

Investigating the maths inside:

Bees with backpacks

Information for teachers



Maths Inside is a project funded by the Commonwealth Department of Education and Training under the Australian Maths and Science partnership Programme.

The aim of Maths Inside is to increase engagement of students in mathematics by using rich tasks that show the ways mathematics is used in real world applications.

# About this module

**This resource was developed by**

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This module consists of the video “Bees with Backpacks” and the following activities:

Activity 1 Making beehives Years 7–9

Activity 2 Dancing with bees Years 7–10

Activity 3 Counting bees Years 7–9

Activity 4 Clever bees Year 11 General

Activity 5 Bee food Years 7–8

Activity 6 Bee patterns Years 7–9

# Feedback

Feedback from teachers about these classroom activities would be appreciated. Please complete the form at <http://tiny.cc/mathsinsidefeedback>.

# Background

Bees are necessary for assisting many other plants to produce the foods we eat, including meat and milk. But in Europe and America, beehives are disappearing. This could have catastrophic effects on food production. This “colony collapse disorder” has not yet been seen in Australia.

Australian scientists are studying bee behaviour to add their knowledge to the problem. Bees are fitted with chips which record their movements in and out of the hive. In this way, the scientists can build up a picture of the behaviour of a healthy hive.

Activity 1: Making beehives

Students construct three different regular polygonal prisms from cardboard and join them to make three different types of beehives. They then test the hives for strength and stability. Students compare the capacities of the different prisms which can lead to formulation of appropriate formulas for perimeter, area and volume.

# Why do this?

Explores the characteristics of shapes

Clarifies the difference between perimeter and area.

Helps develop the area formulas for some regular polygons and volume formulas for different prisms in the context of beehive construction.

# Australian Curriculum links

Establish the formulas for areas of rectangles, triangles and parallelograms, and use these in problem-solving [(ACMMG159)](http://www.australiancurriculum.edu.au/curriculum/contentdescription/ACMMG159)

Calculate volumes of rectangular prisms [(ACMMG160)](http://www.australiancurriculum.edu.au/curriculum/contentdescription/ACMMG160)

Develop formulas for volumes of rectangular and triangular prisms and prisms in general. Use formulas to solve problems involving [volume](http://www.australiancurriculum.edu.au/glossary/popup?a=M&t=Volume) [(ACMMG198)](http://www.australiancurriculum.edu.au/curriculum/contentdescription/ACMMG198)

Calculate areas of composite shapes [(ACMMG216)](http://www.australiancurriculum.edu.au/curriculum/contentdescription/ACMMG216)

Investigate [Pythagoras’ Theorem](http://www.australiancurriculum.edu.au/glossary/popup?a=M&t=Pythagoras%e2%80%99+theorem) and its application to solving simple problems involving right angled triangles [(ACMMG222)](http://www.australiancurriculum.edu.au/curriculum/contentdescription/ACMMG222)

# Getting started

Brain-storm the question: What do bees need to consider when making a ‘good’ beehive?

Students might suggest: efficient use of materials, right size for a bee bed, not too heavy, waterproof, near pollen source, easy to store honey etc

\*Students may need to be reminded that ‘regular’ polygons are equiangular and equilateral. They should recognise the difference between regular and irregular polygons. They should also consider how the polygons might join together.

# Beehive building

Each pair should make one triangular, one square and one hexagonal prism.

Folding to get three equal parts for the triangular prism can be quite difficult for students. They might need to practise on a sheet of paper first of all.

There will need to be at least two layers for each hive.

Students should notice that there is no wasted space in any of the hives. They could test the strength by loading with weights and the stability by applying a lateral force.

Selection of the ‘best’ hive could relate back to the original set of criteria. At this stage, the efficiency of the use of materials could be discussed (is one hive bigger than another?)

# How much honey?

At this point, students should be aware that they have used the same amount of material (one A4 sheet of cardboard) to make each cell. Are the areas, and therefore the volumes, the same?

Some students may compare the areas physically by using cardboard cut-outs to compare, or by trial and error. Others may trace the faces onto grid paper and count the squares.

## What would a mathematician do to prove this?

Depending on their background, students may begin to develop formulas for the areas or use their existing knowledge to apply the formulas. Note that the perimeter is constant at approximately 30 cm.

\*Some students will come to the understanding that as the face of the prism has more and more edges, it approximates a circle. A circular prism (cylinder) will hold the most volume for the given perimeter, but there will be other issues with construction.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Measurements | Triangle | Square | Hexagon | Circle |
| PerimeterP = 300mm | P = 3bb = length of the side | P = 4bb = length of the side | P = 6bb = length of the side | C = 2πrr = radius of circle = C/2π |
| Area | A = 1/2ba a = altitude of the triangle = b√3/2 | A = b2  | A = 6(1/2ba) = 3ba a = altitude of the triangle = b√3/2 | A = π r2 |
| Volume | V = Ah = 1/2bah | V = Ah = b2h | V = Ah = 3bah | V = Ah = π r2h |

# Answers

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Measurements | Triangle | Square | Hexagon | Circle |
| PerimeterP = 300 mm | P = 3bb = length of the side = 300/3 = 100 | P = 4bb = length of the side = 300/4 = 75 | P = 6bb = length of the side = 300/6 = 50 | C = 2πrr = radius of circle = C/2π = 47.77 mm |
| Area | A = 1/2ba =1/2 x 100 x 100 x √3/2 = 4330mm2a = altitude of the triangle = b√3/2 | A = b2 = 75 x 75 = 5625mm2 | A = 6(1/2ba) = 3ba = 3 x 50 x 50 x √3/2 = 6495mm2a = altitude of the triangle = b√3/2 | A = π r2 = 7165mm |
| Volume | V = Ah = 1/2bah= 4330 x 210 = 909 300mm3 | V = Ah = b2h = 1 181 250mm3 | V = Ah = 3bah = 1 363 950mm3 | V = Ah = π r2h = 1 504 650 mm3 |

# Resources needed

A4 sheets of light cardboard,minimum of 3 sheets per pairof students

Sticky-tape or blu-tack

Grid paper

Pen or pencil

Weights (can improvise)

# Further ideas

Is the difference in the volumes of honey in the variously shaped cells significant?

How much honey is in a hive? Use a spreadsheet to help with the calculations.

Are there any differences between ‘wild’ bees and ‘farmed’ bees?

Activity 2: Dancing with bees

Students emulate a ‘waggle dance’ to indicate the direction and distance of a particular place. They do this as an outdoor activity, by creating a video of the directions for a place a long distance away located via google maps.

If this is impractical, there is a modified version for the classroom.

# Background

The ‘waggle dance’ is a mode of communication between bees to let the rest of the hive know of a pollen source. The bees communicate the direction of the source by moving in a figure of eight and the distance by the number of ‘waggles’. The vigour of the waggles indicates the quality of the pollen source.

https://youtu.be/-7ijI-g4jHg

# Why do this?

Uses direction and distance for location (a precursor to vectors)

Accuracy of measurements

Places the technology of google maps in a meaningful context

# Australian Curriculum links

Solve problems using [ratio](http://www.australiancurriculum.edu.au/glossary/popup?a=M&t=Ratio) and scale factors in [similar](http://www.australiancurriculum.edu.au/glossary/popup?a=M&t=Similar) figures [(ACMMG221)](http://www.australiancurriculum.edu.au/curriculum/contentdescription/ACMMG221)

# Getting started

In discussion, students should arrive at the need for both direction and distance for the instructions to be clear. They may also want to consider other factors.

 Students will need to be able to understand angle measures taken from true North, both in a clockwise and anti-clockwise direction.

# Dancing outside

Students should work in groups of two, three or four.

## Locating the beehive

You will need a sunny day so that a clear shadow can be seen.

The stake has to be left in place until all groups have made their videos or taken their photographs.

Students mark their shadow line. Golf tees could be used.

## Selecting the pollen source

Students use *Google Earth* or *Google Maps* to find a relatively well known building, feature, landmark, shop, school, hospital or other location.

It should be less than 10 km from the ‘hive’. Students will need to be able to read the scale or otherwise measure the distance.

They will also need to be able to establish the direction from the marked shadow line.

Make sure that every group has chosen a different location.

## Creating the dance

 Each group will video their dance.

The ‘waggle’ can be indicated by waving the hands or other suitable movements.

Students will need to time their dance at one second for every kilometre. Mobile phones could be used.

## How effective is your dance?

Play each video to the class.

You will need to have a stopwatch to time and a map showing a circular area with radius 10 km centred on the ‘hive’.

After each video:

* every person who can correctly write down the landmark scores a point, and
* the video’s creators also score a point for each correct identification of their location (because the bees who can dance well help the whole colony to thrive).

# Resources needed

A sunny day!

Access to school oval or similar

One stake

Mallet or hammer

Golf tees or similar

Camera (video or still)

Stop watch

Access to the internet

Printouts of the map centred around the hive

# Dancing inside

If it is not practical to conduct an outdoor activity, you can use grid paper to perform a similar activity.

Set the direction of the sun. Students draw this line from the centre of the paper.

Measure the classroom and identify a suitable scale. Draw the classroom’s major features (e.g. the walls, windows and door) on the grid paper.

Each group identifies a place in the classroom (e.g. the fish tank, the clock) and determines its direction and distance. Make sure each group has a different place.

Students can do their dance ‘live’ or video it.

Use one second for every metre.

# Resources needed

Grid paper and pencil

Ruler

Protractor

Measuring tape

Camera (optional)

Stop watch

# Further ideas

Some additional video links to help understand the ‘waggle dance’.

https://youtu.be/bFDGPgXtK-U

<http://video.nationalgeographic.com.au/video/weirdest-bees-dance>

Activity 3: Counting bees

Students conduct a sampling experiment of the form ‘capture-recapture’ to predict the total population.

# Why do this?

Exposes students to one type of sampling, leading to exploration of other types

Multiple experiments reinforce the degree of variability in data and the need to take this into account

# Australian Curriculum links

Explore the practicalities and implications of obtaining [data](http://www.australiancurriculum.edu.au/glossary/popup?a=M&t=Data) through sampling using a variety of investigative processes [(ACMSP206)](http://www.australiancurriculum.edu.au/curriculum/contentdescription/ACMSP206)

# Getting started

It is usually impossible to count the number of animals in a population. Scientists use a variety of techniques to estimate this number. What do you think they might do?

This should lead to the concept of sampling. Students might already have some experience or knowledge of sampling (e.g. survey) as opposed to a census (topical for 2016).

Discuss the capture-recapture technique.

Firstly, the scientists define the population to be estimated. They carefully capture some of the population and mark them or tag them in some way. The tagged animals are released and given time to mix with the general population. A random sample of the population is captured at a later time and the number of tagged animals expressed as a fraction of the entire sample. The sample is released and the experiment repeated. The populations is then estimated.

What animals has this method been used on?

\*Students should be exposed to the concept of a sample representing accurately a population. How might a sample be biased? How big does a sample need to be? Why does the sampling of animal populations need to be repeated?

# Capture-recapture

## The experiment

Prepare bags or boxes of ‘animals’. There should be a large number in each container (e.g. more than 100) but the total does not need to be the same in each container. You could use pop-sticks, toothpicks or counters. Tag 30 of them with a marker. Students could do this.

Another possibility is to use coloured paper-clips but add 30 silver paperclips.

Use opaque bags or boxes.

Students can estimate the number of trials that they think might be needed. They may change their minds depending on the results as the experiment proceeds.

## The analysis

With discussion, students may be able to arrive at the mathematical process themselves.

Share the class results. What were the biggest variations in the number of tagged animals selected? Were there any variations in the accuracy of the estimations and the size of the actual populations? Can you come to any conclusions about the number of trials needed?

# Answers

**Note: The numbers in this example are not the same as your experiment.**

*P* is the number of animals in the population, which is unknown.

If 50 animals were caught, tagged and released, the proportion of the population tagged is $\frac{50}{P}$.

In the samples, 40 animals were caught each time. The mean number of tagged animals was 7, so the proportion of animals tagged is approximately $\frac{7}{40}$.

The two proportions should be approximately equal to each other.

Form the equation $\frac{50}{P}=\frac{7}{40}$ . Solve it to estimate the population, as follows:

$\frac{50}{P}=\frac{7}{40}$ Equate the fractions.

$\frac{P}{50}=\frac{40}{7}$ Take the reciprocal of both sides so that *P* is in the numerator.

$P=\frac{40}{7}×50$ Multiply LHS and RHS by 50, to find the value of *P*.

$$P=285\frac{5}{7}$$

This indicates there are approximately 286 animals in the population.

# Resources needed

Bags or boxes of ‘animals’, some of which are tagged.

Paper to record results

Pencil

Calculator

# Further ideas

You might want to try very different sizes of populations in the bags so that students can do a comparison of the accuracy of sampling 30 animals from a smaller or larger population.

## How many German tanks?

During World War II, the Western Allies used a similar technique to estimate the number of tanks that Germany was building each month.

The table below shows the estimated number of tanks built during certain months and the actual number that were built (according to German production records that were accessed after the war).

|  |  |  |
| --- | --- | --- |
| **Month** | **Estimate** | **Actual** |
| June 1940 | 169 | 122 |
| June 1941 | 244 | 271 |
| August 1942 | 327 | 342 |
| September 1942 | 256 | 255 |

Do the results indicate that the Allies became better at this technique? How? Is this the same technique that we have been using?

Search the internet to discover how the Western Allies collected information from German tanks to make these incredibly accurate estimates.

## Opinion polls: Who will win the next election?

In Australia there are currently five different organisations which conduct opinion polls that attempt to predict the outcome of upcoming federal and state elections. They choose a sample of voters and ask them questions about who they would vote for if an election was held on that day. The results of these polls are published on these webpages:

<https://en.wikipedia.org/wiki/Opinion_polling_for_the_next_Australian_federal_election>

[https://en.wikipedia.org/wiki/Australian\_federal\_election,\_2013](https://en.wikipedia.org/wiki/Australian_federal_election%2C_2013)

What is the current population of Australia? How many people voted in the most recent Australian Federal election?

How many people are usually surveyed in these opinion polls? Approximately what percentage of all voters is this? What does this tell you about sample size?

Are the results reliable?

Activity 4: Clever bees

Students explore the number of possible routes between various numbers of points. They create a network diagram to represent a particular situation and find the shortest route by trial and error. Students then apply the Nearest Neighbour and Minimum Spanning Tree algorithms to arrive at a good approximation of a solution.

# Why do this?

Representing situations with networks (which highlight connections and relationships rather than physical situations) is a key mathematical concept.

Emphasises the importance of recording possibilities systematically.

# Australian Curriculum links

Identify practical situations that can be represented by a network, and construct such networks; for example, trails connecting camp sites in a National Park, a social network, a transport network with one-way streets, a food web, the results of a round-robin sporting competition (ACMGM079)

Investigate and solve practical problems to determine the shortest path between two vertices in a weighted graph (by trial-and-error methods only) (ACMGM084)

# Background

Bees learn to fly the shortest possible route between flowers discovered in random order. Unlike any other known animal besides humans, bees are capable of solving the "travelling salesperson problem". This problem involves finding the shortest route that allows a visit to all the locations and return home.

Scientists at Rothamsted Research, a biological research station north of London, placed flowers in a field in October. At this time of year, there are few natural sources of nectar and pollen and the bees are more likely to focus on their placed flowers.

At first, the bees visited the flower nearest to their hive, and then the next closest flower. The bees kept track—that is, they remembered—of the total distance traveled on each foraging trip. They tried new routes to increase their efficiency, and if a route was shorter, they kept it. If not, they abandoned it. As their experience increased, they rarely altered the sequence of flowers they visited.

After trying about 20 of the 120 possible routes, the bees were able to select the most efficient path to visit the flowers. They did not need to compute all the possibilities. A bee which travelled almost 2000 metres on its first foraging bout had reduced that distance to a mere 458 metres.by the final trip.

# Getting started

Discussion might begin with the bees needing to find the closest flower and then progress to finding the shortest distances between flowers.

\*Students will need to understand that the bees have to visit each flower, in any order, and then return to the hive. [Add a starred item(s) if necessary to help teachers identify some of the mathematical key points, and potential student misunderstandings]

# How many ways?

Students can work together to find the number of routes. This should be easy for one, two and three collection points but will get more complicated with four points. Students will need a method of recording all of the possibilities. Label the points A, B, C etc

\*Some students might be able to identify the pattern in the table, which could lead into a discussion of factorial notation.

# Be a clever bee

In a clear area of your school, choose places for a hive and four flowers. Label the hive (X) and the four flowers (A, B, C and D).

## Is yours the shortest way?

Students work in small groups to find a route, measuring the total distance taken. This might be done informally using paces. Some discussion should take place on the consistency of this method and the suitability of comparting different length paces. More formally, tapes or a trundle wheel could be used.

Again, a suitable recording method will need to be established.

## Using a network diagram

Students may be more comfortable creating a network diagram approximately to scale. However, this is an ideal opportunity to demonstrate that network diagrams show connections rather than physical relationships.

Students will need multiple copies of the final network.

Show the short tutorial <https://youtu.be/BmsC6AEbkrw>

This tutorial explains how to find intervals for optimal routes, using the Nearest Neighbour algorithm for upper bounds and the Minimum Spanning Tree algorithm for lower bounds.

### Another flower

Adding an additional point increases the number of possibilities considerably. Trial and error becomes increasingly less efficient and the use of the algorithms more sensible.

# Answers

|  |  |
| --- | --- |
| Number of collection points | Number of ways of visiting all collection points |
| 1 | 1 |
| 2 | 2 |
| 3 | 6 |
| 4 | 24 |
| 5 | 120 |
| n | n! |

# Resources needed

A clear space to set out places for the hive and the flowers

Labels (X, A, B, C, D and E) or chalk

Trundle wheel or tapes

Paper and pencil for recording

Access to YouTube

# Further ideas

The only sure way to find the shortest route is to test all possible routes. This is called the Brute Force algorithm.

A computer program or a spreadsheet could be used.

Activity 5: Bee food

Students investigate the types of foods that are pollinated by bees. Using a food diary, they examine how their typical diet would be affected if there were no bees. They then share their data to graphically represent the various categories of food.

# Why do this?

Explores a meaningful issue using primary data, collected by students, and secondary data

# Australian Curriculum links

Find percentages of quantities and express one quantity as a [percentage](http://www.australiancurriculum.edu.au/glossary/popup?a=M&t=Percentage) of another, with and without digital technologies. [(ACMNA158)](http://www.australiancurriculum.edu.au/curriculum/contentdescription/ACMNA158)

Identify and investigate issues involving [numerical data](http://www.australiancurriculum.edu.au/glossary/popup?a=M&t=Numerical+data) collected from primary and secondary sources [(ACMSP169)](http://www.australiancurriculum.edu.au/curriculum/contentdescription/ACMSP169)

# Getting started

Some possible stimulus questions:

What is pollination?

What plants are pollinated by bees?

What are other means of pollination?

You may need to point out that some plants which humans do not eat are eaten by animals that humans do eat (e.g. grasses feed dairy cows which produce milk).

# One day’s food

Different types of food need to be listed separately.

This lists food crops that are pollinated by bees:

<https://en.wikipedia.org/wiki/List_of_crop_plants_pollinated_by_bees>

When determining how much of the food has been assisted by bees, the class will need to consider how to count. Will they use raw numbers (e.g. 5 apples) or weight (e.g. 300g milk) or another measure?

There will need to be a sensible method of sharing data, perhaps into a spreadsheet.

Will they group foods into types (e.g. pome fruits) to get a better picture of the data?

# Answers

Some means of pollination are bees and other insects (beetles, flies, wasps, moths, butterflies, ants), other animals (birds, bats, possums, lemurs, lizards), environmental (wind, water).

The most essential staple food crops on the planet, like corn, wheat, rice, soybeans and sorghum, need no insect help at all; they are wind-pollinated or self-pollinating.

Other staple food crops, like bananas and plantains, are sterile and propagated from cuttings, requiring no pollination of any form, ever.

Foods such as root vegetables and salad crops, will produce a useful crop without pollination, though they may not set seed.

Hybrids do not require insect pollination to produce seeds for the next generation, because hybrid production is always human-pollinated.

# Resources needed

Access to internet

Paper and pencil

# Further ideas

Some reasons for the decline of bee populations:

<http://www.un.org/apps/news/story.asp?NewsID=37731#.Vu3_NNJ942x>

https://youtu.be/dY7iATJVCso

Protection of bee populations:

<https://blog.csiro.au/protecting-our-pollinators-indigenous-knowledge/>

The list of bee-pollinated foods could be examined more closely. For example, are there any common characteristics for the foods that have little pollinator impact as opposed to essential pollinator impact?

<https://en.wikipedia.org/wiki/List_of_crop_plants_pollinated_by_bees>

Activity 6: Bee patterns

Background

Beehives are made up of regular (within reason) hexagons.

The hexagons tessellate and form a strong, stable structure. This hexagonal tessellating pattern is also used in the construction of doors. The doors, made with thin sheets of wood on both sides of a cardboard honeycomb structure, have the advantage of being light in weight but exceptionally strong.

# Why do this?

Investigates some of the properties of regular polygons

Introduces angle sums through tiling patterns

Encourages geometrical reasoning

# Australian Curriculum links

Define [congruence](http://www.australiancurriculum.edu.au/glossary/popup?a=M&t=Congruence) of plane shapes using transformations [(ACMMG200)](http://www.australiancurriculum.edu.au/curriculum/contentdescription/ACMMG200)

Demonstrate that the [angle](http://www.australiancurriculum.edu.au/glossary/popup?a=M&t=Angle) [sum](http://www.australiancurriculum.edu.au/glossary/popup?a=M&t=Sum) of a triangle is 180° and use this to find the [angle](http://www.australiancurriculum.edu.au/glossary/popup?a=M&t=Angle) [sum](http://www.australiancurriculum.edu.au/glossary/popup?a=M&t=Sum) of a quadrilateral [(ACMMG166)](http://www.australiancurriculum.edu.au/curriculum/contentdescription/ACMMG166)

# Getting started

Bring in a piece of honeycomb if possible.

Discuss the reasons for bees using hexagons for cells in the hive including strength and the maximising of volume to perimeter (relating back to Activity 1).

Students can brainstorm in what sort of situations a plane needs to be fully covered (e.g. tiling a bathroom floor).

# Beehive geometry

Using only a ruler and a compass, a number of regular polygons can be drawn using only a ruler and compass. The regular hexagon and the equilateral triangle are the easiest to construct, followed by the square.

Students may well need some instruction on the need for accuracy and the technique of making an arc using a compass.

Students should be aware that if their hexagon is regular then its sides will be the same length and its internal angles the same measure. Having to keep the compass at the same opening should be sufficient to ‘prove’ that the sides are the same length. Using a protractor will be needed to check the angles.

# The quadrilateral challenge

A quadrilateral is a simple four-sided plane shape. It can be concave or convex. Students may need to be reminded of these definitions.

By making the instruction that all sides are to be different lengths, students will get shapes more complex than rectangles and squares.

When trying to tessellate, students will need to rotate the pieces.

The class should find (if they have drawn carefully) that every different type of quadrilateral they have drawn will tessellate. Will it always be true?

"Any quadrilateral will tessellate. If you consider the statement to be always true or never true, explain how you know this. If you think it is sometimes true, explain when and why it is true at some times but not at others."

This link shows one student’s reasoning.

<http://topdrawer.aamt.edu.au/Reasoning/Big-ideas/Mathematical-truth/Truth-of-propositions/Do-quadrilaterals-tessellate>

# Tiling patterns

It is best for students to work in groups. Each student will need to cut out a set of the polygons printed on the sheet so there enough to work with. They might photograph their patterns to record the various solutions.

### Angle investigations

A class should arrive at most, if not all, of the semi-regular tilings and therefore will need to know the angle measures of all of the regular polygons used.

Each of the polygons can be divided into triangles and thus the sum of the interior angles calculated. The calculation of the size of each interior angle can then be calculated.

If the results are recorded, students can be encouraged to find a general rule.

# Answers

### Quadrilateral challenge

Each quadrilateral is matched with a 180o rotation of itself. This then forms an irregular hexagon. That hexagon will tile the plane by translating in two directions.

### Tiling patterns

This webpage illustrates the full set of semi-regular tilings.

<https://en.wikipedia.org/wiki/Euclidean_tilings_by_convex_regular_polygons>

### Angle investigations

|  |  |  |  |
| --- | --- | --- | --- |
| Name of shape | Number of sides | Sum of interior angles | Size of interior angle |
| Equilateral triangle | 3 | 180° | 60° |
| Square | 4 | 360° | 90° |
| Pentagon | 5 | 540° | 108° |
| Hexagon | 6 | 720° | 120° |
| Octagon | 8 | 1080° | 135° |
| Dodecagon | 12 | 1800° | 150° |
| n-gon | n | (n–2) x 180° | (n–2) x 180°/n |

# Resources needed

Ruler

Compass

Protractor

Square dot paper or grid paper

Coloured pencils, textas or markers

Scissors

Sheets of card

Glue

# Further ideas

What is the honey comb conjecture?

These YouTube videos show other methods of constructing regular polygons.

https://youtu.be/TAHczLeIUTc

https://youtu.be/yOmjBXWnMXg