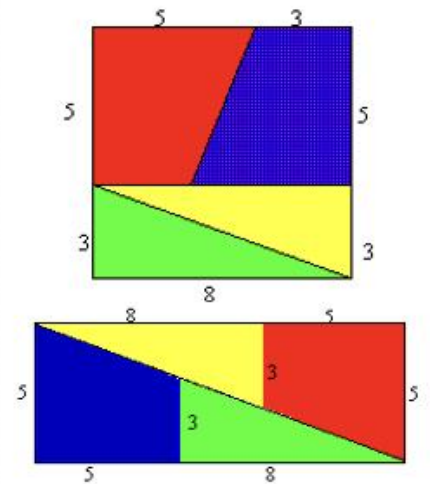
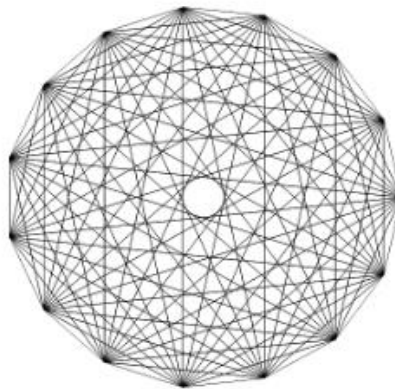
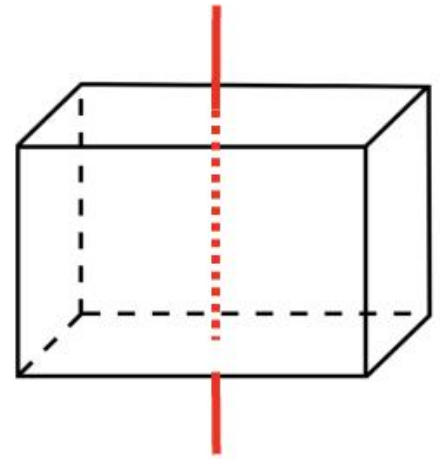
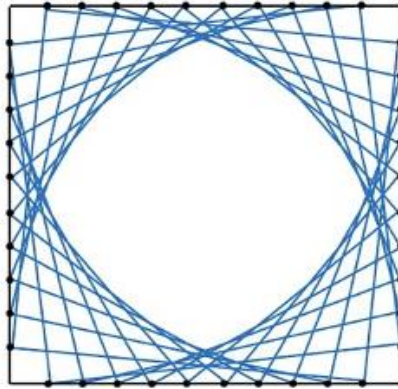
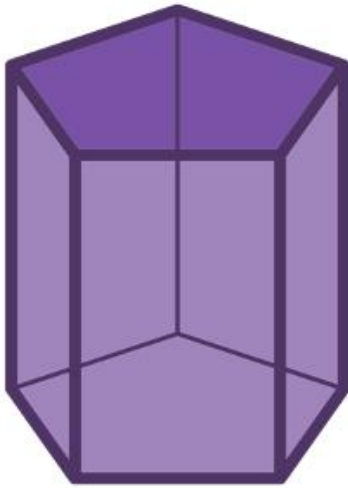
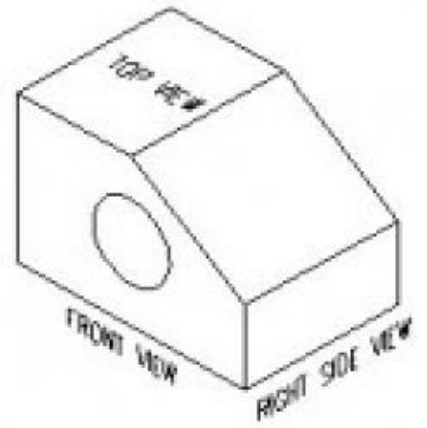
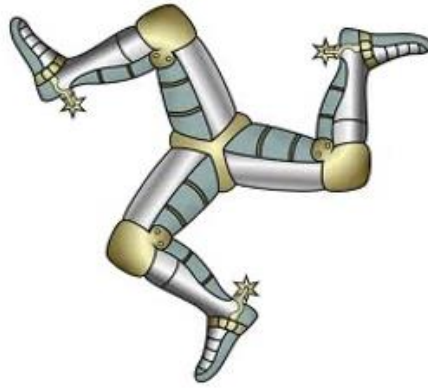
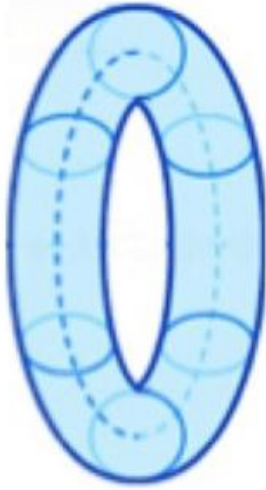


Larger images of all the cards. To be printed with information on reverse side.



PLAN AND ELEVATION

Engineering and architectural drawings consist of separate views from 3 separate directions.

(1) PLAN OR TOP VIEW

A bird's eye view looking vertically down,

(2) FRONT ELEVATION

representing the front view,

(3) SIDE ELEVATION

showing a side view.

ROTATIONAL SYMMETRY

The picture shows a rectangular cuboid and an axis of rotational symmetry.

It can be rotated by 180° about this axis to fill the same space.

A rectangular cuboid has 3 axes of rotational symmetry and 3 planes of reflection symmetry.

MAGIC OR ILLUSION

The rectangle and the square are made from the same 4 pieces of the jigsaw, but they have different areas, and that is not possible.

Can you explain the trick?

3 LEGS OF MAN

This symbol on the coat of arms of the Isle of Man, (a small island off the coast of England) represents the perseverance, strength and independence of its people.

The Tynwald, the Isle of Man's parliament, set up by the Vikings in the 9th century is the oldest continuous parliament in the world.

ENVELOPE

This picture is made up of straight lines, and you can see curves, called envelopes, to which all the lines are tangent.

In the plane an envelope is a curve that is tangent to a family of other curves.

In 3D an envelope is a surface tangent to each member of a family of other surfaces.

ODD MYSTIC ROSE

To draw this pattern, mark 15 points equally spaced around a circle and join each point to every other point by a straight line. The lines form an envelope to a small circle at the centre. In Mystic Rose patterns with an even number of points, all the lines are diameters going through the centre.

TORUS

A cup is topologically equivalent to a torus; both have a single hole. The 'straight lines' on the surface are circles, one type going through the hole and the other type around the hole. It is impossible to shrink circles of either type to points. Other small circles on the surface, that can be shrunk to a point, do not go through or around the hole.

PENTAGONAL PRISM

A cross section of this prism is a regular pentagon. It is shown standing on a pentagonal face.

The vertical faces are rectangles.

It has 7 faces, 10 vertices and 15 edges.

Faces 7 + Vertices 10 = Edges 15 + 2 satisfying Euler's formula.

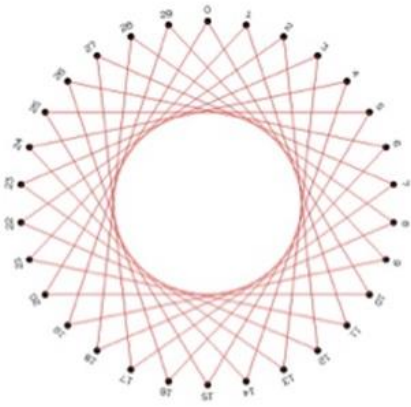
BUCKY BALL

This football is made from 20 hexagons and 12 pentagons.

Can you imagine making this shape by slicing off a pentagonal pyramid at each vertex of an icosahedron?

The carbon molecule called a buckminster fullerene (found in soot) is like Buckminster Fuller's geodesic dome structures.

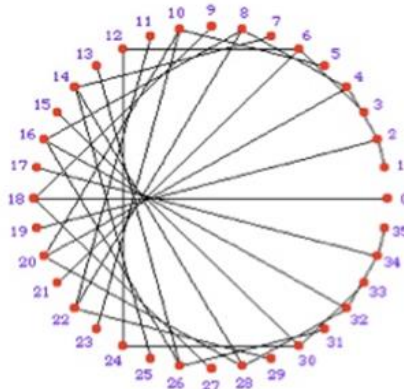
CIRCLE



N=30

$$n \rightarrow n + 10$$

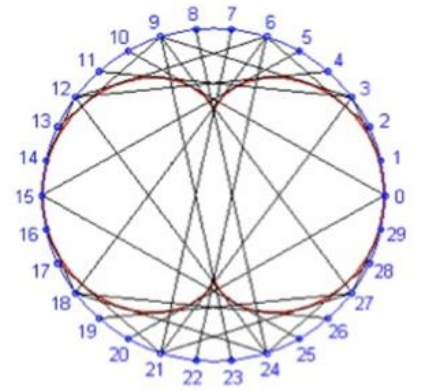
CARDIOD



N = 36

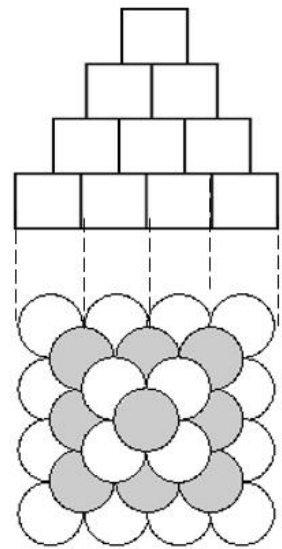
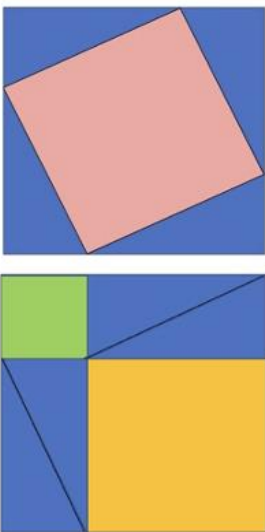
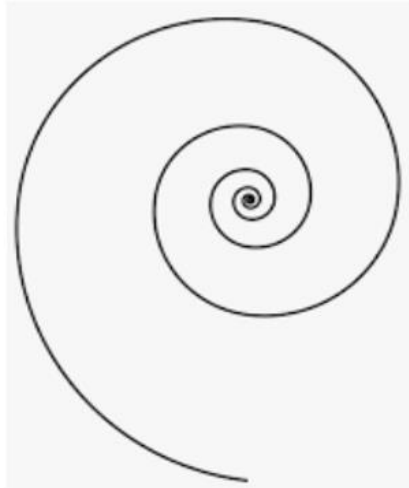
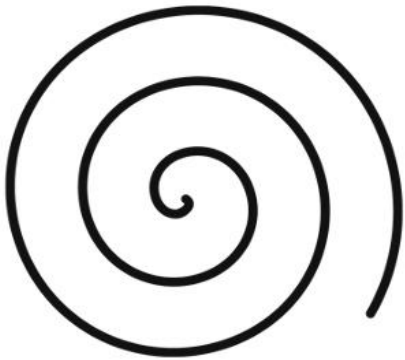
$$n \rightarrow 2n$$

NEPHROID



N = 30

$$n \rightarrow 3n$$



NEPHROID

To draw this pattern mark 30 points equally spaced around a circle.

Number the points 1 to 30 and join points 1 to 3, 2 to 6, 3 to 9 and each point n to the point numbered $3n$ ($n \rightarrow 3n$).

This forms the envelope of a nephroid to which all the lines are tangent.

CARDIOID

To draw this pattern mark 36 points equally spaced around a circle.

Number the points 1 to 36 and join points 1 to 2, 2 to 4, 3 to 6 and each point n to the point numbered $2n$ ($n \rightarrow 2n$).

This forms the envelope of a cardioid to which all the lines are tangent.

CIRCLE ENVELOPE

To draw this pattern mark 30 points equally spaced around a circle and join each point to a point 10 spaces around the circle. ($n \rightarrow n + 10$).

This forms the envelope of an inner circle to which all the lines are tangents. Try drawing patterns using different numbers.

NAUTILUS SHELL

The animal can withdraw into its shell and close the opening.

The interior of the shell divides into chambers.

As the nautilus matures it creates new, larger chambers, and moves its growing body into the larger space, sealing off the empty chambers so that it can always float vertically.

LOGARITHMIC SPIRAL

This spiral, described by Albrecht Durer in 1525, has been called an eternal line, a marvellous spiral, a growth spiral and an equiangular spiral.

It is a self-similar spiral curve often found in nature.

The distance between loops increases as a geometric series.

ARCHIMEDEAN SPIRAL

This spiral is named after the 3rd century BCE mathematician Archimedes.

It is like a coiled rope lying on a flat surface.

It is the locus of a point moving away from a fixed point with a constant speed along a line that rotates with constant angular velocity. The radial distance between loops is constant.

STACKING IN PYRAMIDS

Fruit, or cans on a market stall or in a supermarket are often stacked in pyramids. The picture shows a stack in the form of a square based pyramid with 16 in the bottom layer, then 9, then 4 and 1 on top.

Four layers stacked in a triangular pyramid would have 10, 6, 3 and 1 objects in the 4 layers.

SPIRALS IN PINECONES

Pinecones commonly have 3 steep and 5 gradual spirals ($5/8$ or $8/13$).

This arrangement is called phyllotaxis.

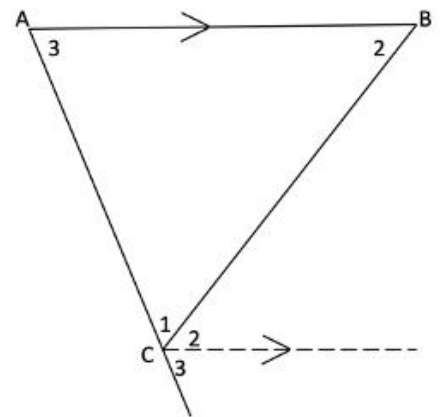
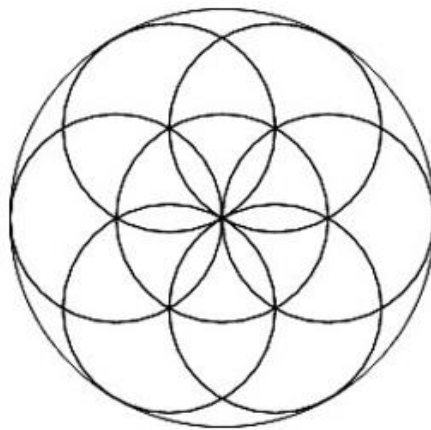
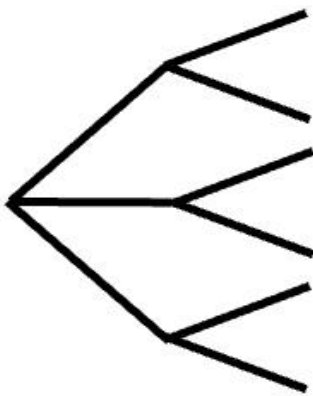
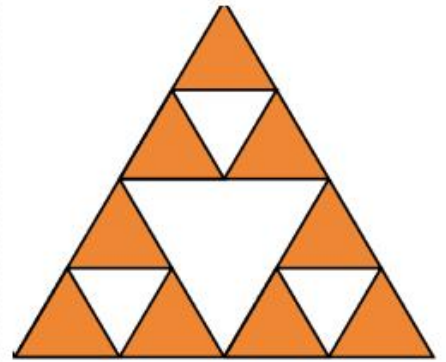
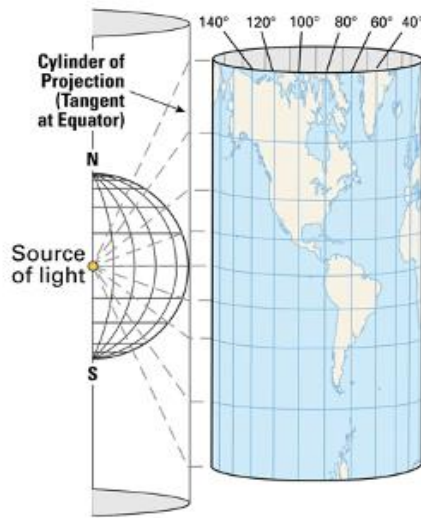
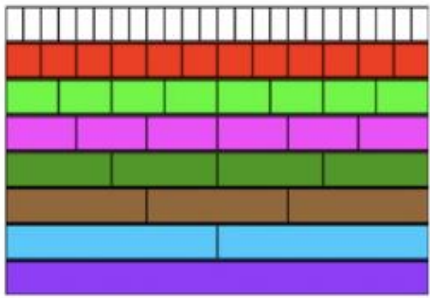
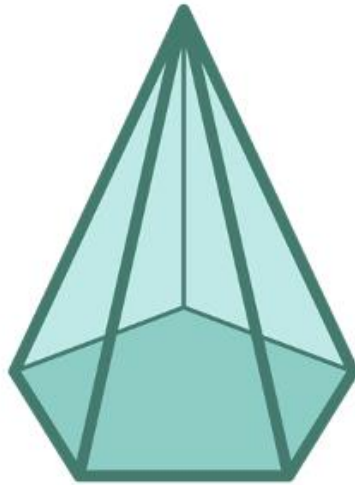
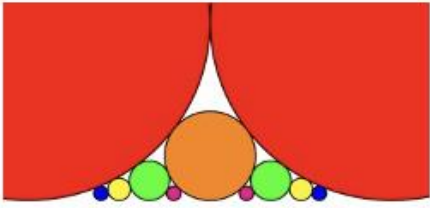
Leaves on a stem often form a spiral pattern called a phyllotactic spiral.

A similar form of spiralling occurs in the outer petals of artichokes and other flower buds.

PROOF OF PYTHAGORAS THEOREM

Another proof in a picture! Focus on areas and take away the 4 congruent triangles in each frame.

The remaining areas must be the same.



PYTHAGOREAN TREE

This is a fractal tree made up of copies of the same image of 3 squares on the edges of a right-angled triangle, at smaller and smaller scales. It can be continued indefinitely with the 'branches' getting smaller and smaller. What if the triangle is isosceles?

PENTAGONAL PRISM

The base of this pyramid is a regular pentagon and the sloping faces are isosceles triangles. The vertex is vertically above the centre of the base. It has 6 faces. 6 vertices and 10 edges.
Faces 6 + Vertices 6
= Edges 10 + 2
satisfying Euler's Formula.

FAMILY OF FORD CIRCLES

These circles touch their neighbours. They all touch the horizontal axis (an infinite circle) at rational points: red circles at integer points, orange circles at $\frac{1}{2}$, green circles at $\frac{1}{3}$ and $\frac{2}{3}$, yellow circles at $\frac{1}{4}$ and $\frac{3}{4}$, etc.

SIERPINSKI TRIANGLE

This is stage 2 of a repeating (iterative) process that replaces the image at each stage by 3 smaller copies of itself reduced in edge length by scale factor $\frac{1}{2}$. The Sierpinski Triangle fractal is formed by repeating this process infinitely often.

MERCATOR PROJECTION

In this projection, invented by Mercator in 1569, the surface of the Earth is projected onto a cylinder preserving directions (angles) but distorting distances. Surprisingly it preserves areas. It is the standard map projection for atlases and navigation at sea, but no use for flight paths.

FRACTION WALL

The base of the fraction wall is one unit in length and each layer of the wall shows smaller and smaller fractions. You can easily compare different fractions using this picture. What fractions are shown in each of the levels? Can you build the fraction wall any higher?

PICTURE STORY

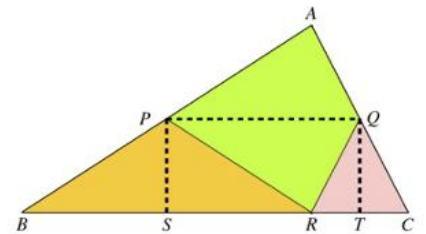
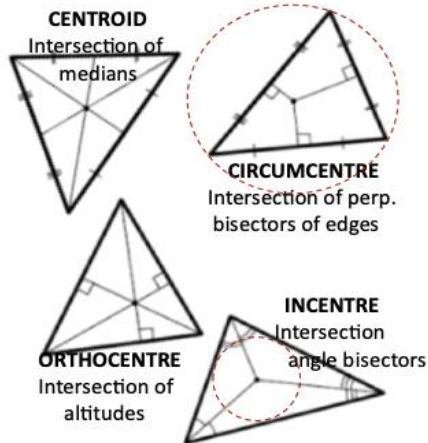
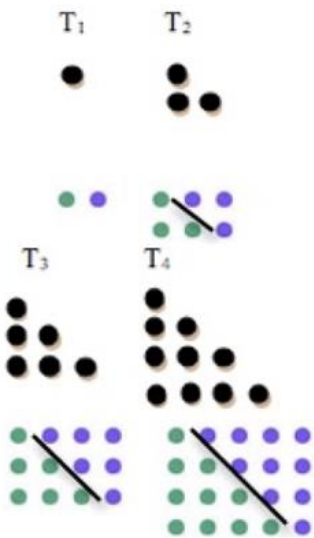
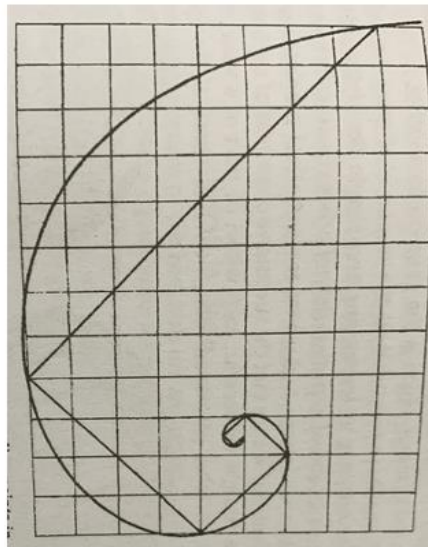
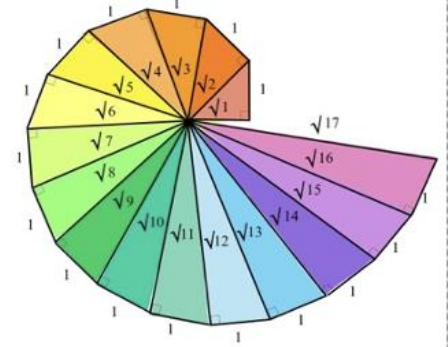
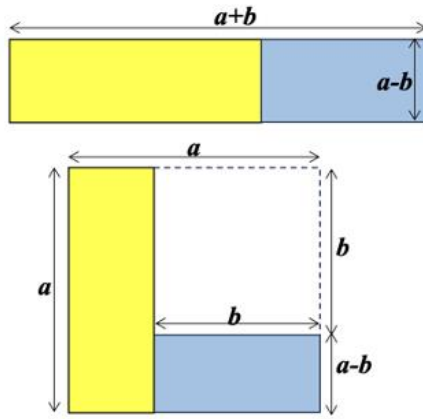
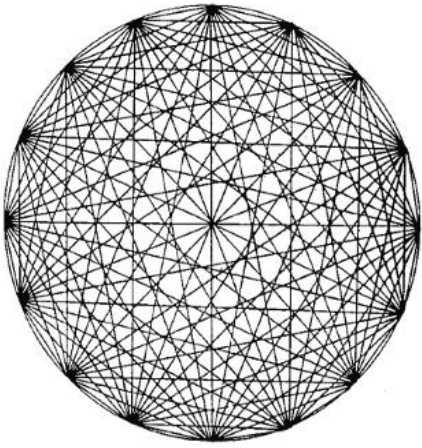
A picture can give a proof without words. The parallel lines show that the exterior angle of a triangle is equal to the sum of the interior opposite angles. The theorem that the angles of a triangle add up to 180° follows because the angles on a straight line add up to 180° .

FLOWER OF LIFE

The flower of life is a geometric shape regarded as sacred by many cultures throughout history including Egyptian, Buddhist, Hindu, Christian and Muslim. It is seen to represent the cycles of life, death and re-birth, the unity of all life, and the interconnectedness of all beings.

TREE DIAGRAM

Tree diagrams use networks for analysing probabilities and games to show all possible outcomes of a series of events. In this diagram the 1st event can have 3 outcomes, and the 2nd event 2 outcomes so the combined events have 6 possible outcomes.



SPIRAL OF THEODORUS

The Greek mathematician Theodorus lived in the 5th century BCE.

This spiral is built from a sequence of right-angled triangles. The triangle at the centre has edges 1, 1 and $\sqrt{2}$. The hypotenuse of each triangle in the sequence forms one of the legs of the next triangle, with the other leg one unit in length.

SUNFLOWER

The seeds in a sunflower form equiangular spiral patterns. Each spiral makes a different angle with the radii. For each angle the number of spirals in the sunflower is a Fibonacci number, the numbers of spirals with the same angle, winding clockwise and anti-clockwise, are successive Fibonacci numbers.

TRIFOLD

Proof by paper folding!
P and Q are midpoints of edges AB and AC.

By folding along the dotted lines you can show that the angles of a triangle add up to 180° and the area of the triangle is

$$\frac{1}{2} \text{base} \times \text{height}.$$

DIFFERENCE OF 2 SQUARES

A proof without words!

For all values of a and b with $a > b$,

$$a^2 - b^2 = (a - b)(a + b).$$

Whatever the values of a and b take a square of edge length a , and cut away a square of edge length b .

The rectangles formed, coloured yellow and blue, together make a rectangle with edges $(a - b)$ and $(a + b)$.

,

STRAIGHT LINE' SPIRALS

This logarithmic spiral is constructed by drawing straight line segments and arcs on a grid.

The radii of the arcs double in length.

The Fibonacci spiral is constructed similarly with the lengths of the radii of the arcs increasing as a Fibonacci sequence 1, 1, 2, 3, 5, 8,...

CENTRES OF A TRIANGLE

- (1) The centroid is the intersection of the medians.
- (2) The orthocentre is the intersection of the altitudes.
- (3) The centre of the circumscribed circle is the intersection of the angle bisectors.
- (4) The centre of the inscribed circle is the intersection of the perpendicular bisectors of the edges.

EVEN MYSTIC ROSE

To draw this pattern, mark 16 points equally spaced around a circle and join

each point to every other point by a straight line.

All the lines are diameters going through the centre.

In Mystic Rose patterns with an odd number of points, the lines envelope a small circle at the centre.

SPIRAL STAIRCASE

The treads of the staircase shown in the picture are attached to, and wind around, a central pole.

Staircases can also take the form of a helix, in which case they wind around a void.

They are helical but are often mistakenly called spiral.

TRIANGLE NUMBERS

The triangle numbers are the sums: 1, 1+2, 1 + 2 + 3, 1 + 2 + 3 + 4, etc. which can

be represented by triangular arrays of dots.

Two copies of a triangle representing the n^{th} triangle number $1 + 2 + 3 + \dots + n$ form an n by $(n + 1)$ rectangle,

showing that the sum of the natural numbers from 1 to n is $\frac{1}{2}n(n + 1)$.

Two consecutive triangle numbers make a square.