart that shows the different girths of each species of tree measured. This can be



Measuring tape

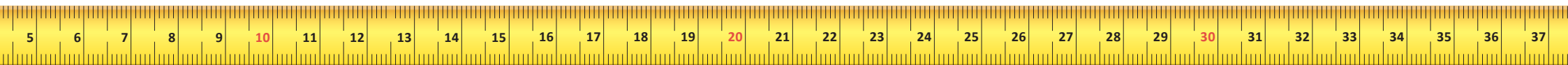
plotted outdoors using rope to show your x and y axis, with pebbles or sticks to show number, and leaves to indicate species, or on the hard surface of the school grounds using chalk.

Explore

As a group discuss whether there is a wide variation both within the same species of tree and between different tree species?

Explore

What might be possible reasons for this? For example, the trees might be different ages or the same ages, or in different growing conditions (like close together or far apart).



Foundation Phase and KS2: Measuring tree height

Estimating the height of a tree

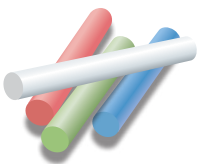
Compare the height of a tree by eye, with objects of a similar height to provide a sense of scale.

Skills

Estimation, number processes, fractions, measurement, data & analysis.

Resources

Tree(s); measuring tape; chunky chalk.



ACTIVITY

Explore

How tall is the tree compared to e.g. a person or a nearby building?

This can lead to discussions about closer objects looking bigger while those that are far away seem smaller.

Explore

What do you need to do to make your estimate better?

1. Working in pairs the height of a tree can be estimated by measuring one learner.
2. Once measured, this learner stands beside the selected tree.
3. Their partner imagines how many times the measured learner fits (head to foot) into the height of the tree - from the ground to the top of the tree.
4. The pair then multiply the number of times the learner fits, say 4 times, by the height of the learner, say 1 metre, to estimate the height of the tree.



How many times does the person fit into the tree height?

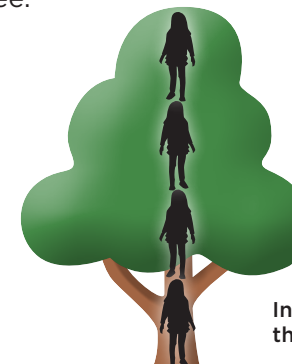
5. As a group discuss how the tree height can be measured this way using the language of fractions.

Extension

In pairs, learners draw the length of the tree in chalk on a hard surface playground, and then draw around the shape of your leanres who was measured lying lengthways at the base of the 'trunk' of the chalk tree.

Learners then draw the tree's shape to make it look like the one that was measured.

Lastly learners mark in chalk how many times the measured learners body fitted into the tree.



In this example the tree is 4m tall

Key Stage 2: Measuring tree height

Using a pencil to measure tree height

Use a pencil at a distance aligned to the tree height and partner, then pace the distance between two points to estimate the height of the tree.

Skills

Estimation, measurement, data & analysis.

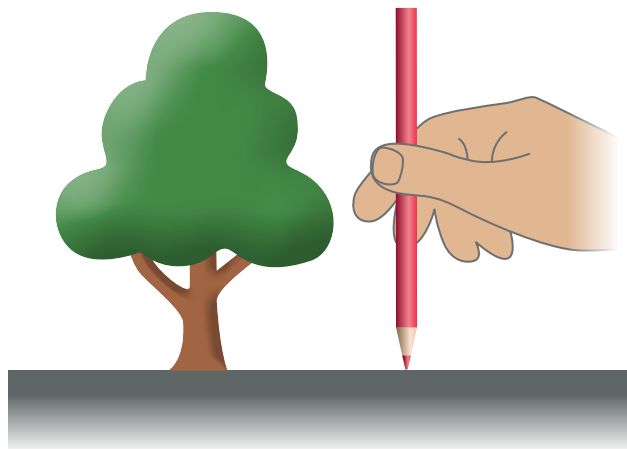
Resources

A tree(s); a pencil, a measuring tape/trundle wheel; stick, chalk or similar to mark position on ground.



ACTIVITY

1. Learners work in pairs and firstly select a tree.
2. Learner 1 stays beside their tree; Learner 2 walks away from the tree but looks back at intervals.
3. When they look back, Learner 2 holds a pencil at arms' length vertically and lines it up with the tree. Learner 2 keeps walking until the bottom of the tree is level with the bottom of the pencil, and the top of the tree is level with the top of the pencil.



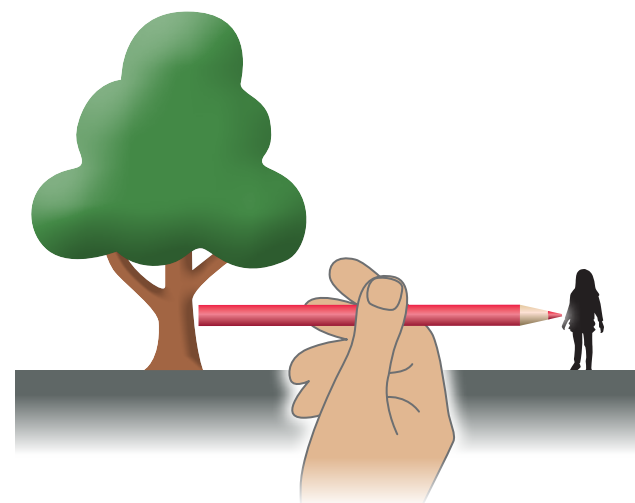
Using a pencil to measure tree height

4. Staying in the same spot, Learner 2 turns the pencil to a horizontal position, with the end of the pencil still at the base of the tree.
5. Learner 1 now walks away from the tree, at a right angle until they reach the "point" of the pencil from Learner 2's view. Learner 2 shouts "stop" as this point.
6. Learner 1 marks this spot.
7. The distance between this mark and the base of the tree is the height of the tree.
8. Learners measure this distance roughly by pacing out.
9. Learners then measure this distance exactly by using a measuring tape or trundle wheel and compare the results.

Extension

Draw a right-angled triangle on the hard surface of a school playground, marking the length of the distance walked on the ground, and the height of the tree.

Ask the learners if they can draw this to scale?



Key Stage 2 and 3: Measuring tree height

Looking through your legs

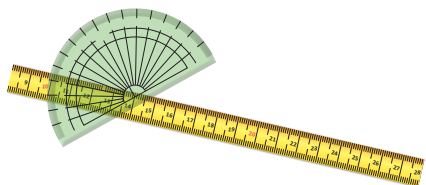
Work in pairs to estimate the height of a tree using the concept of measuring with angles and triangles.

Skills

Estimation, measurement, angles, data & analysis

Resources

Tree(s); measuring tape, protractor.



ACTIVITY

1. Learners work in pairs or groups, trying this out in turn.
2. Firstly choose a tree per pair or group.
3. Learner 1 walks away from the tree, every so often bending forward to look through their legs back to the tree.
4. When they can just see the top of the tree, Learner 1 stops and Learner 2 marks the spot.
5. Learners try taking 'metre length' strides between the tree and the marked spot, and pace the distance, to give an estimate in metres.
6. Learners measure the distance along the ground from the tree to the marker. This is roughly equal to the tree's height.

This works because maths says that if a person can see the top of a tree at a 45-degree angle, then the height of the tree is equivalent to the distance that that the person is from that tree.

Extension

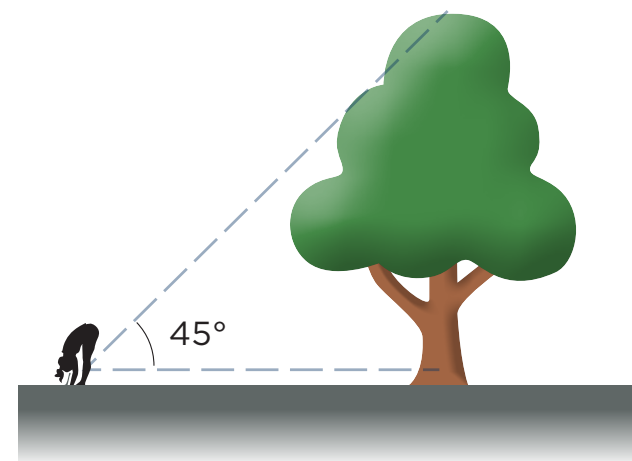
Using a protractor, ruler and chalk/pencil, ask the learners to draw a right-angled triangle on the hard surface of a school playground,



Looking through your legs

or on a piece of paper, marking the length of the distance walked on the ground, and the estimated height of the tree, marking in the 90 and 45-degree angles. What is the remaining angle? What kind of shape is this? (a right isosceles triangle).

Ask the learners to make a model tree and model person in plasticine to scale and find a way to show the relationship between them, using the triangle.



Key Stage 2 and 3: Measuring tree height

Using a meter stick

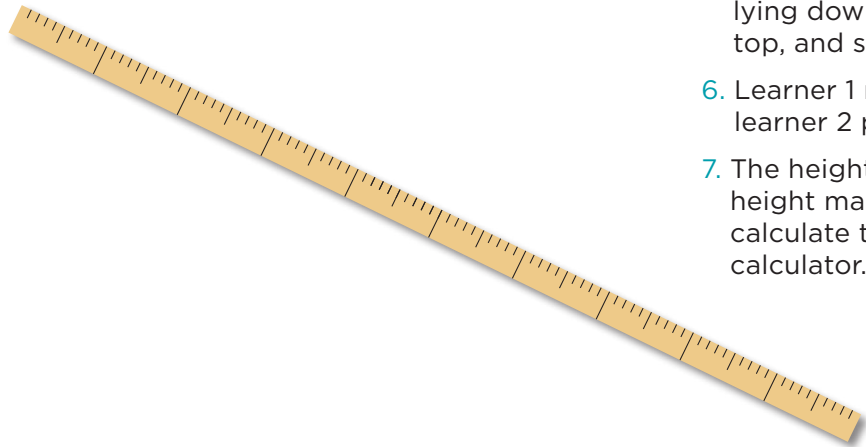
In pairs calculate the height of a tree using a meter stick and the concept of angles and triangles.

Skills

Measurement, numbers, multiples.

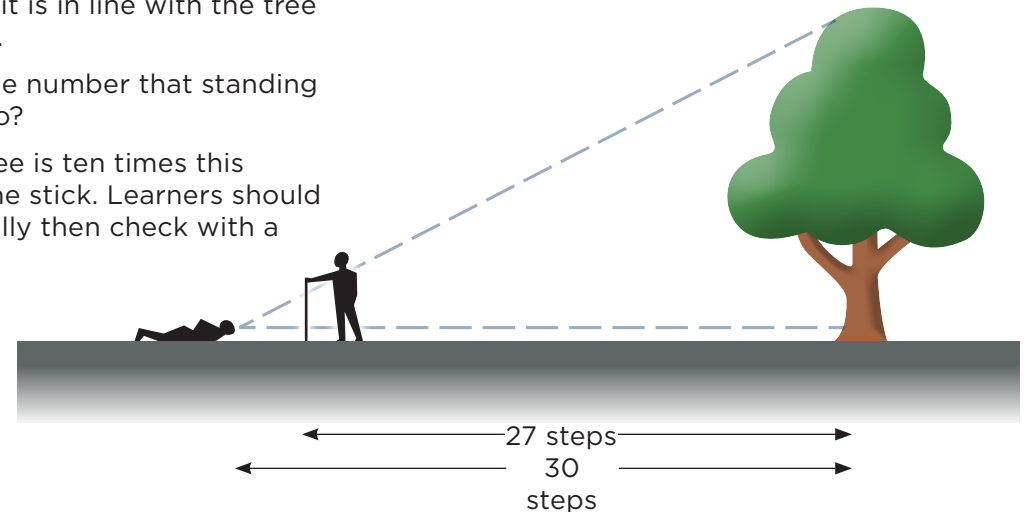
Resources

Suitable tree(s); A meter stick



ACTIVITY

1. Learners work in pairs and choose a tree.
2. Both learners stand up against the trunk of their chosen tree.
3. Learner 1 walks 30 steps away from the tree, lies down on the ground and looks up at the top of the tree.
4. Learner 2 walks 27 steps from the tree and holds up a meter stick.
5. Standing learner 2 should move their finger up and down the stick until the learner 1 lying down can see it is in line with the tree top, and shout stop.
6. Learner 1 records the number that standing learner 2 pointing to?
7. The height of the tree is ten times this height marked on the stick. Learners should calculate this mentally then check with a calculator.



Key Stage 2 and 3: Measuring tree girth

Tree girth and age

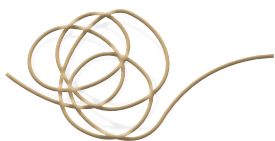
Estimate the age of a tree by counting rings on a cut stump, measure the girth of a tree using simple formulae, and calculate rates of growth comparing different trees.

Skills

Time, measurement, multiples, 2D shapes & 3D objects, data & analysis.

Resources

Range of tree species; cut log/tree stump (optional); tape measure/string; tree identification keys; magnifying glass (optional).

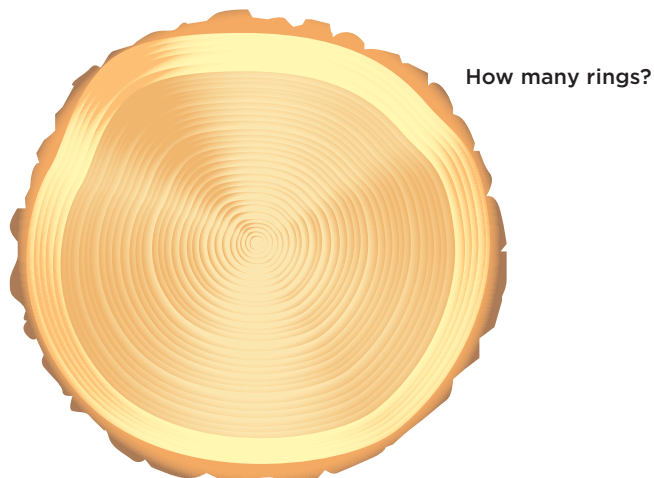


ACTIVITY

How old is a tree? Learners can look at a variety of trees in your school grounds, local park or woodland.

As a group discuss which trees do you think are the oldest and why? (Older trees will tend to be taller, larger and with wider trunks).

In addition to growing in height, trees add a layer of wood to their circumference each year.



Spring growth is porous and light in colour while darker wood is formed at the end of the growing season. This darker wood primarily provides support and strength. The two together represent one year's growth, known as an annual ring. The pattern of annual rings can tell us a lot about the life story of a tree. Counting the rings on the cross section at ground level provides the total age of the tree.

If a log/cut stump of a tree trunk is available, children can count the annual rings. It is, however, sometimes quite hard to see all the rings, particularly if they are very close together – so it may need to be a rough estimate. Wide spaced rings represent periods of rapid growth, while narrow rings represent periods of slow growth.

See our Activity plan - How a tree works for more information on tree trunk structure and function.

However, you don't have to cut a tree down to work out its age! Instead, the girth of a living tree can be used to estimate its age.

1. Learners can use a tape measure or piece of string, to measure around the trunk at approximately 1.3m up from the ground. This is the girth or circumference of the tree.
2. Roughly, every 2.5cm of girth represents about one year's growth. So, to estimate the age of a living tree, divide the girth by 2.5. For example, a tree with a girth of 40cm will be sixteen years old.
3. Learners can carry out a census of trees in the local area to determine which are the oldest and which are the youngest?
4. Learners can display this information in timelines or charts.

Explore

Use ID sheets, books or apps to identify the tree being measured.

Once learners know the species of tree you are measuring, you can make this work more accurately, as different types of tree grow at different speeds.

- Using the growth rate table below, learners can check the type of tree you have measured and divide the girth by the number given. For example, a sycamore with a girth of 110cm is about 40 years old ($110 \div 2.75 = 40$).

Species of tree	Growth of girth per year (cm)
Average	2.5
Oak and beech	1.88
Pine and spruce	3.13
Sycamore	2.75

Whether a tree is in woodland or in the open, also makes a difference to growth.

Explore

As a group discuss why this is? Will woodland trees grow faster or slower than trees in the open?

Trees in the open grow faster because there is less competition from other trees, for light, water and nutrients.

- Learners can build this into their calculations. For example, an average woodland tree increases in girth by approximately 1.25cm per year.

Explore

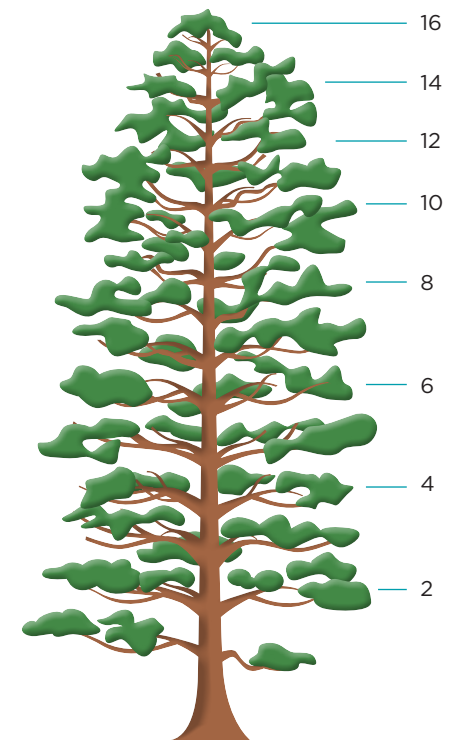
As a group identify whether there are any conifer trees present?

Conifers (pines, spruces, larch, firs) usually grow a whorl of branches each year. If you count the number of whorls of branches up the trunk, you get an approximate age. This is easiest with young trees - up to about 20 years old.

- Learners can estimate the age of any conifers present using this method. Compare it to the method using girth measurement using the data in the table below. How similar are your results?

Extension

Learners can draw a timeline for your tree in chalk in the playground and research and mark on this significant moments or events in recent history that this tree would have lived through.



Whorls - this tree is 16 years old

Key Stage 3 and 4

Some of the more advanced methods described in this Tree Measuring resource for Key Stage 3 and 4 might be suitable to support Mathematics, plus Science and Technology subjects.

Additional resources not included here

Advanced Tree Measuring Technologies

Illustrated by Forestry Commission Forest Research.

Forest Research is the research agency of the Forestry Commission. Measuring tree and wood properties (particularly those of sawn timber) is an important part of understanding the potential of the national forest resource.

Some traditional methods, like using clinometers, to measure the height of a tree, and measuring the diameter of a tree at breast height (DBH) to estimate volume, are described in this resource.

It is important for learners to understand however, that technological developments mean that these may no longer be the most accurate or efficient methods.

Forest Research web pages **Measuring tree and wood properties** <https://www.forestryresearch.gov.uk/research/tree-and-wood-properties/measuring-tree-and-woodproperties/> describe state-of-the-art technologies, and pioneer methods, to measure properties that are vital for commercial exploitation.

These resources can support the study of Mathematics and Technologies at Key Stage 3, 4 and 5.



Key Stage 3 and 4: Measuring tree height

Making and using a clinometer

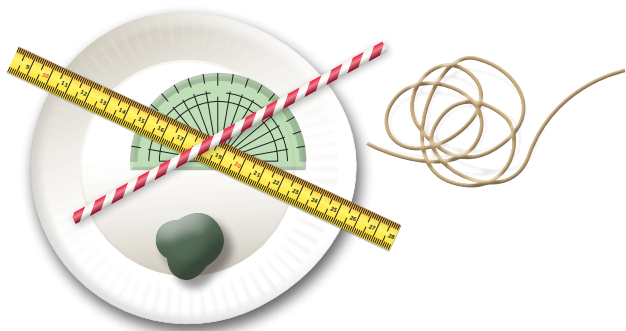
In pairs make a tool and use this to measure the height of a tree using trigonometry, working to scale.

Skills

Measurement, angle, symmetry and transformation, data and analysis, impact of maths in the world, 2D shapes & 3D objects.

Resources

Tree(s); paper plate, a straw (or empty pen tube), some string, a weight (like plasticine), glue or sticky tape, scissors and a measuring tape/wheel, (optional - protractor).



ACTIVITY

Explore

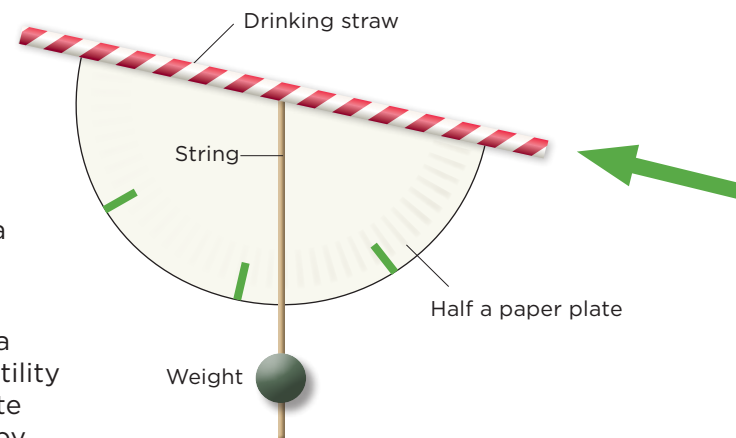
In a group discuss why we need to know a tree's height?

Foresters use tree height for many things. Tree height can give a clue as to how old a tree is. It can also reflect the quality or fertility of the soil. The height of a tree can indicate a tree's dominance within the forest canopy, and is used to calculate the amount of timber per tree.

It's usually impossible to reach the top of a tree to measure its height. Various instruments are used by foresters to measure tree height, using basic trigonometry. A clinometer/inclinometer is a tool that is used to measure the angle of elevation, or angle from the ground, in a right - angled triangle.

The observer stands at a fixed horizontal distance from the base of the tree and determines the angle from the fixed point to the top of the tree and from the fixed point to the base of the tree.

In this activity, learners first make a clinometer, in order to calculate the height of a tree. Please note - Inclinometer/clinometer templates can also be found online.



1. How to make a clinometer

- Cut a paper plate in half and exactly half way along this cut edge stick a piece of string with a weight on the end, so that it dangles beyond the edge of the plate.
- Find the middle of the plate's curved edge (marked 0° in the picture). A position exactly half way between 0° and the cut edge of the plate is 45° . For accuracy, use a protractor to mark 45° . (Place the protractor's straight edge along the plate's cut edge, with its centre exactly half way along.)
- Glue a straw or an empty pen tube along the cut edge.
- Discuss how the care taken in marking and cutting the clinometer will affect the accuracy of the results.

2. Working in pairs, select and measure a tree

- Learner 1 looks through the straw so that the treetop is visible. Learner 1 then walks backwards, away from the tree, keeping the top in sight.
- Learner 2 follows and notes when the weighted string lines up with the 45° line. Both stop when this happens and measure the distance from the tree.
- This distance is equal to the height of the tree minus your height to your eyes (because to be most accurate the triangle has to finish at your feet not your eyes).
- Learners then find out how tall they are, add this to the distance from the tree and you have an accurate measurement of the tree height. (For example, if the distance from the tree is 4 metres and the child with the clinometer is 1 metre tall, the height of the tree is $4\text{m} + 1\text{m} = 5\text{m}$.)

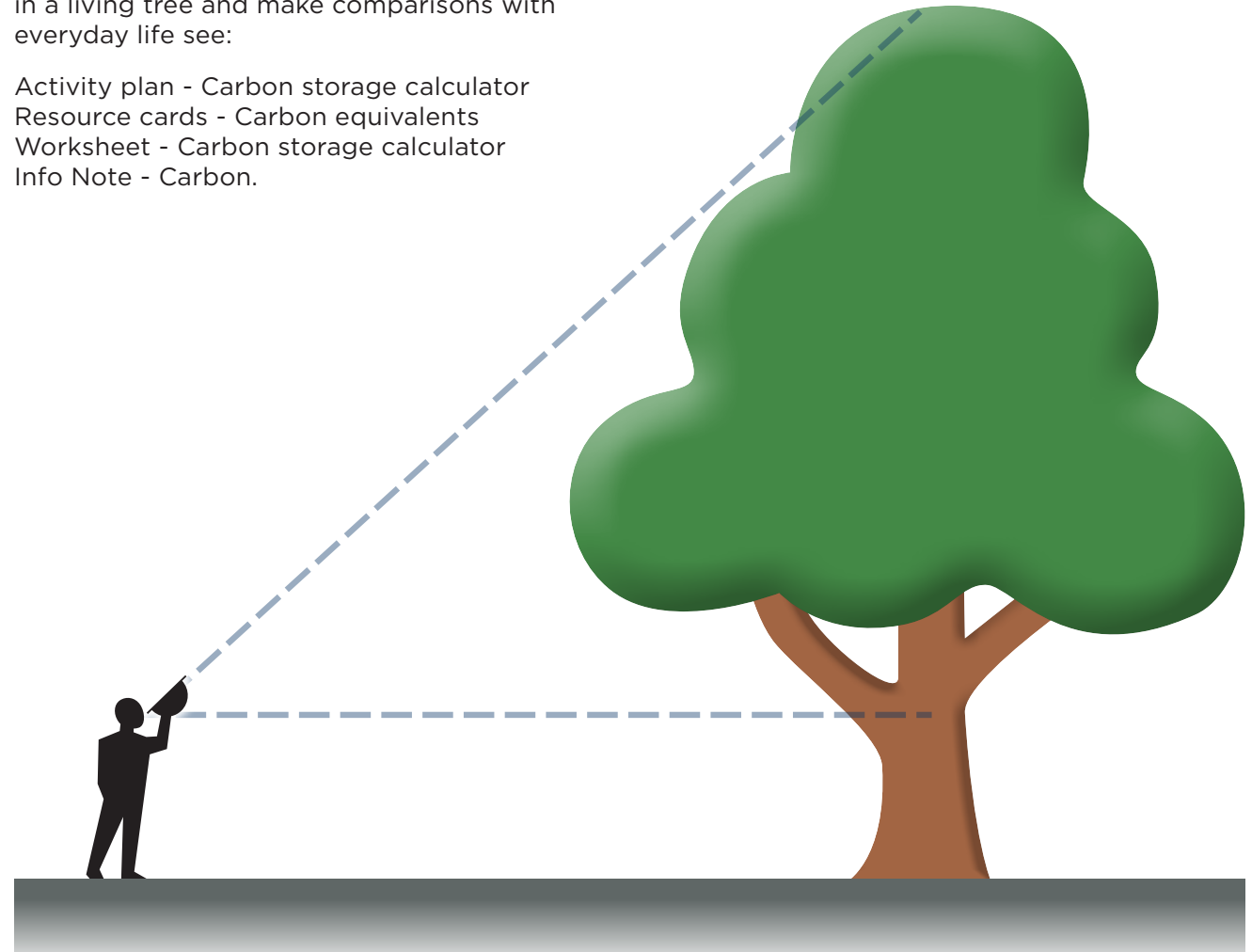
3. Using the measurements learners can then provide a scale drawing or model of the tree.

Extension

Learners can develop a plan of all or part of their school grounds showing the school's trees as scale models.

To find out how much carbon is locked up in a living tree and make comparisons with everyday life see:

Activity plan - Carbon storage calculator
Resource cards - Carbon equivalents
Worksheet - Carbon storage calculator
Info Note - Carbon.



Using the clinometer

Key Stage 3 and 4: Measuring spread and crown

Spread and crown measuring

Working in groups, use a compass to explore the symmetry of spread, and measure branch length to calculate the crown area.

Skills

Measurement, 2D shapes and 3D objects, angle, symmetry and transformation, data analysis, mathematics - its impact on the world.

Resources

Tree(s); a compass, chalk and a measuring tape



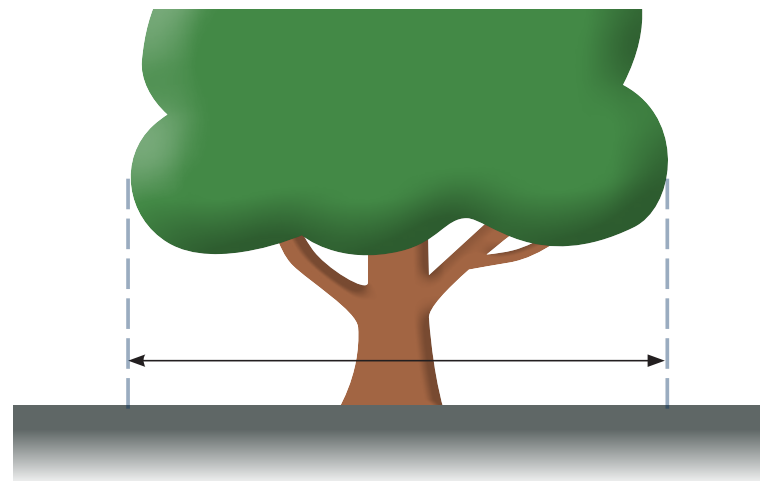
ACTIVITY

Explore

Discuss in groups how far do your trees spread? We can see the branches but what about the roots? What job do the roots do? Did you know that the spread of the branches gives a good indication of how far the roots spread underground?

Tree spread symmetry

1. Learners work individually or in pairs, firstly choosing a tree.
2. Using a compass, the learners chalk mark north, south east and west on the trunk of a tree.



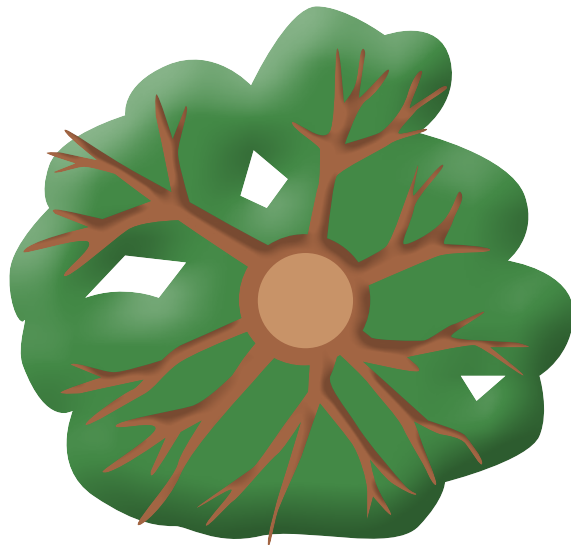
Tree spread symmetry

3. Learners then walk in the four directions in turn, counting the paces until the end of the branch tips above are reached each time.
4. The distance paced in each direction is recorded.

Explore

Discuss in groups whether the tree spread evenly in all directions? Was it symmetrical? If not, what are the possible reasons?

For example, the growth of the branches may favour the sunnier/less windy/more open side, etc.



Crown measuring

Crown measuring

The crown spread of a tree is the distance its branches spread away from its trunk.

1. Learners need to work in groups of three.
2. Firstly the group finds the branch that sticks out the farthest from the tree trunk. One learner stands directly under the tip of the branch.
3. Another learner goes to the opposite side of the tree, and finds the branch that sticks out the farthest on that side and stands under its tip.

4. While they are both facing the tree, each learner takes one or two steps to the side of the trunk so that the distance can be measured between them without having the tree trunk in the way. (i.e. one learner steps to their right, and the other to their left so they should both be on the same side of the tree.)
5. The third learner measures the distance between them.
6. The group repeat this, looking this time for the shortest branches.
7. The group then discusses how to calculate the average crown spread (adding the two distances together and dividing by two).
8. As a group recreate this crown spread visually in 2D by drawing a polygon in chalk to scale, between measured points on a hard surface, on the hard surface of the school playground. Note the compass points on the longest and the shortest branch points.

Sometimes the second measurement is taken at 90° from the first measurement.

Explore

Are there any lines of symmetry in your polygon?

Explore

Why is it important to consider the spread and eventual height of trees? For example, when planning what to plant in your school grounds or close to buildings.

What is the traditional use and timber value of the trees you have looked at?

Things to consider:

- Is there room or need for a wide spreading tree to provide shade and shelter, or do you need to allow sunlight to reach other plants?
- How far apart should you plant your trees so they don't crowd each other when fully grown?
- If a tree reaches its full height or falls down, would it damage overhead cables?
- Remember, some trees can be pruned or coppiced to restrict their growth, or contained as a hedge.

Explore

Discuss what skills may be needed to do the job of a tree surgeon?

Explore

Can the learners spot any trees that have been pruned or coppiced, or might need to be?

Key Stage 3 and 4: Measuring trunk diameter

Measuring the diameter

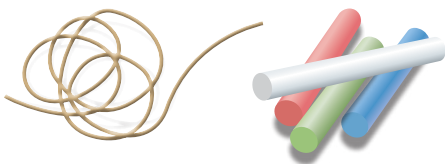
Calculate the diameter of a tree by measuring circumference, using different methods.

Skills

Measurement, data & analysis, mathematics – its impact on the world.

Resources

Trees; measuring tape, string, chalk, calculators and/or callipers.



ACTIVITY

Measuring the circumference of a tree can help us estimate its age. Once we have the circumference, we can also calculate the diameter.

Measuring the diameter of a tree trunk at a standardised height (called ‘diameter breast height’ or DBH) is a technique used by foresters growing trees for wood products. The diameter often correlates with the tree’s wood volume. This helps foresters to estimate the amount of volume in a tree, its timber value, and how it should be managed and used. N.B. Volume is the amount of space occupied by the wood of the tree, while mass is the amount of matter it contains.

The two most common instruments used to measure DBH are a girthing or diameter tape (a ‘d-tape’) and callipers.

Without a d-tape, it is also possible to find the diameter of the tree using a string, a measuring tape, chalk and a calculator.

Help! What if the tree trunk isn’t straight or branches?

If the trunk of the tree divides or branches at a height less than 1.3m from the ground, measure the smallest circumference below the lowest branch. If the tree has a branch or



a bump at 1.3m, it is better to measure the diameter slightly below or above the branch/bump.

Measuring diameter using string and measuring tape

Learners should work individually or in pairs.

1. Using a measuring tape, measure 1.3m up the trunk of the tree from the ground, marking this height with chalk.

Explore

Discuss why 1.3m is used?

This is a standard measure used as an approximation of a typical person’s breast/chest height. Tree trunk (stem) diameter at breast height (DBH) and tree height (H) are commonly used measures of tree growth by foresters.

- Learners wrap your string around the tree trunk at 1.3m.
- Making sure the string is straight and tight around the trunk, and mark or cut the circumference on the string.
- Measure the length of string to get the circumference of the tree.
- Learners then convert the circumference measurement to diameter by dividing the circumference by Pi (3.14).

Measuring diameter using callipers

A tree calliper has an arm and two prongs, one of which is free to slide along a graduated scale on the arm.

- If the school CDT department has callipers, use these; or make your own, using the Template - DIY tree measuring kit. This would be an opportunity for interdisciplinary work between Maths and DT.
- Open the 'jaws' and place on the tree at right angles to the stem (trunk) at a height of 1.3 metres (known as 'breast height').

- Move the sliding arm until it touches the stem. Make sure the arm is at right angles to the scale on the callipers.
- Read off the diameter from the scale to the left of the sliding arm. Take another reading at right angles to the first reading (i.e. at 90 degrees around the tree) and work out the average of the two readings.
- This provides the diameter in centimetres.

Explore

Why is it better to take an average of 2 calliper readings at 90 degrees rather than just one?

Think about natural variation in tree trunk shape and circumference. You could compare this by measuring the circumference of a man-made cylindrical pole e.g. a lamp post.

Explore

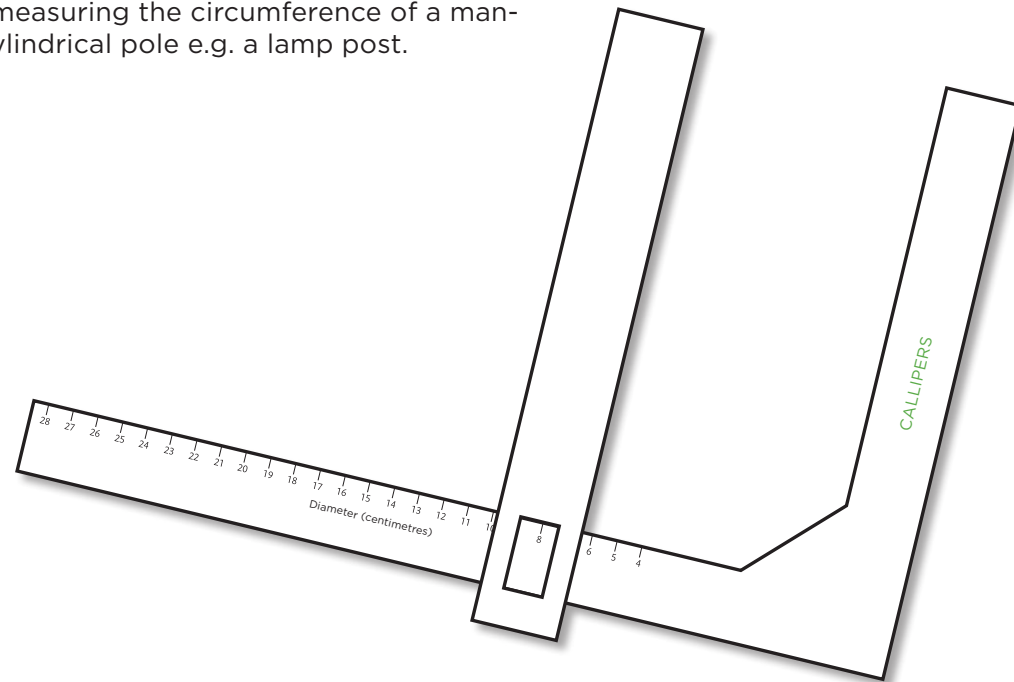
Learners can compare the results from both techniques to measure the same tree.

How similar are the results? Which method provided the most accurate measure, and why?

Extension

Identify the trees you have been measuring using ID sheets, books or apps.

Decide how to illustrate the relationship between species - diameter and what sort of data plot to use (e.g. using a scatter diagram). Discuss whether any patterns emerging?



Key Stage 3 and 4: Measuring height

Using a hypsometer

Make, and use, a hypsometer then working together use this to measure tree height.

Skills

Measurement, angle, symmetry and transformation, data analysis.

Resources

Tree(s); 2 meter sticks or measuring tape; hypsometer.



ACTIVITY

Various instruments are used by foresters to measure tree height. This includes the Christen's hypsometer, a linear scale on a stick. Like the clinometer, the measurements use basic trigonometry. The hypsometer must be positioned at a fixed distance from the eye, and the observer must stand a specified distance from the tree to measure height.

1. Learners work in pairs, firstly making a hypsometer by cutting out the shape on stiff card, from the Template - DIY tree measuring kit.
2. In pairs learners select the tree you want to measure for height.
3. One learner leans a 2 meter stick vertically against the tree at its base. This point is marked clearly e.g. using a coloured band, or by asking another learner to stand and



indicate this point.

4. One learner walks far enough from the tree so that when looked at through the hypsometer, the top of the tree is no more than 45 degrees up.
5. The learner moves backwards and forwards until the whole of the tree is within the end brackets of the hypsometer scale.
6. The learner reads off the scale the number nearest to the top of the 2m stick or pointer. Label the metre stick so that is clear in the diagram.
7. This number is the approximate height of the tree in metres.

Explore

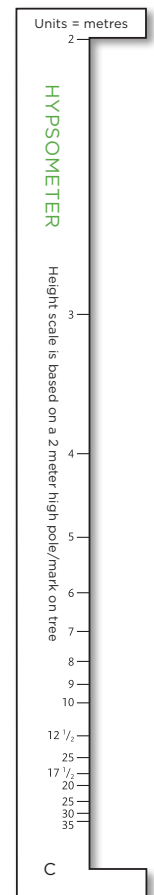
Discuss whether this technique for tree height measurement would be possible in forests or plantations where many trees grow close together?

Ask the learners to find out what foresters do in this situation?

This triangulation method assumes trees grow straight up. Can the learners see how much the tree measuring leans from its base? Discuss how this might increase errors in your results.



Using the hypsometer



Key Stage 3 and 4: Measuring the area of ground covered by tree stems (trunks)

Number of tree stems in a hectare

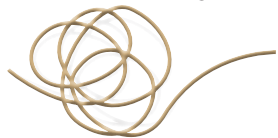
Make a simple tool and use this to estimate tree density in an area.

Skills

Measurement, estimation and rounding, data & analysis, maths - its impact on the world.

Resources

Group of trees, card, string, Template - DIY tree measuring kit.



ACTIVITY

Foresters use the relascope as a simple, handy and quick method to estimate the density of trees (amount of timber) in a given area. The relascope and its use for measurement was invented and introduced by Austrian forest scientist Walter Bitterlich in 1947.

Learners first make a relascope

1. Cut out shape on stiff card using the Template - DIY tree measuring kit.
2. Attach a bit of string, about 55cm long, by threading it through the hole marked x.
3. Tie a knot at both ends so it can't come out.
4. Your relascope is now ready to use.

Measuring using a relascope

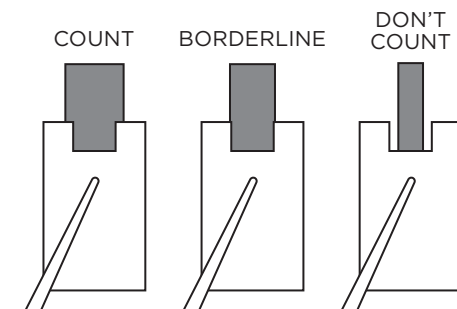
1. Individually learners should walk into a group of trees and stand on one spot - this is the sampling point.
2. Learners hold the relascope at eye-level at the length of the attached string, away from the eye.



Using the relascope

3. Learners move in a circle (360 degrees) on the spot and count any tree at 1.3 m above the ground (breast height), which is wider than the notch in the relascope.

Tip: it might help to first mark those trees in your sample area which are taller than 1.3m. Don't count any tree narrower than the notch. If a tree is borderline, count it in. NB. Bigger trees near you are more likely to be counted as in. This action is known as the 'relascope sweep'.



4. Multiply the number of trees counted by the relascope factor (marked on the relascope). For example, if 7 trees are counted, the answer is $7 \times 2 = 14$.
5. Discuss whether the relascope factor is always 2? What is the relascope factor?
6. The answer provides an estimate of the area of the cross-section of the trees (known as the basal area) in square metres of tree stem area in a hectare. 1 hectare = an area $100\text{m} \times 100\text{m}$ or $10,000\text{m}^2$. In the above example, the group of trees sampled will cover an area of 14m^2 within one hectare.
7. Learners can compare the results of several students surveying the same area.
8. Can any variation in results be explained?

Explore

Learners can sample the area of trees in their school grounds. Find out the total area of the school grounds in square metres and hectares?

Based on the results above, learners can calculate what proportion of the school grounds area is covered by trees. How accurate is this estimate?

How are the trees in your school grounds being cared for and sustained? Learners can also compare the current tree cover with historical maps of the area.

Extension

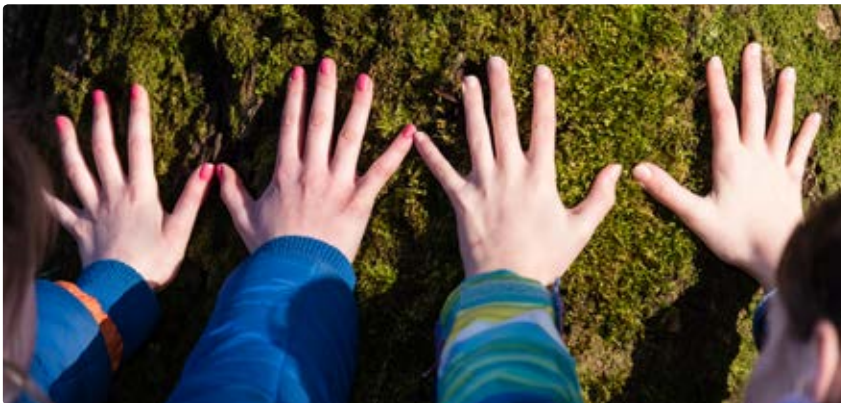
Work with the DT department to make a relascope from a suitable material.



The relascope

Tree Measuring

Connecting Trees with the Curriculum for Wales



Looking for more learning resources, information and data?

Please contact: **education@naturalresourceswales.gov.uk** or go to **<https://naturalresourceswales/learning>**

Alternative format; large print or another language, please contact: **enquiries@naturalresourceswales.gov.uk**
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