Education Outdoors New Zealand

# Maths Outdoors

**Maths Outdoors is a Teacher resource of learning activities to use outside the classroom and away from school.**

**Enrich your learning programmes with outdoor mathematical activities and applications.**



EONZ
EDUCATION OUTDOORS NEW ZEALAND (Inc)

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# Maths Tipping

**Location** A space large enough for the class to spread out with at least an arms-length between each student.

**Equipment** None.

**Group size** Whole class.

**Directions**

1. Students stand in a space in a defined area.
2. The teacher or a student (e.g. the winner of the previous game) stands where everyone can see them and is the caller. They call the name of the student who has to answer the question. Students are selected randomly from anywhere in the group.
3. Individual students say the number before or after a given number, within a designated time, e.g. 3 seconds. If correct the student takes one step in any direction to attempt to touch another student on the shoulder. If tipped, the student must sit down.
4. If the answer given is incorrect, that student sits down. Last one standing wins.
5. Examples of questions:
   - 'Give the number before/after __.'
   - 'Give the next odd number after __.'
   - 'Give the next prime number after __.'
   - 'Give the multiple of 3 before __.'
   - 'Give one factor of the number __.'

# The recall of basic facts

**Location** An open space sufficiently large for a class in teams of 10.

**Equipment**

1. A pack of 10 large cards for each team, each card numbered 1, 2, 3, 4, 5, 6, 7, 8, 9, 0. *The cards could be A5 size sheets photocopied from the pages in the PDF file: EONZ Math Outdoors #0-9.pdf from the website*
2. A set of arithmetic questions. Note that the answers can not contain two numerals the same (22, 33, 44, etc.) unless an additional pack of numbers is provided.

**Groups size** Whole class.

**Directions**

1. Divide the class/group into teams of ten.
2. Give one set of number cards to each team to distribute among the members. The teams line up in number order in straight lines, one behind the other.
3. The teacher asks a question that has a numerical answer (e.g. What is 7x7?). The players in each team that have the numbers that make up the answer must run forward to a designated line, turn and face their team, and form the correct number (e.g. 49). The pupils must be positioned in the correct order.
4. The first team that forms the answer correctly gains a point. The winning team is the first one to reach a pre-determined total.

**Extensions**

1. Repeat the game without talking.
2. Include questions with decimals.
3. Widen the range of questions, e.g. "Using any operation, what is the largest number that can be made with 3, 5 and 1?"
4. Add more cards to the pack (+, –, ÷, x, . ) requesting that the operation be shown for a problem *(e.g. #3 above)* rather than the answer.

# Outdoor Bean Bag Target

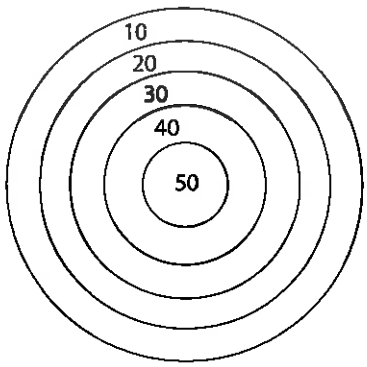
**Location** A flat area with space for the target and to throw the bean-bag. Note that the greater the distance to throw the bags the more difficult it is to achieve accuracy *(perhaps also an opportunity to gather data on distance v. accuracy?!).*

**Equipment**

1. Four hand-held bean-bags or 'hackie' sacs.
2. Chalk or ropes to mark out a target.
3. Pen/pencil and paper for recording.

**Preparation** On the ground mark out a large target with 5 rings.

Each ring has numbers in multiples, with the largest number in the centre, e.g.:




**Group size** Two even-sized groups.

**Directions**

1. Organise students into 2 teams with 2 bean bags per team.
2. Students take turns throwing the bags, call out the numbers bags land on, and add up their total.
3. A bean bag on a line gets the lower of the two scores.
4. A recorder keeps a record of the team's score.

**Extensions**

1. Each team member may throw more than 2 bean bags.
2. Use more difficult numbers for adding.
3. Rank highest to lowest scores.
4. Calculate the mean score.
5. Start with a total and subtract the scores so the winner is the first to achieve exactly or nearest to zero.
6. Correlate distance from the target with the scores.

# Multiples investigation

**Location** A space large enough for a class, could be indoors *(may be a good activity to have on camp when it is the third day of wet, horrible weather...).*

**Equipment** One A4 sheet of paper and a felt pen for **each** pupil, or alternatively have packs of numbered cards already prepared *The cards could be A5 size sheets photocopied from the pages in the PDF file: EONZ Math Outdoors #1-32.pdf from the website.*

**Group size** Whole class.

**Directions**

1. The class forms a large circle facing inwards.
2. The pupils each receive a number as they count around the circle in order from one to the total number in the class. Each pupil writes their own number in large figures on their piece of paper with a felt pen, or alternatively is given an appropriate number card.
3. They hold their number across their chests for everyone in the class to see.
4. The teacher explains that when a multiple is called that is true for any pupil's number they must raise that number above their heads for the rest of the class to see. The next time their number is a multiple of the one called they return their number to their chest position. Each number can therefore be viewed in only one of two possible positions.
5. To check that all pupils understand the instructions, the teacher should begin by saying "A multiple of 1", and all cards should be raised in the air.
6. The teacher says, "A multiple of 2". A check is made that all multiples of 2 are now at chest level, with only multiples of 1 being held up.
7. The teacher says, "A multiple of 3". All multiples of three should now change position.
8. The teacher continues the instructions for multiples of 4, 5, 6... etc, up to the final number in the class.
9. When completed the only numbers which should remain up will be the square numbers, 1, 4, 9, 16, 25, etc. The pupils can be asked to name this type of number and to speculate why this happened.
10. The pupils return to the classroom to write up the investigation and develop a table that illustrates each step of the development. Any hypotheses can be tested appropriately.

**Extension** Try to write the rules for multiples of 2 (i.e. 2n); multiples of 3 (3n); for the series 1, 4, 9, 16, (i.e. $n^2$).

# Seed classification

**Location** School grounds or at camp.

**Equipment** Worksheet for each group (sample below, see Appendix, p. 63, for a blank pupil version); pen/pencil

Glue for each group.

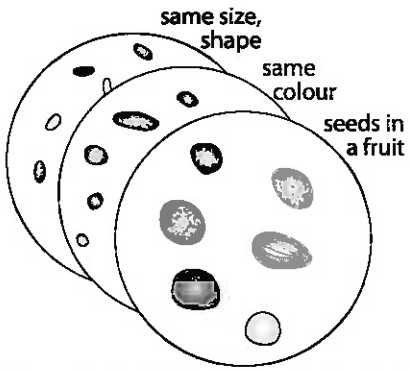
**Group size** Small groups (e.g. 3 people), or individuals.

**Explanation** While seeds are obviously essential in the reproduction of seed plants (conifers, flowering plants), they are an important food source for many animals and important in human diet. Seeds have a plant embryo and a store of food for the initial development of the embryo, both encased in a seed coat and, until released, also within a fruit, which may be dry or succulent. It is the store of food which animals and humans utilise. Seed of many native trees will be found on the ground in hard or leathery fruits and sometimes the fruit may be mistaken for the seed, and the fruit may contain many seeds. A seed plant invests much energy and materials in seeds as, in addition to reproducing to enure its survival as a species, the seeds are dispersed to reduce competition with its offspring. Plants have many ways of dispersing seeds, from feathery fronds to increase drag in the air so they can be blown on the wind, to edible fruits containing armoured seeds that survive a trip through an animal's gut and being deposited (along with fertiliser!) some distance from the parent plant. Ferns and other 'lower' plants do not produce seeds.

**Directions**

1. Find some seeds outside.
2. Sort the three seeds into groups and glue them down when you are satisfied with the groupings.

Why did you group these seeds together?




How many seeds are there?

The worksheet in the appendix has the instructions, three circles and the questions repeated for each circle.

**Extension** Use stones or other objects having a variety of attributes within the same object class (e.g. leaves, twigs, screws, etc.).

# Environmental Classification

**Location** Bush, beach or school grounds.

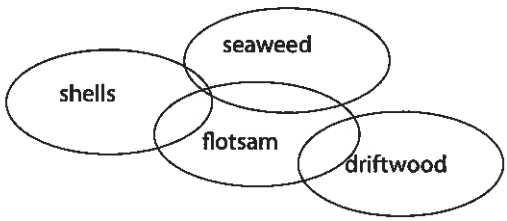
**Equipment** Hoops or string to define sets.

Objects from any environment.

**Group size** In pairs or small groups.

**Directions**

1. Each group of pupils is given 15 minutes to collect a range of objects from a specified area, taking care to minimise disturbance to the environment.
2. Each group is given some hoops (or loops of string) and asked to organise their objects into different types and place each type into a different hoop.
3. Each group is asked to describe their categories (or sets) in words to the other groups.
4. The pupils are challenged to reclassify their objects for a different criteria (e.g. by size, colour, shape, natural or manufactured, living or dead, material type, etc.)
5. Extend the activity by considering the intersection of sets:




**Remember to return objects as close to where they were found as practicable.**

# What is in the bush?

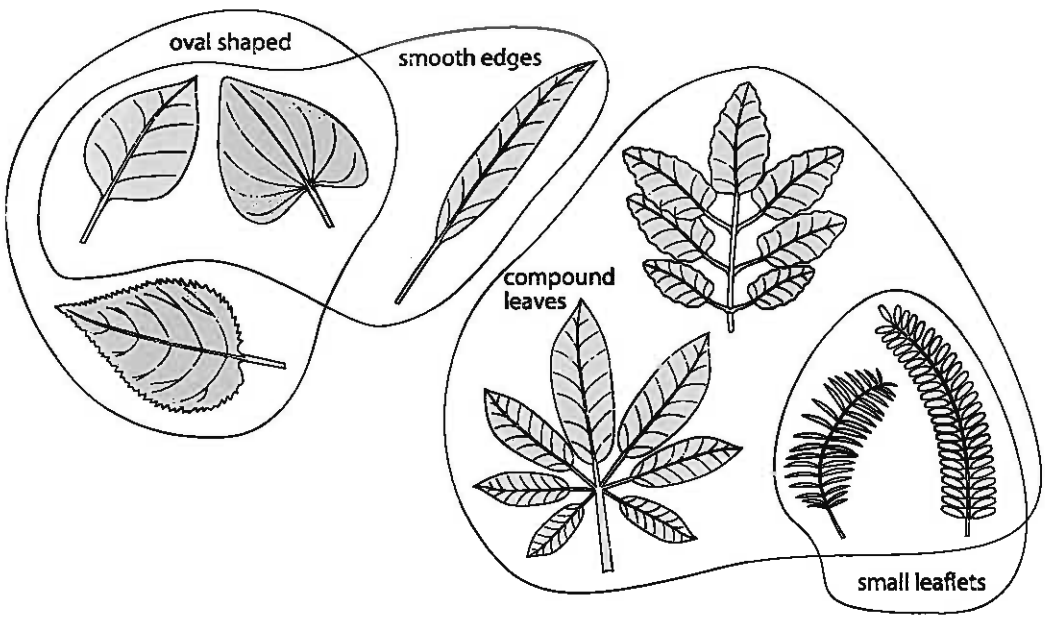
**Location** An area of bush.

**Equipment** String, pen/pencil, paper, paste.

**Group size** Small groups.

**Directions**

1. Find an area of bush where there are many different trees.
2. Tie your string to one tree and walk around this area unwinding your string until you come back to that tree. Tie the other end to the same tree. ***Hint:*** Do not enclose too large an area!
3. Count the number of large trees in this space - this will be your universal set.
4. Using different ideas, how many subsets of this area can you find, e.g. tree heights, leaf shapes, leaf lengths, ground cover, types of plants, etc.
5. Can any of your subsets intersect? If so which and why?
6. Collect leaf samples from these trees and make a Venn diagram to show some of your subset relationships by pasting your leaf samples onto a chart.



# A Fence

**Location** Where there is a fence, preferably with posts, battens and wires.

**Equipment** Metre rule or tape measure, pen/pencil, paper.

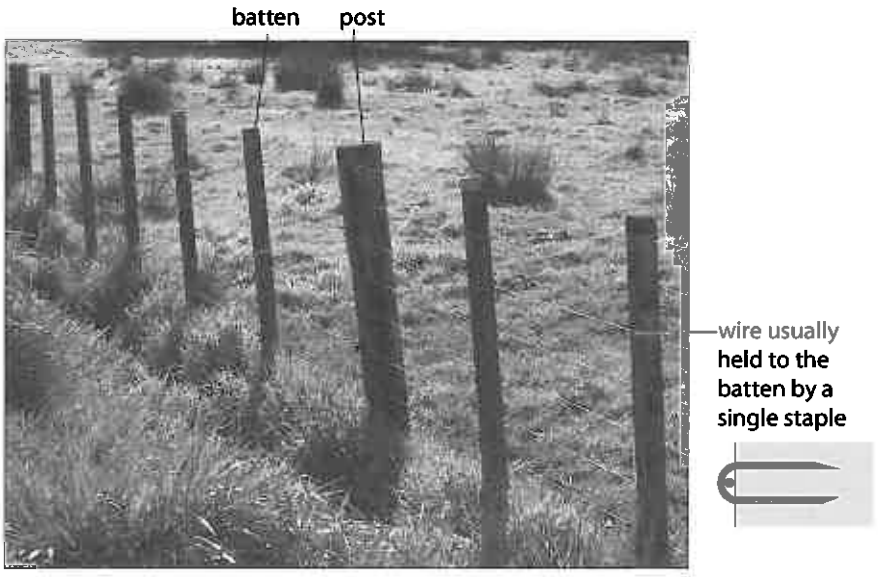
**Group size** Small groups.

**Directions** Look at a fence:

1. Are the small posts (battens) evenly spaced?
2. Are the large posts evenly spaced?
3. Draw a section of the fence – what can you say about the wires?
4. Count the staples on the battens between 2 large posts.
5. Can you arrive at the answer for (4) without having to count all the staples?
6. Measure the distance between 2 battens:
   - along the top wire
   - along the bottom wire

   What can you say about these measurements?

   What does it tell about the battens?
7. Look at the fence and see if you can find an example of each of these shapes: rectangle, triangle, parallelogram, circle, quadrilateral. Draw a diagram of the fence and label, showing where these shapes are found
8. Describe the most important things to know when building a fence.



# Frog March

**Location** An open space with a surface suitable for marking shapes.

**Equipment** As appropriate for marking squares or circles on the surface (chalk, masking tape, rope, hoops, wire squares, etc.

**Preparation** For each group mark out nine squares (or circles) in a line:

**Group size** Groups from 4 *(they should be even numbered, the larger the group the longer it can take them to work it out).*

**Scenario** Two families of four frogs are marching towards each other down a path of single lily-pads. The problem is to work out how the families can pass each other to continue their march according to some simple rules.

**Directions**

1. Begin by having each of the first group of four pupils stand on a square to the left of the middle square, and those in the second group of four pupils each occupy one of the four squares to the right of the middle square. All pupils stand facing the middle and unoccupied square. The squares represent the lily pads.
2. The left side must end up in the places of the pupils on the right side, and vice versa. Only **one** frog may move at a time.
3. ***Legal moves:*** Any frog may move onto an unoccupied lily pad in front of them. A frog may leap over one other frog onto a vacant lily pad provided that frog is facing them. *Cooperation is required!*
4. ***Illegal moves:*** Any frog moving backwards. Leap-frogging over a frog that is not facing them. Two or more frogs moving at the same time. Leap-frogging over more than one frog into an empty space. Cooperation is required!
5. This activity can be introduced to smaller groups (e.g. teams of 2) and then, as the groups solve the problem, gradually combine groups (maximum 10 to 12 students).

**Extension** Do the activity with different sized groups, starting with small groups. Get the students to count the number of moves required for each group size. The groups can then work out the quadratic function and graph the results.

# Weather and temperature

**Location** School or camp.

**Equipment** Maximum-minimum thermometer, rain gauge, wind measuring device (anemometer), UV card *(obtained from the Cancer Society)*, pen/pencil, paper for a record sheet

**Group size** Small groups.

**Instructions**

1. Decide when daily weather records will be recorded, e.g. at 9.00 am, 12.00 pm, 3.00 pm etc.
2. Weather records may include:
   a) Air temperature *(actual, and maximum-minimum over a period)*
   b) Rainfall
   c) Wind velocity
   d) Wind direction
   e) Cloud cover (measured in eighths)
   f) Sunshine hours
   g) UV rating
3. Air temperature changes can be recorded in graph form on a regular interval basis, for example every 2 hours from 8.00 am to 8.00 pm. Measurements could be taken in the following places *(but the bulb of the thermometer must always be shaded as otherwise it is measuring the solar gain, or other radiant heat gain, not the air temperature):*
   a) On an unshaded sealed or concrete area
   b) On the south side of a building
   c) Over a pool or river water surface
   d) In the dining room
   e) In the kitchen
   f) In a bush or wooded area
   g) Soil temperature at depths of 5 and 10 cms *(a suitable diameter calibrated rod should be available to make a hole in the soil to the required depth – thermometers are not durable probes!).*
4. Collate this information into graphs. They can be superimposed to allow for comparison.

**Extension** Use the time series data to make a prediction, e.g. what will be the likely temperature at 3.00 pm two weeks from now. Discuss the problems with making this prediction.

# Statistical Surveys

**Location** School grounds or camp grounds.

The school environment offers many opportunities for pupils to develop skills in data gathering for statistical analysis. A class can be split into several groups to investigate different topics that may cause problems.

**Equipment** Calculator, pen/pencil, paper, .

**Group size** Small groups.

**Directions** Each group needs to choose their study topic, and then:

1. Gather appropriate data through counting, observation, questionnaires, or interviews.
2. Display their findings using statistical graphs.
3. Determining whether a problem exists or not.
4. Prepare a report including suggestions for solutions to any problems.
5. Present the report to the class and other interested people.

**Topics for study may include**

1. **Lunch time seating:**
   a) How many pupils attend the school?
   b) How many pupils eat lunch at school?
   c) Where do they eat their lunch?
   d) Where are they meant to eat lunch?
   e) How many seats are provided outside?
   f) Are there enough outside seats at lunchtime? Are all the seats being used? Does the usage vary at different times of the year?
2. **Use of the school canteen:**
   a) How many people use the school canteen at interval / lunch time?
   b) Is the canteen big enough for the numbers using it?
   c) Is the method of queuing efficient?
   d) What is the average number of people served per minute? Is the capacity of the canteen a limiting factor?
   e) What are the most popular items sold at the canteen?
   f) Which foods would pupils like to buy at the canteen but are not currently available?
   g) How could the canteen promote the eating of healthy foods (other than by not stocking foods regarded as "unhealthy").
   h) Is there a relationship between the sugar and/or fat content of foods and their relative popularity?

3. **Litter**
   a) Where are the litterbins located around the school?
   b) What are the levels of rubbish in the bins before school, after interval, after lunch and after school?
   c) How much litter is there around the school? Where?
   d) Are there enough rubbish bins?
   e) Are they situated in the best places?
   f) What are the most important factors causing people to not put their litter into the bins provided?

4. **Transportation:**
   a) How do pupils travel to school?
   b) Are there enough car and motorbike parks?
   c) Are there enough bike stands?
   d) Should other facilities be provided, e.g. air pump?
   e) Is security of pupils' transport a problem at school?

5. **Library:**
   a) How many people use the library at interval, lunch time and after school?
   b) Which year groups make the greatest use of the library?
   c) Why do pupils use the library?
   d) Is the library large enough for all those who wish to use it?

# Human Graph

**Location** Concrete or asphalt surface.

**Equipment** Chalk.

**Group size** Divide a class into three equal groups.

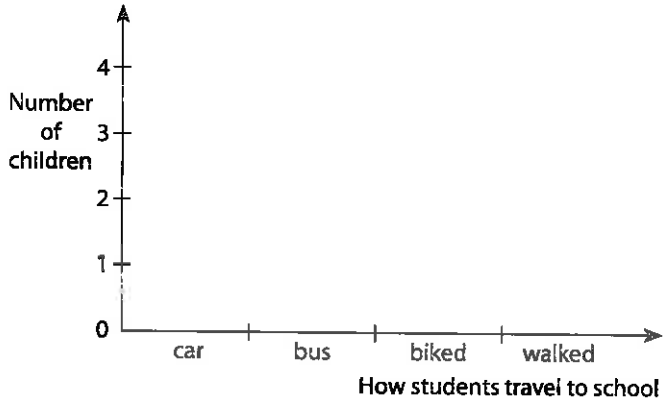
**Directions**

1. Each group discusses what type of information they are going to gather in their group, e.g. eye colour, height*, clothes colour, hair colour, how they came to school *(*note: this is the only characteristic in this list showing continuous variation, producing a normal distribution curve with a large sample).*
2. *(Data collecting)* Each group draws a set of axes on the ground. ***Vertical axis:*** numbered to show how many children (frequency) ***Horizontal axis:*** labelled with the categories, e.g. blue, brown
3. *(Data Presenting)* Each group member then stands on the graph in line with the category they belong in. e.g. stand in the blue category if they have blue eyes. *(Make sure each successive child is in line with the next number on the vertical axis.)*
4. *(Data Analysis or interpreting the results)* Next, have the group tell you what the graph shows.

   Encourage appropriate Maths language, such as: more, less, equal, most, least, longest, shortest, etc.

   Children should give answers like "In room 2 more people have blue eyes than any other colour because the human graph went up to number 9"; or "in room 2 the least common eye colour is green because the human graph only went up to number 2 and that was the shortest line."
5. Each group can make two human graphs, each using different categories.

   Finish by making a class human graph with every class member involved. Interpret the data as a class.



# Litter survey

**Location** School grounds or camp ground.

**Equipment** Record sheet per group *(example below)*, gloves/tongs, bag, pen/pencil.

**Group size** Small groups.

**Directions**

1. Go outside and collect 10 pieces of litter* *(tongs or gloves should be provided for safety)*. [*For this exercise, litter is defined as human manufactured or grown items no longer required by the owner.]
2. Sort your litter into groups: paper, plastic, metal, glass, and food scraps. Record the numbers in the table below. Put your litter in the bin when finished.
3. Did any pieces of litter fit into more than one category?
4. Draw a graph to show what you found.
5. Write a story about your graph.

**Extension** This is a useful exercise to distinguish between human-origin and natural litter, what we define as rubbish, to investigate how materials are recycled, the proportion able to be recycled, and the costs and environmental benefits of recycling. It is also an opportunity to survey attitudes towards littering. Although packaging is often blamed as the source of litter, containment and protection of food in particular makes packaging essential, so littering is obviously a human behaviour problem. The sample table below suggests recording types of litter within some categories, allowing opportunity for more informative graphs.

**Litter in our school**

| Pieces of litter | | | | | | |
|---|---|---|---|---|---|---|
| | 10 | | | | | |
| | 9 | | | | | |
| | 8 | | | | | |
| | 7 | | | | | |
| | 6 | | | | | |
| | 5 | | | | | |
| | 4 | | | | | |
| | 3 | | | | | |
| | 2 | | | | | |
| | 1 | | | | | |
| **Category** | | **Paper** | **Plastic** | **Metal** | **Glass** | **Food scraps** |
| **Litter types** | | F = food packaging G = goods packaging<br>O = other (could be described in notes) | | | | S = skins<br>U = uneaten |

# Cemetery Statistics – A Social Survey

**Location** An old cemetery, or an older section in a cemetery.

**Equipment** Worksheet of guiding questions *(questions below, levels 4/5 and 6 separate pupil versions in the Appendix p. 64, 65)*, pen/pencil, tracing paper, wax crayons, pen/pencil.

**Group size** Small groups of 2-3, allow up to three hours if students are answering all of the questions.

***Note:*** A visit to an old or historic cemetery, or urupa, can prove a valuable educational experience by revealing much information about the culture of the people who once lived in the area. It is important that pupils first realise burial grounds are considered sacred or tapu by all cultures so that visitors should treat a cemetery with respect and care. Permission, if possible, should be sought for a class visit. Take into consideration any cultural practices or customs your students would follow when visiting a cemetery.

**Directions** Use these questions as a guide in finding information *(Hint: drawing graphs may help you to answer some of these questions)*:

***Levels 4/5:***

1. When was the cemetery founded?
2. Who was the first person buried? When? How old were they at the time of their death?
3. How long has it been since someone was buried in the cemetery?
4. What kinds of headstones or markers are used upon the graves? Are these materials local or transported from elsewhere?
5. Can the whakapapa or family tree of certain families be traced from the grave markers?
6. How many different nationalities or countries are represented within the cemetery? (How could you know?)
7. What was the median life span of people in this community?

*Level 6:*

8. Is there evidence of any common accidents, epidemics or wars? If "yes", what evidence?
9. Over the years, what changes occurred in the designs, shapes, or types of markers, or in the epitaphs?
10. Are all the inscriptions visible? What kinds of stones show weathering? Make rubbings of a variety of geometrical motifs that occur on gravestones. Identify all of the transformations that you can.
11. Do all the gravestones face the same way? If "yes", why?
12. Who lived longer in this community, men or women?
13. Can the economic status of a family be determined in any manner? If "yes", how?
14. What feelings do you have about the people that are buried in this cemetery?

**Note** that the worksheet in the Appendix has been split into two parts: the first page has questions 1–7 for Levels 4/5, the second page has questions 8–15 for Level 6.

# Growth rates of trees

**Location** A readily accessible area where trees have been recently felled and the rings are easy to see in the stumps.

**Equipment** Felt pens or toothpicks, magnetic compass, pen/pencil and paper.

**Group size** Small groups (2–3) but depends on the number of stumps at the site.

**Explanation** Trees increase in height by growing at their tips, and in girth by growth in a layer just underneath the bark (the cambium layer). This produces a pattern of concentric rings made up of alternating lighter and darker areas. The lighter areas represent rapid growth, generally during spring and early summer, the darker areas the slower growth occurring when conditions are less favourable in late summer and winter. A pair of light and dark rings represent one year. Counting either light or dark rings gives an accurate measure of the age of a tree. Trees that grow quickly have larger rings. As trees may live for hundreds of years, the relative sizes of rings in a tree is an indicator of climate changes during its life. Local conditions may also have an effect in that the warm (north facing) side of an exposed tree may grow more rapidly than the colder (south-facing) side, producing an oval trunk, and the prevailing wind may also affect the growth pattern.

**Directions**

1. Study the pattern of annual growth rings on a tree stump:
   a) When was the tree felled? Why would you need to know this?
   b) What was the age of the tree when it was felled?
   c) Are the growth rings true circles? If not, what could cause it?
2. Use felt pens of toothpick flags to mark the growth rings that correspond to particular dates in history, e.g. when they were born, the first ascent of Everest, the beginning and end of World War 2, etc.
3. Draw a pencil line with a ruler across a stump through the pith (centre) across the greatest diameter. Use a magnetic compass to determine the direction of this line. Is this direction the same for all adjacent tree stumps? If this was a grove of trees compare the shape of the stumps with those in the middle of the grove with those on the perimeter.

4. Are there any differences in the growth ring patterns between stumps of trees in other locations, such as those on ridges compared to those in adjacent valleys? Why could be some reasons for this?
5. Measure the width of each of the outer 10–20 growth rings (e.g. measure between the edge of one light coloured ring and the equivalent edge of the next). Draw a graph plotting the width of each growth ring for each year. Locate local weather statistics for the past 1–20 years and see if there is any relationship between rainfall and average temperatures and the width of rings with the most or least annual growth.

# Graph Walk

**Location** Concrete or asphalt surface.

**Equipment** Chalk, 2 long ropes.

**Group Size** Whole class activity.

**Directions** Mark out X and Y axes in chalk on the ground and pace out chalk integer scales for –8 to +8 on the X axis and –10 to +10 on the Y axis

1. Half the class are to stand along one edge of the graph and to record copies of the graphs in their exercise books.
2. The other half of the class are to stand along the X axis on each integer marked in chalk on the ground and facing towards the top of the graph. They are to listen and follow the teacher's instructions.
3. The teacher says: "Look at the number at your feet. If your number is positive move forward that number of paces, if your number is negative move backwards that number of paces".
4. They should form a straight line modelling the graph of $y = x$. A rope can be laid along the line to preserve the position. Leave the rope in position.
5. The walkers resume their position on the X-axis. The teacher says: "Double the number at your feet and subtract one. Walk that number of paces".
6. The walkers should form another straight line modelling $y = 2x–1$. The second rope can be used to preserve the position.
7. The teacher discusses with the class the significance of the patterns and the intersecting point (1, 1), and the Y intercepts (0, 0), (0, –1).
8. The walkers and the recorders swap roles and the solution for another pair of equations is modelled.
9. On returning to the classroom the teacher develops the graphing concepts by asking the pupils to imagine themselves standing at various positions on the X-axis when they plot further graphs. The learning should be linked the physical movement previously experienced outside the classroom.
10. Variations of this teaching method may be used for:
    - First concepts of linear functions.
    - Extending the concepts to quadratic and other functions (the rope emphasises the shape and continuous nature of the curves).
    - Solutions to simultaneous equations.
    - Inequalities and linear programming applications.

# What is out there?

**Location** Classroom, school grounds or at camp

**Equipment** Worksheet for each group or pupil, pen/pencil

**Group size** Small groups or individual activity

**Directions** Look for things inside or outside your classroom that match the words inside the boxes. Draw them in the boxes.

| Rough | Smooth | Curved |
|---|---|---|
| Pointed | Small | Big |
| High | Low | Straight |

# When is local midday?

**Location** A smooth area where the sun can cast a shadow before and after midday and where an object with a point (e.g. a stick) can cast a narrow shadow.

**Equipment** A pointed stick able to be placed vertically in a fixed location.

**Group size** Small groups (2–3).

**Explanation** During a day an observer will see the sun rise in the sky in the east, reach its highest point at midday (shared by locations on the same longitude), and then set in the west. The length of the shadow cast by a vertical object varies during the day and from day to day (as the point of sunrise changes during the year), so does not indicate time accurately over more than a day. A vertical stick (gnomon) in the ground is of most use for finding the local midday which, if Greenwich Mean Time (GMT) is known, will also give the longitude. A sundial requires that the shadow casting edge (style) be sloped at the same angle as the local latitude.

The sun appears to move around the earth's axis at about 15° per hour. The position of the sun indicates local apparent time (LAT), in contrast to the local mean time (LMT) given by our clocks. LAT varies because the speed of the earth in its orbit around the sun varies during the year as the orbit is elliptical, not circular. At some times of the year the LAT is ahead of LMT by more than 16 minutes (November), and at other times it is behind by more than 14 minutes (February).

In New Zealand midday is never 12 o'clock. Our standard time differs from GMT by 12 hours, but as Greenwich is at longitude 0°, a 12 hour difference would require our location to be at longitude 180°E. The longitude of NZ ranges from 178°33' E (East Cape) to 166°25' E (West Cape, Fiordland), but all of New Zealand has the same LMT, or standard time, for convenience (i.e. GMT + 12, plus daylight saving when applicable).

Midday (i.e. the sun is at its highest) will occur later than midday on LMT (which is based on GMT and assumes we are at longitude 180°). Using the proportion of a longitude away from the 15° 'hour lines', midday at East Cape would be (180° – 178.5°) ÷ 15 hours away from midday, i.e. $^{1.5}/_{15}$, or $^{1}/_{10}$ of an hour (6 mins) after LMT midday, so midday as indicated by a shadow would be 12.06 pm LMT. At West Cape midday would be about (180° – 166.5°) ÷ 15, i.e. $^{13.5}/_{15}$, or $^{9}/_{10}$ of an hour, or 54 minutes after LMT, so midday there as indicated by a shadow would be 12.54 pm LMT. During daylight saving add an hour. It is because the earth rotates west to east that LAT midday occurs at East Cape 48 minutes before LAT midday at West Cape.

**Directions**

1. Place a stick vertically in the ground, using a plumb-bob or spirit-level to ensure it is vertical.

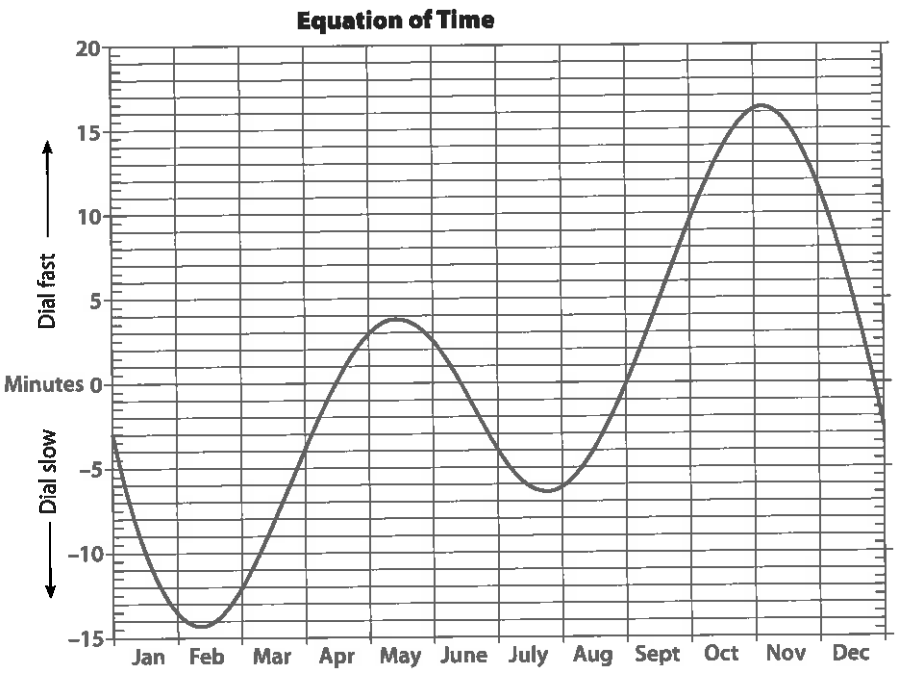
2. Starting before midday (adjusting the starting time according to location) mark the length of the shadow, noting the exact time (clock time, or local mean time, LMT) when it is shortest. That is local apparent time (LAT) midday. The shadow line also runs precisely north-south.
3. The earth rotates about 1° in four minutes. Divide the number of minutes after LMT by 4 to give the number of degrees to subtract from 180° to give the local longitude east.

**Notes**

Although a shadow stick is often taught as being a simple sundial, the shadow is an accurate indicator of time for only that day. In addition, it can not, as is often also suggested, be calibrated using standard time. The 23.5° tilt of the earth's axis means that the sun rises and sets at a different time and place each day, changing the length and direction of the shadow each hour. The spherical shape of the earth also means that the ground on which the shadow is cast is obviously at a different angle at different latitudes, so the shadow moves at different rates at different times.

It was discovered very early, probably by the first century CE, that if the style was parallel to the earth's axis and the hour lines were a projection of an equatorial dial on to whichever angle the local dial was at that location, a sundial gave an accurate reading of local apparent time. This was accurate for the whole year if the Equation of Time (or the analemma) was used to correct for the earth's tilt and elliptic orbit (add, subtract minutes as appropriate), and would even show local mean time if the hour marks were displaced for a longitude correction.

The term "clockwise" came from the direction that the shadow moved on a sundial in the northern hemisphere.



# An equatorial sundial

**Location** Any area where the sun shines all day.

**Equipment** Bamboo skewer, A4 sheet of heavy paper, pen/pencil, protractor, magnetic compass, scissors; ***or,*** magnetic compass, scissors, printed template.

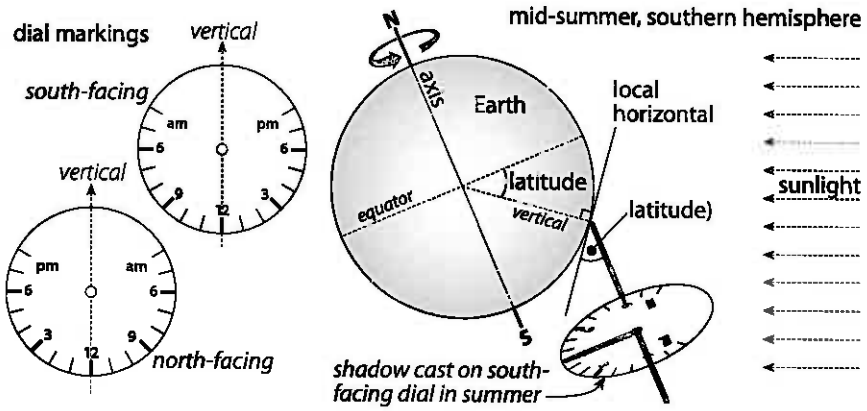
**Group size** Small groups.

**Explanation** The gnomon of a sundial must be parallel to the earth's axis, so the style of the gnomon (the edge casting the shadow) is placed at the angle of latitude for its location and points to true north. Note that 24 hours is the time between one midday and the next, the earth rotating about 361° in 24 hours as it moves on in its orbit about the sun by nearly 1° each day.

The sun appears to move around the earth's axis at about 15° per hour. Only the equatorial type of sundial has its hour marks 15° apart as the dial plate is in the same plane as the earth's equator. All other sundials need to have the hour lines constructed according to the latitude of their location and the plane of the dial.

**Directions** Either use the template in the Appendix (p. 66), or these instructions:

1. From the centre of the piece of paper (the dial plate) draw a circle and inside that draw hour lines at 15° intervals. Only the daylight hours need be included (e.g. 4 am–8 pm). Mark the meridian (midday) line. If it is to be used all year the dial needs to be marked on both sides (the underside is a mirror-image of the upper side).
2. Push the skewer through the centre of the lines on the paper, ensuring that the paper is perpendicular to the skewer.
3. Push the skewer into a mount (e.g. Plasticine, etc.) pointing true north with the skewer (style) at an angle with the horizontal* equal to the latitude at that location. The 12 o'clock marking should be vertical and nearest the ground. Between the spring and autumn equinoxes (mostly summer), the shadow falls on the south-facing surface; for the next six months the shadow will fall on the north-facing surface.




**the horizontal plane can be determined by a bowl of water, a spirit-level, a clear tube filled with water, or as perpendicular to a plumb-bob.*

# Making a protractor

**Location** School or camp.

**Equipment** Scissors, pen/pencil, paper.

**Group size** Individual.

**Directions**

1. Take a piece of paper and fold it in two.
2. Fold it again placing the edges of the folds together. Open it out and you have two folds meeting at right angles (90 degrees).
3. Label each line in turn, 0° (or 360°): North

   90°: East

   180°: South

   270°: West

   This is a form of compass.
4. Cut out a circle about 15 cm in diameter. Fold it into halves, quarters and then eighths. Open out the folded circle and label the fold lines in degrees: 0° or 360°, 45°, 90°, 135°, 180°, 225°, 270°, 315°, 360°.
5. You have made a 360° protractor.

# Where are the trees?

*The exercise below is a simple sketch-mapping exercise.*

**Location** School grounds or camp grounds.

**Equipment** Magnetic compass, pen/pencil, paper.

**Group size** Small groups.

**Directions**

1. Choose one part of the playground or camp grounds. With the compass find magnetic north and mark it on the map. Later, find the current magnetic declination and mark true north on the map. *Reminder: by convention, north is always at the top of the map.*
2. Sketch a map of it and mark on it where the trees are. Put other large things on it such as a hill, buildings, a river, etc. It may be useful to do this from two or more viewpoints.
3. Is there any relationship between where the trees are and other features in the area? Describe it.
4. If there is a relationship, what could be some reasons for it?

**Extension** Choose an appropriate scale, e.g. 10 cm to 1 m (1:100) and try to draw the plan to scale.

# Scale

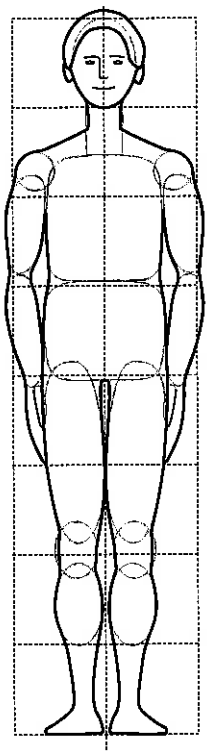
**Location** Classroom, school grounds or camp.

**Equipment** Metre rule, pen/pencil, paper.

**Group size** Small groups.

**Directions** Maps, plans and diagrams are usually drawn to scale

1. Try drawing a friend using a scale of:
   a) 1 cm to 1 m
   b) 1 cm to 10 cm
   Which do you think is the best scale for this? Why?
2. Measure and draw a building or an area around the camp using a scale you decide on with your teacher



If drawing a person, a good start is to use the "number of head lengths" for scale.
An 'average' adult is about eight head lengths tall. A tall, thin adult is about nine head lengths; a short, plump person about seven head lengths. A 10 year old child is about seven head lengths, a three year old about five head lengths.
If a grid is drawn as shown for the 'average' adult (left) the other body parts are also in similar proportions. Start by drawing ellipses and rounded corner rectangles for body parts, as shown in grey on the drawing on the left.
A male is shown on the left; a female would have narrower shoulders, wider hips and may be more slightly built.

# Mapping your camp-site or school

**Location** Camp ground or school grounds.

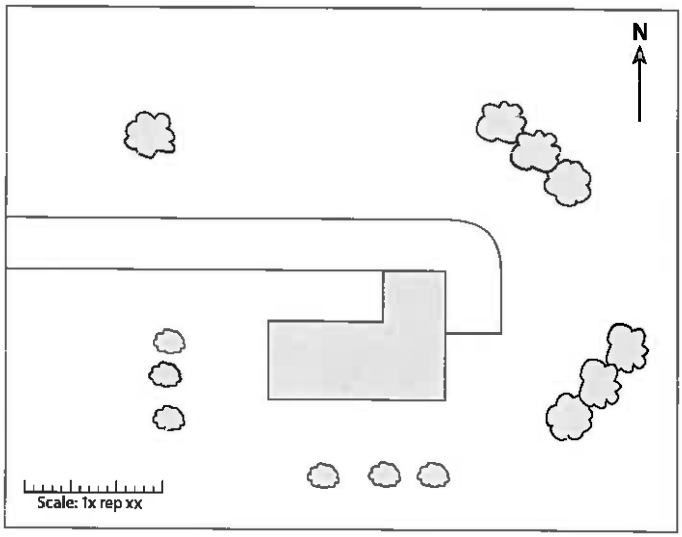
**Equipment** *Sketch map:* Magnetic compass, ruler, pen/pencil, paper.

*See the Appendices p. 60 for instruction on Plane Tabling for making an accurate map; the materials list is included with the instructions.*

**Group size** Small groups.

**Directions**

1. Find an area of camp or school grounds.
2. With the compass find magnetic north and mark it on the map. Later, find the current magnetic declination and mark true north on the map. *Reminder: by convention, north is always at the top of a map.*
3. Plot position of huts, cookhouse, trees, etc.; or the classrooms, bike sheds, etc., at school.
4. Work out an appropriate scale for the campsite.
5. Draw up a scale model of the campsite, marking in huts, etc.



# Making a plan of your cabin or classroom

**Location** Camp cabin or classroom.

**Equipment** Graph paper, pen/pencil; *optional:* magnetic compass

**Group size** Cabin groups, or small groups.

**Directions**

1. Draw on the graph paper a scale drawing of your bunkroom or classroom. Mark north on the plan.
2. Elsewhere on the graph paper draw a scale outline of the number of beds in the room plus two extra beds (or desks if using the classroom).
3. Cut these out carefully.
4. By placing the bed outlines in the room outline, rearrange the original beds to fit in the two extra ones as well. Remember to allow dressing and storage space. Do the same with the extra desks for the classroom.
5. Draw your final layout on another piece of graph paper.

# Measuring your pace

**Location** An open space.

**Equipment** Measuring tapes, chalk, notebook, pen/pencil.

**Group size** Groups of 3–4, for 30–45 minutes.

**Directions**

1. Estimate (in cm) the length of your pace for a variety of movements and write your estimates in a table:

| Type of movement | Estimate | Measurement |
|---|---|---|
| Walking normally | | |
| Fast walking | | |
| Jogging | | |
| Running | | |
| Fast walking | | |
| Side-ways steps | | |
| Walking backwards | | |

2. Measure the distance travelled for ten of your paces for each variety of movement. (Some discussion may be necessary to establish conditions for reliability, e.g. beginning the movement some distance before beginning the measurement start to ensure a steady speed.) The average pace measurement is entered into the table and compared with the estimate.
3. Plot the results as a bar graph with the distances recorded in centimetres. Should the distance backwards be recorded as a negative value, or is the length of pace a non-directional measurement?

**Extension** Use uphill and downhill ground surface. What happens to pace length?

Use a site with obstacles to find whether the pace for each type of movement changes.

Estimate distance from A to B on a map with a scale. Then measure using paces. Is there a significant difference? Why? (e.g. changing terrain or obstacles may lengthen the distance measured.)

How could this skill be useful for a hiker, tramper or orienteer?

# How much water do we use?

**Location** School grounds or camp.

**Equipment** Litre measure, buckets, watches with second hands or stop watches, pen/pencil, paper.

**Group size** Small groups.

**Directions**

1. Use litre measures to find out how much water your bucket holds. (You may find it easier to do this work if you put a mark on the side of the bucket at the 4 or 5 litre level)
2. Use your marked bucket and your watch to calculate the water flow rate from some of the taps and showers around the camp or school.
3. Measurements could be in litres per minute. If it takes 10 seconds for a tap to fill up to the 4 litre mark on your bucket, how many litres would flow from the tap in one minute? Write your answer in litres per minute.
4. Draw up a chart for the taps and showers you have tested.
5. Work out some interesting facts like:
   a) If 25 children all had 2 minute showers, about _____ litres of water would be used.
   b) This camp/school uses approximately _____ litres of water a day.
   c) This camp/school uses approximately _____ litres of water for the dishes.
   d) This camp/school uses approximately _____ litres of water for showers, etc.

# Measuring an inaccessible object

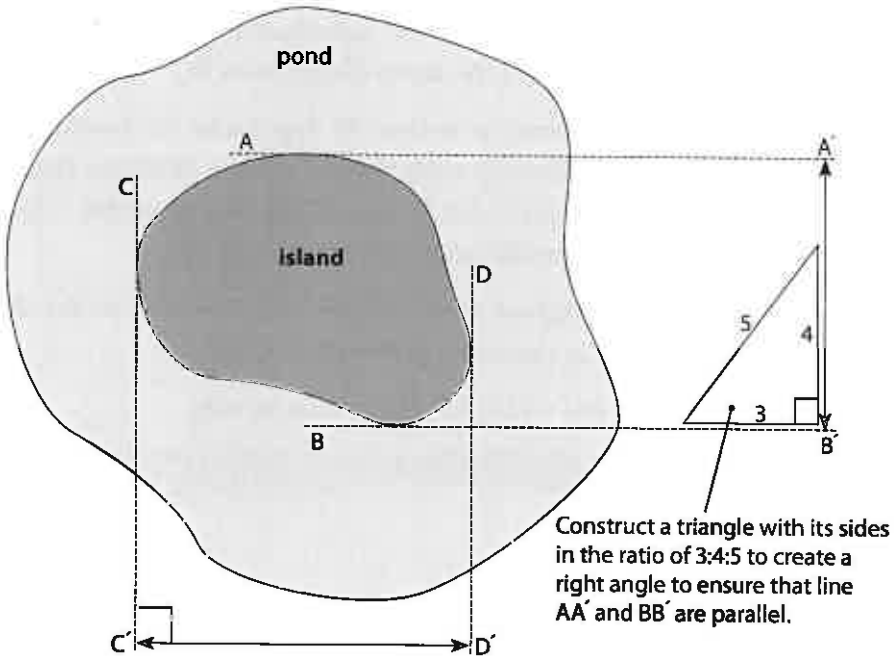
**Location** A building, island, rock outcrop, or other large feature which cannot be reached directly to measure one of its dimensions.

**Equipment** Magnetic compass, metre rule or tape measure, pen/pencil, paper.

**Group size** Groups of 3–4.

**Directions** This is to find out the distance across an object or natural feature that you cannot reach to measure directly.

1. Imagine a line between A and B. Move to one side of the obstacle and make a line parallel to AB that is exactly the same length as AB. Call it A′B′.
2. Measure your parallel line.
3. Think about how you can check this line is exactly as same length as AB.
4. If possible, repeat for another dimension of the feature.



# River width estimation

**Location** Stream or river with open land on accessible side.

**Equipment** Trundle wheel or measuring tape, pegs or sticks, prismatic compass, pen/pencil, paper.

**Group size** Small groups.

**Directions** **Method 1:** Estimating the width of a river by constructing congruent triangles.

a) Choose a tree or some other clearly visible object on the opposite bank of the river (A). Place a peg or stick on the bank of the river directly opposite the tree (B).

b) Take a bearing on the tree with the prismatic compass.

c) Add or subtract 90 degrees to the bearing and walk on the new bearing a distance of 10 paces along the bank of the river. Mark the position with another peg or stick (C).

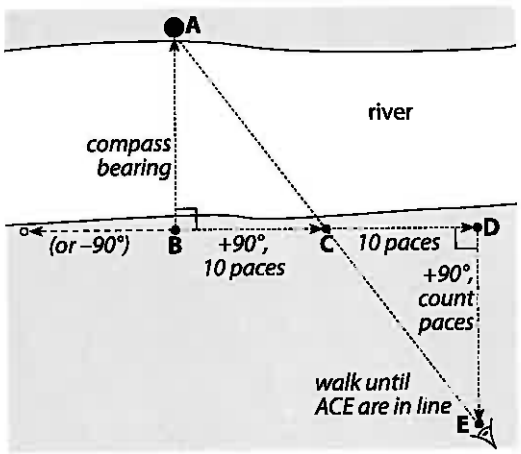
d) Measure distance BC with the trundle wheel or measuring tape.

e) Continue to walk on the same bearing another 10 paces, but measure it to ensure it is the same distance as BC. Mark the position (D).

f) Add or subtract a further 90 degrees to the bearing which ever is the direction directly away from the river. Walk on this bearing until the tree and point C are in line. Mark this point (E). Measure distance DE with the trundle wheel or measuring tape.

g) Draw a diagram with ABCDE in it. Use this to decide which measurement is the same as the river width.

h) Record the width of the river in metres.



**Method 2.** Estimating the width of a river using isosceles triangles, useful when access is restricted on its bank.

a) Choose a tree or some other clearly visible object on the opposite bank of the river (A). Place a peg or stick on the bank of the river directly opposite the tree (B).

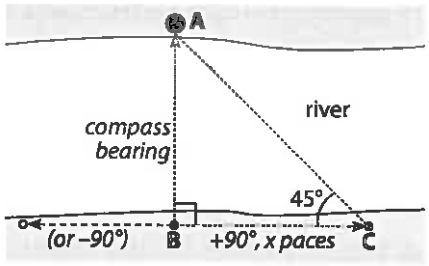
b) Take a bearing on the tree with the prismatic compass.

c) Add or subtract 90 degrees to the bearing and walk on the new bearing along the bank of the river. Take regular bearings on the tree and stop at the point where the difference between the current reading and the first bearing is greater or less than 45 degrees. Mark the position with another peg or stick (C).

d) Measure the distance BC in metres with the trundle wheel or measuring tape.

e) Triangle ABC is a right-angled triangle that is also isosceles.

f) Record the width of the river in metres.



# Measuring Leaves

**Location** School grounds or camp.

**Equipment** 1 cm square grid on plastic *(copy Appendix p. 67 on OHT transparency)*, thread or thin string, coat hanger or small hoop, notebook, soft pencil.

**Group size** In pairs.

**Directions**

1. Collect ten different broad-leaves, preferably dead ones.
2. Make a pencil rubbing of the shape of the first leaf in the notebook.
3. Estimate of the perimeter of the leaf in centimetres, and the area of the leaf in square centimetres, and record them next to the rubbing.
4. Check the estimate of the perimeter by measuring the distance around the leaf with a piece of string or cotton. The one centimetre square plastic grid can be used as a ruler.
5. Check the estimate of the area by placing the plastic grid over the leaf and counting the squares. Fractions of a square can be estimated and combined as appropriate. A common method is to count all fractions $\geq 0.5\,cm^2$, and to not count any fraction $<0.5\,cm^2$.
6. Repeat the procedure for the remaining nine leaves.
7. Plot a scatter graph of area against perimeter, recording a point for each leaf.
   - Is it generally true that leaves with the largest area also have the greatest perimeter?
   - Which shapes of leaves generally have the smallest area and largest perimeter?
   - Is there a relationship between area and perimeter? If yes, describe the relationship.
8. Calculate the mean and median perimeter and area for the collection of ten leaves.
9. Search for another leaf that matches the average measurements. Record this eleventh leaf and its measurements in the notebook.

**Extension** Pick a branch on a tree that can be reached easily. How many leaves are on the branch?

One way to estimate without counting every leaf is to take samples:

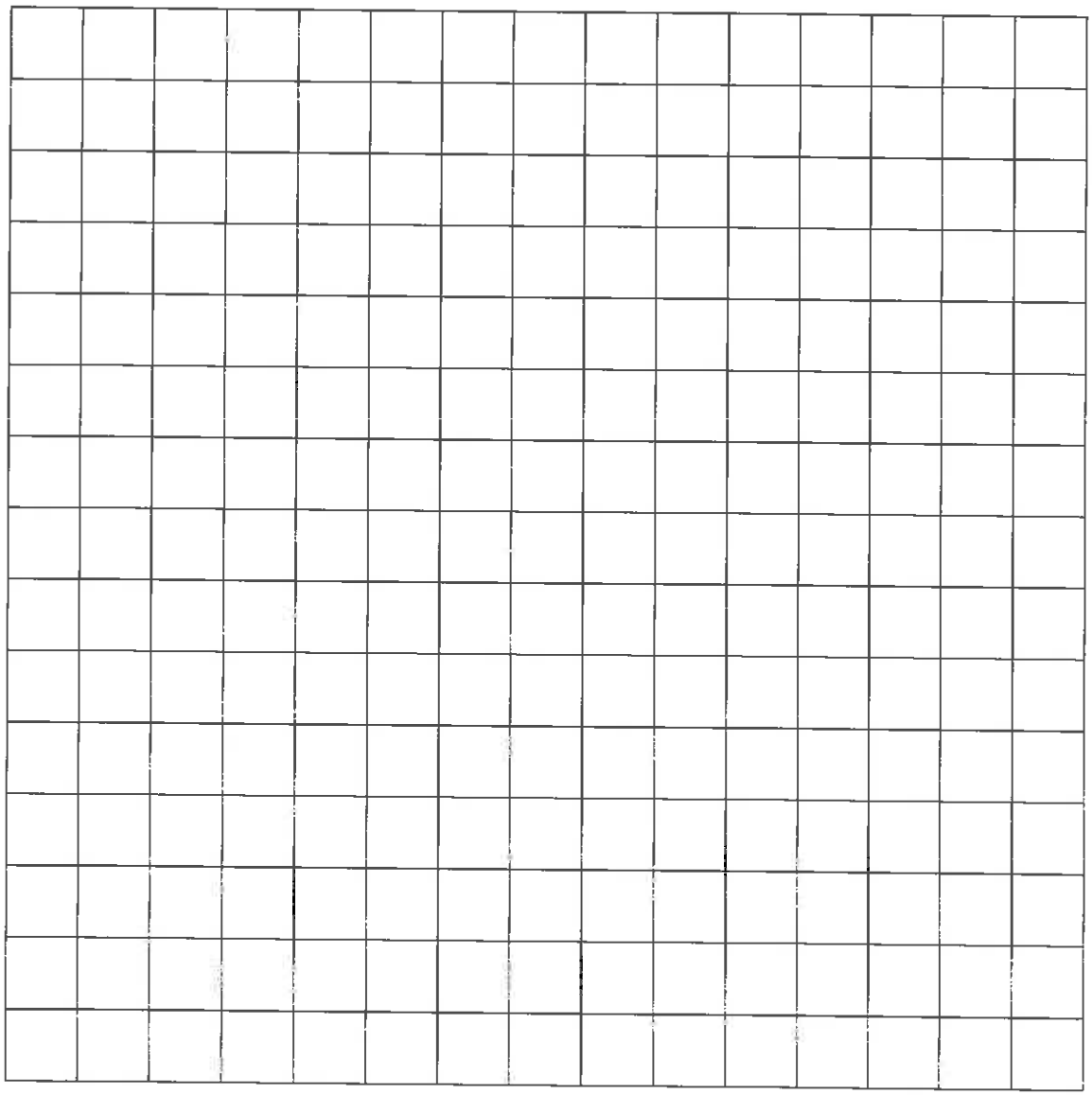
a) Stretch a coat hanger into a circular shape or use a small hoop and place it against a group of leaves. How many leaves are in the circle? Repeat several times and calculate the average number of leaves per sample.

b) How many circles do you think would fit a branch?

c) Using your answers from a) and b), how many leaves do you estimate there are on the branch?

d) Measure the areas of a range of leaves and calculate the average leaf area. Multiply by the answer to c) to calculate the total likely area of leaves on the branch.

e) What could be some sources of error with estimating the total area of leaves on this tree? *[Hints: leaf size may vary with height, and only the lower leaves are likely to be sampled; when measuring the areas of a range of leaves the number of each size class measured should correspond to the distribution of leaf sizes.]*



# Using scale to measure

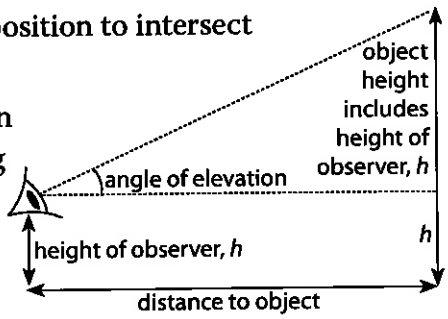
**Location** An open space with some tall objects.

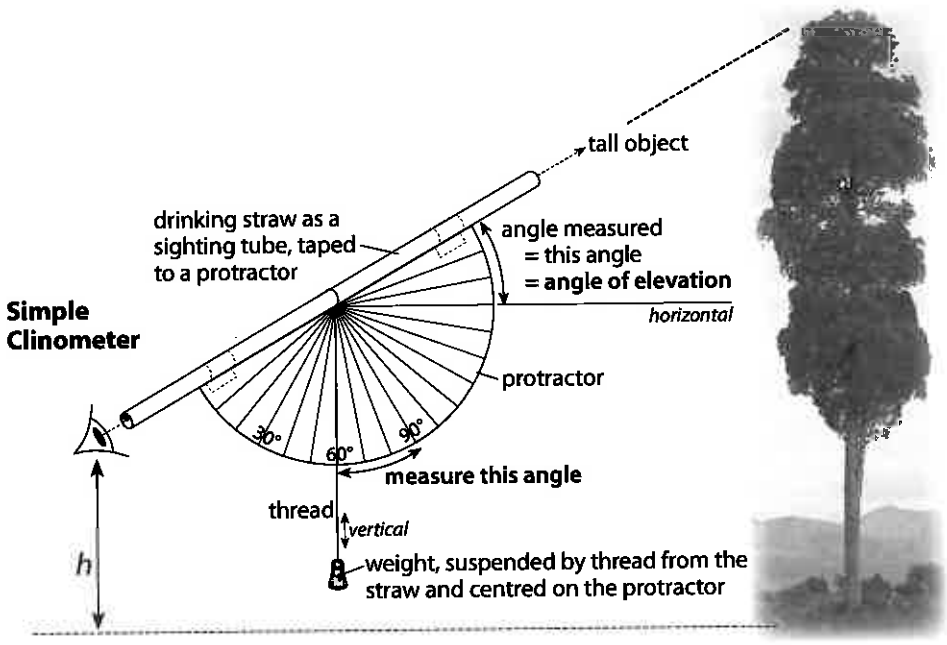
**Equipment** Clinometer, metre rule, calculator *(optional)*, pen/pencil, paper.

**Group size** Groups of 3–4.

**Directions** Using scale to find height:

1. Stand a measured distance back from a tall object such as a tree or a pole. 10 m is usually a suitable distance but you may choose how far as long as you measure it from the base of the object.
2. Measure the angle from your eye height to the top of the object (the angle of elevation) using the clinometer.
3. Make a scale drawing to measure the height of the object using a scale of 1 cm : 1 m (1:100). Use the following steps:
   a) Draw in the distance you were from the object (to scale, i.e. 1 cm : 1 m). Mark in your height.
   b) Draw in the sight line angle from your eye height using a protractor, extend the line to over the object.
   c) Draw a vertical line at the object position to intersect the sight line.
   d) Measure the height of the object in centimetres on your scale drawing and calculate the real height in metres.



# Measuring height with shadows

**Location** An open space with tall objects, but the day must be sufficiently sunny for objects to have sharply defined shadows.

**Equipment** Metre rule, calculator *(optional)*, pen/pencil, paper.

**Group size** Groups of 3–4.

**Directions**

**1. Shadow method with a metre rule:**

a) Hold a metre rule perpendicular to the ground and measure the length of the shadow of the metre rule.

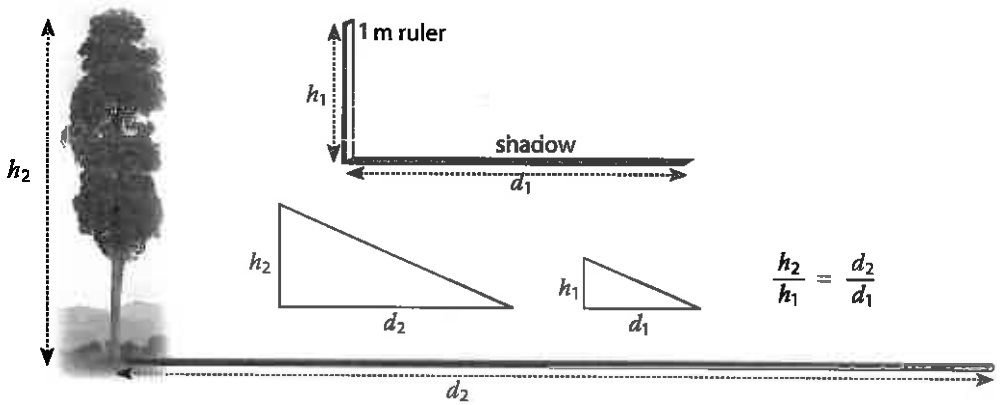
b) Measure the length of the shadow of the object (e.g. a tree).

c) Make sure all measurements are in the same unit (i.e. metres or centimetres).

d) Draw two triangles to scale to represent the measurements you made:

- one triangle for the metre rule and its shadow on the ground;
- one triangle for the object and its shadow.

e) Using the triangles calculate the height of the object.




**2. Shadow method with a student:**

a) Have a student stand near (e.g.) a tree.

b) Measure the height of the student and the length of the student's shadow.

c) Measure the length of the shadow of the object.

d) Make sure all of the measurements are in the same unit.

e) Draw two triangles to scale to represent the measurements you made:

- one triangle for the student and their shadow;
- one triangle for the object and its shadow.

f) Calculate the height of the object.

# Measuring height: Finger–pencil method

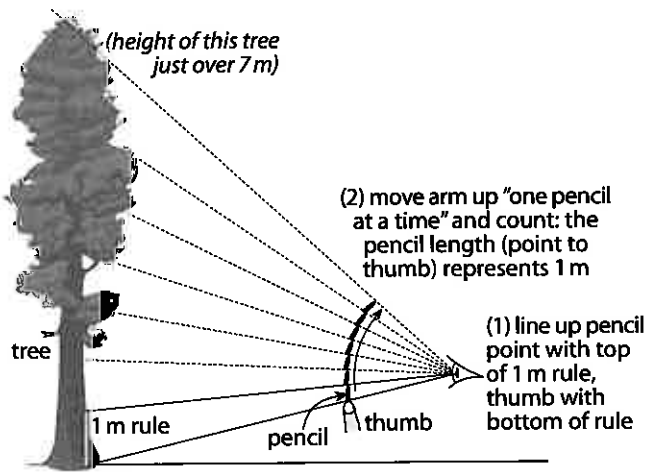
**Location** An open space with tall objects (e.g. trees).

**Equipment** Metre rule, calculator *(optional)*, pen/pencil, paper.

**Group size** In pairs.

**Directions**

1. **With a metre rule:**
   a) Tape a metre rule to the tree with one end of the rule resting on the ground.
   b) Stand at some distance from the object with your feet on the same level as the base of the tree.
   c) Hold a pencil vertically at arm's length.
   d) Shut one eye and sight across the top of the pencil so that the top of the pencil is lined up with the top of the metre rule.
   e) Move your thumb up the pencil until it is in line with the bottom of the metre rule. Keep that grip!
   f) Move the arm upward so that the thumb is now on a line with the top of the metre rule.
   g) Note the point where the top of the pencil comes on the tree, and move your arm upwards until your thumb is line up with that point.
   h) Repeat, counting the number of repetitions necessary to get to the top of the object. The last step may be a fraction of the length you are using to measure and you will have to estimate that fraction.
   i) Calculate the height of the tree.




2. **The finger–pencil method with a student:**
   a) Have a student of known height stand beside the object.
   b) to h) as above, but using the student's height in place of the metre rule.
   i) The height of the object is the number of repetitions times the student's height. *(The student's height should be measured in metres).*

# Measuring height: Pencil method

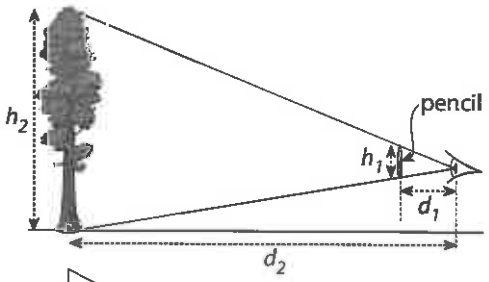
**Location** An open space with tall objects, (e.g. trees).

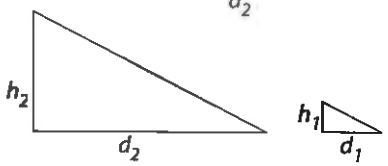
**Equipment** Metre rule, calculator *(optional)*, pen/pencil, paper.

**Group size** In pairs.

**Directions**

1. Stand at a distance from the object.
2. Hold a pencil vertically at arm's length.
3. Shut one eye and move forwards or backwards until the top of the pencil is lined up with the top of the object, and the bottom of the pencil is in line with the base of the object.
4. Measure the distance *($d_1$)* from your eye to the centre of the pencil while the pencil is being held vertically at arm's length.
5. Measure the distance *($h_1$)* from the top to the bottom of the pencil.
6. Measure the distance *($d_2$)* between you and the object.
7. Draw two triangles to scale to represent the measurements you made:
   - one triangle for the pencil and yourself;
   - one triangle for the object and yourself.
8. Calculate the height of the object.




$$\frac{h_2}{h_1} = \frac{d_2}{d_1}$$

$$h_2 = \frac{d_2 \cdot h_1}{d_1}$$

# Measuring height with a mirror

**Location** An open space with tall objects, e.g. trees.

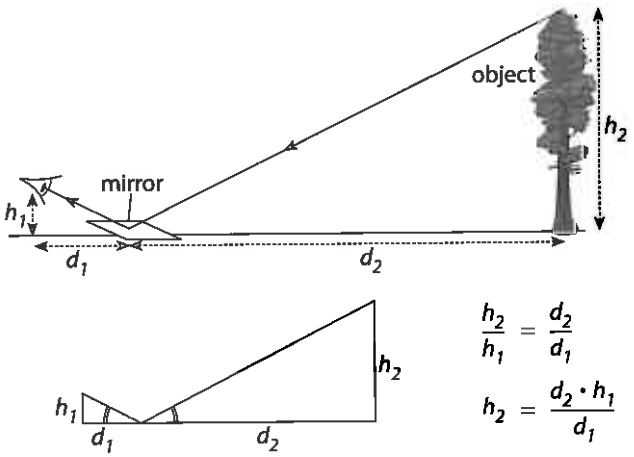
**Equipment** Metre rule, mirror, calculator *(optional)*, pen/pencil, paper.

**Group size** Groups of 2–3.

**Directions**

1. Place a small mirror on the ground some distance from the object and on the same level as the base of the object.
2. Back away from the mirror slowly until you can see the top of the object in the centre of the mirror.
3. Measure the distance from your eye to the ground and from the mirror
4. Measure the distance from the mirror to the base of the object.
5. Start by drawing triangles as above to calculate the height of the object.

**Principle** Light rays are reflected from the mirror at an angle equal to the angle at which they strike it. The two triangles thus formed are similar and their sides are proportional.




**An easy way of estimating height:**

1. Face away from the object, bend down and look through your legs.
2. Keep in this position and walk away until you can see the top of the object.
3. Distance between you and the object is the approximate height of the object.

# Magic Leaf

**Location** School grounds.

**Equipment** Grid sheet for each student *(copy the grid below, or copy the same grid on p. 67 of the Appendix)*, crayons.

**Group size** Individual

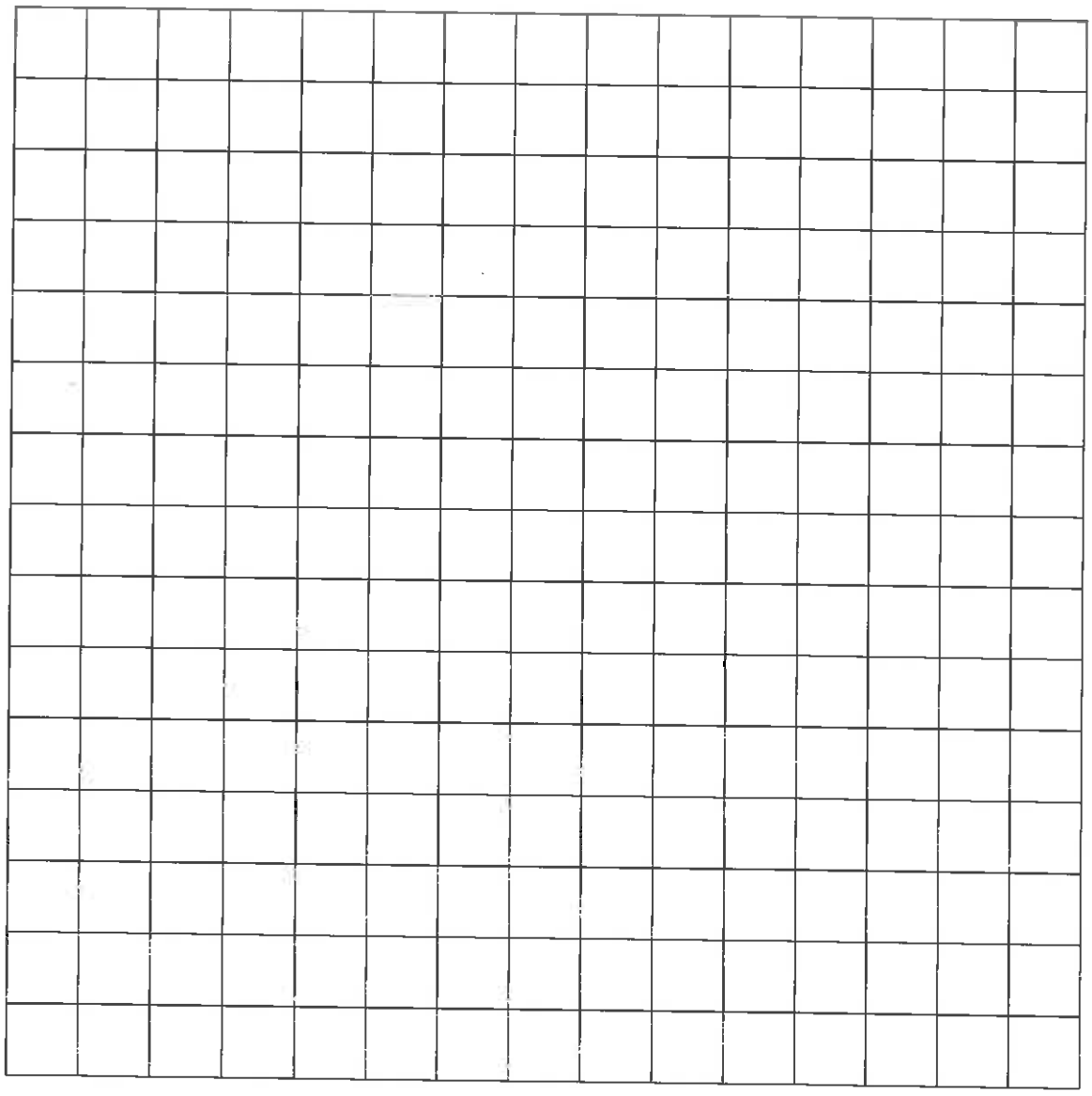
**Directions**

1. Find a leaf that you like.
2. Place it under the squares on the worksheet.
3. Use the side of a crayon to colour over the squares.

   Ensure that the edges of the leaf are clearly defined.

   Count how many squares are inside your leaf.

   My leaf is about ___ $cm^2$ in area.



# Estimating distance

**Location** School grounds or camp grounds.

**Equipment** Long measuring tape, a metre rule or a metric chain, pen/pencil, paper.

**Group size** Individual

**Directions**

1. Guess the length of your sleeping hut in metres (or other building). Now measure the actual distance in metres and centimetres.
2. Now guess the width of your sleeping hut in metres. Measure the actual distance in metres and centimetres to the nearest centimetre.
3. Measure the hall, dining room and grounds. Each time guess the distance first and them measure to the nearest metre.
4. Write you results on the table you have made. Do your guesses become more accurate?

| Object | My guess | Actual distance *(m and cm)* | My error |
|---|---|---|---|
| Hut length | | | |
| Hut width | | | |
| | | | |

**Extension** You can use height as well as distance for this activity

# How big is your cabin?

**Location** Camp, or a room at school.

**Equipment** Measuring tape or metre rule, pen/pencil, paper.

**Group size** Groups of 3–4.

**Directions**

1. Measure total floor area of cabin.
2. Measure usable floor space, i.e. where you can stand. Give answer in square measure.
3. Estimate volume of air space in cabin. Consider the room as an empty box, do not count bunks, etc.
4. Measure the volume of air space. Compare with No. 3.
5. Calculate mean values:
   a) What is the mean floor space per person?
   b) What is the mean usable floor space per person?
   c) What is the mean air space per person?
6. If there was one person less in your hut what would be the means for 5 a), b), c)?

# Tent Maths

**Location** Camp, or school grounds where you can pitch a tent.

**Equipment** Tent, stiff paper, string, straws, sticky tape, paperclips, rulers.

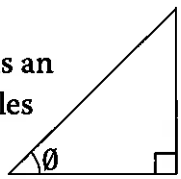
**Group size** Small groups.

**Directions**

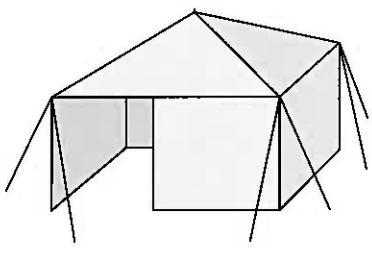
1. Pitch a tent and measure its dimensions.
2. Make a scale model using paper, string, straws, etc.

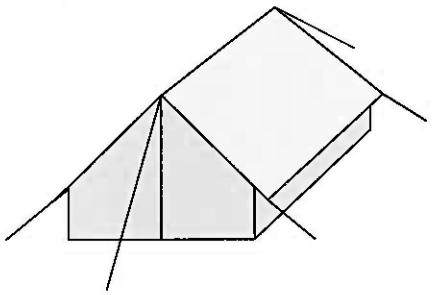
**Possible mathematics applications**

1. Area of floor or ground space. Maximum sleeping capacity if people sleep on lilos (rectangles). Practical aspects noted, such as touching tent walls or poles.
2. Area of nylon, including or excluding hem allowances. Familiar shapes: square, rectangle, triangle, etc.
3. Volume of tent interior: in parts, lower and upper.
4. Length of centre pole, side poles; number of poles.
5. Length, breadth, height of tent, number of pieces of canvas.
6. Length of guy ropes:
   - allowance for knots (e.g. 15%);
   - total length and number of guy ropes.
7. Angles guy ropes make with the ground. If Ø= 45° there is an isosceles triangle somewhere; how many isosceles triangles could you find?




8. Angles of slope of the roof.
9. Shapes: discuss advantages and disadvantages of different shapes.





10. Maximum volume for least area of canvas.
11. Cost of tent, expected life, cost per year over its life.
12. Stability.

**Extension** Make a bivvy or shelter big enough to shelter all your group. Floor area, height, dimensions of plastic/flysheet etc.

# Snow Maths

**Location** An area with snow

**Equipment** Large can, camping gas stove, plate, ruler, pencil, calculator, two measuring tapes, a set of markers (wooden pegs), poles marked at 10 cm intervals.

**Group size** small groups

**Directions**

1. Calculating the volume of snow and water.
   a) Find a small snow drift that has formed on a hard surface that is no deeper than the can.
   b) Invert the can and press it into the snow without crushing the snow inside
   c) Slide the plate under the can to trap the snow inside and invert the can carefully
   d) Measure the depth of snow in the can
   e) Heat the can on the camping stove to melt the snow
   f) Measure the depth of water in the can
   g) Check that the ratios: volume of water : volume of snow, and, depth of water : depth of snow, are equal.
2. Estimating the volume of snow in a gully.
   a) Use two measuring tapes and a set of markers to divide up the surface area of the snow field into a large grid of 5 m squares. (10 m squares for a large gully, 1 m squares for a small gully or for greater accuracy.)
   b) Count the number of complete squares and estimate the area of each of the partial squares to the nearest square metre. Calculate the total surface area of the snow.
   c) Using poles marked in 10 cm intervals measure the depth of the snow for the whole gully by dividing the sum of all the measured depths by the total number of markers
   d) Calculate the volume of snow in the gully by multiplying the surface area by the mean depth.
   e) Now use the method in 1. above to calculate the volume of water that is equivalent to the snow contained in the gully.

**Extension** To estimate the volume of a pond, a similar method as in 2. above could be used. Ideally, use a boat, kayak or raft, and a rope knotted at regular intervals held across the surface of the water to indicate the points where the depth should be measured.

# Measuring Timber

**Location** Where you have access to logs and stumps.

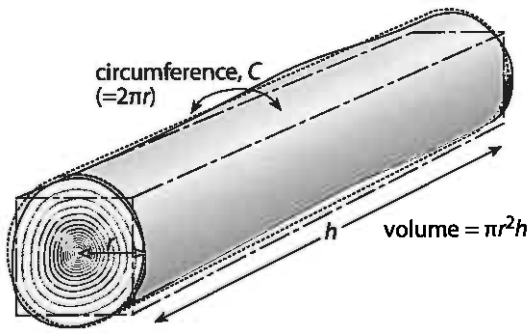
**Equipment** Measuring tapes, calculators & notebooks, prismatic compass, tooth-picks, pen/pencil, felt pen.

**Group size** Small groups.

**Directions** Estimate the amount of timber in a round log of wood in cubic metres.

1. Measure the length of the log in metres
2. Measure the girth (or circumference) of the log at approximately the middle of the log in metres. If it is not possible to get a tape around the girth at the required point for a log lying on the ground it will be necessary to estimate the diameter of the log; timber workers use callipers and average the measurements taken at different angles to allow for a non-circular section.
3. Estimate the volume using a cylinder as the mathematical model. Remember to calculate the radius of the log first.
4. Some timber workers prefer to use a square-sectioned log as the mathematical model. They approximate the side of the square as one quarter of the girth of the log. The volume is calculated by: volume = $(C/4)^2$ x length

   Show how the timber workers would have come up this equation.




**Notes** Wood volume is calculated by a variety of methods, depending on the end-use of the wood. For a saw-miller the useable volume is all that matters. Logs are cut in straight cuts, but come as irregular shapes, and may be cut in different patterns depending on the timber required and what is possible from the size and shape of the log. Consequently, various formulae are used. When trees are cut down the volume can be quickly estimated by weighing the logs and using the average density for the species being cut.

# Stream Profile

**Location** Slow flowing shallow stream with easy access

**Equipment** Measuring tape, knotted string with a weight, pen/pencil, paper, something that floats, a stopwatch.

**Group size** Small groups.

**Directions**

1. Take depth measurements at the middle of the stream at regular intervals. Have a partner on the bank to record the depths as you measure them.
2. The method you use to measure the depths may be some knotted string with a weight at the bottom (lead line), or a measuring stick. The size of the intervals between measurements could be 1 m for smaller streams or 2 m for larger streams. Your partner could measure these intervals on the bank.
3. Make a scale drawing of the stream bed profile using your recorded measurements.
4. Use a float and a stopwatch to find the speed of the stream flow over the deepest parts of the stream that you measured and the shallowest parts of the stream that you measured. Time the float over a measured distance of each part of the stream; the distance should be 3–10 m. Use the time it takes for your float to cover each distance to calculate the speeds ($m\,s^{-1}$) of the stream flow in the deepest and shallowest parts of the stream.
5. Compare the results.
   a) What factors seem to effect the velocity of a stream?
   b) Repeat a few days later and see if the results are the same. If they are different what might be some reasons for the difference?
6. Use the method above to take a profile across the stream bed at a wide and a narrow point.

**Level 7 Extension**

1. Calculate the area of the cross-section of the river using the different methods you have been shown (mid-ordinate and trapezia).
2. Enter your data into a spreadsheet and model with a function.
3. Integrate the function to calculate the area of the cross-section.
4. Calculate the flow of the river in cubic metres per second.
5. See if you can find a website that records the river flow and how it changes over time.

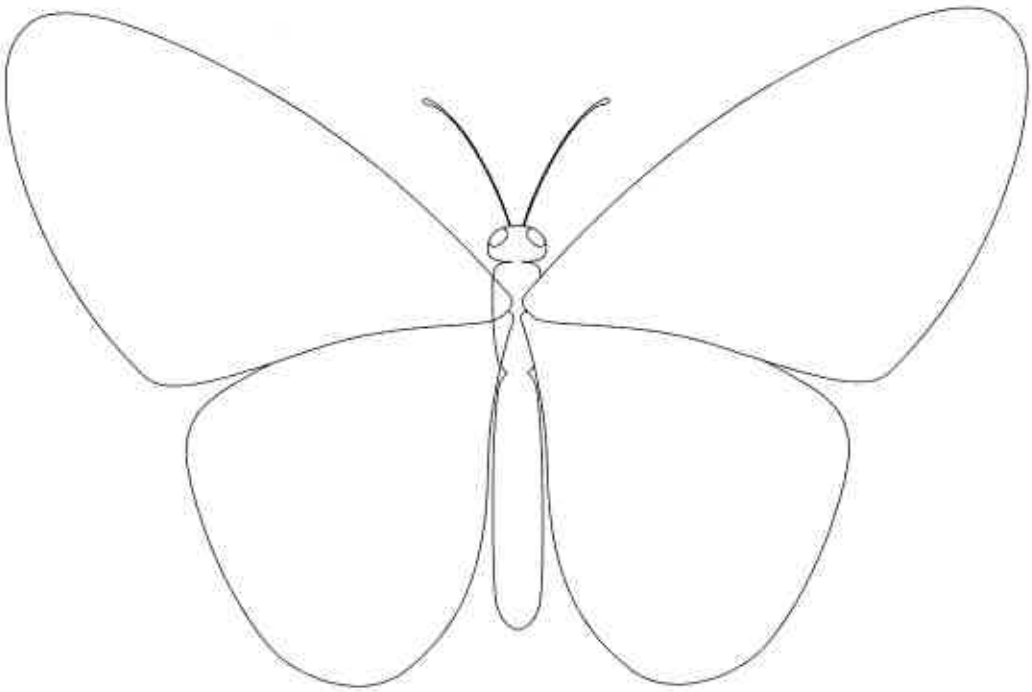
# Butterfly

Location Classroom.

Equipment Worksheet for each student *(as below, and Appendix p. 68)*, crayons

Group size Individual.

Directions Decorate the butterfly's wings to show a pattern. Try to make the left and the right wings look symmetrical.



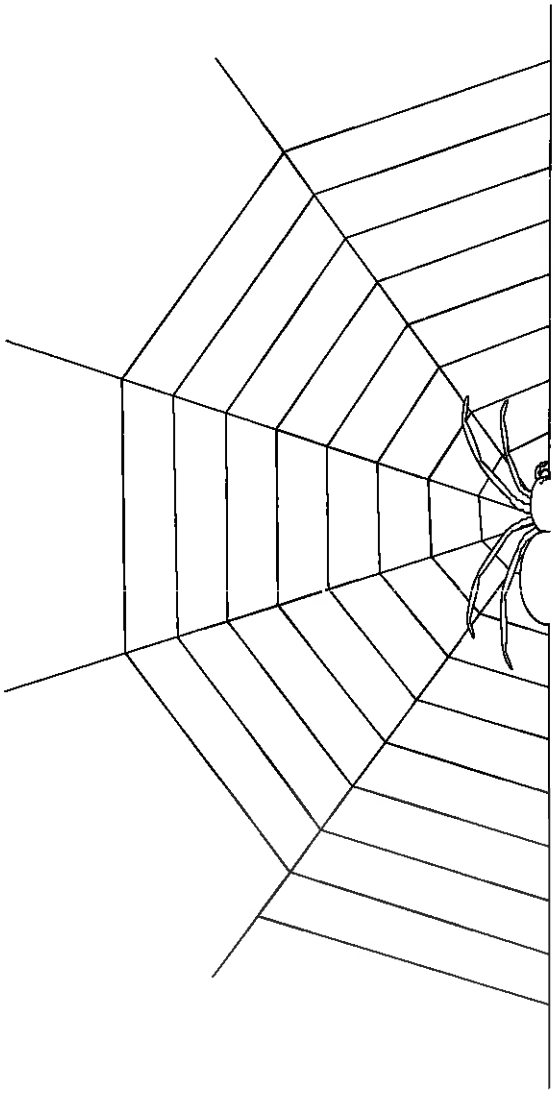
# Spiders Web

**Location** Classroom.

**Equipment** Worksheet for each student *(as below, and Appendix p. 69)*, crayons.

**Group size** Individual activity.

**Directions** Finish the drawing of the spider and its web by drawing the missing half (detail has been given for those pupils who wish to add detail, but otherwise stick legs would be sufficient).



Draw something else which has two sides that look the same.

# Leaves

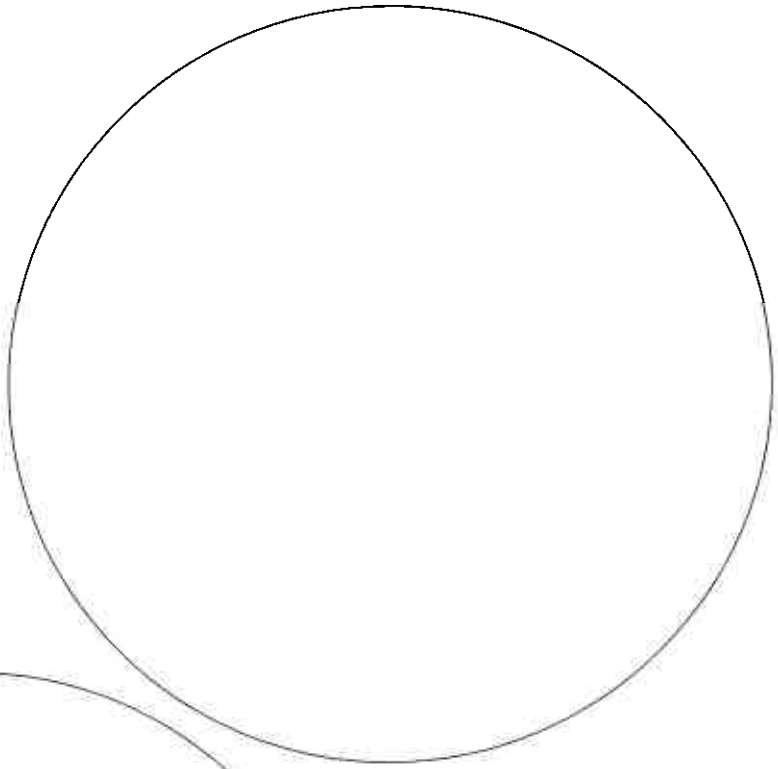
**Location** School grounds, camp.

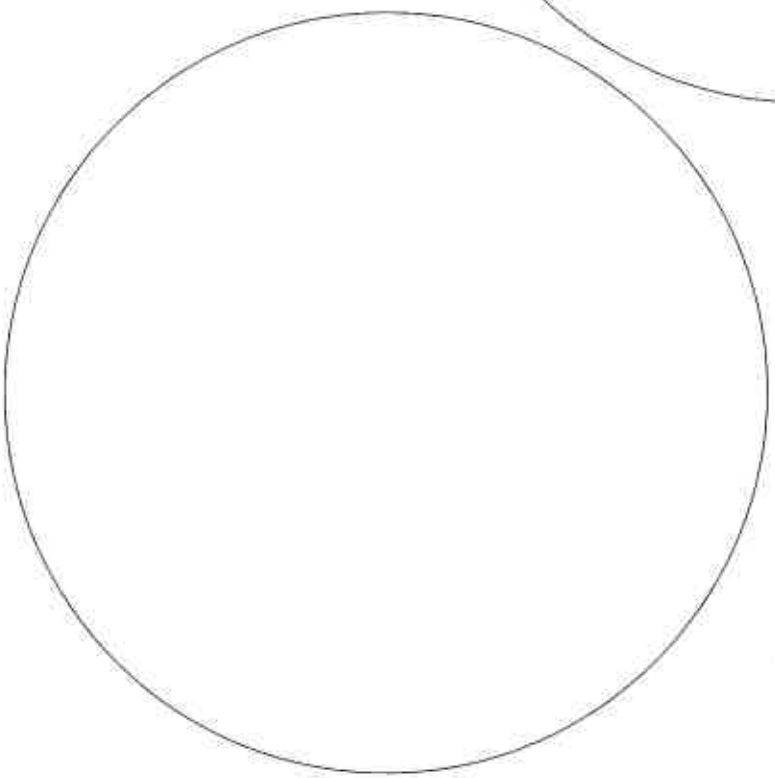
**Equipment** Paper, crayons *(see the Appendix, p. 70, for a worksheet of this page).*

**Group size** Individual.

**Directions** Leaves have many different shapes:

1. Find two small leaves and draw one into each circle.
2. Draw a line through each of your leaves so that you have divided each leaf in half.





What other things can you find which have two equal halves?

You could draw these on another piece of paper...

# Signs

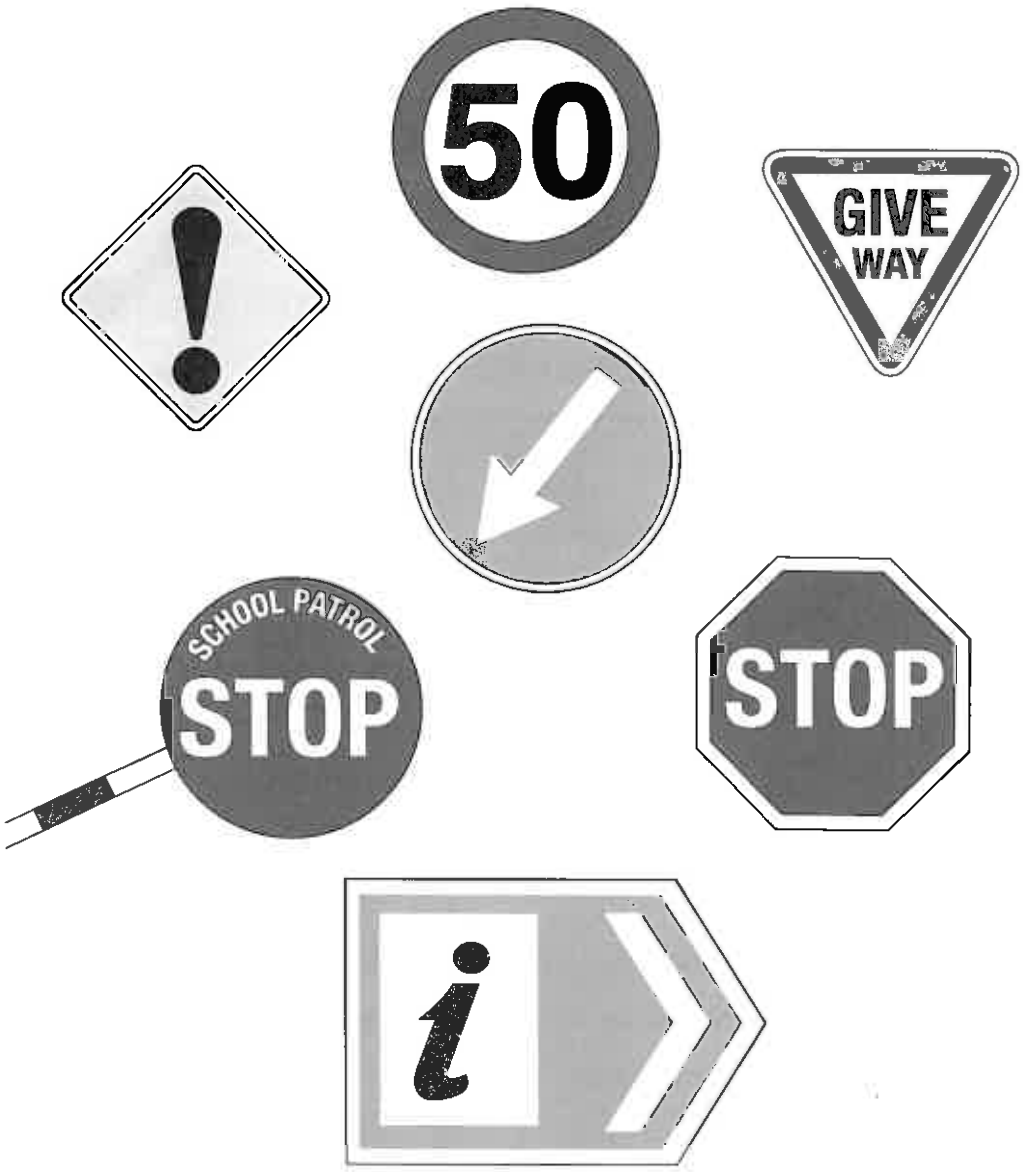
**Location** Asphalt or concrete area

**Equipment** Chalk, pen/pencil, paper, or alternatively a worksheet for each group; a copy of the highway code as a backup.

**Group size** Small groups.

**Directions**

1. Students look for different sign shapes around the school.
2. Draw the sign on the ground and write the name of the shape beside the shape.
3. Alternately, get students to draw road signs and name their shapes.



# Chinese Puzzles

**Location** An open space.

**Equipment** 30 m rope, Chinese puzzle cards (tans).

**Group size** Arrange students into groups of no less than 8.

**Directions**

1. Have the group select a leader.
2. Remainder of group spread themselves along the rope holding it in both hands.

3. Show the leader a shape card.
4. The leader moves the team members to reproduce the shown shape.

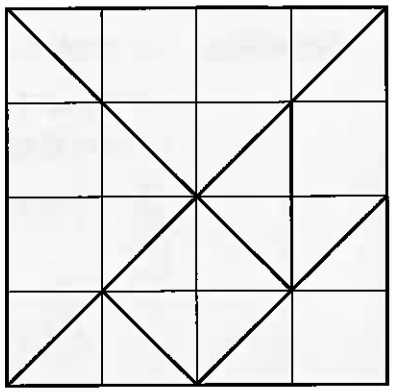
e.g. start with one card, then two cards, then three:

*make this shape* *make a square* *make a triangle*

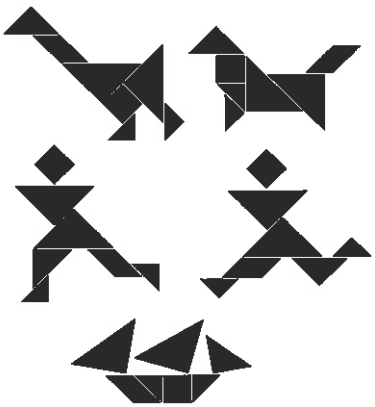
*or specified shapes from specific combinations, e.g. a trapezoid from two triangles:*

5. Team members cannot let the rope go but may slide along the rope when required.
6. The rope must not double back on itself.
7. When satisfied the leader has the team place the rope on the ground.
8. The team is then shown the card to check their success.

To make a *tangram* set, start with a square divided into 16 squares. The seven *tans* are cut from the square in the pattern shown below. There are two large triangles, one middle-sized triangle, two small triangles, one rhomboid and one square.



The seven tans (shapes) are used to make shapes, a few of the many hundreds possible are shown below:



**Extension**

1. Do not allow the leader to move from the front.
2. Blindfolding the entire team except the leader.
3. Having more than one team work in the same area at the same time.
4. Make up more difficult shape cards.
5. Only the leader may talk.
6. No one may talk.

# Direction and line patterns

**Location** School grounds, camp or classroom.

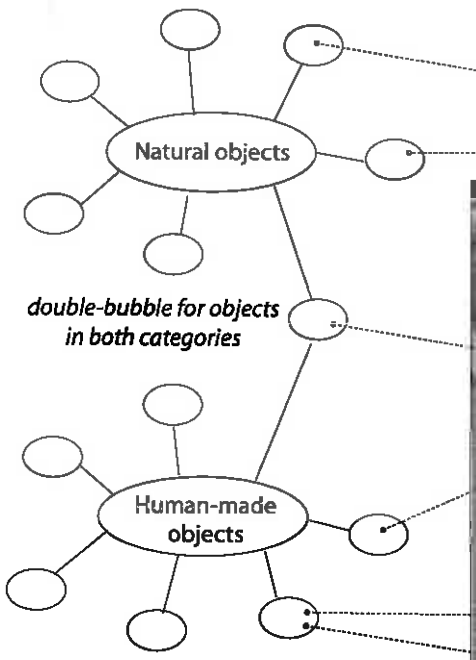
**Equipment** Pen/pencil, paper.

**Group size** pairs or small groups.

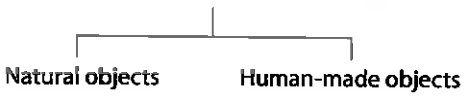
**Directions**

1. Look around inside for objects which have horizontal, vertical and oblique lines. Now do the same for objects outside.
2. Make lists to divide them into:
   a) natural objects;
   b) those made by people.

Use two bubble maps:




Use a tree map:




# Treasure hunt locus

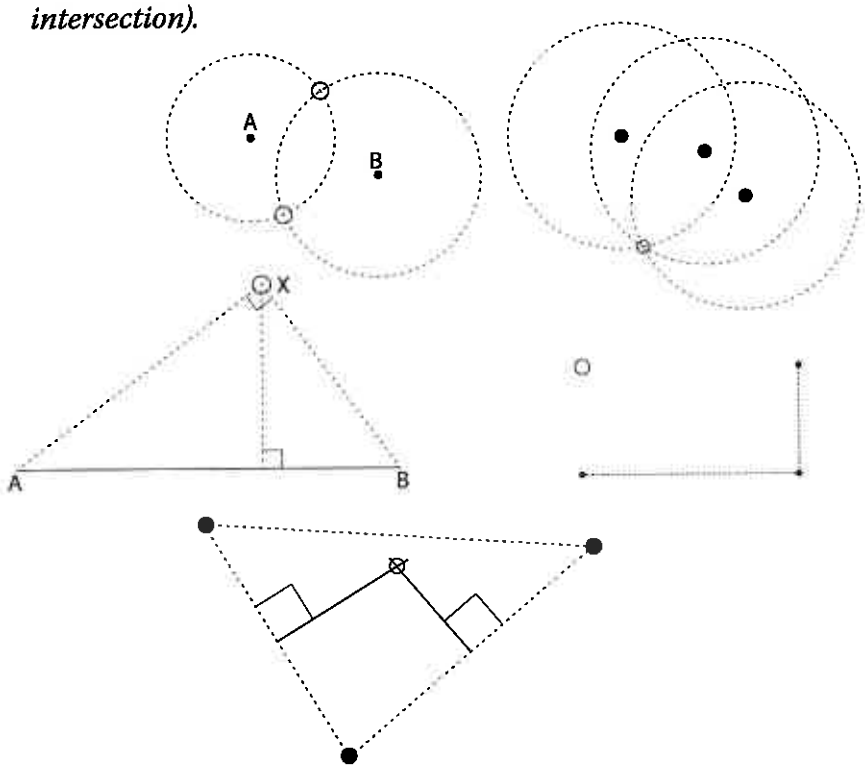
**Location** An open space.

**Equipment** One ice-block stick per task (the treasure), string, marker pegs, measuring tapes, written instructions for each task.

**Group size** Groups of 3–6.

**Directions**

1. The tasks need to be set up before the class in a round-robin format.
2. Each group has to locate the 'treasure' *(the stick pushed into the ground so only a small part is showing)* by applying the geometric constructions suggested in the instructions.
3. Sample tasks might include:
   a) Locate the 'treasure' 7 m from peg A and 8.5 m from peg B.
   b) Locate the 'treasure' equidistant from three marked points.
   c) Locate the 'treasure' at a point X, which is the vertex of a right angled triangle AXB, and 6 metres from line AB.
   d) Locate the 'treasure' at the fourth vertex of a rectangle (or any other suitable quadrilateral) with pegs marking the positions of three of the vertices.
   e) Locate the 'treasure' at the circumcentre of a triangle formed by three marker pegs. *(Solved by constructing the perpendicular bisectors of two of the sides of the triangle and finding a stick at their intersection).*



# Estimating Polygons

**Location** An open space.

**Equipment** Protractor, string.

**Group size** Groups of 3–6.

**Directions**

1. Three pupils stand where they estimate the vertices of an equilateral triangle might lie.
2. The remaining group members use the string and the protractor to test for equal lengths and angles.
3. Other members of the group attempt a closer estimate for a smaller or larger equilateral triangle. The result is tested as before.
4. The activity is extended to other regular polygons.
5. Other possible measurements that could be checked are diagonals and exterior angles and interior angles.

# What is the shape?

**Location** An open space.

**Equipment** Protractor and graph paper for each student, magnetic compass, cones to mark corners. *Note: a)–e) below are included in the Appendix, p. 71, but without the answers.*

**Group size** Individuals, or groups of 3–4.

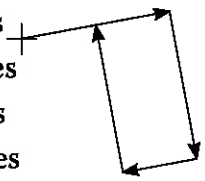
**Directions**

1. Using a protractor and 1 cm graph paper, construct shapes from the sets of directions.
2. Using a compass pace out in each direction the number of paces, mark the corner and then step out in the next direction.

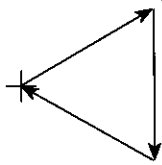
*e.g.* 0 degrees for 8 squares (or paces)
90° for 8 squares
180° for 8 squares
270° for 8 squares. *(Makes a square with sides 8 paces long.)*

3. How far are you from the start?

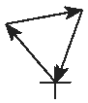
a) 80° for 10 squares
170° for 10 squares
260° for 5 squares
350° for 10 squares



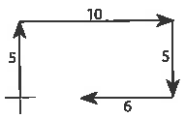
b) 60° for 10 squares
180° for 10 squares
300° for 10 squares



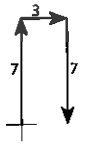
c) 320° for 5 squares
80° for 5 squares
200° for 5 squares



d) 0° for 5 squares
90° for 10 squares
180° for 5 squares
270° for 6 squares




e) 45° for 7 squares
90° for 3 squares
180° for 7 squares




**Extension**

1. Each group mark out some shapes and work out the bearings for those shapes. Get groups to swap bearings.
2. Get the group to work out the bearings to make the shape of the first letter of their names.

# Maths Trails

**Location** School grounds or camp grounds

**Equipment** Locality map, pen/pencil, paper, outdoor measuring equipment *(optional)*.

**Group size** Small groups

**Directions**

1. There are many variations for developing maths trails that can be used by classes of all levels.
   - **Thematic Walks:** Junior classes can stroll as a group with teacher/parent helpers around the school grounds looking for examples of numerals or geometric shapes that the children can spot on the way. Small rewards might be given to pupils who can correctly identify the mathematical feature, which is the theme for the walk.
   - **Route Maps:** Pupils can follow a specific route on foot or bicycle either following a map or a list of directions. Clues of the type used in car rallies can be used at various checkpoints along the way. Solutions can be recorded on a work sheet.
   - **Orienteering Trails:** These trails allow for participants to determine their own order for visiting key points and so allows for a mass start to the activity without the likelihood of groups bunching together. Check points can be identified by co-ordinates or grid references on the map and once at the location a mathematics question can be answered about some notable feature. Solutions to the questions can be recorded individually or, alternatively, an element of self checking can be built in by having multi-choice answers spell out a suitable message or numerical solutions be entered into a table in the form of a cross number.

2. While it is relatively easy to invent questions for Maths trails that involve estimating, counting, or identifying geometrical properties of common shapes, questions that relate to other topics in the Mathematics syllabus are rather more difficult. Some suggestions are:
   - Mathematical symbols on road signs and other notices
   - Number sequences in rows of mail boxes or houses
   - Measure the slope of a driveway or tree trunk
   - Clock faces prompt questions of time, angle, roman numerals, etc
   - Estimating of distance, area, volume, water flows, time, etc
   - Use mathematical language, e.g. concentric, consecutive
   - Reading tables, e.g. tide or bus timetables, phone call rates, etc
   - Calculating scale factors of enlargement with applications
   - Circle properties and calculations

- Dates on monuments and plaques, historical data
- Develop a time-line for local historical events

3. Preparing a Maths Trail is as worth while an activity as following a maths trail, particularly if the writing can be shared. While writing a trail is a good professional develop activity for teachers, why not get a senior class to develop a trail for a junior class who try out the trail for the first time as well as developing their own mathematical and communication skills.
4. Maths Trails are ideal activities for parental involvement. Organise a trail for families to enjoy as part of a parents evening.

**Further Trail Ideas**

**Rope Trail:**
- Put a wool tie each 2 metres on a long rope
- Throw the rope onto a safe area
- Use the wool tie as the centre, place a PE hoop on the rope
- Study the contents of the hoop

**Under/Over:**
- Visit the first station
- Study only things that are "under"
- Visit the next station
- Study only the things that are "over"
- Visit the next station for things that are "under"

**Alphabet Trail:**
- Stop at each station
- Select a letter
- Look for mathematical "words" that start with that letter
- Use each letter only once

**Sensory Trail:**
- Blindfold a partner
- Take then to a station
- Ask them questions
- Ask them to identify the station by asking questions

**Micro Trail:**
- Select a place where kneeling is possible
- Put a knot in the string each 100 mm
- Use a hand lens to study the area near each knot

**Tree Trail:**
- Select a variety of trees in the grounds
- Link these into a trail
- Make a visit to each station once a month
- Log all results

## Theme Trails

Apply the words to an existing trail:

- Select a word
- Colour
- Below
- Shape
- Height
- Smell
- Flying
- Sounds

# Appendix

## Section A: Support files

These PDF files support these activities:

**Recall of basic facts (p. 2):**

This file contains 10 numerals, 1 to 9 and 0. There are five A4 pages to be cut in half for the separate numerals. *This file may be downloaded from the EONZ website: www.eonz.org*

**Multiples investigation (p. 4):**

This file contains 16 A4 pages of numerals 1 to 32. The pages are to be cut in half. *This file may be downloaded from the EONZ website*

## Section B: Techniques

## An introduction to plane table mapping

*This describes the technique suitable as an extension for the mapping exercise on p. 27.*

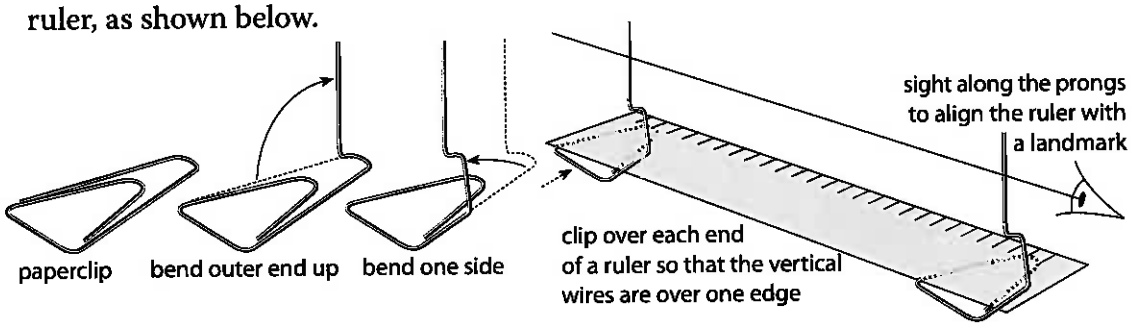
**Location** School grounds or camp grounds.

**Equipment** Pencil and eraser; a flat surface (the plane table) with a piece of A4 paper taped to it, placed on a support (e.g. stool, box); tape measure; magnetic compass; pins for sighting, *or* make a simple alidade (sighting ruler) by clipping a bent-up paper clip to each end of a ruler on one edge; spirit level (or make a level, e.g. one or two 15 cm lengths of clear plastic tubing about 3–4 mm internal diameter filled with water having a tiny amount of detergent); two pegs or markers; *optional:* a plumb-bob (mass on a string).

**Group size** Small groups.

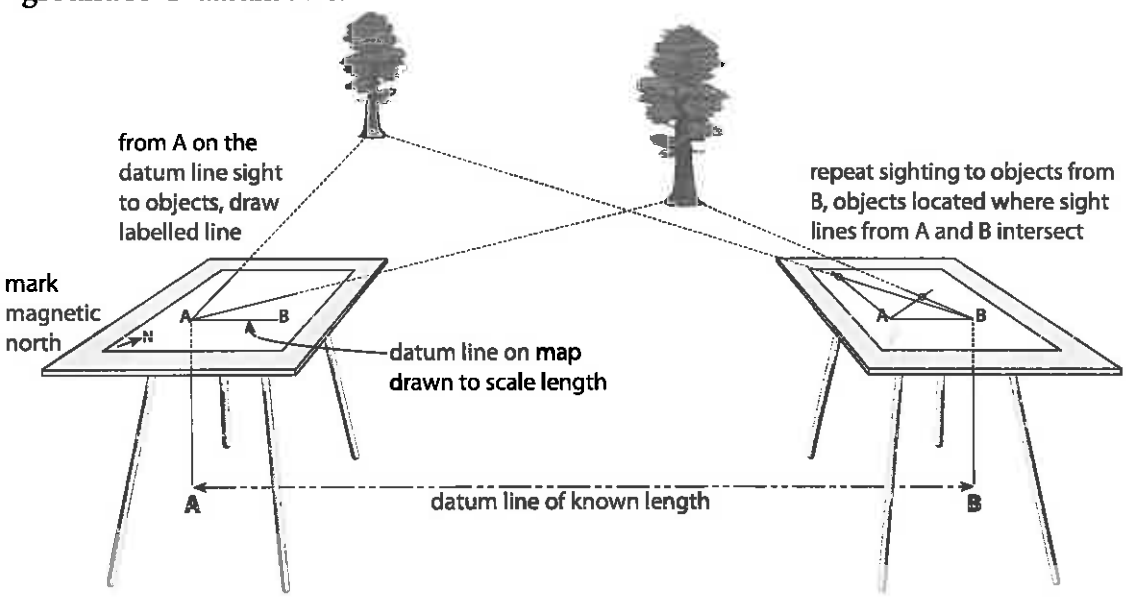
**Technique** Plane table mapping is a technique developed from the 1600s. It uses triangulation to directly draw the location of objects on a map drawn to a suitable scale. Although now replaced by complex equipment, it is a simple and accurate technique for mapping small areas.

1. Either use pins to sight the objects, or make a simple alidade with paper clips and ruler, as shown below.

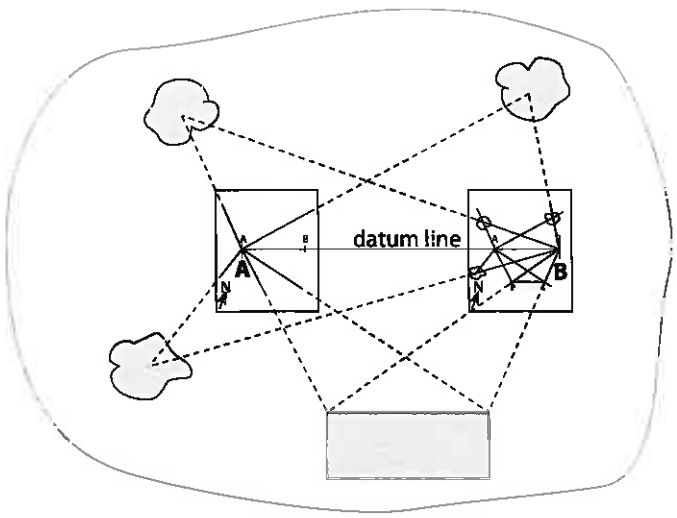



2. Estimate the dimensions of the area to be mapped and choose an appropriate scale e.g. if the area is about 250 m x 200 m a 1 cm to 1 m (1:100) scale would be appropriate to an A4 page (29.7 x 21 cm).
3. Choose a datum line (A–B) that from each end will give a clear view of major features and with no features between the ends, preferably aligned east-west. Measure a suitable length (e.g. 50 m, 100 m) and mark the ends with pegs or markers.

4. Set up the plane table on its support over point A of the baseline. Level the table with the spirit level. *If using plastic tubing, tape the tubing in a U-shape to the edge of the table and arrange the table so that the water at each end of the tube is the same distance from the edge of the table; two tubes on adjacent edges allow the table to be easily levelled.* Mark the end of the datum line on your map. If a plumb-bob is available it can be used to precisely locate this end of the map datum line over the marker of the actual datum line.
5. Find magnetic north with the compass and mark it on the map. *If the plane table or its support contain iron this will need to be done by sighting from a suitable distance.* Later, find the current magnetic declination and mark true north.
6. Take a sight on point B, either using pins to mark the sighting or the simple alidade. Draw the A–B baseline on the map to the scale length.
7. Take sights on other key features (e.g. trees, huts, stream bends, track bends, etc.), drawing lines lightly on the map and labelling each line with its feature.
8. Move the plane table to point B, positioning it so that point B on the map is directly above point B on the ground datum line. Take a sight on point A and move the plane table so that the A–B datum line on the map is lined up precisely with the ground A–B datum line.




9. Repeat sights on each of the features labelled from point A. Where a feature's sight line from point b intersects the sight line from point A is the scale location of that feature. Mark it with the intersect lines and label. To make it easier you may wish to erase the remainder of each sight line from point A as you go.




10. Complete the map by adding symbols, a key, scale, etc.

## Section C: Student worksheets

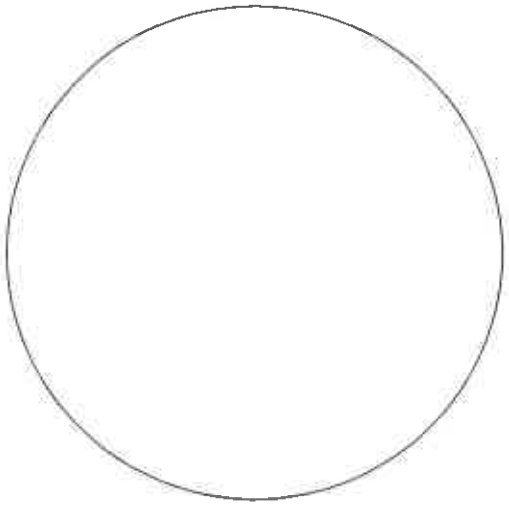
This section includes student worksheets to be copied for class use for the activities listed below, and two sample pages from each of the support files available on the EONZ website

### Work sheet masters

# Seed classification

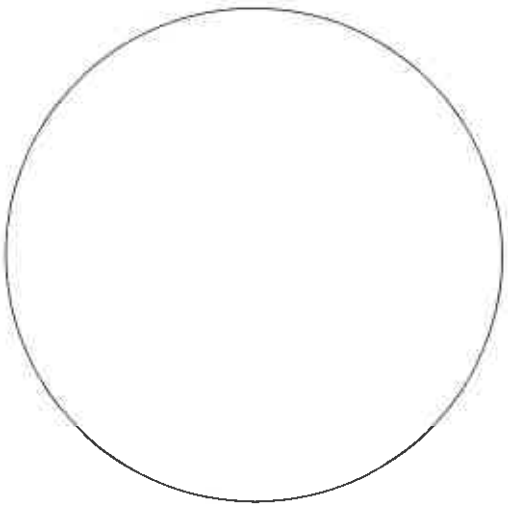
Name

1. Collect some seeds *(or other objects, as directed)* outside.
2. Sort your collection into groups and glue them into the circles below when you are satisfied with the groupings.



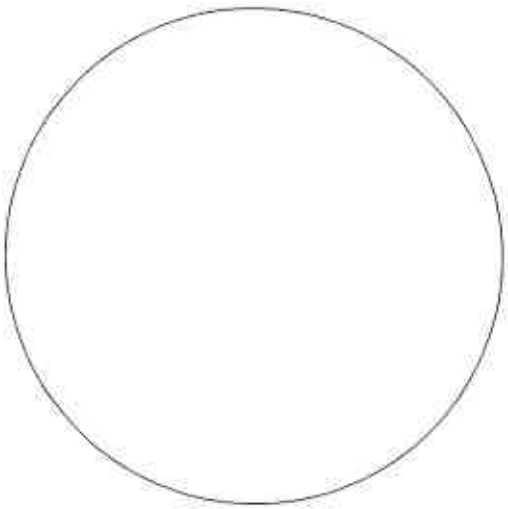
Why did you group these together?

How many are there?



Why did you group these together?

How many are there?



Why did you group these together?

How many are there?

# Cemetery Statistics: A Social Survey

*Use these questions as a guide in finding information:*

1. When was the cemetery founded? _____

2. Who was the first person buried? _____

   When? _____

   How old were they at the time of their death? _____

3. How long has it been since someone was buried in the cemetery? _____

4. What kinds of markers are used upon the graves? _____

   Are these materials local or transported from elsewhere? _____

   _____

5. Can the whakapapa or family tree of certain families be traced from the grave markers?

   _____

6. How many different nationalities or countries are represented within the cemetery? _____

   As well as their place of birth, what other clues were there? _____

   _____

7. What was the median life span of people in this community? _____

*Hint: drawing graphs may help you to answer some of these questions:*

8. Is there evidence of any common accidents, epidemics or wars? _____

   If "yes", what was the evidence? _____

   _____

9. Over the years, what changes occurred in the designs, shapes, or types of headstones or grave markers, or in the epitaphs?

   _____

   _____

10. Are all the inscriptions visible? _____

    What kinds of stones show most weathering? _____

    Make rubbings of a variety of geometrical motifs that occur on gravestones. Identify all of the transformations that you can.

11. Do all the gravestones face the same way? If "yes", why? _____

12. Who lived longer in this community, men or women? _____

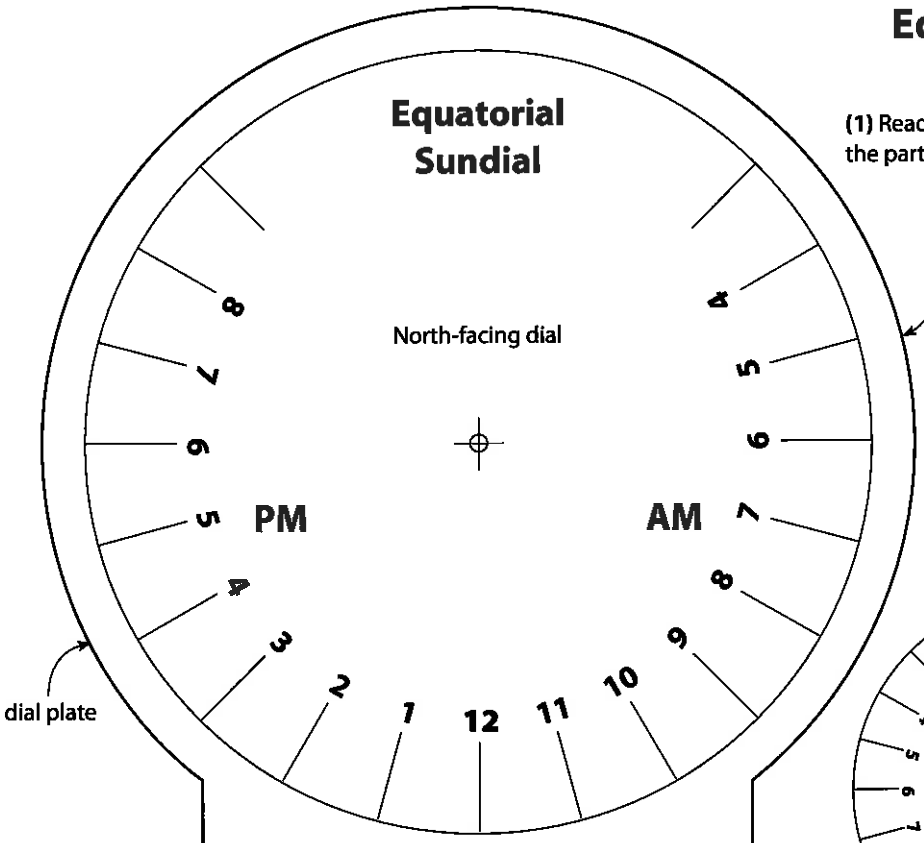
13. Can the economic status of a family be determined in any manner? If "yes", how"?

    _____

14. What feelings do you have about the people that are buried in this cemetery?

    _____

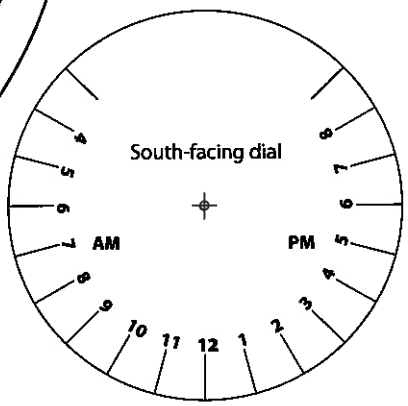
# Equatorial Sundial



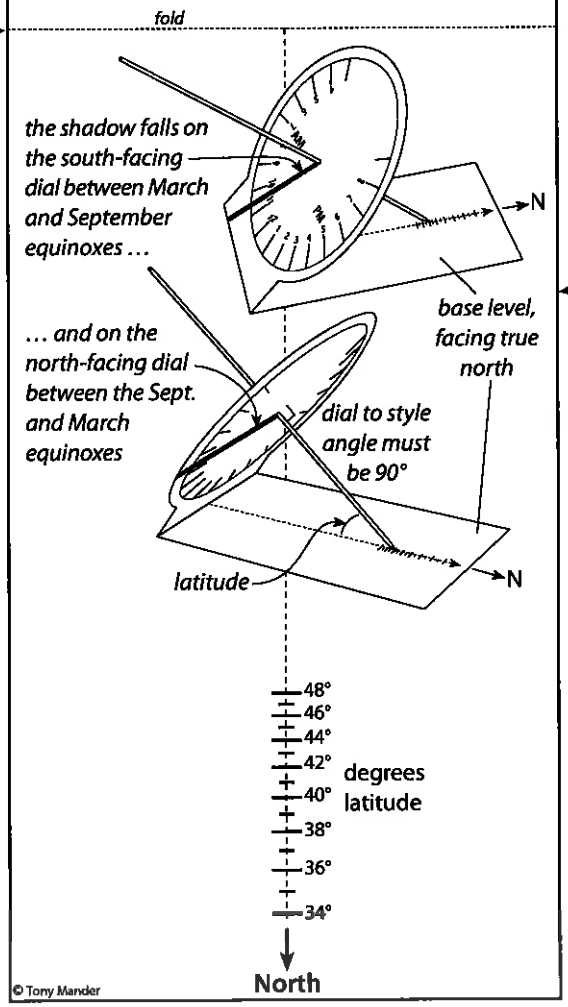

**(1)** Read all the instructions and identify the parts before starting construction.

**(2)** Cut around the outline.

**(3)** Draw the south-facing dial on the other side (hold it gently against a window and trace the hour markings through the paper and add the numbers); its appearance is shown below:



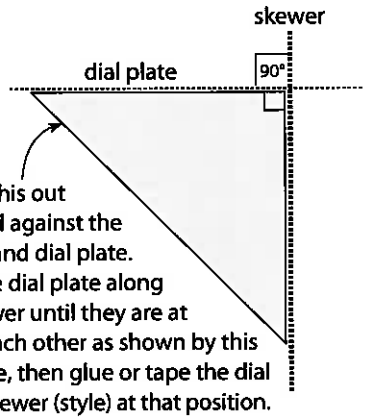

**(4)** Fold upwards on this line




**(5)** Push the pointed end of the skewer through the centre of the dial from the south-facing side.

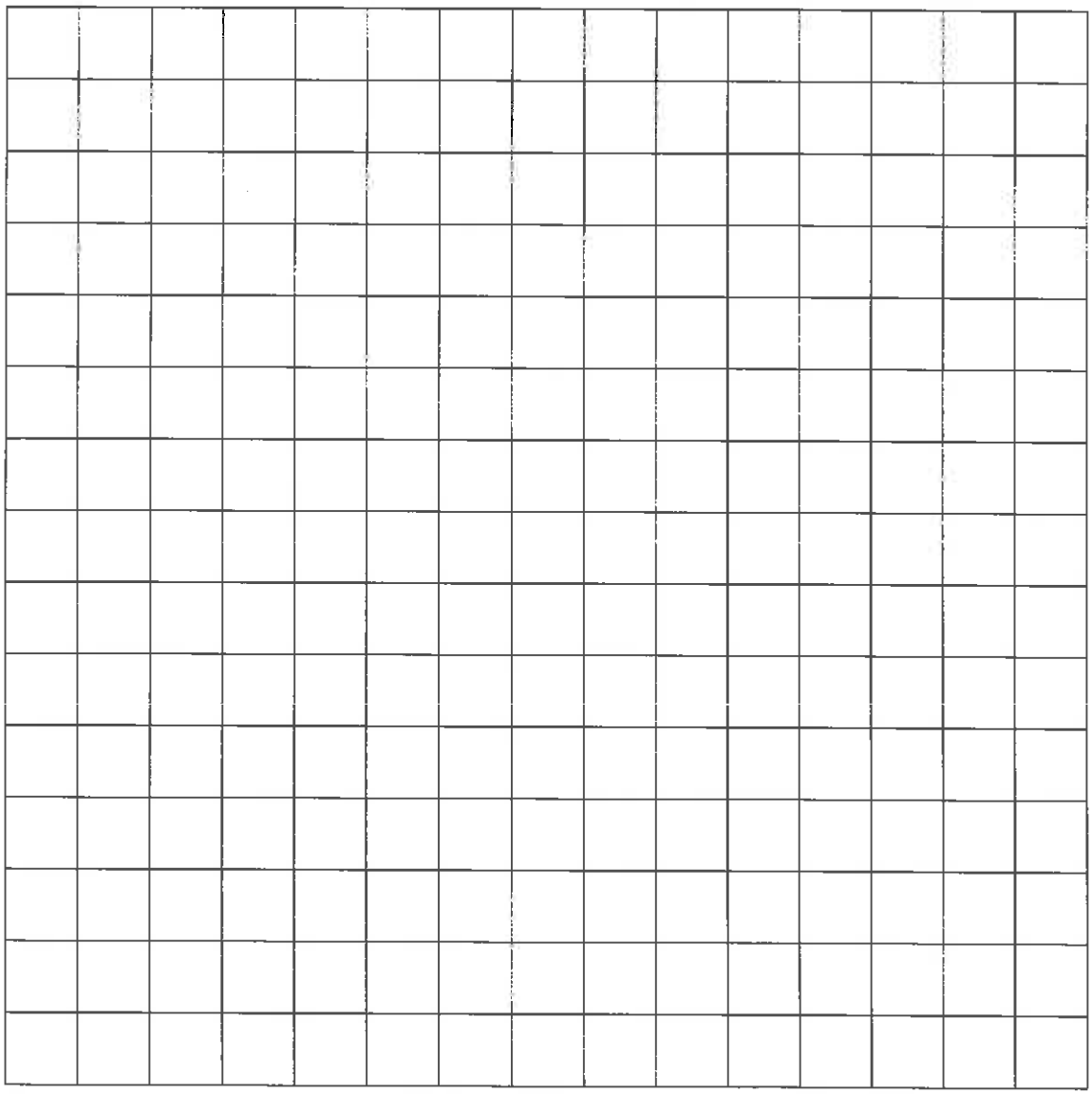
**(6)** Tape or glue the point of the skewer on the degrees latitude line corresponding to the latitude of your location. This will give a skewer (or style) to base angle equal to the latitude. The style is the name of the edge that casts the shadow on the dial. *(In sundial terminology, the skewer is really the gnomon; the style is the shadow-casting edge of the gnomon.)*

**Materials, tools**
A4 sheet of white card *(140–160 gsm, this page copied on it)*
1 bamboo skewer *(~150 mm long, 2.5 mm thick)*
sticky tape or glue
scissors, pen



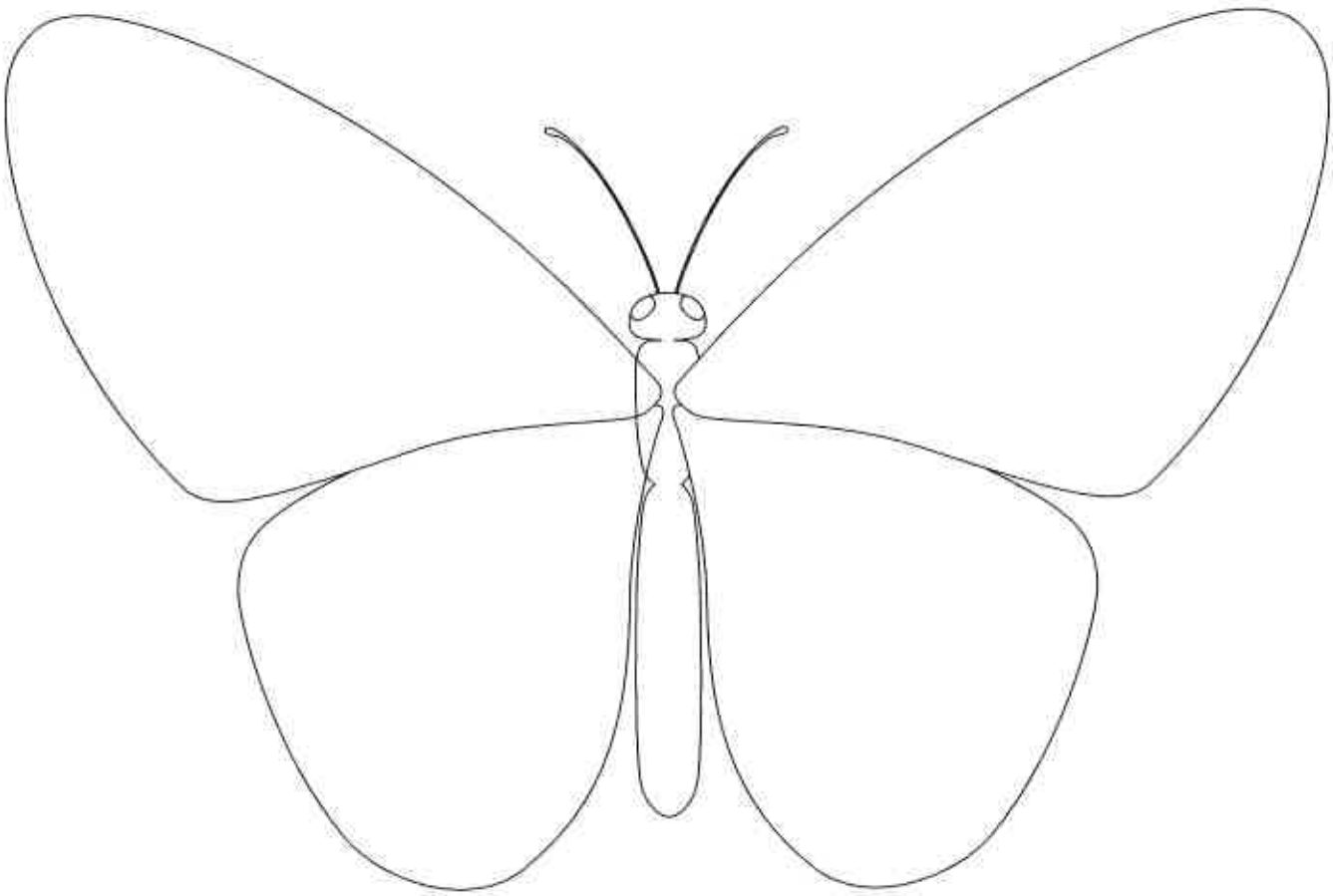

**(7)** Cut this out and hold against the skewer and dial plate. Slide the dial plate along the skewer until they are at 90° to each other as shown by this template, then glue or tape the dial to the skewer (style) at that position.

**(8)** Place the base on a level surface and align its centre true north. Local apparent time can be read from the shadow of the skewer on either the south-facing or north-facing dial plate depending on the time of year.



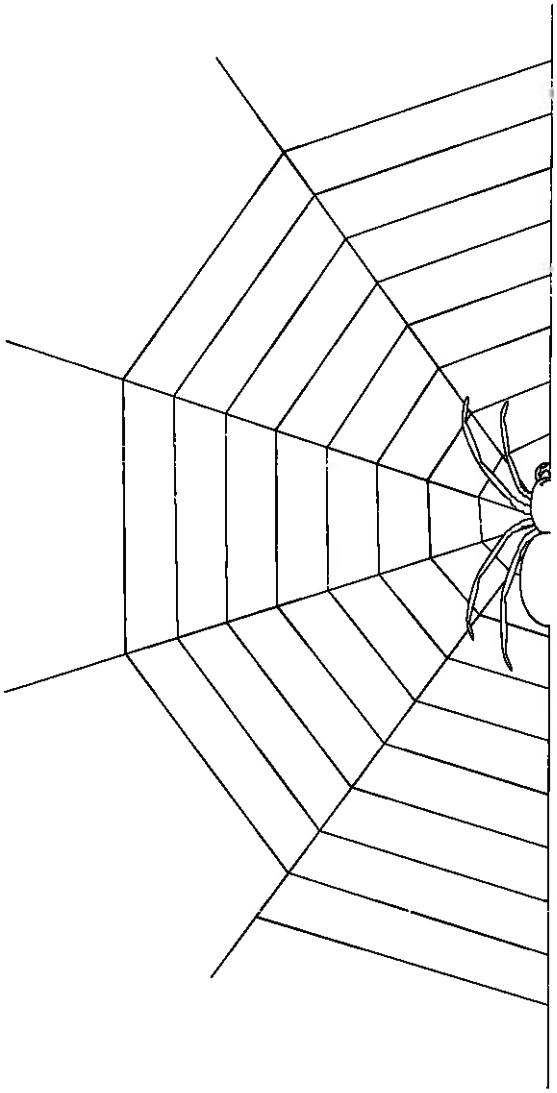
# Butterfly

Decorate the butterfly's wings to show a pattern. Try to make the left and the right wings look symmetrical (one wing is like a reflection of the other).



# Spider web

Finish the drawing of the spider and its web by drawing the missing half (a simple outline of the spider would be sufficient).

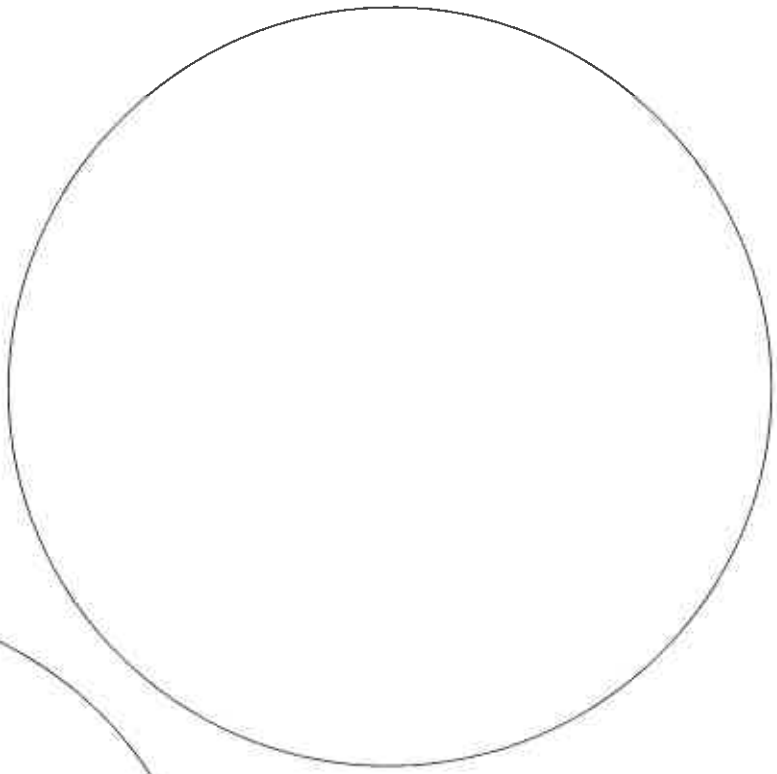


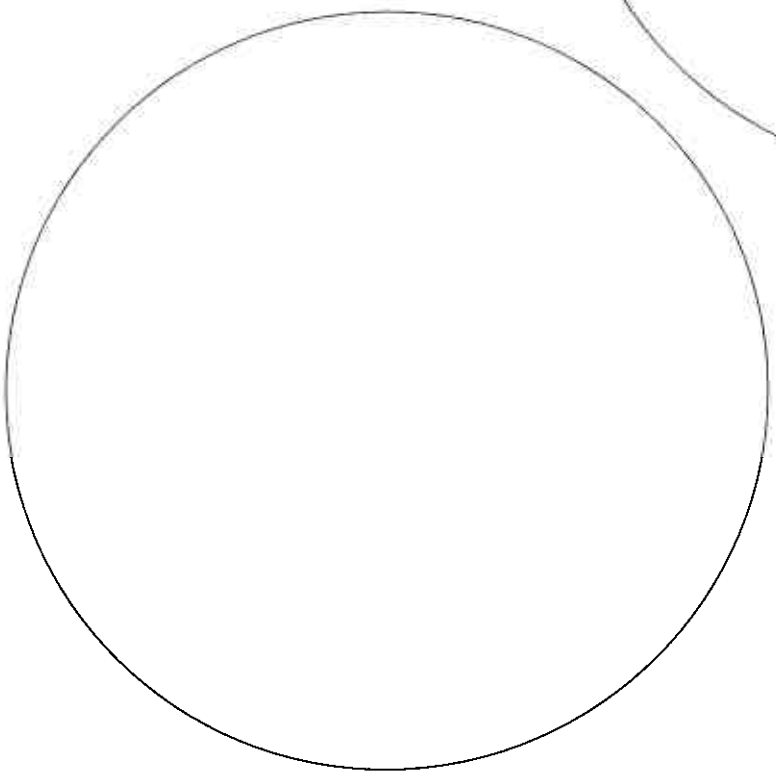
Draw something else which has two sides that look the same:

# Leaves

Leaves have many different shapes:

1. Find two small leaves and draw one in each circle.
2. Draw a line through each of your leaves so that you have divided each leaf in half.





What other things can you find which have two equal halves?

You could draw these on another piece of paper

1. Using a protractor and 1 cm graph paper, construct shapes from the sets of directions.
2. Using a compass pace out in each direction the number of paces, mark the corner and then step out in the next direction.

a) 80 degrees for 10 squares
170° for 10 squares
260° for 5 squares
350° for 10 squares

b) 60 degrees for 10 squares
180° for 10 squares
300° for 10 squares

c) 320 degrees for 5 squares
80° for 5 squares
200° for 5 squares

3. How far are you from the start?

d) 0° degrees for 5 squares
90° for 10 squares
180° for 5 squares
270° for 6 squares

e) 45° for 7 squares
90° for 3 squares
180° for 7 squares

1. Using a protractor and 1 cm graph paper, construct shapes from the sets of directions.
2. Using a compass pace out in each direction the number of paces, mark the corner and then step out in the next direction.

a) 80 degrees for 10 squares
170° for 10 squares
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d) 0° for 5 squares
90° for 10 squares
180° for 5 squares
270° for 6 squares

e) 45° for 7 squares
90° for 3 squares
180° for 7 squares

# Acknowledgements

EONZ wishes to acknowledge the considerable time and effort of the individuals who have contributed to the production of this teaching resource.

The names of many contributors are unknown. We extend our thanks to all those who have this resource possible. If you did contribute to this resource we would like to acknowledge your efforts. Please email us and we will add you to the list of contributors.

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