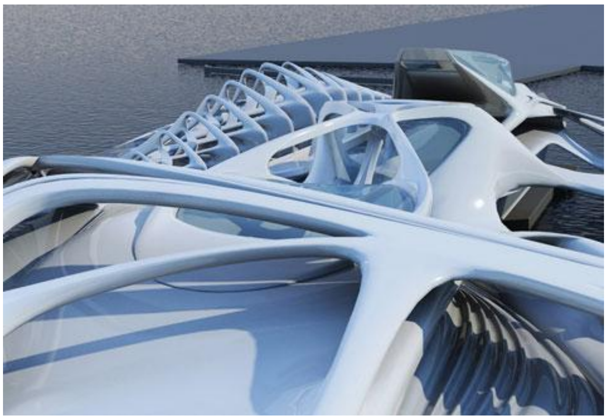
Go Figure

It's all a Math Problem

Edition 1 May 2011

GeoArchitecture

By Guillermo and Francisco Avelar



Technology has transformed life as we know it. From paper to computer. With the use of geometry, architects are now familiar with the term "3D Architecture." This term refers to the creation of virtual plans to create buildings and any kind of special structure. 3D architecture allows architects and engineers to plan ahead in a more detailed way and makes editing much easier. With some mouse clicks, architects can create the plans for houses, sky scrapers and any other kinds of structure. From columns and walls to roofs and windows, various 3D software let engineers and architects explore the third dimension of blue prints.

Contrary to what one might think, architecture is not only about building a house; it also includes basic geometric shapes that can support the structure. Architects use different types of software to help them visualize what they are about to build, whether it is in 3D or in 2D. With architectural software such as *AutoCAD, Google SketchUp,* and *Revit,* architects can explore their construction zone. This type of software allows architects to calculate the height, width, and length of a wall, which helps them calculate the total area of construction they are going to use, and it also allows them to estimate the amount of materials they are going to need. These programs also allow architects to locate places inside the wall where the plumbing systems and tubes will be. These programs are not only used by architects, but by engineers and interior designers as well. The initial visualization of the project is needed for an architect to start building a digital image. *Continued on page 3*

Spiraling Around the World!

By Kang Eun Shin and Vivian Melara

Beautiful spirals in mathematics and in nature

Spirals are commonly known as those intricate, hypnotic shapes, although much more than hypnosis is involved when it comes to these complex designs of nature´s creation. In general terms, a spiral is a curve that emanates from a center point, getting farther away as it revolves around the point. Some types of spiral are: Logarithmic Spiral, Theodorus Spiral, Archimedean Spiral, and Parabolic (Fermat's) Spiral. *Continued on page 4*

Why a Math Magazine?

By Ms. Mimi Yang, Honors Geometry Teacher

As a kid, math had always been my favorite subject in school. I loved how the numbers fit together like pieces of a puzzle, and that in the end you could always verify your correctness using diagrams, intuition, or an alternative solution. It was not until I became a math teacher that it started to dawn on me that math was, in fact, *much* more than that.

I bet that many of our students seldom consider the idea that we have inherited the ingenuity of many brilliant problem-solvers before us. Before the days of the GPS, even navigation across the vast oceans was quite a daunting task. By looking at the stars and measuring angles with simple instruments, brave sea-voyagers were able to find their way to new lands and back home. To support their navigation, entire systems of mathematics were dreamed up by mathematicians of the utmost imagination. My students are familiar with the story of Erastothenes, who figured out the circumference of the earth thousands of years before there were satellites to prove his math to be true. He accomplished this amazing task using only his imagination, some simple trigonometry, and his understanding of simple parallel lines geometry. Mathematicians of his time studied to satisfy their curiosities of how the world worked – it was as much a philosophical pursuit as it was a science. Their work continues to profoundly affect mathematics today.

Today, mathematicians work together with professionals of all fields to further the application of mathematical theories in the "real" world. From the houses you live in to the art that decorates your walls, many things are based on the engineering feats and artistic visions that have been made possible through various geometric developments. The recent discovery of fractal patterns has been applied to the prediction of weather and diseases, thereby deepening the reach of geometry into, truly, *every* facet of our lives.

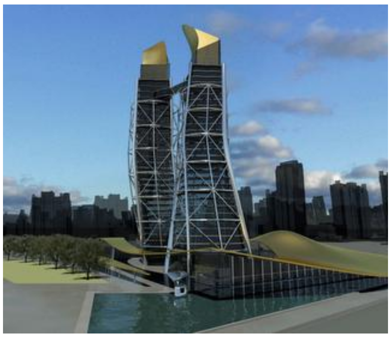
I hope that you enjoy this Geometry magazine put together by my students. They have worked very hard to bring to life the topics that we have studied this year, and in the process some of them learned to ask questions when they were looking at a deeper mathematical explanation that they did not understand. I allowed them to research via the web, because I think that all students need to practice being life-long learners and using appropriate resources. We went though many back-and-forth drafts and revisions, and in the end, I could not be more proud of the plethora of topics that they have pulled together, and the thoughtful understanding that they have shown.

Math is all around us. Go out and explore!

Ms. Yang

Continuations from the Front Page

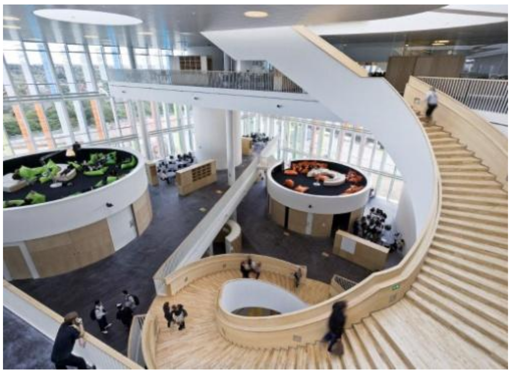
GeoArchitecture



…For example, try to visualize an important door; maybe one used for a main entrance. With 3D software you can make a complete detail of this door with its actual dimensions. How many hinges will it require? What type of a door knob is more appropriate? Even the types of screws you are going to use can be visualized and specified in detail by your digital drawing. Before, architects had to manually construct drawings of the project, and if a tiny mistake was made during the planning phase, the traditional manual drawing would have to be re-done. With the new digital software, architects can simply change the small mistake without any trouble.

Everything that surrounds us is connected with math, and architecture is no exception. How is architecture related to math? Architecture involves shapes, an area of geometry. If you have a close up on the basic results of any blueprint, whether in 2D or 3D, everything is composed of shapes: quadrilaterals, circles, or even domes and cubes. The basic tools on the creation of a house plan are shapes. To create various structures, architecture combines different shapes to form one single, solid piece of construction.

When it comes to designing a structure using technological programs, proportions play an important role. Most of the programs used for architecture, such as *AutoCAD*, provide their users with the ability to neatly sketch a design providing them with the actual side lengths based proportionally with the illustrations. Another important factor is that they doe not only provide architects with the area and perimeter of the object drawn, but they also make it easier for them to calculate the volume of the materials that are needed. Angles are also important in the design. With the use of angles, the 3-D model gives an actual perspective to what the actual eye would see when built. It provides the exact inclination and precision of measurement to reach an ideal and perfect creation. Technology has become a tool in today's society, and it had helped in a way that makes geometric work easier, accurate and more efficient.



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www.kvitters.com/search/AutoCAD%202007
http://www.amblondon.um.dk/NR/rdonlyres/43792230-AD16-45A8-ADBB-B6EF7F28079C/0/OerestadCollege3XN1Copy.jpg

Continuations from the Front Page

Spiraling Around the World!

LOGARITHMIC SPIRAL

The logarithmic spiral is a type of spiral curve that often appears in nature. Examples: the shell of a nautilus, the Romanesca broccoli, spiral galaxies, fractal designs, etc.

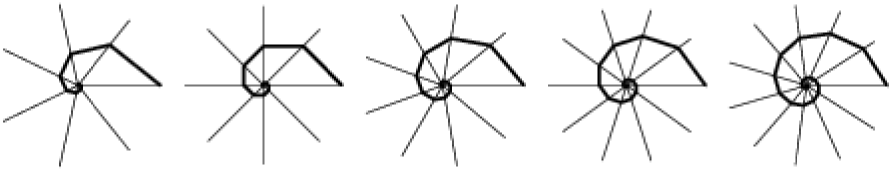
Sources (respectively):

http://tattingmydoilies.blogspot.com/2010/02/mirabilis-spirals-in-nature.html

http://mountainbreaths.blogspot.com/2011/01/looking-at-seed-catalogs.html

http://en.wikipedia.org/wiki/Logarithmic_spiral

This spiral was first described by Descartes and later studied in depth by Jacob Bernoulli who called it "the marvelous spiral". Bernoulli was so fascinated by this spiral that he had one engraved on his tombstone.

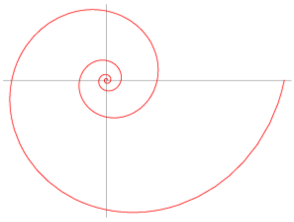


Construction of logarithmic spirals
Source:
http://mathworld.wolfram.com/LogarithmicSpiral.html

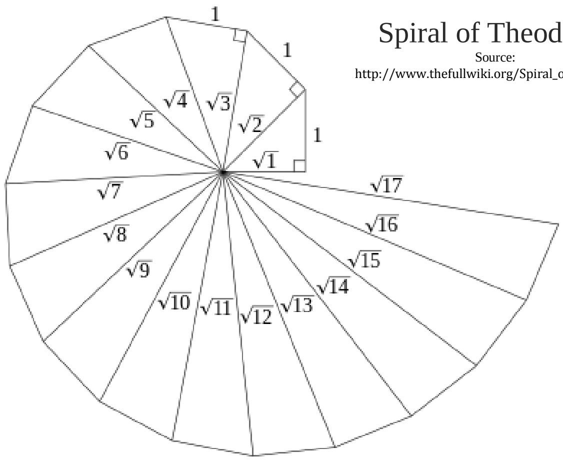
The logarithmic spiral can be constructed by creating equally spaced radial rays (separated by the same number of degrees) that originate from a common center point. For example, in the image on the left at the top, there are seven radial rays and they are each separated by 51.4 degrees. As the number of rays increase, the smoothness of the spiral increases as well. The edge segment in between two rays is perpendicular to one of the rays (right or left ray depending on which direction the spiral started from). In the diagram above some "rough" logarithmic spirals are shown. It is visible that the measurement of the angles between each ray are the same, only the outside "choppy" segment lengths keep on changing in between each stage. That's why the curve progressively gets farther away from the center point.

SPIRAL OF THEODORUS

Similar to the logarithmic spiral, the Spiral of Theodorus is also a spiral constructed by contiguous right triangles. It was first composed by Theodorus of Cyrene. This spiral is created by starting with an isosceles right triangle with legs of one centimeter. Then another right triangle is formed with a leg of one centimeter and the previous hypotenuse. This process is repeated and, as shown in the diagram above, the hypotenuse keeps on getting longer as more triangles are drawn, yet the outer length is always the same measurement. In comparison to the Logarithmic spiral, the Spiral of Theodorus does not quickly get "far away" from the center point; each "layer" of curves has an even distance (space) from each other. Furthermore, the central angle measurements decrease as more right triangles are added to the spiral. The triangles each time get longer and the outer leg of one centimeter keeps being the same length. That causes the central angles to get smaller (they're connected to one point).



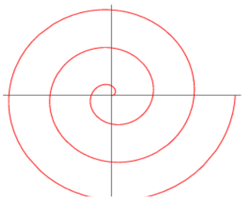
Logarithmic Spiral
Source:
http://mathworld.wolfram.com/LogarithmicSpiral.html



Spiral of Theodorus
Source:
http://www.thefullwiki.org/Spiral_of_Theodorus

ARCHIMEDES' SPIRAL

This spiral was studied by Archimedes of Syracuse, a Greek mathematician who was fascinated by it in his book *On Spirals* in 225 B.C. He was able to work out the various tangents in the spiral and thus it was named after him. The spiral consists of all the points (ie. the *locus* of points) over time of a point moving away from a fixed center with a constant velocity. In nature, we can see this type of spiral in several common examples, like in the conches shown below (middle and right). As you can see, they are very similar to the actual mathematical spiral (left).



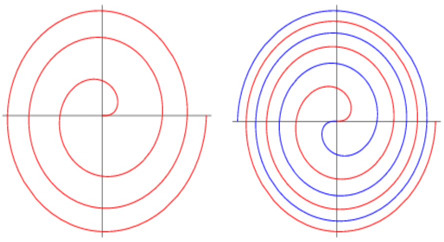
Archimedes' Spiral
Source:
http://mathworld.wolfram.com/ArchimedesSpiral.html

Sea Shells
Source:
/online.redwoods.cc.ca.us/instruct/darnold/.../HistoryOf**Archimedes**.doc

FERMAT'S SPIRAL (PARABOLICAL SPIRAL)

This spiral's origins date back to Pierre de Fermat, a French mathematician that worked out this spiral in 1636. Fermat's spiral is related to the Archimedes' spiral because it has the same basic shape. The only difference is that, because both negative and positive values are accepted, the spiral seems to be duplicate but opposite copies of the same pattern. In the following images you might see why. The spiral is also called parabolic because of the shape of the curve, resembling a semi parabola or a type of parabola that finishes at the "principal vertex" of the curve. This spiral can also be seen in nature among flowers such as the one shown below.

Not only are these spirals found in nature, but also in history in ancient crests like the Celtic crest and in science among the stars in many galaxies' shapes. Spirals, of course are not only present in the Logarithmic, Theodorus and Parabolical ways but also in other convoluted types. To learn more about spirals and where they are found in nature, the websites below will help you.



Archimedes' and Fermat's Spiral
Source: http://mathworld.wolfram.com/FermatsSpiral.html

Fermat's Spiral in Nature
Source: http://www.flickr.com/photos/mgrat/2674837850/

Sources:
http://en.wikipedia.org/wiki/Spiral_of_Theodorus
http://mathworld.wolfram.com/LogarithmicSpiral.html
http://mathworld.wolfram.com/ArchimedesSpiral.html
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http://en.wikipedia.org/wiki/Archimedean_spiral
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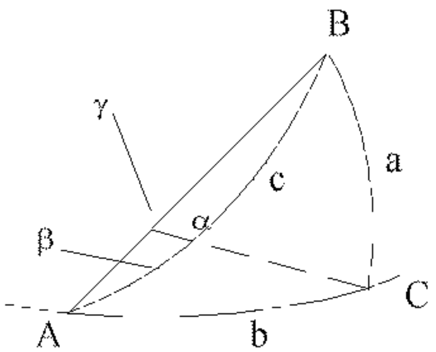
http://www.flickr.com/photos/mgrat/2674837850/
http://online.redwoods.cc.ca.us/instruct/darnold/.../HistoryOfArchimedes.doc

Spherical Triangles

By Eduardo Avila and Matias Gonzalez

History:

Spherical trigonometry was first studied by the ancient Greek mathematicians such as Menelaus of Alexandria, who wrote a book on spherical triangles called *Sphaerica* and developed Menelaus' Theorem. He and other mathematicians developed and studied this topic with a practical purpose: it was used for navigation, because they did not have GPS or satellites thousands of years ago to help them find their way. During Menelaus' time it was very difficult to study spherical geometry in depth, because they did not have the knowledge we have now. Spherical trigonometry was



This is spherical right triangle; this is how a normal triangle looks on a sphere, with curve lines.
http://www.math.uncc.edu

also studied by the late Islamic world; they would use it to analyze the stars (astronomy) so they could make their calendar. During the Islamic time it was a very common practice to study astronomy, and it was also used in their calendars to find precise dates and arrange their holy days. In the early 9th century, many mathematicians started to develop new theories and new formulas to find distances and to find angles many of those methods and formulas are still in use today.

What are spherical triangles?

Spherical trigonometry is a branch of spherical geometry that deals with polygons (especially triangles) on the sphere and studies the relationships between their sides and angles. This branch of spherical geometry especially works with triangles, basing relationships on normal or basic trigonometry but the triangle`s angles now add up to more than 180 degrees. This is because the triangle has no straight lines when it is overlaid on a sphere, and therefore the rules of regular trigonometry do not apply.

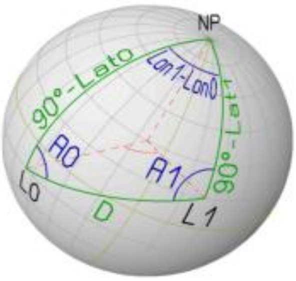
Spherical triangles may be analyzed the same way as with "normal", or flat, triangles, using trigonometric functions and the Pythagorean Theorem. The Pythagorean Theorem was developed by a famous Greek mathematician called Pythagoras. He discovered a way to find an unknown side length in a right triangle by using two you already know. The formula he wrote is $a^2+b^2=c^2$, the sides a and b represent the legs and c is the hypotenuse. Trigonometric functions are a set of principles that use triangle relationships to find lengths. They serve the same function, finding unknown sides and angles. This is still useful in navigating our earth, even though it is a spherical plane. You can use two distances you already know to form a right triangle to find a distance that you do not yet know. Take the example that you want to go from El Salvador to Miami, but you do not know the distance you will be traveling. What you do know is the distance from El Salvador to Austin and from Austin to Miami. You can figure the distance out using basic Pythagorean Theorem taught in middle school. Uses for spherical trigonometry have been fading out in the last couple of years. The reason behind this is the invention of the GPS, or Global Positioning System. This GPS uses satellites to find your exact position on the surface of the earth. Doing spherical trigonometry calculations has become outdated and is replaced by the use of a GPS device instead.

There are some differences that spherical geometry has with basic trigonometry and plane geometry. The first difference of spherical geometry is that is done in a sphere 3D and not in a 2D object (plane). Another thing is that in normal geometry the angles of a triangle make 180 degrees; on the other hand in spherical geometry the angles of a normal triangle make more than 180 degrees because there are no straight lines, just curve lines. Something else is that in spherical geometry the existence of parallel lines was negated; there are no parallel lines because all line intersect eventually when they are on the surface of a sphere. Another difference is that in plane geometry, the distance is represented by a line while in spherical geometry with an arc. Yet spherical geometry and other plane geometry have things in common like both have a quadrilateral shape (square), the only difference is that the sides are not parallel and the angles are not 90 degrees as in a normal quadrilateral or square. Those are the some of the difference between spherical geometry and plane geometry.

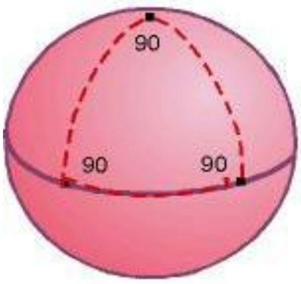
Applications:

Some of the applications for spherical geometry are found in astronomy and navigation, and both of this application used a sextant. A sextant is a tool that sailors and astronomers used to find the were on the sea, or to analyze stars in the sky. These are the main application for this branch of geometry. It was mainly used for past navigation; it was used to measure the distance from one point in the globe to another, in combination with the Pythagorean Theorem and trigonometry. It was also studied that if you used angles inside the triangle and basic trigonometry you could find the exact angle needed to depart at a certain marine port and reach another one. This use of spherical trigonometry was common in ancient times to find latitude and longitude in a globe.

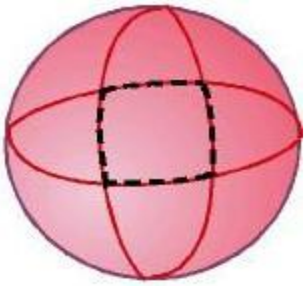
Another way spherical geometry was used was to find the most fuel-efficient routes for the ships in transporting goods. Astronomers used the same basis for navigation to find angles and distances to certain stars and planets using basic trigonometry. Another application of spherical geometry was for keeping track of time. These was part of the job of the astronomers. To keep track of time, they had to see how much the world had orbited around the sun, and therefore they used spherical geometry to create one of the first calendars with divisions into months, weeks and days.



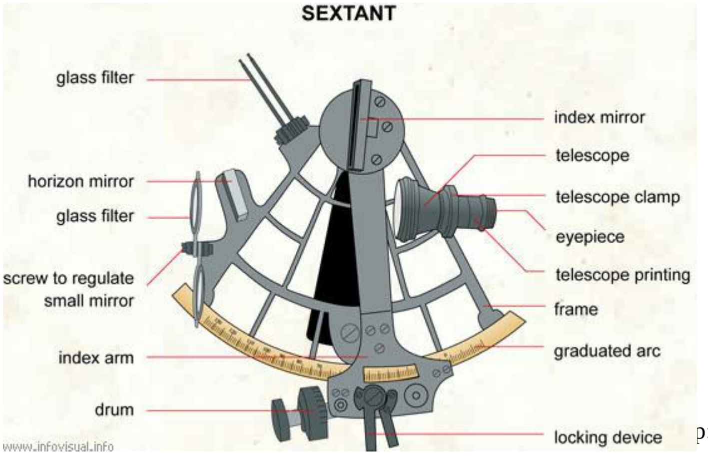
This is an example that this triangle has angles that add to more than 180 degrees, plus the edges are not straight lines. Picture from Wikipedia



The sum of the angles of a triangle is always greater than 180 degrees in spherical geometry. - http://math.youngzones.org



This regular quadrilateral can be called a square by this definition, but does not have the same properties as a square in Euclidean geometry. http://math.youngzones.org



This object on the left is a sextant. This ancient tool was used both astronomers for seeing space and sailors to navigate. What this toll did was that it measured the angle that you where seeing as you can see on the picture. Image from www.math.uncc

Reference

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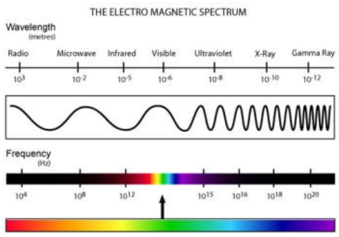
- http://www.erikdeman.de/html/sail042e.htm
p://www.rwgrayprojects.com/rbfnotes/trig/strig/strig.html
- http://mathworld.wolfram.com/SphericalTriangle.html
-http://www.math.uncc.edu/~droyster/math3181/notes/hyprgeom/node5.html
- http://math.youngzones.org/Non-Egeometry/spherical2.html
- http://videos.howstuffworks.com/discovery/28013-assignment-discovery-spherical-geometry-video.htm

Math Waves in Science

By Jose Miguel Domínguez and Diego Infante

Sine and cosine waves are mathematical functions that describe oscillations which are smooth and repetitive. Waves are mostly expressed with the formula $y(t) = A \cdot \sin(\omega t + \varphi)$, in which A is amplitude, ω is the angular frequency, and φ is the phase. Amplitude is the amount by which the function deviates from the original formula (also known as the height or magnitude of the wave); angular frequency is how many oscillations occur in a unit of time; and phase states where in the cycle the oscillation starts. On a graph, amplitude is basically looks as how high the crest of the wave goes, the higher the amplitude, the higher the wave’s crest. Another important term is the wavelength, which is the distance between a point on a wave and the exact same point in another wave, or how long every cycle is inside the wave. The wavelength dictates basically how many waves there are in a certain period; the larger the wavelength the less waves in that period and vice versa. These mathematical variables and their actual significance are applied in real life situations in many facets of our daily lives.

An important mathematical concept of sine waves is that of superposition. Superposition can be either destructive or constructive. If two waves have the same amplitude, frequency and wavelength and are traveling in the same direction, they create both types of interference, constructive and destructive. If the two waves’ crests are superimposed, then they form a wave with twice the amplitude of the individual waves. If the crest of one wave is lined up with the other’s trough, then they interfere destructively and effectively cancel each other out. This has to do with phase, because when the two trough are lined up, the waves have phi=0 and are **in-phase**, and when they aren’t they are **opposite-phase**, and have phi=0.

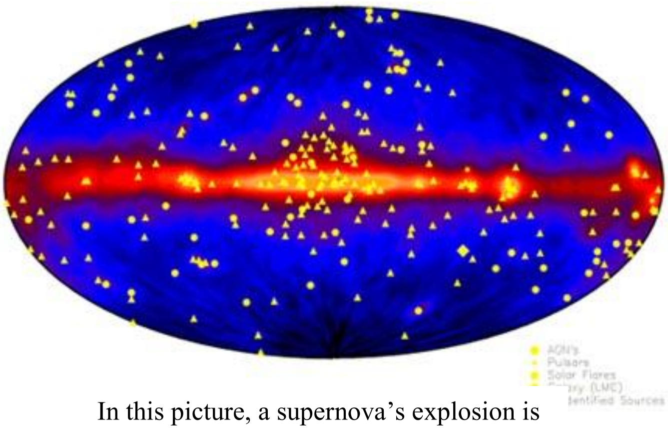


This picture shows all the different kinds of waves and their respective wavelengths. This image is from: http://importantnewsforias.blogspot.com/

One of the most important applications of waves in real life is the electromagnetic spectrum. By altering a wave’s amplitude (the *A* in the formula as discussed previously), new and important technologies have been created and used by humans in sciences and medicine. We have realized that wavelength, or how long each cycle of a wave is, even dictates what we *can* and *cannot* see. Visible light is only a small part of the spectra of possible waves and wavelengths, and as wavelengths grow shorter, other invisible light rays such as UV Rays, X-Rays and Gamma Rays can be found and their power harnessed for various human needs. Going in the opposite direction in the spectrum, infrared radiation, microwaves, and radio waves can be found with larger wavelengths than that of visible light. The spectrum extends from 10^{-16}nm to 100km, encompassing many different kinds of waves, all of which are helpful to humans in different ways.

Thanks to X-Rays, which bear the letter “x” for investigating the previously “unknown” structures that lie underneath the skin, we can now accurately see the bones inside our bodies, a huge advance that helped diagnose weaknesses in diseased persons or simply give us a greater understanding of the human skeleton. Also, gamma rays allow us to use radical new surgery techniques such as using gamma rays to operate with a gamma knife in the hands of doctors such as Dr. Aizik Wolf. The gamma knife technique allows the doctor to literally use the gamma rays in substitution for a knife in different kinds of neurosurgery, particularly those of the neck, brain and spinal cord. Altering wavelengths through science to obtain varying rays lead to such new discoveries in space and in our bodies. More commonplace uses for waves exist, such as using them to cook our food daily, such as in microwaves, or for communication by means of radio waves. Waves have influenced every part of our life dramatically, allowing us to image space through NASA satellites utilizing gamma rays. They do this by making the gamma rays hit an electron, forcing them to be stopped and imaged, allowing them to see supernova explosions or black holes that release huge amounts of gamma rays invisible to the human eye by their short wavelength. All of these uses stem from a simple mathematical formula with incredible variations and results. Who knows how far we will be able to exploit the wave and help ourselves?

This is a scanner that utilizes gamma rays to scan the brain for any potential diseases.
This image is from:
http://comicbooks.about.com/od/theincrediblehu2/ig/The-Incredible-Hulk-Gallery/Hulk-2---Gamma-Rays.htm



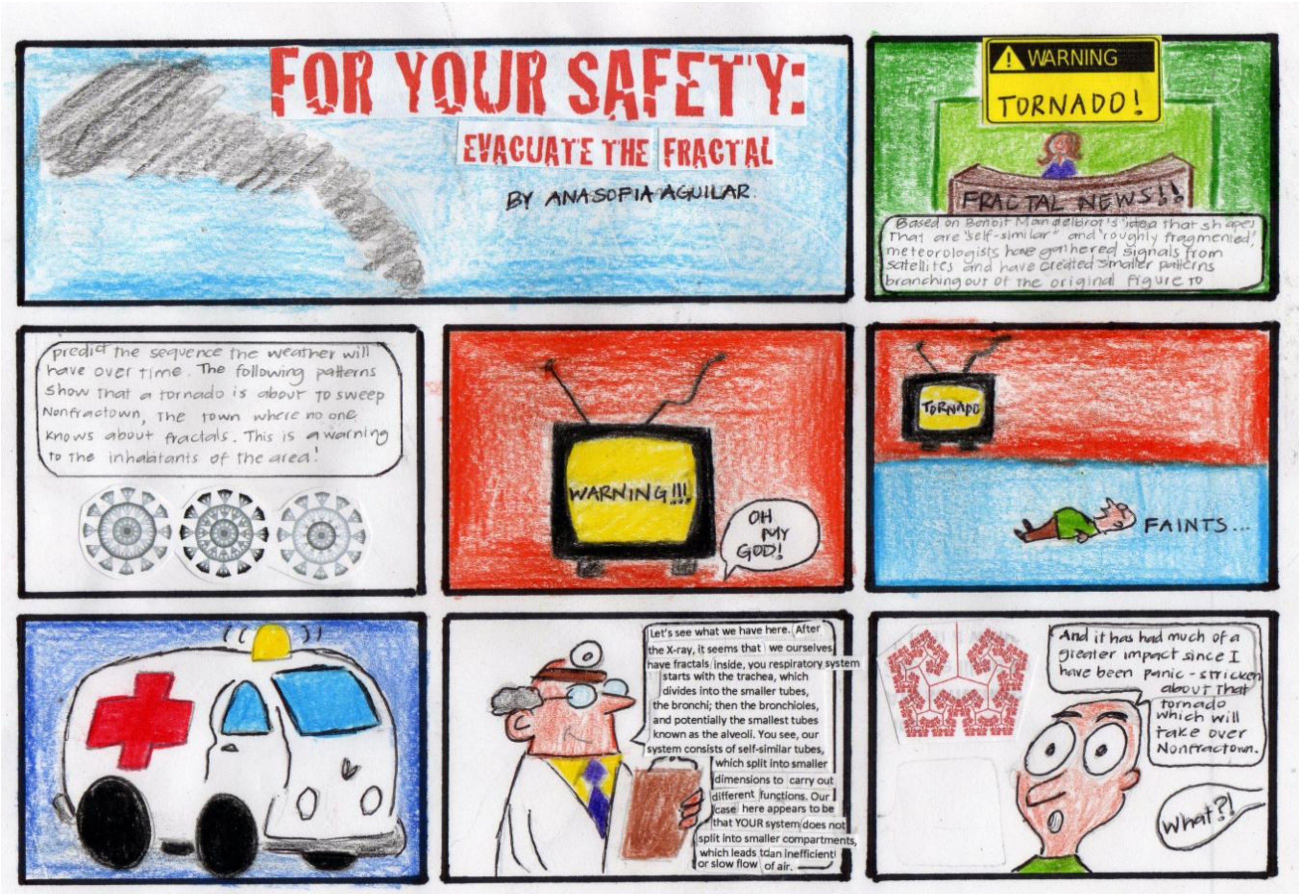
In this picture, a supernova’s explosion is visible thanks to gamma rays in a NASA telescope. This image is from:
http://science.hq.nasa.gov/kids/imagers/ems/gamma.html

SOURCES:

http://science.hq.nasa.gov/kids/imagers/ems/index.html
http://en.wikipedia.org/wiki/Sine_waves

Comics

Continues on GoFigure Edition 2



Brain Teasers

All Credits go to http://www.scientificpsychic.com/mind/mind1.html

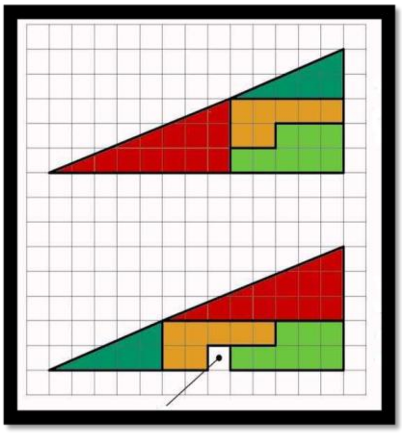
1.) Think of a number. Then add 7 to it. After, subtract 2. Then, subtract your original number. Multiply by 4. Subtract 2. Your answer is...

2.) A bear walks south for one kilometer, then it walks west for one kilometer, then it walks north for one kilometer and ends up at the same point from which it started. What color was the bear?

Answers in Edition 2

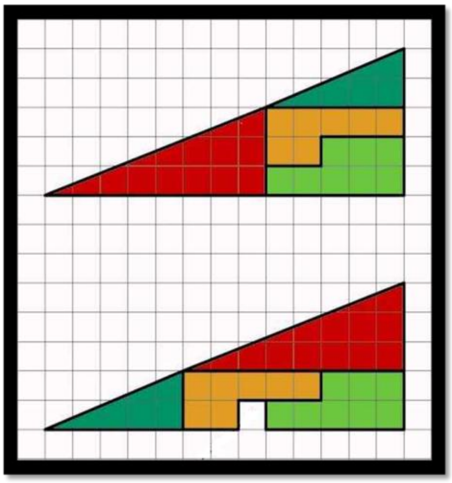
How Can This Be True?

By Emilio Moreno and Kevin Interiano



In the Picture above we can see two identical triangles made with the same pieces, but how is it possible that the second picture has a missing space? First of all start up reviewing the concept of slope.

Slope: describes the steepness, incline, or grade of a line.



As you might have noticed the slopes of the pieces that make up the hypotenuse are not equal, therefore, it is not a single straight line that forms the "hypotenuse", but two separate pieces that create the illusion that it's all one line. If the hypotenuse is not a straight then both pictures are not triangles but two non-congruent quadrilaterals!

Although you can't see the crooked line because this problem is an optical illusion you are able to conclude that the pictures are not the same although it is constructed with the same parts.

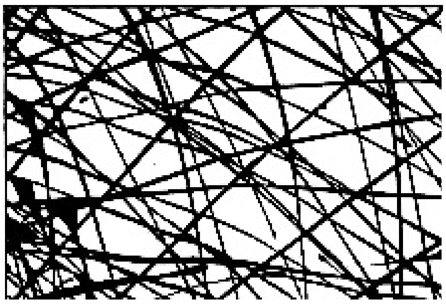
Source
"Jigsaw Paradox." *Department of Mathematics | Department of Mathematics*. N.p., n.d. Web. 12 May 2011. <http://www.mathematik.uni-bielefeld.de/~sillke/PUZZLES/jigsaw-paradox.html>.
Picture Credit
Math Pages Blog: Explanation of a Geometry Paradox." *Math Pages Blog*. N.p., n.d. Web. 12 May 2011. <http://mathpages.blogspot.com/2008/02/explanation-of-geometry-paradox.html>.

Did You Know?

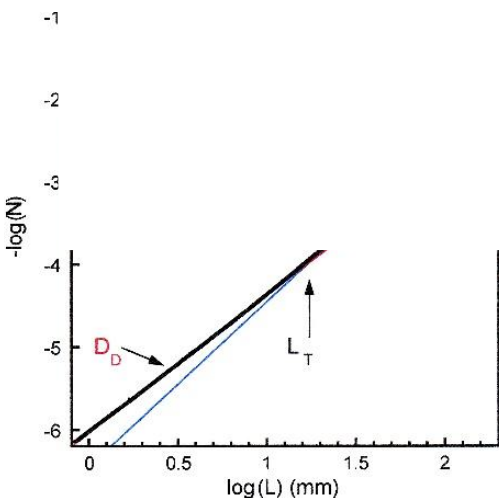
By Ana Sofia Aguilar

The late Jackson Pollock splattered his paint on to the canvas inherently creating fractals. The artist, by natural processes, worked from all four sides in a square canvas, potentially creating figures that are self-similar to each other in smaller or larger dimensions.

If you would like to imitate Pollock's fractal masterpieces, it only takes a pendulum to make the appropriate swing and splatter of paint for a mesmerizing geometrical design.



FRACTALS IN JACKSON POLLOCK'S WORK



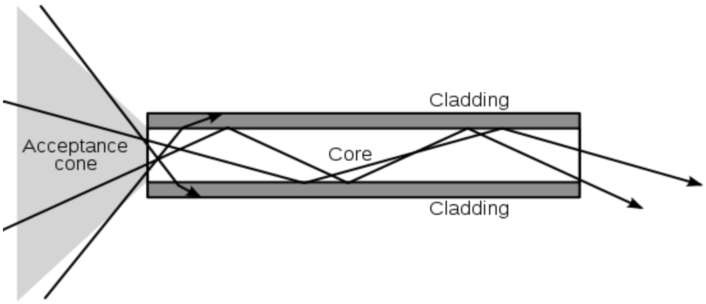
COMPUTARIZED ANALYSIS OF POLLOCK'S FRACTALS

Pollock's use of fractals has been asserted by the calculation of fractal dimension (D), using "box-counting" in a computer, as shown above. The method involves calculating the amount of space (L) each fractal occupies in the canvas, which demonstrates that the dimension of the figures have shown to have "scale invariance" or different magnifications from the original pattern. The dimension values obtained in the computer graph unveil the self-similarity, which is calculated with the slope. Pollock's trajectories were also pivotal in the constructing of fractals because it was necessary to create a perfect pattern of the space in between the fractals.

Optical Fibers: Essential to Transferring of Information

Optical fibers were developed to be a military use but it eventually became the main route of communication.

By Philip McAndrews and Luis Zavaleta

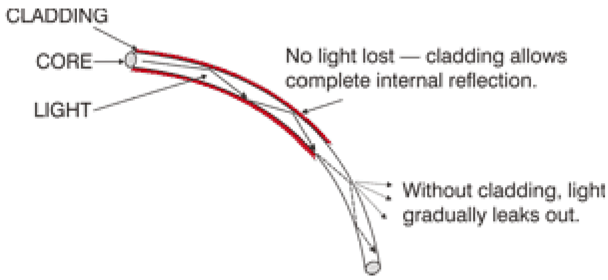


(this image is from Wikipedia)
This illustration expresses the way waves react from the acceptance cone and travel through the core

Optical fiber cables transmit a lot of information very quickly. They run on a very basic principle: the angle at which the light wave hits the inner part of the tube, will be the same angle at which it will be reflected, and close to zero information will be lost. The angle at which the light waves hit the inner tube therefore determines the outcome of the wave's direction.

History of Optical Fibers
In The 19th and 20th Century

Optical fibers were first used in Paris during the 1840's by Daniell Colladon, a Frenchmen. He used optical fibers to guide light in a modern way. Its real practical use came in the 20th century, when TV pioneers experimented with it. Optical fibers reappeared in history when they were used in 1963 by Japanese scientists in order to communicate information at the speed of light.

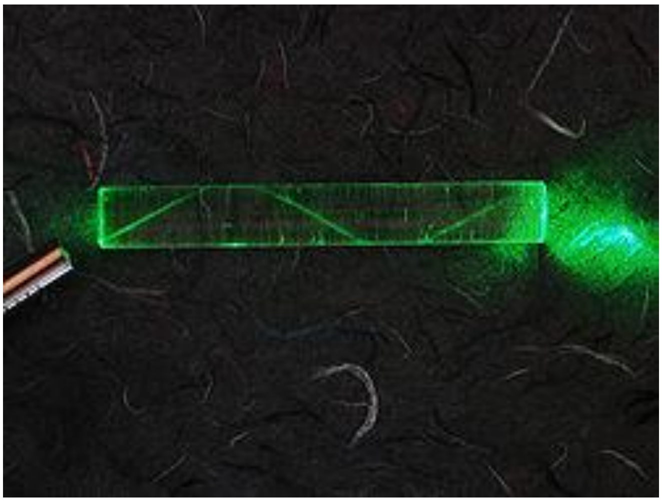


(this image is from Fiber-Optics.info)
This image shows how the light can gradually leak out if there is no cladding for the light waves to bounce off.

Later, after optical fibers started to be widely used for communication, NASA found them useful for their cameras sent to the moon. Today, optical fibers can be found in Cat-5 cables that are used for transmitting information over the internet. Optical fibers have survived the test of time for many of its practical properties -- for being flexible, it can be bundled in cables, and the information travels as fast as light.

Why a military use?
The U.S. military moved swiftly to improve fiber optics in the 1970's. The U.S. Navy used fiber optics for communications and tactical systems.

Commercial Applications
Many big companies like AT&T and GTE used fiber optics in order increase the speed of the networks. After, fiber optics was seen to be very efficient, so the technology became widespread. In order to level the playing field, the U.S. government installed fiber optic telecommunication networks that were not privately owned, so smaller companies could use them.



FIBER-OPTICS.INFO
http://www.fiber-optics.info/history
Reflection Fun
http://reflectionfun.tripod.com/page7.html
Wikipedia
http://en.wikipedia.org/wiki/Optical_fiber

Under The Square Root

Looking Beyond the Pythagorean Theorem

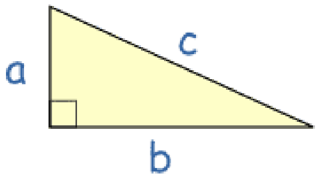
By Shany Freund and Mariana Alfaro

What is the Pythagorean Theorem?

In a right triangle, the square of the hypotenuse is equal to the sum of the squares of the other two sides. The Pythagorean Theorem is one of the oldest and most well-known mathematical relationships in history. It was first discussed and described by Pythagoras, a Greek mathematician, 2,500 years ago.

Pythagorean Theorem Formula:

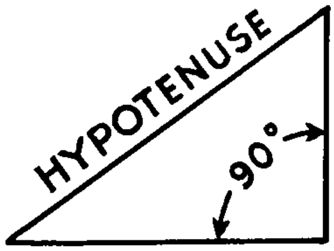
$$a^2 + b^2 = c^2$$



(Picture from http://www.mathsisfun.com/pythagoras.html)

What is a Hypotenuse?

In any right triangle, the hypotenuse is the longest side. The three sides are related in a way that if you square the length of the hypotenuse, you will get the same answer as if you square the length of the other two sides and add them together.



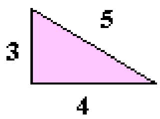
(Picture from http://elisaespinosa.blogspot.com/)

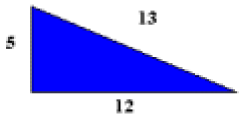
What are Pythagorean Triplets?

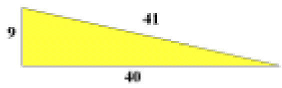
A set of positive integers (a, b, and c) that fits the formula $a^2 + b^2 = c^2$ is called a Pythagorean triplet.

Examples of this are

3, 4, 5 | 5, 12, 13 | 9, 40, 41







(Information from: www.mathsisfun.com/numbers/pythagorean-triples.html)

Pythagorean triplets are unusual, yet they are endless.
The easiest Pythagorean triple to prove is (3,4,5). It can also help you to find others, follow this example:

Make n any integer greater than 1. Then, 3n, 4n and 5n would also be a set of Pythagorean Triple. This is true because:

$$(3n)^2 + (4n)^2 = (5n)^2$$

Examples:

n	(3n, 4n, 5n)
2	(6,8,10)
3	(9,12,15)
	... etc ...
...	

Infinite triples can be made using the (3,4,5) triple.
Another way to prove this infinite nature is using Euclid's proof.
The difference of the squares of two consecutive numbers is always odd.
This helps support the proof.
Examples:
$2^2 - 1^2 = 4-1 = 3$ (an odd number)
$4^2 - 3^2 = 16-9 = 7$ (an odd number)
And also, going in the opposite direction, every odd number can be expressed as a difference of the squares of two consecutive numbers.

n	n^2	Difference
2	4	4-1 = 3
3	9	9-4 = 5
4	16	16-9 = 7
5	25	25-16 = 9*

Etc.

* Notice that in the table above, the entry marked with an asterisk * represents a relationship that correspond to Pythagorean triples.

There is an infinite number of odd numbers; many of them happen to have perfect square roots themselves (odd numbers such as 9, 25, 49, 81, etc…) .

Perfect squares are subset of odd numbers, and since a fraction of infinity is infinity, we can conclude that there are an infinite number of odd squares. Therefore, an infinite number of Pythagorean Triples.

Properties of the Pythagorean Triplets

Pythagorean Triplets always consist of all even numbers or two odd numbers and one even number.
It is easy to construct sets of Pythagorean Triples;
When m and n are any two positive integers (m < n):
$a = n^2 - m^2$
$b = 2nm$
$c = n^2 + m^2$

Example:
$a = 4^2 - 2^2$
$a = 16 - 4$
$\mathbf{a = 12}$
$b = 2(4)(2)$
$b = 16$
$c = 2^2 + 4^2$
$c = 4 + 16$
$\mathbf{c = 20}$

Sources:

- http://www.mathsisfun.com/pythagoras.html
- http://www.mathsisfun.com/numbers/pythagorean-triples.html
- http://elisaespinosa.blogspot.com/
- http://mathworld.wolfram.com/PythagoreanTheorem.html
- http://jwilson.coe.uga.edu/EMT669/Student.Folders/Morris.Stephanie/EMT.669/Essay.1/Pythagorean.html

Examples of modern uses of the Pythagorean Theorem

1. You can use the Pythagorean Theorem to find the length of the shade of this flagpole.

Let x be b

$a^2+b^2=c^2$

$60^2+b^2 = 100^2$

$3600 + b^2 = 10{,}000$

$b^2 = 6400$

$b = \sqrt{6400}$

$b = 80$

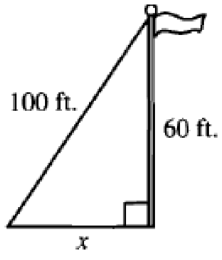
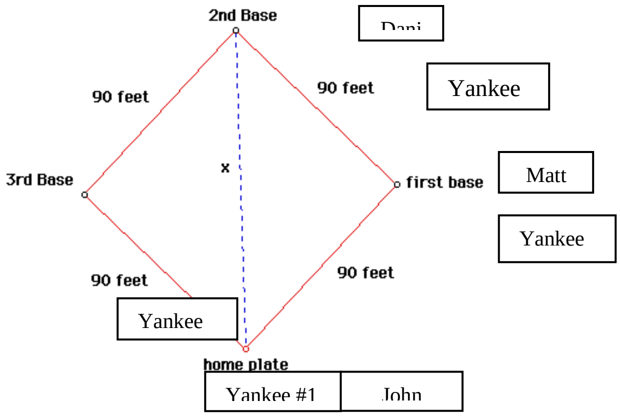


Figure 3.20

2. John, Matt and Daniel play for the Red sox. John is the catcher, Matt plays in first base, and Daniel plays in second base. The NY Yankees are making home runs, and so John, Matt and Daniel decide to end this with the second and third out. Yankee #1 swings and strikes, John catches the ball, throws it over to Matt who passes it to Daniel. Daniel manages to make the second out in second base, and throws the ball over to John who will stop Yankee #4 from coming in and scoring another run, by making the third out. How many feet does the ball need to travel in order to reach from Daniel to John before the runner in third base makes a run?



It creates a triangle, with legs that measure 90 feet.

Let x be c

$a^2 + b^2 = c^2$

$90^2 + 90^2 = c^2$

$8100 + 8100 = c^2$

$16{,}200 = c^2$

$127.2792206 = c$

The ball traveled about 127.3 feet from Daniel to John.

With this we see that even sports involve math. While we play them, we do not think about it, but we are indeed applying the Pythagorean Theorem.