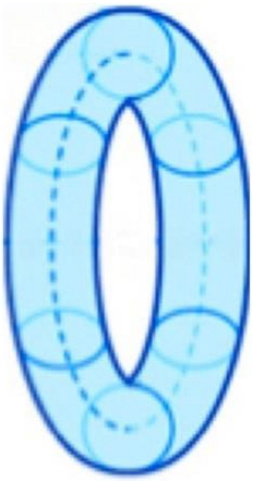
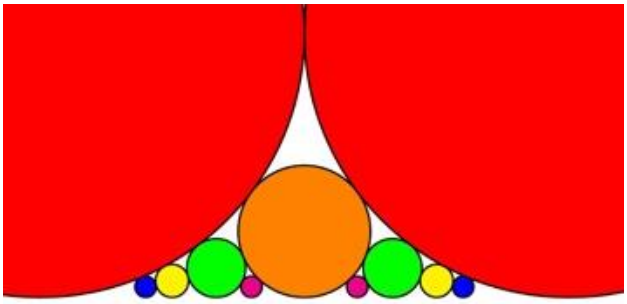
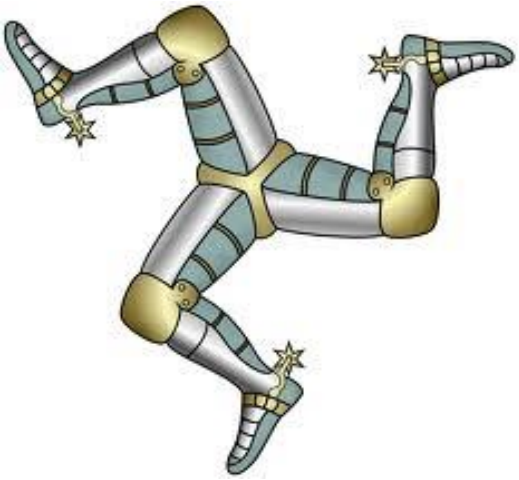
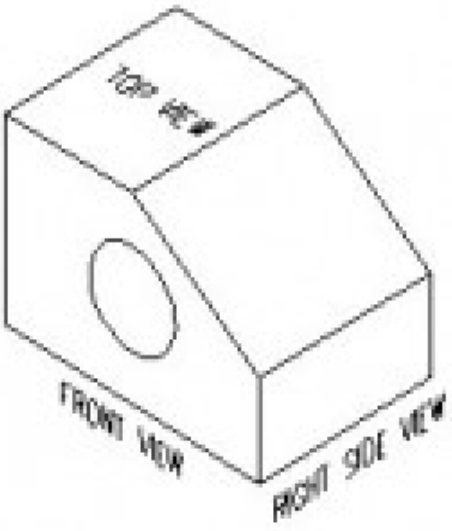
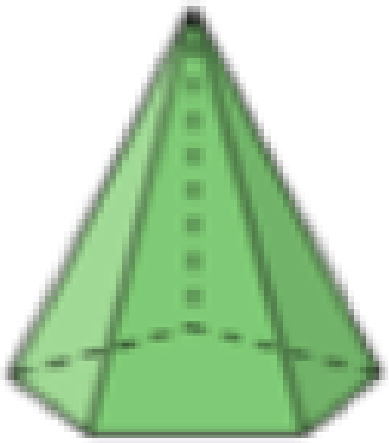
DRAW AND TALK CARDS. Print the cards with descriptions on the back and cut them out











FAMILY OF FORD CIRCLES

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

TORUS

A cup is topologically equivalent to a torus. Straight lines are circles on the surface. There are two types of paths. One type goes through the hole and the path cannot be shrunk to a point. The other path does not go through the hole and can be shrunk to a point

PLAN AND ELEVATION

Engineering and architectural drawings consist of separate views from 3 perpendicular directions (1) PLAN - a bird's eye view looking vertically down, (2) FRONT ELEVATION - representing the front face and (3) SIDE ELEVATION - a side face.

3 LEGS OF MAN

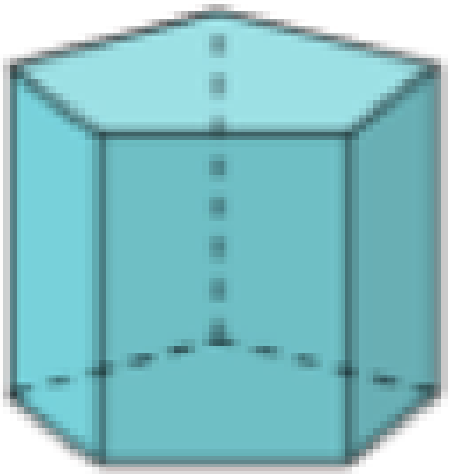
This symbol on the coat of arms of the Isle of Man represents the perseverance, strength, and independence of its people. The Tynwald, the Isle of Man's parliament, set up by the Vikings in the 9th Century, is the oldest continuous parliament in the world.

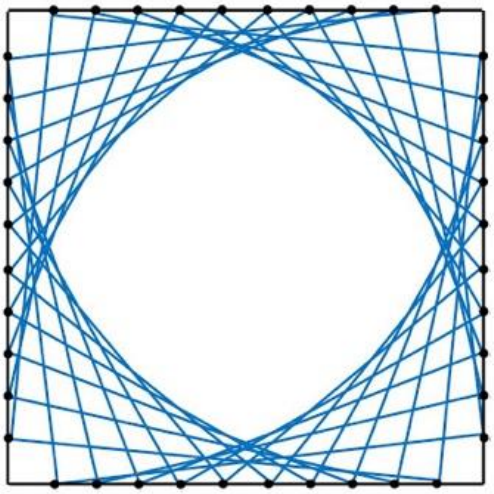
PYTHAGOREAN TREE

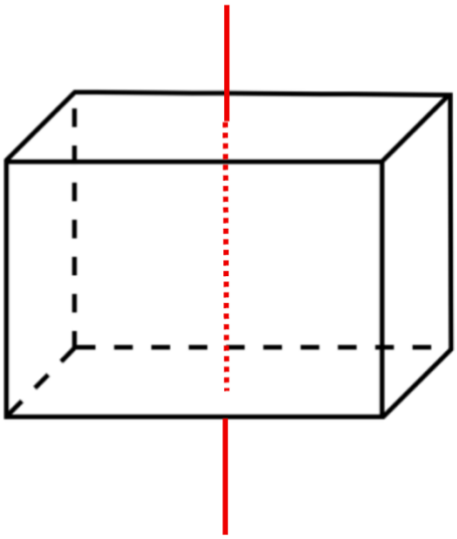
This tree is made up of copies, at smaller and smaller scales, of the same image of 3 squares on the edges of an isosceles right-angled triangle. Continued indefinitely with the 'branches' getting smaller this becomes a fractal. What happens when the right-angled triangle is not isosceles?

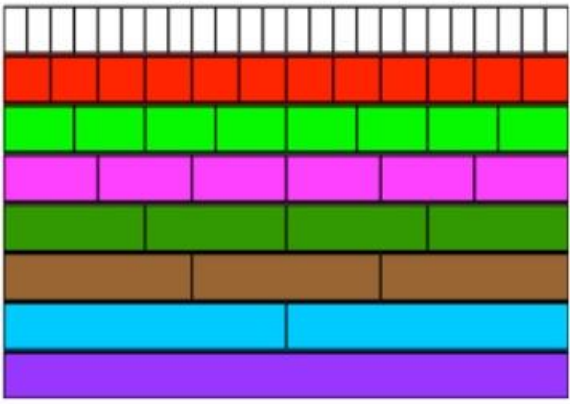
PENTAGONAL PYRAMID

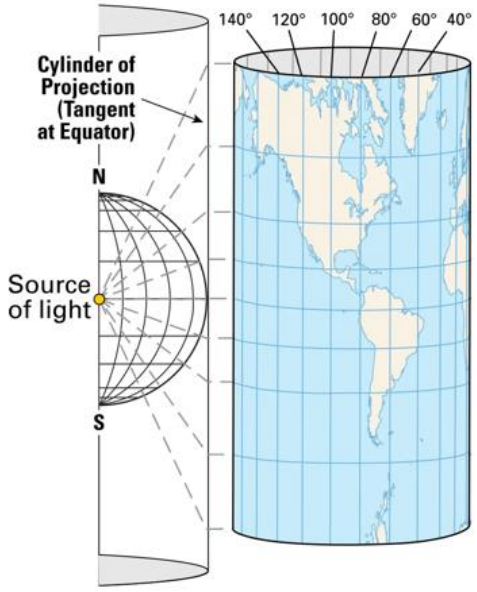
The base of this pyramid is a regular pentagon and the sloping faces are isosceles triangles. The vertex is vertically above the centre of the base. It has 6 faces, 6 vertices and 10 edges.

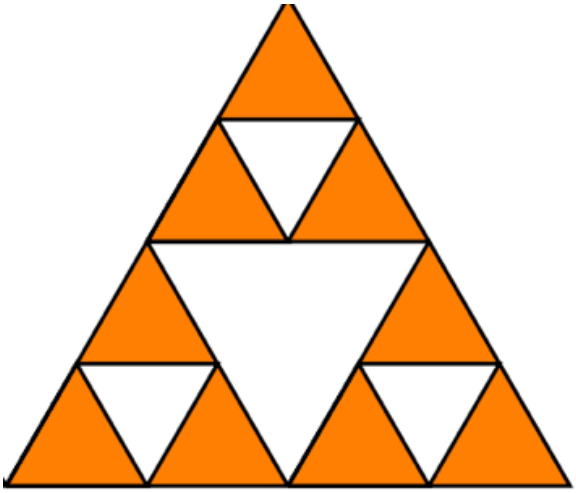









140°
120°
100°
80°
60°
40°
Cylinder of Projection (Tangent at Equator)
N
Source of light
S



ENVELOPE

This picture is made up of straight lines and you can see a curve, called an envelope, to which all the lines are tangent.

An envelope is a curve that is tangent to a family of other curves in the plane or to each one of a family of surfaces in 3D.

PENTAGONAL PRISM

The cross section of this prism is a regular pentagon. The picture shows it standing on a pentagonal face. The vertical faces are rectangles. It has 7 faces, 10 vertices and 15 edges.

FRACTION WALL

The base of the fraction wall is one unit in length and each layer of the wall shows smaller and smaller fractions. Using the Fraction Wall you can compare the different fractions.

ROTATIONAL SYMMETRY

The picture shows a rectangular cuboid and one of the 3 axes of rotational symmetry. It can be rotated by 180^{o} about this axis to fill the same space.

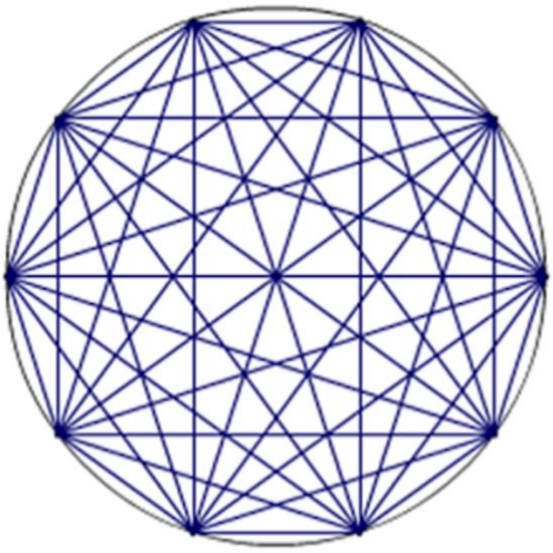
A rectangular cuboid has 3 axes of rotational symmetry and 3 planes of reflection symmetry.

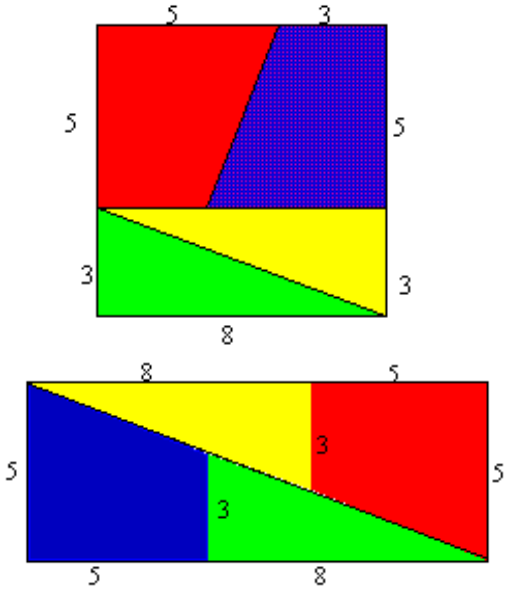
SIERPINSKI TRIANGLE

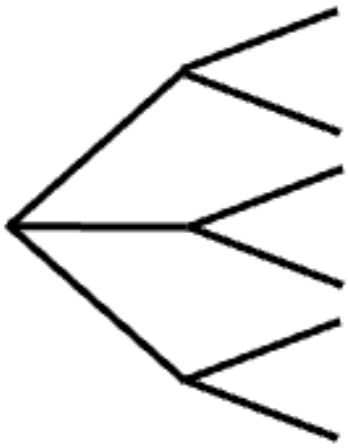
This is stage 2 of a repeating (iterative) process that replaces the image at each stage by 3 smaller copies of itself reduced in edge length by scale factor 3. The Sierpinski Triangle fractal is formed by repeating this process infinitely often.

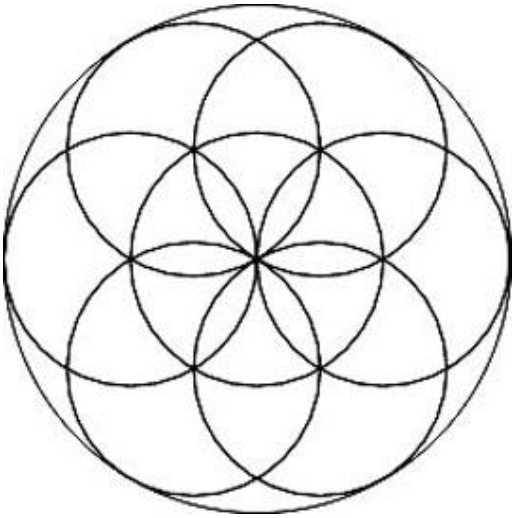
MERCATOR PROJECTION

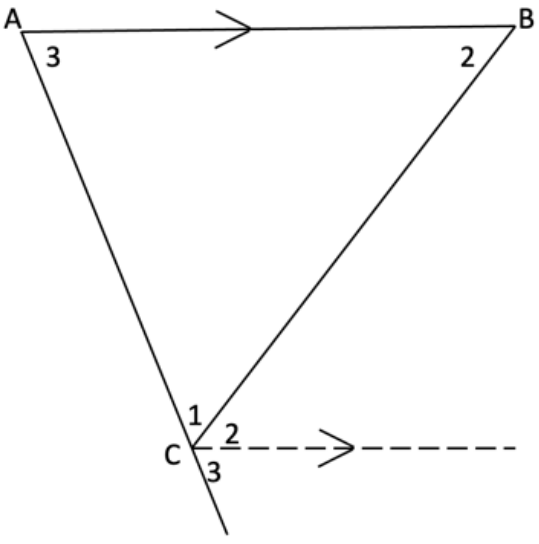
In this projection, invented by Mercator in 1569, the surface of the earth is projected onto a cylinder, preserving directions but distorting distances. It is the standard map projection for atlases and navigation at sea but no use for flight paths.




5
3
5
5
3
3
8
8
5
5
3
5
3
5
8






A
B
3
2
1
2
C
3

EVEN MYSTIC ROSE

To draw this pattern, mark 10 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. For an odd number of points the lines envelope a circle at the centre.

BUCKY BALL

This football is made from 20 hexagons and 12 pentagons. Imagine making this shape by slicing off a pentagonal pyramid at each vertex of an icosahedron. A carbon molecule (in soot), called a buckminster fullerene, has this structure, a pattern found in the Buckminster Fuller geodesic domes.

TREE DIAGRAM

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

MAGIC OR AN 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?

PICTURE STORY

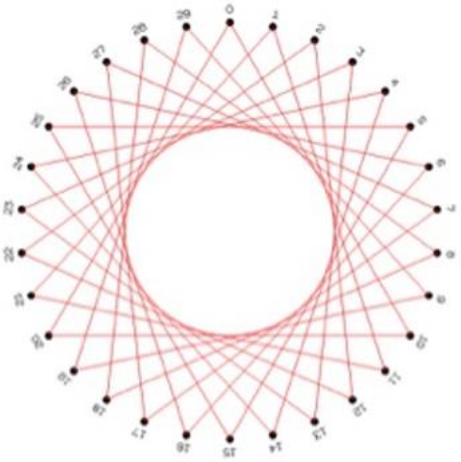
A picture can give a proof without words. The parallel lines show that the exterior angle of a triangle is equal to the sum of the interior opposite angles. The theorem that the angles of a triangle add up to 180^o follows because the angles on a straight line add up to 180^o.

FLOWER OF LIFE

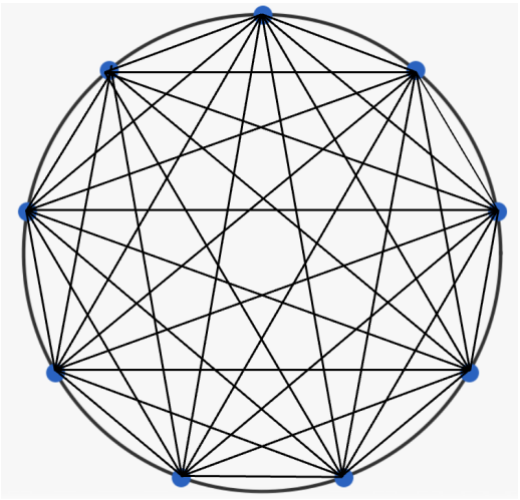
The flower of life is a geometric shape recognised as sacred by many cultures throughout history including Egyptian, Buddhist, Hindu, Christian and Muslim. It represents the cycles of life, death and re-birth, the unity of all life and the interconnectedness of all beings.

CIRCLE

Ruler, compasses and protractor needed.

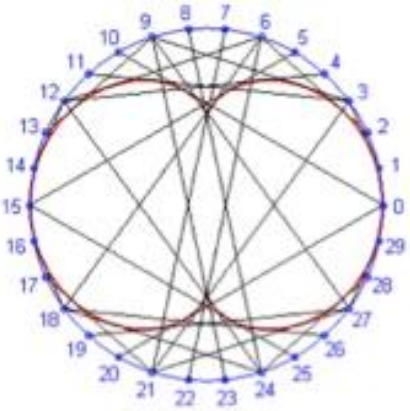


N=30 $n \to n+10$

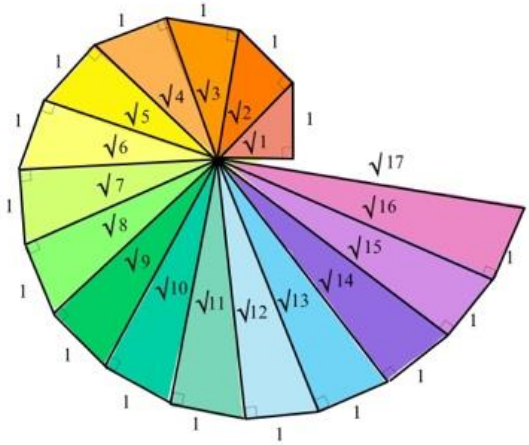


NEPHROID

Ruler, compasses and protractor needed.

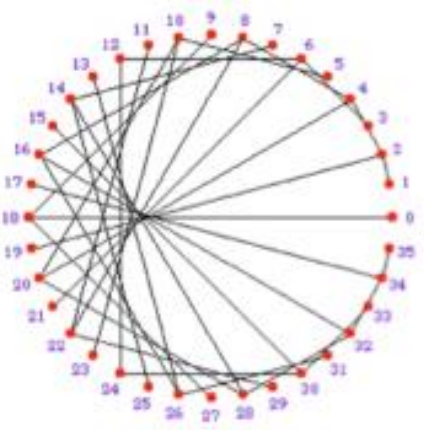


N = 30 $n \to 3n$

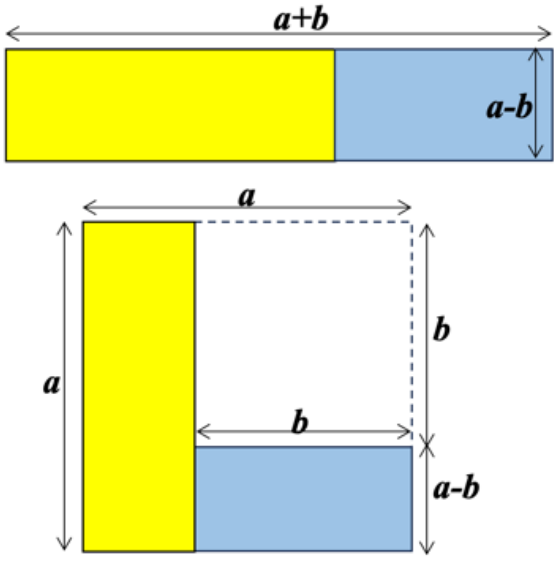


CARDIOD

Ruler, compasses and protractor needed.



N = 36 $n \to 2n$



ODD MYSTIC ROSE

To draw this pattern, mark 9 points equally spaced around a circle and join each point to every other point by a straight line. For an odd number of points the lines envelope 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.

SPIRAL OF THEODORUS

Theodorus was a Greek mathematician in the 5th century BCE. This Pythagorean spiral is built around a right-angled triangle with edges 1, 1, and √2.

The hypotenuse of each triangle in the sequence forms one leg of the next triangle, with the other leg one unit in length.

DIFFERENCE OF 2 SQUARES

A proof without words! Whatever the values of *a* and *b* with *a* > *b*, take a square of edge length *a*, and cut away a square of edge *b*. The yellow and blue rectangles formed together make a rectangle with edges (a – b) and (a +b). Areas tell us that, for all values of *a* and *b*,

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

CIRCLE ENVELOPE

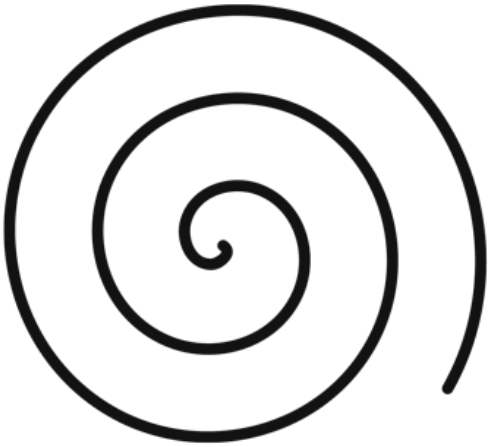
To draw this pattern mark 30 points equally spaced around a circle and join each point to the point 10 spaces round the circle (n→n+10). This forms the envelope of an inner circle to which all the lines are tangents.

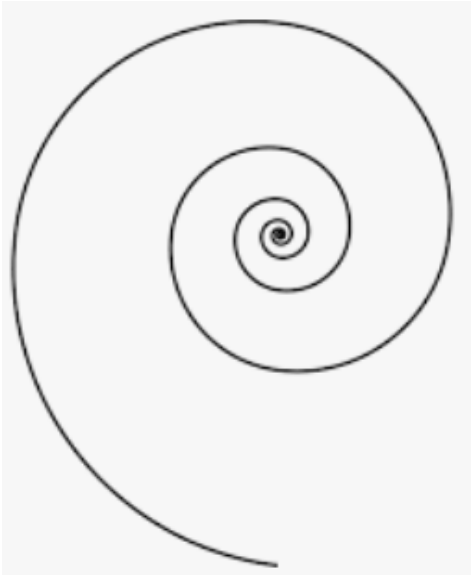
NEPHROID

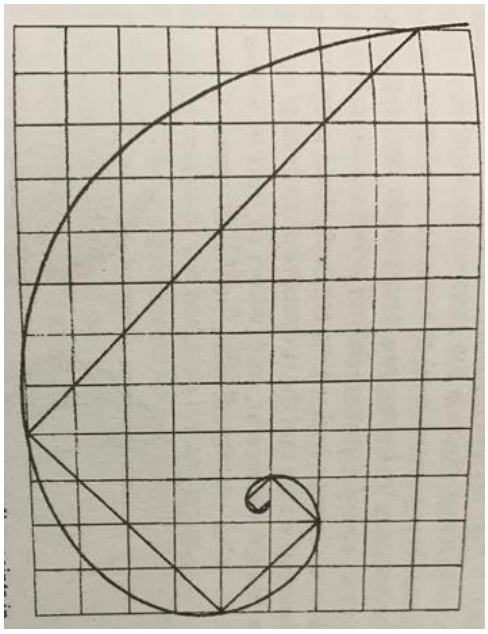
To draw this pattern mark 30 points equally spaced around a circle. Number the points 1 to 30. Join points 1 to 3, 2 to 6, 3 to 9 and each point n to the point numbered 3n (n→3n). This produces the envelope of a nephroid to which all the lines are tangents.

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→2n). This produces the envelope of a cardioid to which all the lines are tangents.







LOGARITHMIC SPIRAL

This is a self-similar spiral curve often found in nature.
The distance between the loops increases in a geometric series.
It was first described by Albrecht Durer in 1525 and has been called an eternal line, a marvellous spiral, a growth spiral, and an equiangular spiral.

ARCHIMEDEAN SPIRAL

This spiral is named after the 3rd century BCE Greek mathematician Archimedes. 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 distance between the loops is constant.

'SPIRAL' STAIRCASE

The treads of this staircase are attached to, and wind around, a central pole.
Staircases can take the form of a helix or of a double helix and they wind around a void, but they are often mistakenly called spiral.

NAUTILUS SHELL

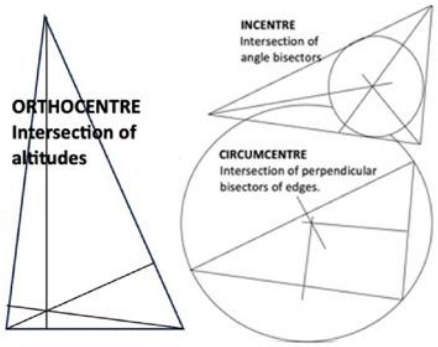
The animal can withdraw into its shell and close the opening. The interior of the shell divides into chambers. As the nautilus matures, it creates new, larger chambers, and moves its growing body into the larger space, sealing off the empty chambers.

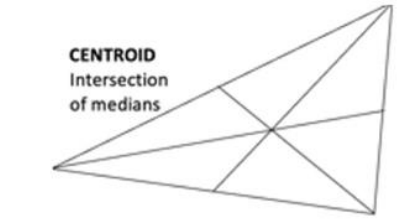
'STRAIGHT LINE' SPIRALS

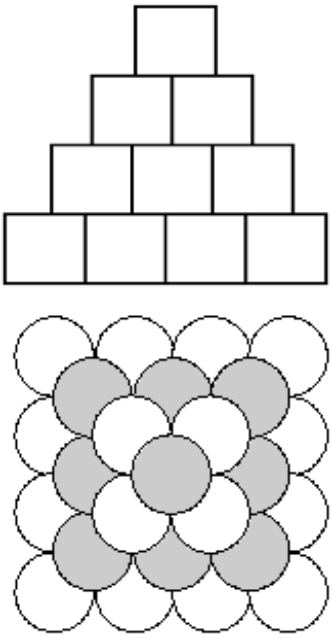
This logarithmic spiral is constructed by drawing straight line segments and arcs on a grid. The radii of the arcs double in length.
The Fibonacci spiral is constructed similarly with the lengths of the radii of the arcs increasing as a Fibonacci sequence 1, 1, 2, 3, 5, 8…

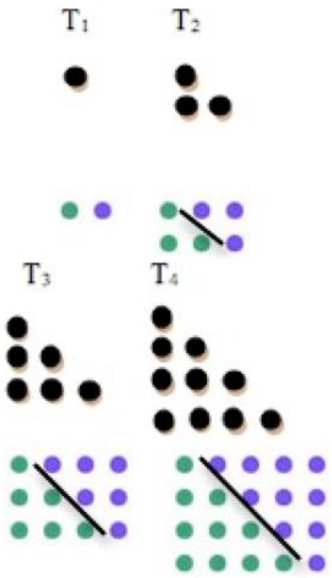
SUNFLOWER

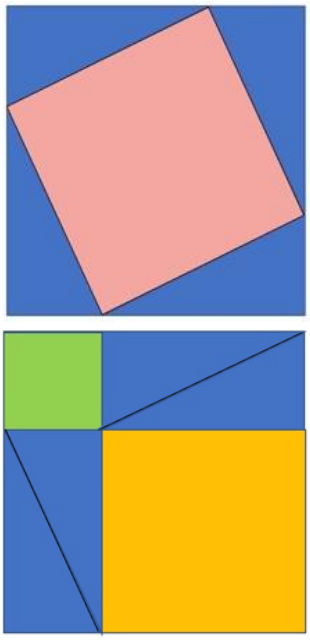
The seeds in a sunflower form spiral patterns. You can trace the spirals along different slopes. For each slope the number of spirals is a Fibonacci number. The number of spirals with the same slope winding clockwise and anti-clockwise are successive Fibonacci numbers.





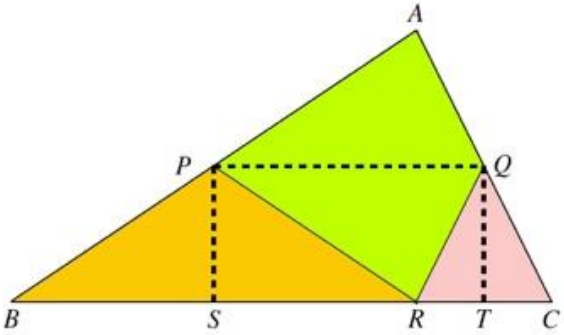






TRIFOLD

Imagine the dotted lines as fold lines or cut out the triangle and fold it.



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.

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 made of n dots form an n by (n+1) rectangle showing that the sum of the natural numbers from 1 to n is $\frac{1}{2}n(n+1)$. Consecutive triangles form a square.

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 $\frac{1}{2}$ base × height.

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 pattern called a phyllotactic spiral. A similar form of spiralling occurs in the outer petals of artichokes and other flower buds.

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.

PROOF OF PYTHAGORAS

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.