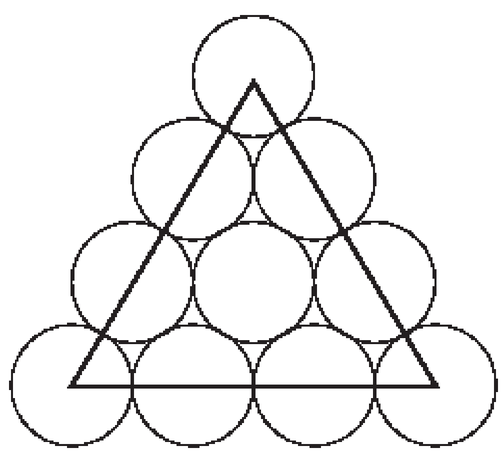
Contents

Brain Teasers

1. **Coloured weights:** This is a variation on an old problem. You have six weights. One pair is red, one pair is blue and one pair is white. In each colour one weight is a little heavier than the other but they look exactly alike. All the heavier weights (in each colour) weigh the same and so also the lighter weights. Using only two separate weighings on a balance, how can you identify which is the heavier weight of each pair?

2. Arrange 10 Re. 1 coins (or any identical coins) in a triangle or bowling pin format as shown. In your mind, join the centres of each coin to each other. You can see several shapes, including several equilateral triangles. What is the smallest number of coins you must remove so that you will not be able to draw an equilateral triangle of any size with the coins as centres?

From Mathematical Circus, by Martin Gardner



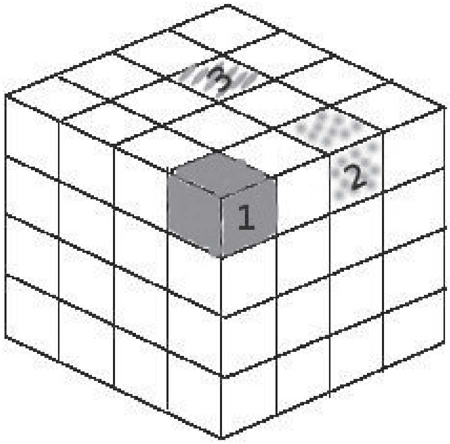
Answers to last issue's Brain Teasers

1. A solid, four-inch cube of wood is coated with blue paint on all six sides. Then the cube is cut into smaller one-inch cubes. These new one-inch cubes will have either three blue sides, two blue sides, one blue side, or no blue sides. How many of each will there be?

Ans: It is easiest to answer this question by looking at the figure that shows a big cube made up of 64 smaller cubes, 4 in each direction. The cubes at the corners numbered 1 will have three faces painted. There are 4 such corners at the top of the cube and 4 more at the bottom, so there are 8 cubes with three faces painted.

The cube marked 2 has two faces painted and there are 8 such on the top edges, 8 on the bottom edges and 8 on the vertical edges (for example, below the cube marked 1). Hence there are 24 in all.

The cubes that have only one face visible are marked 3 in the figure and will therefore have



only one face painted. On each of the 6 faces of the cube there are 4 such and so there are also 24 cubes that have only one face painted. What is left over is the total (64) minus those already counted, that is, 64-8-24-24=8 so there are 8 unpainted cubes that are the ones which are sitting as a 2x2 cube in the very heart of the big cube.

2. Four adventurers (Alex, Brook, Chris and Dusty) need to cross a river in a small canoe. The canoe can only carry 100kg.

Alex weighs 90kg, Brook weighs 80kg, Chris weighs 60kg and Dusty weighs 40 kg, and they have 20kg of supplies. How do they get across?

Ans: This is the usual optimisation problem. We need to send two men across so that one can row the boat back and we have to select the combinations so that we do not exceed 100 kg which is the maximum the canoe can carry.

Now Dusty cannot accompany either Brook or Alex since their total weight will exceed 100 kg. In fact, Alex cannot travel with any one at all, so he cannot be sent unless there is some other person on the other side who can row the canoe back.

So the obvious choice is that first Chris and Dusty row across; Dusty returns, since he is the lighter of the two. Now that Chris is on the other side, Alex rows across and Chris brings back the canoe.

At this point Alex is across and both Chris and Dusty are at the starting point. The two Chris and Dusty now row across and once more Dusty returns. You can see that Dusty's job is to essentially bring the canoe back. Now Brook rows across but since he is only 80 kg he takes the supplies along. As usual Chris brings the canoe back.

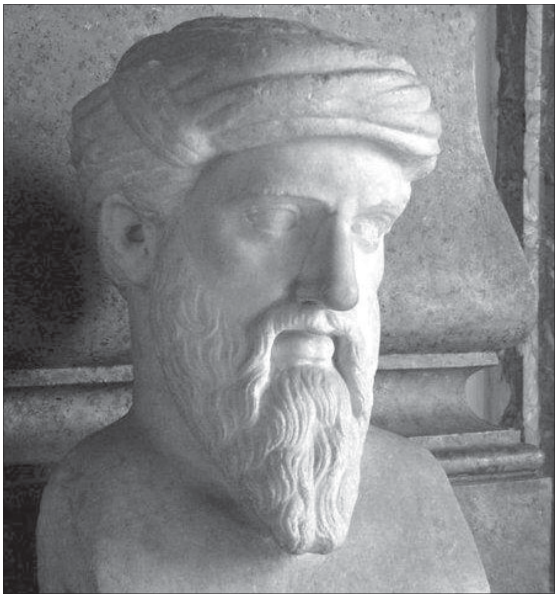
Finally, Chris and Dusty row across together for the final time and all of them are across.

3. How many steps are required to break an m x n bar of chocolate into 1 x 1 pieces?

You cannot break two or more pieces at once (so no cutting through stacks).

Ans: The simplest way to reach the answer is to understand that by breaking an existing piece horizontally or vertically, you merely increase the total number of pieces by one. For instance, if you break the chocolate once it becomes two pieces. If the chocolate was made up of two pieces in the first place, it is clear that one step breaks it up completely. Since the chocolate is made up of m x n pieces, to break it up completely you need (m x n) – 1 steps. Try it with a 4 x 2 piece of chocolate.

From www.mathisfun.com



Did Pythagoras discover his theorem?

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The Theorem

All of us study *Pythagoras' theorem* in our school. It is actually very simple. Consider a right-angled triangle, that is, a triangle that has one right angle, or an angle measuring 90°. The sides that bound this angle are perpendicular to each other. The side opposite to or facing the right angle is the longest of all the sides and is called the *hypotenuse*. If the two shorter sides measure lengths a and b, while the hypotenuse has a length c, then Pythagoras' theorem can be written as an algebraic equation: $a^2+b^2 = c^2$. In words, in a right angled triangle, the square of the hypotenuse is equal to the sum of the squares of the two other sides.

The set of numbers (a,b,c) given by the equation above are usually called *Pythagorean triples*. Given any two numbers (p,q) the triple is easily generated by constructing the set of three numbers with the following identification $a = p^2-q^2, b = 2p^2q^2, c = p^2+q^2$. You can see that $a^2+b^2 = (p^2-q^2)^2 + (2p^2q^2)^2$ or, expanding the terms using $(x-y)^2 = x^2+y^2-2xy$, we have $a^2+b^2 = (p^4+q^4-2p^2q^2)+(4p^2q^2)$, or simplifying, $a^2+b^2 = p^4+q^4+2p^2q^2 = (p^2+q^2)^2 = c^2$.

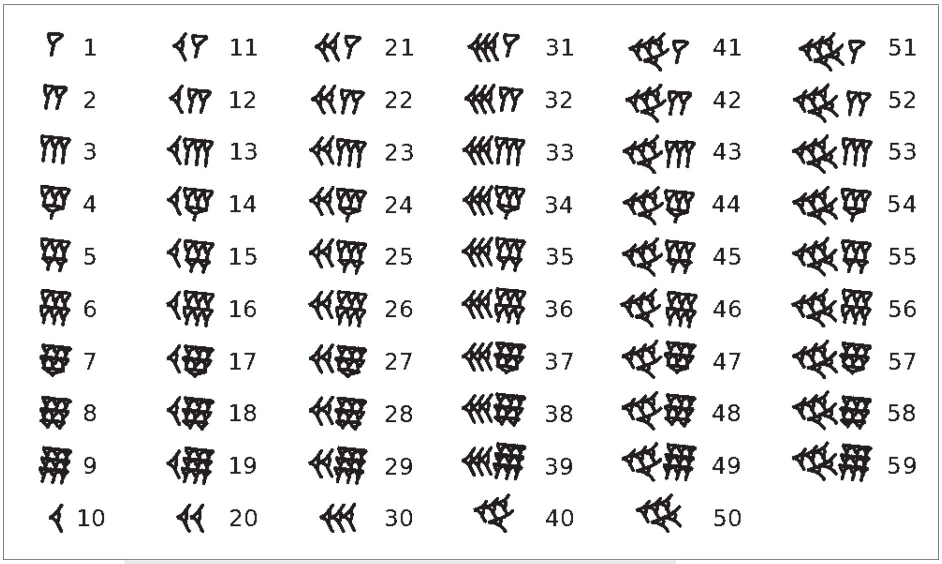
The theorem is named after the Greek mathematician **Pythagoras** who is traditionally believed to have stated this theorem. He is supposed to have lived about 2,500 years ago during 570 BC-495 BC.

The theorem can be proved in many different ways and is possibly the most "proved" theorem in Mathematics. Because of its popularity even outside mathematics it has attracted attention among artistes, writers, musicians, etc.

There were others

But was Pythagoras the first one to discover this theorem? While he did discover the theorem, it appears he was not the first one to do so. The popular reference to his name is debatable since the theorem has been discovered many times, by

The Plimpton Tablet



different people at very different times and places. In fact it is the most *discovered* theorem, in one form or the other.

The Babylonians

First of all there appears a statement of a problem posed by the **Babylonians**, more than 1000 years before Pythagoras, some time between 2000 BC and 1786 BC. This stated problem has a solution that happens to be the set of numbers (6,8,10). Now (6,8,10) belong to a set of numbers called Pythagorean triples as we defined earlier. That is, these are numbers such that the sum of the squares of the first two numbers is the square of the third number: $6^2+8^2=36+64=100=10^2$. You can find several examples of such numbers, the simplest being (3,4,5).

A **Mesopotamian** tablet, called *Plimpton 322*, contains a table with many entries probably related to these triples (see figure on previous page, from http://en.wikipedia.org/wiki/Pythagorean_theorem). This tablet was written around 1800 BC. Such tablets were produced by Babylonians by writing on wet clay with a stylus. It has fifteen rows of four columns of numbers with the last one just numbering the rows from 1 to 15. The 11th row of the tablet, for example, is interpreted as containing the Pythagorean triple (3,4,5). It is not clear what they did with these numbers but nevertheless it is an algebraic discovery of the Pythagoras theorem since there is no reference to geometry here.

The Indians

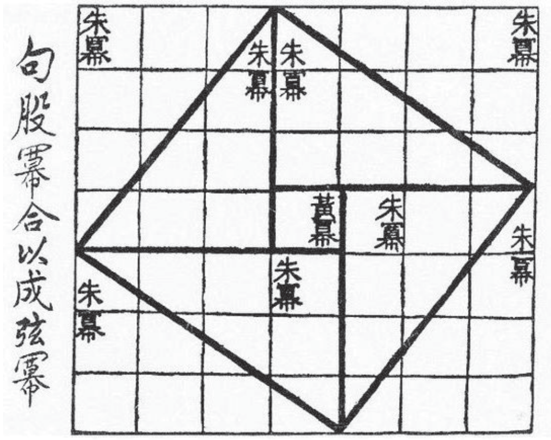
Some time around the 8th century BC, the theorem appears in the Indian text ***Baudhayana Sulba Sutra***. **Baudhayana** was an Indian mathematician whose statement of the Pythagorean theorem, in translation reads: "A rope stretched along the length

Sexagesimals

The tablet is not easy to read since it was written in a type of *cuneiform* script. Also, the Babylonians did not use our modern decimal system but used a *sexagesimal* notation for numbers! What is that?! It is a numerical system with 60 as base instead of 10. Think of 60 minutes in an hour, so 70 minutes is one hour and 10 minutes or 1:10.

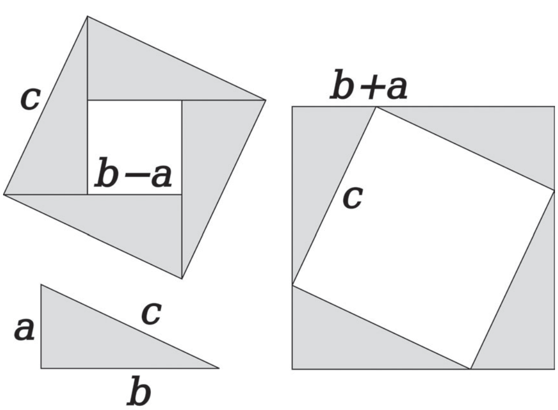
However, it is also a little confusing since they also counted 60 as six 10s! So, they had a Y shaped symbol for one and a < shaped symbol for 10. So Y equals 1, YY equals 2, < equals 10, <Y equals 11, etc., upto <<<<<YYYYYYYYY equals 59. Of course they saved space by grouping the symbols close together. Adding to the confusion is the fact that they had no symbol for zero, but this will not trouble us here!

So, for instance, the 11th row in the Plimpton tablet, has, as its entries (leaving out the first one which is complicated to explain), 45, 1:15, 11. This refers to a triangle with short side a=3/4 and hypotenuse c=5/4. So 3/4 is written as 45 (since 3/4 of 1 hour is 45 minutes) and 5/4 is written as 1:15. The last column simply says that this is the 11th row.



of the diagonal produces an area which the vertical and horizontal sides make together." The word Sutra literally means a rope but is now intrepreted to mean rules.

Here again the Pythagorean triples appear algebraically along with a geometrical proof for an isosceles triangle. In fact, Baudhayana is credited with calculating the value of pi (the ratio of the circumference to diameter of a circle) before Pythagoras. He also addressed the problem of finding a circle whose area is the same as that of a square. He also found the square root of 2 upto five decimal places by calculating the diagonal of a square of unit sides: "The measure is to be increased by a third and by a fourth decreased by the 34th. That is its diagonal approximately". That is, the square root of two equals 1 + 1/3 + 1/(3x4) - 1/(3x4x34) = 577/408=1.414216.



Another mathematician, **Aapastambha,** appears to have provided a more general proof of the Pythagorean theorem.

The Chinese

Not to be left behind, Chinese mathematicians also seem to have discovered independently the theorem. A mathematical text, ***Zhou Bi Suan Jing***, from around the 1st century BC records a geometrical proof of Pythagoras' theorem. The contents of the text must have been known much earlier. The proof is simple and easy to understand from the figure given in the Chinese text sourced from http://en.wikipedia.org/wiki/Pythagorean_theorem.

The figure contains a large square which is divided into four triangles and a smaller square. The four triangles are congruent with the sides being identical but with different orientation. Let us assume the large square has a side with length *c*. The two sides of the triangle are *a, b* where *b* is larger than *a*. By construction the small square in the centre has sides given by *b-a*. The area of the larger square is the sum of the areas of the four triangles and the small square. Therefore $c^2 = (b-a)^2 + 4(ab)^2 = a^2+b^2$, which constitutes a geometric proof of Pythagoras' theorem.

Modern Times

As you may have noticed, given two positive integers *(p,q)* we can always construct the Pythagorean triple *(a,b,c)* with integer values satisfying the theorem. Can one generalise this? The answer came in the form of ***Fermat's Last Theorem*** which states that there are no three positive integers *(a,b,c)* that satisfy the equation $a^n+b^n=c^n$ for any integer *n* greater than 2. This theorem was first conjectured (guessed at) by Pierr**e de Fermat in 1**637 who famously said that he had the proof but could not fit it in the margin of his notes! It remained the most famous unsolved problem until it was finally proved in 1995 by British mathematician **Andrew Wiles**.

Learning – in the Middle Ages

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England in the middle ages

Middle Ages refers to a period in time in English (and European) history from about the 5th to the 15th centuries. It is difficult for us to understand how much religion meant to people even a century or two ago. Frequent diseases, famines and wars meant that people died younger, and they worried about death a lot. They looked for a purpose and meaning in life and found it in religion.

For example, in England about a thousand years ago, every day farmers working in the fields heard the church's bells and saw its tower rising above their huts. In that stone church they had been baptised and been married, and in its grounds they would be buried after their death. On Sundays and holy-days everyone attended the mass which was in Latin. Few worshippers understood the words but their strangeness must have increased their awe and wonder.

To a humble peasant or tradesman, living in a cramped and smelly hut, the spacious and peaceful church must have seemed like another world. As he stood or knelt on the stone floor, statues, carvings and colourful wall paintings reminded him of heaven and hell.

The role of religion

The priest lived alone, since church law forbade him from marrying. He was expected to visit the sick and help the poor. He could teach people a few simple prayers. If he was sufficiently educated he taught Latin to a few boys and trained them to help him. In time some of these pupils might become priests.

To support himself the priest charged fees for baptisms, weddings and burials. In a village he would have some farm land, and he also took a *tithe* (one-tenth) of everyone's

Suffolk Church

Canterbury Cathedral

produce. Most of this went to the bishop of the *diocese* (a large area in which the *parish* of the church was), only about a quarter stayed in the village. In a town craftsmen and traders paid a tenth of the value of goods which they made or sold. The bishop's church was usually called a cathedral because it had his *cathedra* (throne).

At first the bishops lived quietly and simply. Over centuries the Catholic church grew rich and became the largest landowner in Europe, collecting its own taxes and making its own laws. Bishops were the chief tenants of the king, some were even appointed ambassadors to foreign courts. Their grand style of living put them out of touch with the humble priest and his parish. In his small local village, the priest would offer education.

Religion and education

Education, in the sense of book learning, was entirely in the hands of the Church. Teachers were priests and monks. The word "clerk" meant both a churchman and a person who could read and write. There were no schools, but rich parents hired churchmen as private tutors to their children. Some rich families sent their daughters as nuns to convents; after their education they would return to the family.

Education often only meant good manners and the ability to ride, hunt and fight. More advanced was the learning of Latin in a "grammar school", which was attached to a large church or cathedral. These were intended for students learning to be monks, but others were also taught.

The syllabus

Classes began soon after sunrise and went on for around nine hours, on all days of the week. Only Sunday afternoons were off. There was no history, geography, science or

anything like we have today. All the time was spent reading, writing and speaking Latin.

Books were scarce and expensive because they were all handwritten. Some books were beautifully illustrated with great attention to the smallest details. This was especially so when the book that was being copied was the Bible, which is the holy book of the Christians. A beautifully delicate illustration from the Lindisfarne Gospels, an illuminated manuscript written around 700 AD at Lindisfarne in England (now on display in the British Library in London) is shown on the cover page.

Because books were expensive, they were often chained to the shelves in the library! One such shelf of chained books is shown in the picture on the front inside cover. In fact, in school the teacher might have one book and the pupils had to learn everything by heart. If they did not pay attention they were beaten with a cane. The most common cane was acually a branch of the birch tree, as can be seen from the picture. It was believed that caning children was the best way to prevent them from making mistakes. In spite of what seems to us so terrible today, many boys grew to love learning. After mastering Latin they went on to study arithmetic, geometry and astronomy.

Advanced subjects like religion, law and medicine were taught in very few towns, which became famous as centres of learning. This was how the universities of Oxford and Cambridge started, more than 800 years ago. Students came from far and wide to study there. They had to find a place to stay and look after themselves in a strange town.

Even these scholars were not encouraged to think for themselves, or to find out more about the world. Whatever the ancient Greeks or Romans said was taken to be the truth. One of the first people to criticise this attitude was an Oxford scholar and teacher called Roger Bacon, who lived from 1210 to 1290 CE. His beliefs got him into trouble with the Church, he was imprisoned in 1272. For example, he believed that one day there would be mechanically driven ships and flying machines piloted by human beings!

Based on The Middle Ages
by ***R.J. Cootes***

Swing it like Sarfraz!

The Science of Swing and Reverse Swing Bowling

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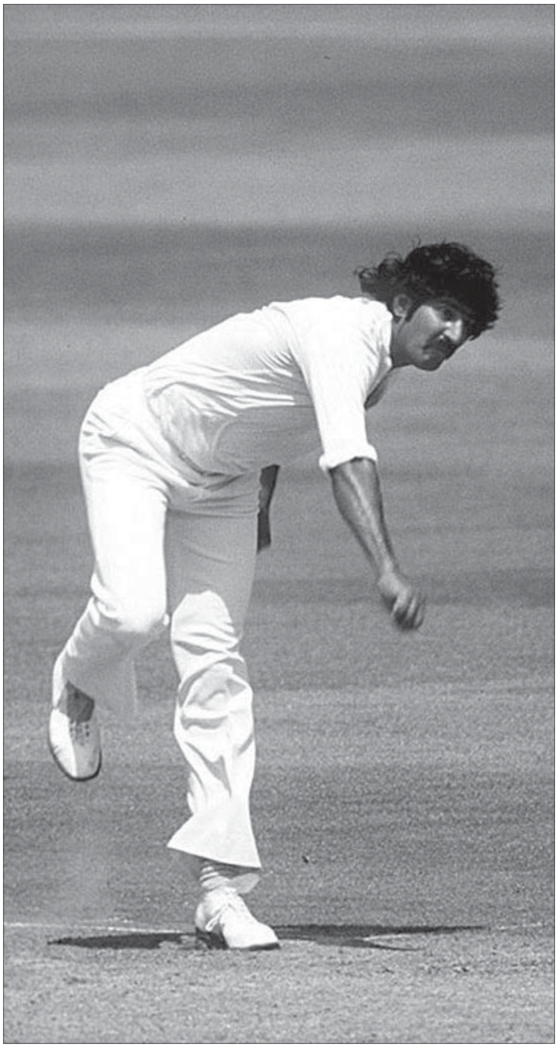


It's cricket-fever season again! Let's take this opportunity to learn some science of cricket. While batting is an art form by itself, this article is about bowling. Not just any kind of bowling but what is called swing bowling. Swing bowling is the hall-mark of almost all medium pace bowlers. Those who want to know how the ball is spun by a spinner must read up on this elsewhere: it's a lot more complicated!

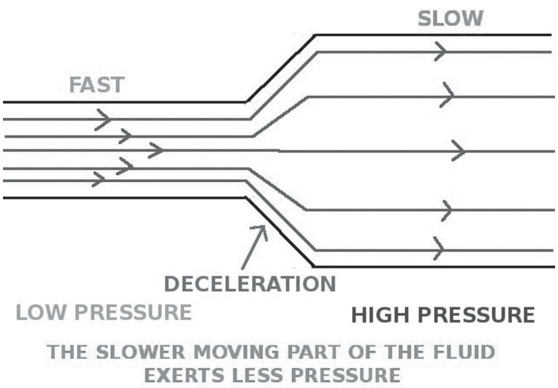
Everyone has seen or at least heard a conversation which included, "Just look at the way the ball turned; the batsman had no chance" or some variation of these lines. But when you throw a stone in the air you don't expect it to swing. What is so special about the cricket ball (or even football, although this article does not talk about this either) so that it swings and moves in the air, even before it hits the ground? This is the art and science of swing bowling.

Laminar flow

The main science of swing bowling is that there is air around us and air can provide movement just as it can lift and propel an aeroplane. The first thing we need to understand is how air flows around or over an obstacle. In fact, you might have seen the waters of a river flow smoothly in the dry season or swirl around rocks and debris in the rainy season. So, depending on the rate of flow, the same water shows very different behaviour. Air is like that too.

Bernoulli's principle

When the flow is smooth, Bernoulli's principle relates the rate or velocity of the flow to the water pressure: the faster the flow,



the slower the pressure. Also, remember that fluids mostly move from regions of high pressure to regions of low pressure.

The figure shows the effect of pinching the water into a narrow tube and then letting it broaden out.

The smooth behaviour is called laminar flow. The rough flow is called turbulent flow and the transition of the water (or air or any fluid) from one to the other depends on several properties of the water including its speed and viscosity which is measured by the Reynold's number.

Boundary layer

As the velocity increases, the flow becomes turbulent and eddies form; see the

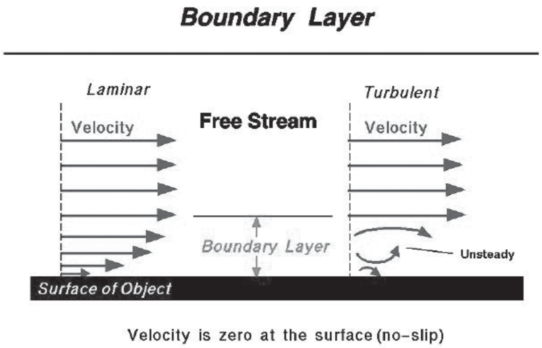
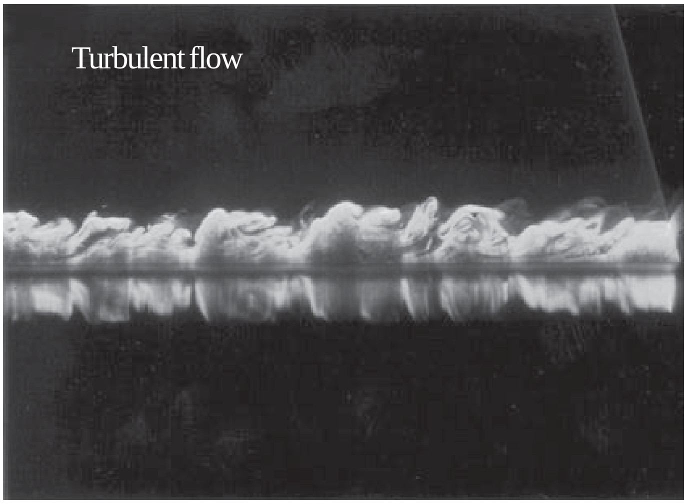


figure. In either case, the speed of the layer of water just inside the tube (and touching it) is approximately zero. This is called the boundary layer and is smooth and steady for laminar flow.

Boundary layer for a cricket ball

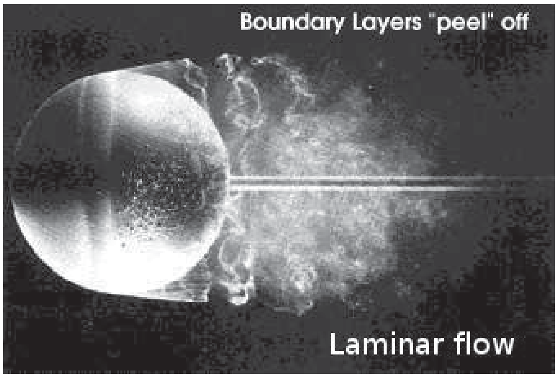
Now what happens when a ball is moving in the air? The air is a fluid and if the speed of the ball is small and the ball is very smooth, the air flows smoothly over the ball in a laminar flow. The air flows smoothly around



the ball, touching it, so the boundary layer is in contact with it.

Air tunnel experiments have been conducted when air is rushed past a ball in a controlled fashion and the resulting air flow photographed. The nature of the air flow is highlighted by injecting smoke into the tunnel: the pattern that the smoke forms shows the nature of air flow.

As the speed increases, the air curves around the front of the ball, but 'peels off' at

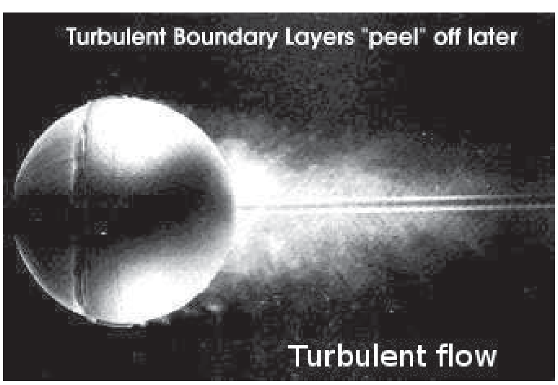


the back. See the wind-tunnel photo where the air is moving from left to right. The air flow is still laminar but not in contact with the ball at the back. As the wind speed increases further, the flow becomes turbulent and it turns out that the boundary layer 'peels off' later than in the case of laminar flow. See the next picture. Since the turbulent flow side has air at higher speeds, it also corresponds to lower pressure.

Armed with this information, we now return to the question of why the cricket ball swings.

The cricket ball

Well, we all know it used to be red and now it's all colours! Most important is that the cricket ball is stitched together in the middle.



This is called the *seam*. The stitches stand out sharply against the otherwise smooth surface and this causes the air flow over it to become turbulent even at lower speeds when the air flow would not normally have become turbulent. All the fancy swing that you can get out of the ball depends on the presence of this seam and one other fact that we will soon come to.

Normal swing of a cricket ball

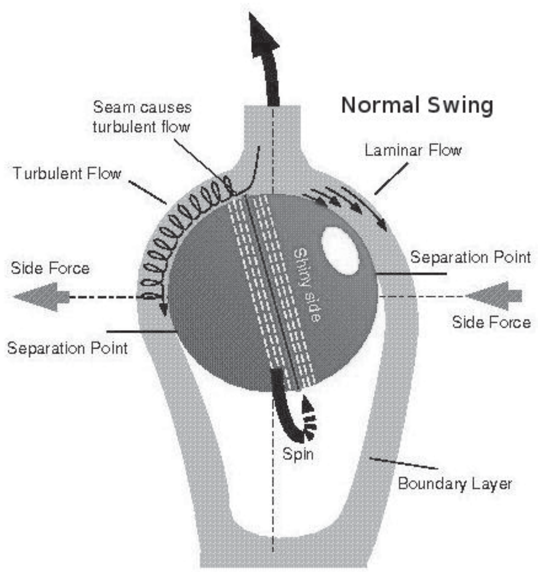
For this, the ball is held so that its seam is not facing the batsman but is held at a slight angle. See the figure. The ball is shown being bowled upward in the picture. The thick black arrow indicates the direction the ball will swing (to the left). Why does this happen?

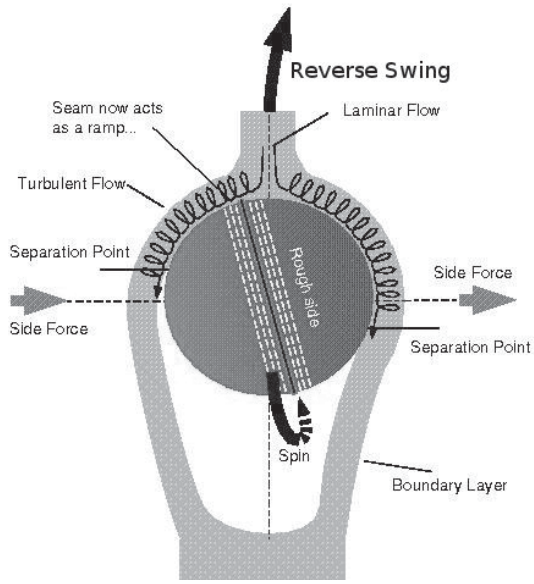
The air flows on both sides around the ball. But on the left side it almost immediately encounters the seam and becomes turbulent. On the other side there is laminar flow. So the boundary layer separates from the ball earlier on the smooth side, as explained earlier. Once this separation occurs on the smooth side, the air immediately in contact with the ball is not the grey-coloured flowing air, but the uncoloured (or white) inner layer of air that is hardly moving at all. This smaller velocity corresponds to having a higher pressure on this side. On the other side, the flowing air has become turbulent and has not yet separated from the surface of the ball, so it has lower pressure.

At this point, therefore, there is a sideways force on the ball from the smooth flow to the rough flow side and so the ball moves to the left, that is, *in the* direction of the seam. Since the ball is moving away from the straight, that is, away from the batsman, this gives you an *out-swinger*.

If the ball were held facing the other way, that is, tilted a little to the right, the ball would also swing right, giving an *in-swinger*.

It turns out that the best swing is obtained if the seam is held at about 20 degrees angle from the straight (direction of batsman) and





the speed of the ball is about 50-100 km/hr. Of course, in addition an even better swing is obtained if the portion of ball facing forward is very smooth so that you get the maximum contrast between the rough (seam) and the smooth sides. Since it is not permitted to damage the ball by roughening it, you may have often seen fielders smoothing the surface by shining it against their trousers. For this the entire team must cooperate so that only one side is shined always, otherwise the whole effect is lost!

Spin of the ball

So far we just talked about holding the ball with the seam angled from the straight. But you may have noticed that the bowler also spins the ball when he releases it. The figure shows a black dotted line showing a backward spin on the ball. The main reason for spinning it is stability. It is very hard to balance on a stationary bicycle but you can easily do so when you are moving. This is because the wheels are spinning and it makes the whole structure stable. In the same way, spinning the ball gives it stability so that the seam continues to remain angled so as to give maximum swing, otherwise the ball will simply wobble uncontrollably. Studies show that the optimum swing is obtained when the ball is spinning backwards at about 10 or 11 revolutions per second.

Faster and faster

What happens if the bowler bowls faster?

Turbulence sets in early so that that even the air flowing on the non-seam side becomes turbulent and so there is hardly any pressure difference between the two sides. By about speeds of 130 km/hr the ball does not swing, however hard the bowler may try! But then something interesting happens.

For the fastest bowlers, who can bowl with speeds greater than about 135 km/hr, a new and strange phenomenon happens: the ball begins to swing in the reverse direction, that is, opposite to the direction of the seam. Why does this happen?

Reverse swing

The speed is now so high that turbulence sets in fairly early on both sides, even before the air layer reaches the seam! In fact, when the turbulent air layer reaches the seam, it makes the boundary layer thicker and weaker, so the air layer on the seam side begins to separate earlier than it would have done if there had been no seam (see figure on the previous page).

So now the air layer has separated earlier on the seam side, the pressure difference is now in the opposite direction, with the seam side being at a higher pressure. there is a force on the ball from left to right, or you get a reverse swing: a bowler with the same action who was bowling out-swingers has only to increase his speed and with the same action will now bowl in-swingers! This caused great confusion in the 1980s when this kind of bowling was first invented.

Reverse swing at lower speeds

Old balls are rougher than new ones and this also affects the air flow. Even at lower speeds, if the non-seam side is roughened, then the air meets the rough surface first. This causes turbulence to set in early and reverse swing can develop even at lower speeds. Of course, once you have a ball that is smooth on one side and rough on the other, you don't need to tilt the seam. The ball swings even if the seam is pointing straight at the batsman: this is called ***contrast swing***.

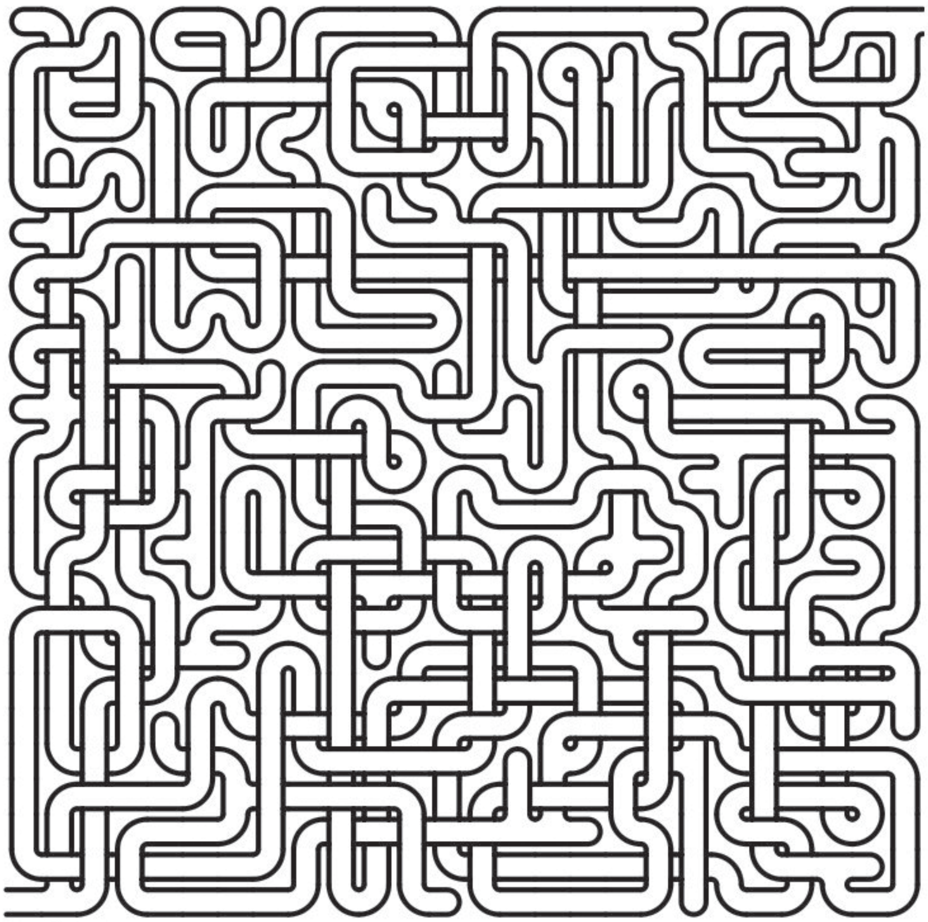
History of swing

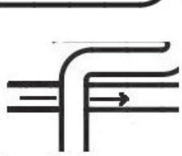
Conventional or normal swing bowling has been known for more than a century. However, reverse swing bowling was invented only about 30 years ago, mainly by Pakistani pace bowlers Sarfraz Nawaz and Sikandar Bakht, who had the speeds required to bowl reverse swing. They in turn passed on the knowledge to legendary bowler Imran Khan. Later on Wasim Akram (who was called the Sultan of Swing) and Waqar Younis also used this style to great effect. Slowly the knowledge spread to other countries and bowlers including English Jimmy Anderson and Sri Lankan Chaminda Vaas used reverse swing very effectively. In India, Ishant Sharma, Ajit Agarkar, Zaheer Khan, and the latest Bhuvneshwar Kumar, are all known for their ability to swing the ball. Of course, it is not enough to know the science of swing bowling: it needs to be practiced diligently as well!

Based on the article by
Rabindra Mehta,
NASA scientist,
along with inputs from
MVN Murthy and R. Shankar,
IMSc, Chennai.

Lead the Rabbit to the Carrot

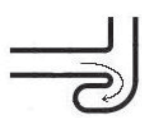
Maze courtesy: davidbau.com



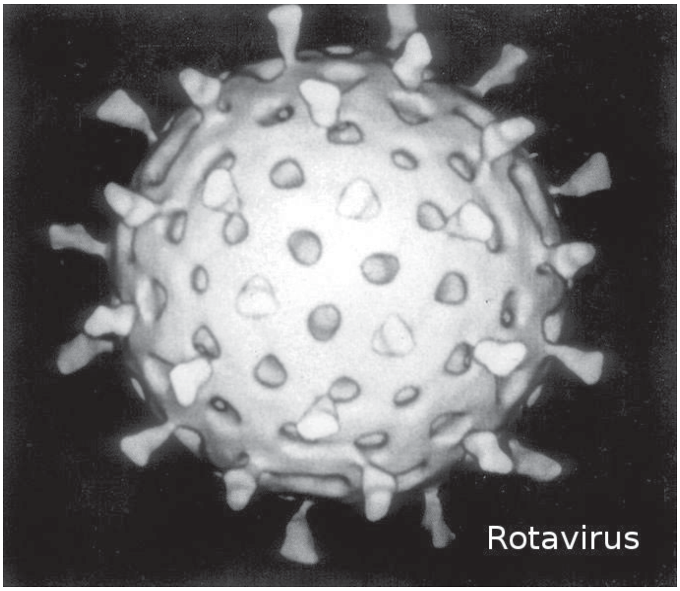


Underpass

Overpass



Dead-end



Rotavirus

Viruses

D. Indumathi

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Viruses are found wherever there is life and have probably existed since living cells first evolved. A virus is a small infectious agent that can replicate only inside the living cells of an organism.Viruses are considered by some to be a life form, because they carry genetic material, reproduce, and evolve through natural selection. However they lack key characteristics (such as cell structure) that are generally considered necessary to count as life, so they are "organisms at the edge of life". Viruses can infect all types of organisms, animals and plants and even bacteria.

Types of viruses

Virus particles (known as virions) are made up of two or three parts: i) the genetic material made from either DNA or RNA, which are long molecules that carry genetic information; ii) a protein coat that protects these genes; and in some cases iii) an envelope of lipids (fat) that surrounds the protein coat when they are outside a cell.

Viruses can have very different shapes. The average virus is about one one-hundredth the size of the average bacterium so they are too small to be seen even with a powerful optical microscope.

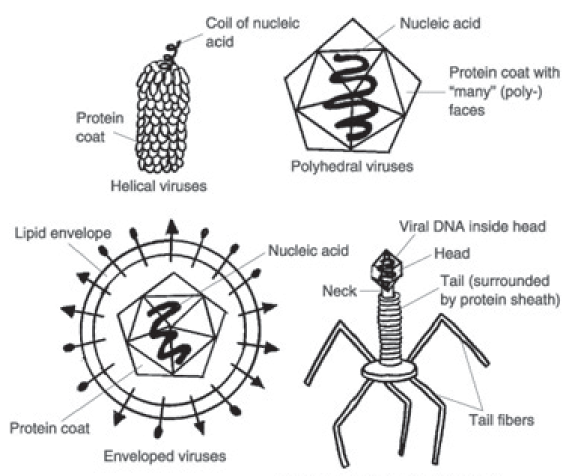
Life cycle of a flu virus

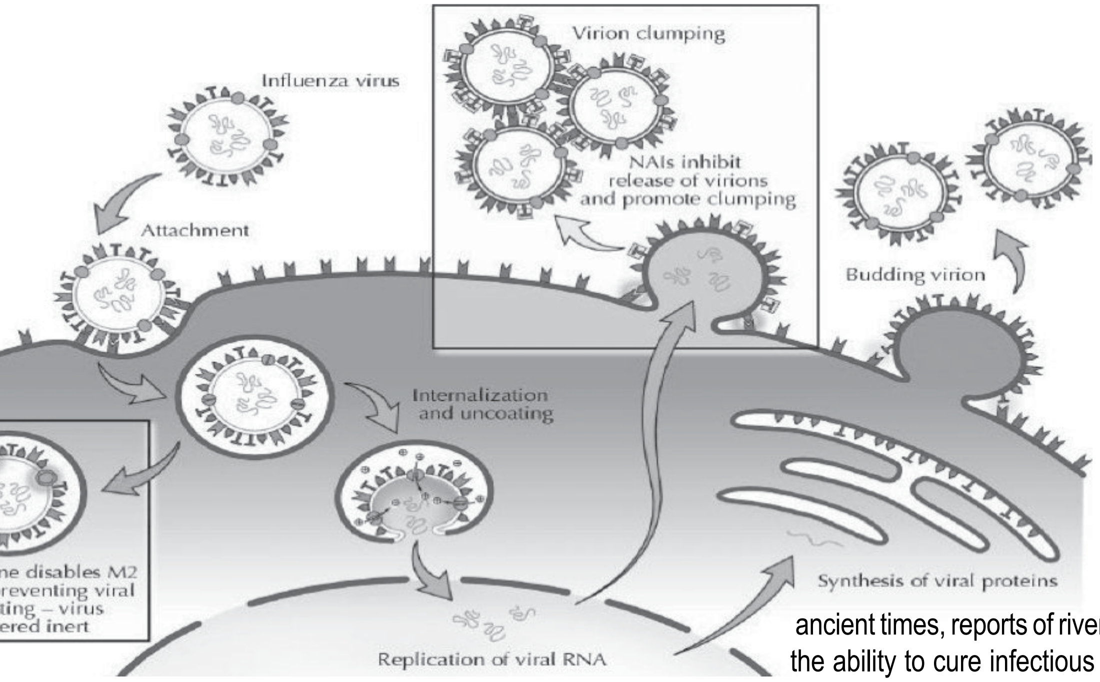
The H5N1 "avian" flu is highly deadly among birds while the 2009 H1N1 "swine" flu crossed over from pigs to infect humans with disstrous effects. How does a virus infect a host such as a bird or a human?

For the virus to multiply it must enter cells of the host organism and use the host material to reproduce. To enter the cells, proteins on the surface of the virus interact with proteins of the cell.

When an unsuspecting victim inhales a flu virus, a protein on the surface of the virus called hemagglutinin (the 'H' in H1N1) *binds* to a receptor called sialic acid on tsurface of cells in the respiratory tract. *This is called attachment*, or adsorption.

A hole forms in the cell membrane, then the virus particle or its genetic contents are released into the host cell. Now the virus takes control of the host cell's replication mechanismsand multiplies quickly by the million. After a virus has made many copies of itself, it usually has exhausted the cell of its resources.





The host cell is now no longer useful to the virus, therefore the cell often dies and the newly produced viruses must find a new host.

The process by which virus progeny are released to find new hosts, is called *shedding*. This is the final stage in the viral life cycle. The newly formed viruses leave the cell by budding off the surface. The hemagglutinin on the new viruses can then bind to the sialic acid on the surface of other host cells, thus infecting new cells. For this to occur, however, the viruses need to escape the host cells. Another viral surface protein, neuraminidase (the 'N' in H1N1, for example), breaks down the sialic acid receptors so the viruses can escape.

Control of H1N1 flu

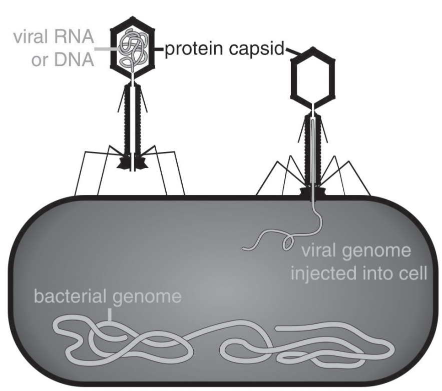
Medicines such as **Tamiflu** and **Relenza** stop the multiplication of the virus because they are structurally similar to sialic acid and will bind to the neuraminidase, but they cannot be broken down. Therefore, neuraminidase cannot bind to sialic acid on the cell surface when it has Tamiflu or Relenza called neuraminidase inhibitors (NAIs) bound to it. When NAIs are present, some of the newly produced virus will get stuck to the original host cell and will not be able to infect other cells. Some viruses will still escape, so NAIs don't cure the flu but rather reduce its severity.

Bacteria versus viruses

Since ancient times, reports of river waters having the ability to cure infectious diseases such as leprosy have been documented. By late 1917 the scientist d'Hérelle, working at the Pasteur Institute in Paris, announced that he had discovered "an invisible, antagonistic microbe of the dysentery bacillus". These are bacteriophages (or bacteria-eaters), that have immense use in killing bacterial infections by literally killing off the bacteria from within itself using viruses. A diagram of how some bacteriophages infect bacterial cells is shown in the figure (not to scale).

Perhaps we may succeed in finding anti-biotics that areeffective against all infections. Perhaps the potential of viruses can be tapped to fight disease. But right now we do not know all the answers.

—Compiled from several sources



How can an 'imaginary' number be *real*?

R. Ramanujam,
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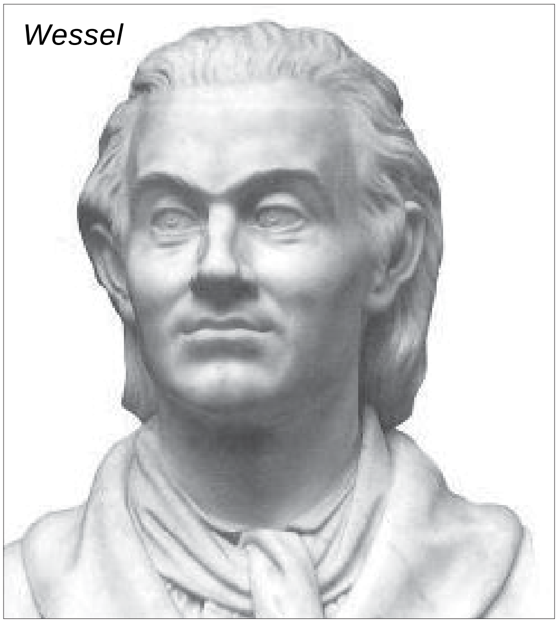
Recap: When a number of mathematicians were asked to name the most beautiful theorem in mathematics ever, they voted the ***Euler identity*** for that title. When the *Physics World* magazine asked its readers to name the greatest equation ever, Euler's equation tied with Maxwell's equation.

The identity or equation says: $e^{(\pi i)} + 1 = 0$. It is named after the famous Swiss-German mathematician **Leonhard Euler** (pronounced "*Oiler*", 15 April 1707 - 18 September 1783). Euler is considered one of the greatest mathematicians of all time, and **Srinivasa Ramanujan's** genius was often compared with that of Euler.

This equation is considered beautiful, as it features the most important *constants* in mathematics: e, π, i, 0 and 1; as also the most basic mathematical operations of addition, multiplication and exponentiation; as also the equality symbol. All these are used exactly once, making for great elegance.



Wessel

Of these, the operations addition, multiplication, exponentiation and equality are known to us, as also the numbers 0 and 1.

π is the ratio of the circumference of a circle to its diameter, and is the same for every circle. It is an irrational number, in the sense that it cannot be written as a fraction (in the form p/q where p and q are integers with no common factor).

i, called the *imaginary number* is the solution to the equation $x^2 + 1 = 0$; or, it is that number, when multiplied by itself, yields -1. (Notice that usual numbers, when multiplied by themselves, always give a positive answer, e.g., 7x7, etc).

e is the Euler's constant, the base of the natural logarithm, the unique number such that the value of e^x is equal to the slope of its tangent line for every x. It is also an irrational number.

Both 0 and 1, as well as π, have been discussed in articles in various issues of ***JM*** last year. We now continue this series.

One of the most important mathematical constants, one which stars in a central role in Euler's equation, is i, the square root of -1, usually referred to as the *imaginary number*.

What is it?

This is not an easy *number* to comprehend, if we think of numbers as quantities, like in counting, or fractions, or decimals. After all $2^2 = 4$, $(-2)^2 = 4$, $0^2 = 0$, $(0.1)^2 = 0.01$, and we can go on like this, and always find that squares are always positive, so we make sense of square roots of a number, $\sqrt{x}$, only when x is positive.

Well, use your *imagination*! Try (hard) and imagine a number—let us call it i—which when multiplied by itself, gives (-1). That is $i \times i = -1$. Why should we do such a thing? Because it is useful to do so. By simply accepting that *i* exists we can solve many problems or situations that need the square root of a negative number. For instance, we can find the square root of -9 by writing $-9 = -1 \times 9$ and hence $\sqrt{(-1 \times 9)} = \sqrt{(-1)} \times \sqrt{9}$ and hence $\sqrt{-9} = 3 \times i$.

Thus we can solve not only $x^2 + 1 = 0$, but all equations of the form $x^2 + k = 0$ for any positive *k*. This is only the beginning; there is much more one can do. Indeed, imaginary numbers have a variety of essential, concrete applications in science and engineering.

A geometric meaning

Imaginary numbers may seem strange at first, but really, they are no stranger than negative numbers. The constant –1 was also considered to be very strange until four centuries ago. It is used to answer the question, what is 3–4, but how can you have less than nothing? Its intuitive meaning of "opposite" helps us a little, and we use it in coordinate systems by going `backwards' from the origin. The absolute value of a negative number allows us to `measure' it. But we can have a very similar outline for imaginary numbers as well.

There is a visual meaning to imaginary numbers, and that is the concept of *rotation*.

What does the equation $y^2 = 9$ mean? Think of it as $1 \times y^2 = 9$, that is, the transformation *y* when applied twice turns the number 1 into the number 9. The two answers would be 3 and –3, that is, "scale by 3" or "scale by 3 and flip".

Similarly we can ask, what is the transformation *y* which, when applied twice turns the number 1 into the number –1? How about a *rotation*? If we imagine *y* to be a rotation (anticlockwise) by 90 degrees, applying it twice gives us a rotation by 180 degrees, which is a flip ! See Figure 1. If we rotate twice in the other direction (clockwise), we turn 1 into -1. This is "negative" rotation or a multiplication by $-i$. See Figure 2.

Thus *i* is a *new imaginary dimension* to measure a number. Two rotations in either direction gives –1: it brings us back into the familiar dimensions of positive and negative numbers. That numbers are 2-dimensional is what is staggering at first. But once you get used to the idea, it is natural, and fun!

Well, why rotate only by 90 degrees? Why not 45 degrees? Why not indeed. It looks like in

Some facts about i:

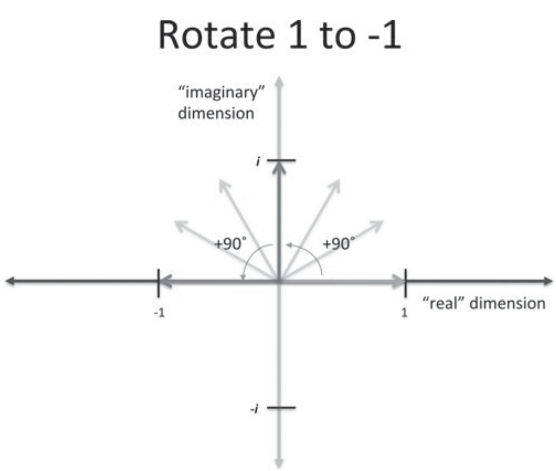
$i^2 = -1;\ i^3 = -i;\ i^4 = 1;\ i^5 = i;\ i^6 = -1$ and so on.

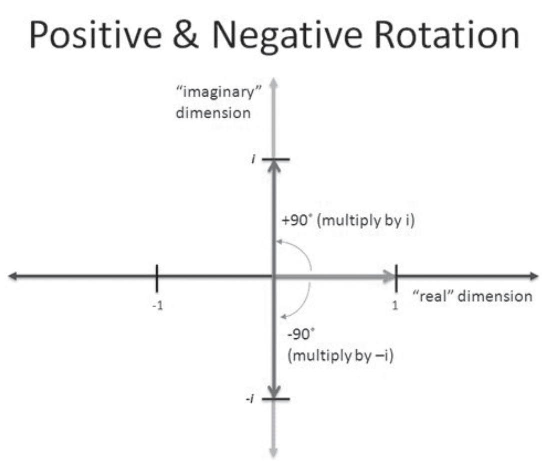
$1/i = (1/i)(i/i) = i/i^2 = -i$.

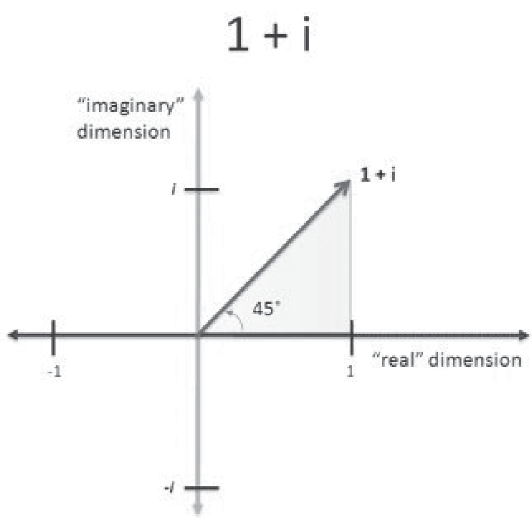
$i^{-1} = -i;\ i^{-2} = -1;\ i^{-3} = i;\ i^{-4} = 1$ and so on.

$i\,(a + b\,i) = a\,i + b\,i^2 = -\ b + a\,i$.

$(a + b\,i)\,/\,i = -\,i\,(a + b\,i) = b -\ a\,i$.







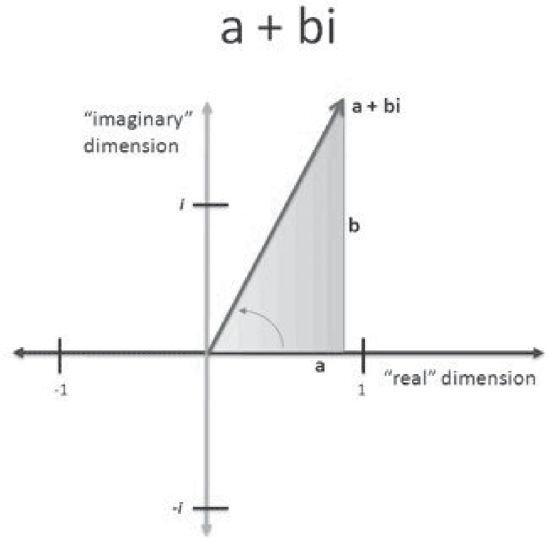


Figure 3, a 45 degree angle, with equal parts in the real and imaginary; we can call it (1 + *i*). Indeed, any combination of real and imaginary numbers makes a triangle, and the angle becomes the "angle of rotation".

A *complex number* is the fancy name for numbers with both real and imaginary parts. They're written as $a + b\,i$, where a is the real part and b is the imaginary part; see Figure 4.

The 'size' is immediately clear from the picture: it is $\sqrt{(a^2 + b^2)}$.

This is only the beginning, there is an interesting story to learn, but we are here only to introduce the constant *i*, so we will stop here, only pointing out that:

1) *i* is not a variable.
2) *i* is not found on the real number line.
3) *i* is not a real number.

How old is *i*?

Solving equations is an old preoccupation for mathematics. About 300 CE, the Alexandrian mathematician **Diophantus** worked on what we now call *linear* and *quadratic equations*. In the 9th century in Baghdad, **Al Khwarizmi** presented six standard forms for linear or quadratic equations and produced solutions using algebraic methods and geometrical diagrams.

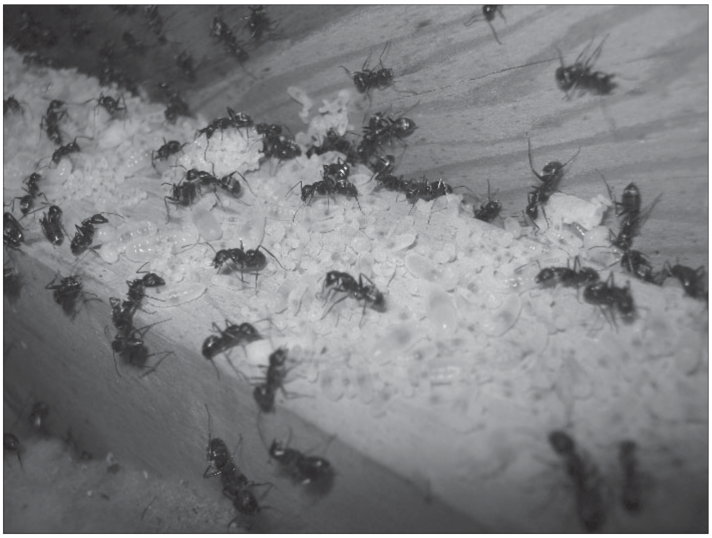
The period from **Pacioli** (1494) to **Descartes** (1637), a period of about 150 years, brought the solution of equations to a stage where they can even be understood by school students today. This story is full of intrigue and deception because methods of solution were kept secret. The issue which caused most consternation at the time was the meaning of $\sqrt{-1}$.

In fact, **Cardano** (1501-1576) in his *Ars Magna* of 1545 had to solve a problem where $\sqrt{(-15)}$ appeared. In modern notation, Cardano's multiplication was $(5 - \sqrt{(-15)}) \times (5 + \sqrt{(-15)})$ which he found to be 40, using the imaginary number. He called it 'fictitious'. By 1572, the Italian engineer, **Bombelli** (1526-1572) had provided the correct rules for working with these 'imaginary' numbers.

In the 17th and 18th century, while they might not have been comfortable with their *meaning*, many mathematicians were routinely working with negative and imaginary numbers in the theory of equations and in the development of the calculus. The use of imaginary numbers was still not widely accepted until the work of **Leonhard Euler** (1707-1783) and **Carl Friedrich Gauss** (1777-1855). The geometric significance of complex numbers as rotations and points on a plane was first described by **Caspar Wessel** (1745-1818).

Do You Know?

1. I plan to become a space scientist and explore Mars. Can one create a miniature Mars at home for studying it?
2. We were discussing Spiderman recently. Can one actually mix human and spider DNA?
3. I read that over-eating can cause memory impairment in old age. Is this true?
4. Every time I ride a bicycle, this question occurs to me: why are bicycles much more stable in movement than when we try to keep still?
6. Why do we never "feel" our organs? (We feel them only when pressed against something else.)
5. In its later stage of life, when fusion stops and the star gets its carbon core, does all that pressure on the carbon core produce diamonds?



Answers to last issue's Do You Know?

1. I have heard of the dance of bees, but how do ants know to gather in large numbers when one of them, presumably, has discovered a tasty bit in our kitchen?

Ans: Ants forage randomly. On their way back to the nest with food they leave a *pheromone* trail that other ants will randomly encounter and identify as "pointing" to a food source, according to the concentration of pheromone at each point.

So the pathfinder forager ant leaves pheromone trails from the spot where the tasty morsel is residing in your kitchen all the way back to the colony - hence it is able to organise a nice foraging party. Other ants follow the pheromone trails and also reinforce it, but once all the food is consumed, they stop leaving pheromone trails and disappear from your kitchen floor.

One in five foragers are pathfinder ants that can detect previously marked pheromone paths for up to 48 hours.

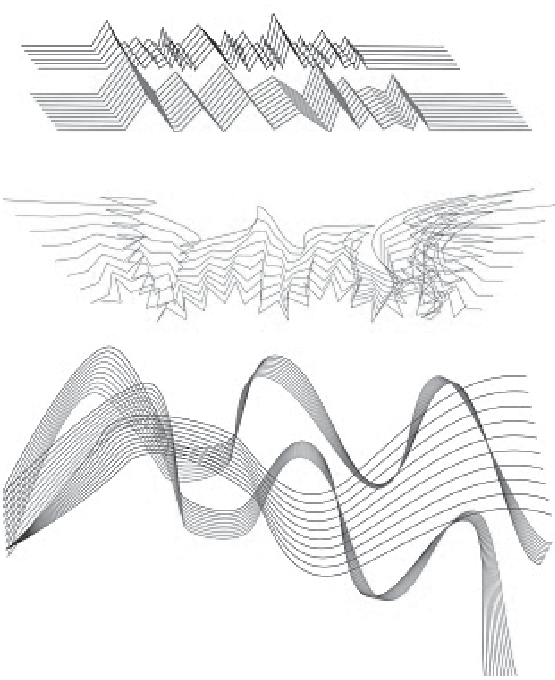
Perhaps the best way to avoid this is to clean your kitchen daily.

2. What would we see if we had glasses that converted sound waves into light waves?

Ans: The difference between light and sound is the wavelength and frequency. The audible sound spectrum is 20-20,000 Hz. The visible light spectrum is 400-790 Thz. (1 Thz = 10^{12} Hz or a million million Hz).

Suppose that there is an equipment that amplifies the frequency of sound so that it appears in the visible spectrum. This would be something like a mapping of light for each audible frequency of sound.

Now if you visualise this apparatus, it would show points of light for each sound wave hitting a set of microphones. Because the source is amplified many times also assume electronic noise in the amplification process. The result will be like taking a 4x4 pixel image and magnifying it to 40m x 40m pixel image. The human brain will not be able to resolve the contrast in order to identify objects as we see today. That is, sound reflected from a chair will not form an image of a chair; but based on the property of the chair (wooden or metallic) will reflect sound with low or high frequency. So objects which make low frequency sounds will have red hues and objects with high frequency sounds will show up as blue or violet.



What our brains will probably see is blobs and bands of colour based on high and low frequency. When somebody hits the bass drums or knocks on the floor with their boot we will see red. A child's shrill scream will show as blue. A room full of wooden chairs will show red bands, a room full of metal chairs will show violet bands. The dancing and dynamic display of colours would be parallel in many ways to the sound it's converted from, just like audio visualisers software. Intensity, frequencies, structure of waves, these all could easily be portrayed in the form of light.

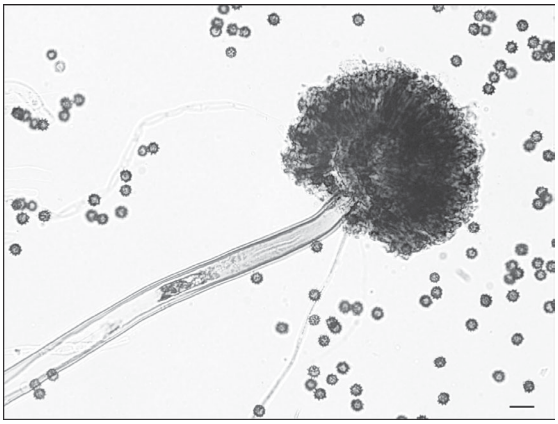
The intriguing question is: could we get accustomed to it by such a degree that we could communicate through these sound-lights? Right now, we can only say we don't know. But there are stories of colour-blind people who have learned to *hear colours*, so why not *see sounds* as well?

3. What causes or inhabits the black cracks that form on old, infrequently used bars of soap?

Ans: It is a mould called **Aspergillus niger.**

Bar soap is essentially the sodium salt of a fatty acid, which, like table salt, absorbs moisture. Even a brand new bar is hydrated (meaning moistened) to some extent, being kept so by its impermeable wrapper and subsequent everyday wetting. But if it is exposed to the air for long periods, it dries out and shrinks, causing its surface to crack. Drying mostly afflicts older bars that have worn small, because when soap becomes too small to use we don't throw it away immediately but leave it aside.

The mould A. niger is ubiquitous in soil and its spores are readily dispersed in air, where still, indoor conditions allow them to settle. Soap is



typically left in rooms where humidity builds up from hot water usage. Any condensation or splashes accumulate in the soap's cracks, these recesses being slowest to dry. Coupled with cosy indoor temperatures, the mould is encouraged to start growing, in the form of vegetative "hyphae" that penetrate the soap for fatty nutrition and the visible reproductive film above.

Does this affect our health? Though A. niger in high doses can cause bad reactions in people, in small amounts it seems not to cause problems. On the other hand, it has many beneficial uses in food production and medicine. It is used to find out micronutrient content in soil for agriculture. It is also used by clinical researchers to evaluate anti-fungal treatments.

Most interestingly, one product of A. niger, *gluconic acid*, is itself used in cleaning agents!

4. Why is it that on the surface of an apparently homogenous potato a new sprout bursts forth? Is there something special at that point?

Ans: The surface of a potato may seem more or less homogenous, but close inspection, especially of a potato that has not been exhaustively scrubbed clean, will reveal small structures known as "eyes". These are buds from which the potato (which is a swollen, underground stem of the plant) will sprout.

At one end the potato spud retains the scar or stub of the stem that connected it to the mother plant. At the other is a central bud with other buds arranged around it in a rough spiral. These are ready to grow in the right season and conditions. Since the daughter tubers grow roughly radially outwards from the mother, the next generation will spread outwards a little further reducing competion. Potatoes are

clever little things really. Gardeners know the end with the buds as the rose end, and attempt to plant the tuber with it facing upwards.

Scientists say that the spud is actually a stem tuber, so technically potato is not a root crop, and the buds are akin to those on a stem.

5. My birthday cake had some "trick" candles on it that I couldn't blow out, however hard I tried. How do these work?

Ans: A "trick" candle is like that. You blow it out and it 'magically' re-lights itself in a few seconds, usually accompanied by a few sparks.

The difference between a normal candle and a trick candle is what happens just after you blow it out. When you blow out a normal candle, you will see a thin ribbon of smoke rise up from the wick. This is vapourized *paraffin* (candle wax). The wick ember you get when you blow out the candle is hot enough to vapourize the paraffin of the candle, but it isn't hot enough to re-ignite it. If you blow across the wick of a normal candle right after you blow it out, you might be able to get it to glow red-hot, but the candle won't burst into flame on its own.

Trick candles have a material added to the wick that is capable of being ignited by the relatively low temperature of the hot wick ember.

What substance is added to the wick of a magic candle? It's usually fine flakes of the metal *magnesium*. It doesn't take too much heat to make magesium ignite (430°C), but the magnesium itself burns white-hot and readily ignites the paraffin vapour. When a trick candle is blown out, the burning magnesium particles appear as tiny sparks in the wick. When the 'magic' works, one of these sparks ignites the paraffin vapour and the candle starts to burn normally again. The magnesium in the rest of the wick doesn't burn because the liquid paraffin isolates it from oxygen and keeps it cool.

6. Why is it warm in the hay? Can it actually catch fire on its own?

Ans: The answer to the second question is, perhaps surprisingly, yes.

Hay is one of the more studied materials in spontaneous combustion. As hay varies by the type of grass and location grown utilized in its preparation, it is very hard to establish a unified theory of what actually occurs in hay self heating. It is anticipated that dangerous heating will occur in hay that contains more than 25% moisture content. The largest number of fires occurs within 2 to 6 weeks of storage, with the majority occurring at 4 to 5 weeks.

How does this happen? The process may begin with microbiological activity (bacteria or mould), but at some point, the process has to become chemical. Microbiological activity will also limit the amount of oxygen available in the hay. Moisture appears to be quite important, no matter what process. At 100°C, wet hay absorbs twice the amount of oxygen of dry hay. There has been conjecture that the complex carbohydrates present in hay break down to simpler sugars, which are more readily oxidized.

Do you know why we talk of searching for "a needle in a haystack"? People did use needles –to check how hot the hay was!

A hay needle or rick needle is pushed inside the haystack, and when pulled out, it seems to radiate heat. There is a mercury thermometer in the end, and if the reading was 71°C or above, then it was considered a fire risk. If the temperature measured was below this, and when measured over time showed a downward trend, the haystack would be left as it was.

Source: New Scientist Forum

science news

Headlines

. Bees like coffee too!

. An "earth" 130 light years away

. Mathematical sculpture

. Genes for storing digital data

For more on these, read on.

Bees like coffee too!

Apparently a little caffeine can improve honeybees' long-term memory, a new study shows. Bees are more likely to remember flowers that had caffeine in their nectar.

Many plants naturally contain caffeine in their leaves. It tastes bitter, so hungry animals tend to avoid eating plants that contain it. Caffeine is often present in a plant's nectar too. The nectar attracts passing bees, who sip it from the flowers.

Researchers from Newcastle University in England measured caffeine levels in the flower nectar of four common citrus plants and three types of coffee plants. Then they made their own fake nectars. Some contained caffeine, others didn't. Then they trained the bees to link the artificial nectars with a flowery smell.

A day later, the bees underwent tests. Those that had sipped the nectar with caffeine were more likely to remember that flowery smells meant a sugary treat. A lot better. Those bees were more likely to stick out their tongue when they smelled a floral scent. This showed they remembered that scent signaled a treat. Bees that had gotten other nectar were more likely to keep their tongues in their mouths when they sniffed the scent. So these bees didn't remember the connection as well.

Three days later, the memory still held! Twice as many of the bees that had gotten caffeine associated a flower's smell with nectar as did those who had gotten other nectar.

All this suggests that caffeine may turn the bees into repeat customers. Once they consume nectar with caffeine, bees can more easily remember the flower that supplied the sweet treat and go back for more. Bees help flowers reproduce by carrying pollen from bloom to bloom. So caffeinated nectar may give

some plants an advantage.

Coffee with nectar may help children writing exams too, perhaps?

An "Earth" 130 light years away

How do planets circling stars outside our own solar system look? We cannot quite "see" them, but would like to know what materials they contain. Such exoplanet studies got a big boost recently when Canadian scientists identified some of the gases that make up the atmospheres of four exoplanets circling the same star.

They studied the infrared light coming from a planet called HR 8799c. Their analysis showed that the planet's atmosphere contains water and a gas called carbon monoxide. This planet gets its name from its star — HR 8799. This planet is five to 10 times as massive as Jupiter. It is also about 130 light-years away. (That means its light took 130 years to reach the Earth.)

Planet hunters usually study an exoplanet by studying light from its host star. A brief dimming of starlight suggests a planet has crossed in front of its star. And a wobble in starlight indicates a planet's gravity tugging on the star. Such information points to the existence of an exoplanet and gives a rough gauge of its size. But not much else. In the new studies, scientists measured light emitted directly by the exoplanets. From that, they figured out that the planets have atmospheres and what's in them.

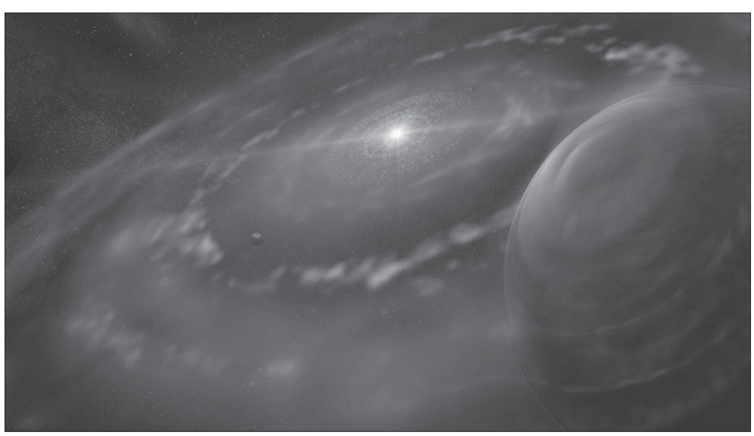
An atmosphere blankets a planet with gases. Earth's atmosphere contains a rich mix of oxygen, nitrogen and other gases. The atmospheres of gas giants such as Neptune and Saturn contain large amounts of helium and hydrogen.

Astronomers identified and measured the gases surrounding the exoplanets by looking at how they affect light that leaves them. Light travels as a collection of waves of energy. Each colour has its own wavelength, which can be measured as the distance from the top of one wave to the top of the next wave. Some wavelengths are invisible.

Light leaving a planet can be changed as it passes through that planet's atmosphere. One type of gas in the atmosphere may absorb light only at a particular wavelength. Or a gas may add a different wavelength of light. When a planet's light reaches Earth, scientists can detect which wavelengths have been altered. From that, they can calculate what gases here, an atmosphere the light must have passed through to cause such changes.

All four of the exoplanets studied are scorching hot. That's why scientists could measure them. Hot objects whether hot potatoes or hot planets send out waves of invisible light called infrared radiation. Because these planets are so far from their star, their light can be distinguished separately from their Sun's.

As the infrared light passed through each planet's



atmosphere, it underwent telltale changes that scientists have now begun to identify.

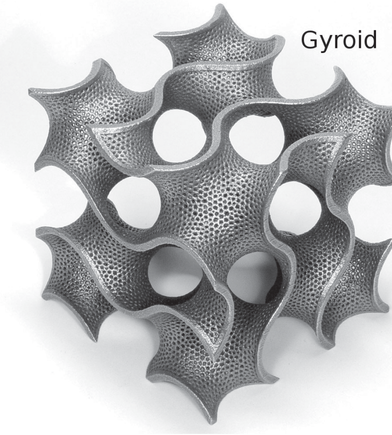
Scientists can learn much about a planet by studying its atmosphere. Such information may even help astronomers make an educated guess about how that planetary system formed. By learning more about the formation of the possibly hundreds of billions of exoplanets in our galaxy, scientists may even learn more about Earth's early life.

We need to look far into space to be able to see far into our past!

Mathematical sculpture

What does $x^2 + y^2 = 25$ mean to you? A circle of radius 5 (in some units), right? So it is not surprising that there are mathematical descriptions of nice geometric objects. Can one design beautiful sculptures by purely mathematical methods?

The American sculptor Bathsheba Grossman does precisely that. A mathematician from Yale University, she got interested in elaborately curved shapes called minimal surfaces. Mathematicians are interested in minimal surfaces because they have no peaks, valleys or folds that would increase their surface area. Want to make



Gyroid

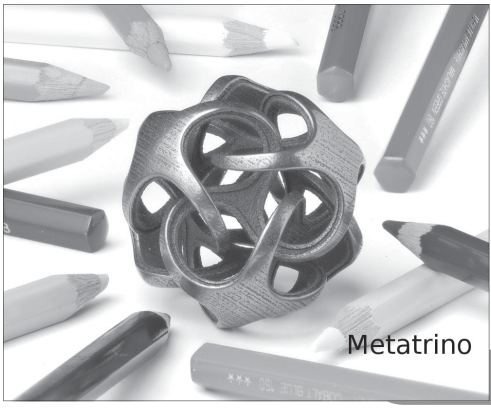
one? Dip a loop of wire into a bucket of soap suds and then pull it out. The shape formed by the soap film is a minimal surface. The geometer Erwin Hauer created many such shapes and this inspired the artist in Grossman.

Today she creates abstract sculptures that are as geometrical as they are artistic. She first creates virtual, three-dimensional models on the computer. Only later does she turn those into physical sculptures. Some baffle the eyes. How do they hold together?

Some of Grossman's pieces, such as the Gyroid, represent solutions to specific mathematical expressions or problems. These sculptures bring out the beauty already present in the mathematics. Grossman's artistic eye inspires other works, such as Metatrino. Mathematics still plays a role, since the sculpture shares the same symmetry as an octahedron, the natural eight-sided shape of an uncut diamond crystal.

Grossman says that most successful artists have a "secret weapon" a technique, style or subject matter that makes their work instantly identifiable. Grossman's secret weapon? Geometry. She uses her knowledge of geometry to create new objects that can be glimpsed only through equations and complex matehmatical constructions.

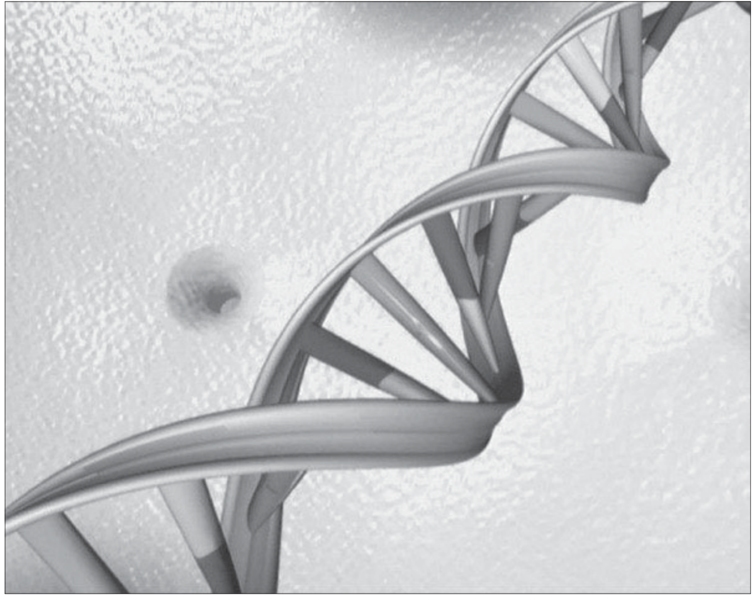
One technology that has enabled her work is three-dimensional printing. This process transforms virtual models created on a computer into actual objects you can hold in your hands. The first 3-D printers created only plastic models. But now, more advanced printers can work with metal. Without them, many of Grossman's constructions could not be realized. If a cast had to be made of the Gyroid,



Metatrino

you would have to break the mould to extract the sculpture. With 3-D printers, no cast is necessary: they build up objects, blob by blob, layer by layer.

New technology brings new possibilities for art.



Genes for storing digital data

We tend to think of genes as providing biological memory. DNA can be found in nearly every cell of every living thing. The molecule is a chemical blueprint that effectively instructs cells on how to work. If holding the "blueprint of life" isn't impressive enough, consider this. Scientists have now shown that DNA also offers a good way to store digital data.

European researchers have reported in the journal Nature that DNA can be used to store different types of information. These include text files, images, even an audio recording! DNA may even work better than magnetic media, which is currently used to store large amounts of data. The text file they used had all 154 sonnets penned by William Shakespeare. Another file included a 26-second audio excerpt of the famous "I have a dream" speech by Martin Luther King, Jr.

The researchers did not use DNA from any living organism, though. Instead they created a synthetic, or lab-built, mimic of DNA. A DNA molecule looks like a twisted ladder with rungs made from pairs of molecules known as nucleotides. Key chemicals in DNA nucleotides are represented by the letters A, T, C and G.

The storage process had many steps. First, they converted their files into computer code. Then, they translated that code into another code. This one used those A's, T's, C's and G's from DNA. They sent that code to a laboratory where scientists built billions of new strands of DNA based on the code, putting every A, T, C and G in its place. The lab then sent the DNA to the researchers in a small test tube.

To test their technology, the researchers sequenced the DNA. They figured out the coded order of nucleotides. That means those files were translated perfectly into DNA and back again.

The information is remarkably compact, which means that it takes up very little space. For instance, one of those Shakespeare sonnets, the researchers estimated, could be stored in less than a trillionth of a gram of DNA. Even more importanty, the new technology might avoid a potential problem that all storage devices experience today: quickly becoming outdated.

Scientists project that within 10 years or so, DNA-coded information may offer a reasonably priced way to store digital data for decades or longer.

A new meaning for the phrase "thumb drives", perhaps?

Sources: Sciencenews.org, Science, Nature

activity page

Boggle'd

Boggle is a word game designed by Allan Turoff and trademarked by Parker Brothers and Hasbro. Here we play a smaller version of the traditional game.

How to play

Search for words that can be constructed from the letters of sequentially adjacent squares, where "adjacent" squares are those horizontally, vertically or diagonally neighboring. Words must be at least three letters long, may include singular and plural (or other derived forms) separately, but may not use the same letter square more than once per word. An example "CORE" is already done for you.

The original game has a time limit of 3 minutes and uses 4 X 4 squares. Here, your time limit is the next JM issue! Do write in your word list to the JM address given in the magazine and we'll print the ones with the most number of words. Don't forget to write in your name and address.

Sudoku

Rules

. Use the numbers from 1 to 6.

. Every row must have all the numbers from 1 to 6

. Every column must have all the numbers from 1 to 6

. Every sub-rectangle must have all the numbers from 1 to 6

. The central shaded square (in the medium puzzle) must have the numbers 1 to 4

(A sub-rectangle is the 2 x 3 rectangle; the 6 x 6 square is broken up into 6 such sub-rectangles.)

Use the numbers already filled in as hints to complete the grid. Each Sudoku puzzle has a unique solution.

Send in your answers to us at the JM address given elsewhere in the magazine. Don't forget to write in your full name and address.

EASY

	2				
3				5	
		1			
				3	
			2		
5	1				6

MEDIUM

	3				
				2	
3					2
1	6				
				5	6

C	T	C
O	R	E
R	U	S

C	T	C
O	R	E
R	U	S

Crossword

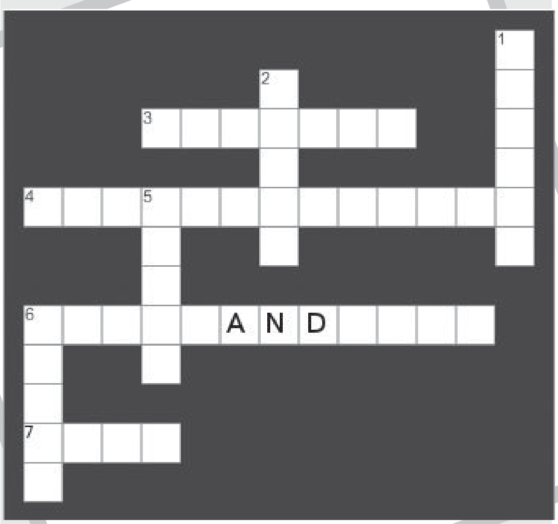
How well do you know your Simple Machines? Can you solve this cross word from http://education.jlab.org?

Across

3. The point about which 5 down pivots (7).
4. A ramp or slope (8,5).
6. This simple machine lets cars and bicycles roll (5,4).
7. It helps you cycle effortlessly (4).

Down

1. A wheel over which a rope or belt is passed (6).
2. A spiral version of 4 across; can be put in walls (5).
5. There are three basic types of this simple machine (5).
6. It is thick at one end and thin at the other; used to split wood (5).



PPYOL

ROCAL

LREAP

GAATE

LYBRE

Jumble

Unscramble the letters to get five ordinary English words. Fill them in the boxes above. Make a word with the circled letters and guess the answer to the puzzle below.

The branch of mathematics coming from the name of the book **Hidab al-jabr wal-muqubala** *by al-Khowarizmi.*

Ans: _ _ _ _ _ _ _ .

Send in your answers to JM at the address given in the magazine. Don't forget to write in your name and address.

Solutions to January-February issue's Activities

Boggle'd
Possible words are else, ire, isle, leisure, lest, let, lie, lies, list, rest, resty, rile, riles, rise, ruse, rust, rusty, set, sir, sire, sty, sure, surety, terse, tries, use, yes, yester, yet.
Alas. No-one sent in solutions to Boggle'd. Try out the one in this issue: it's a great way to improve your visual skills.

CrossWord
Across
4. Venus 5. Pluto 6. Mars 8. Earth 9. Mercury 11. Jupiter 12. Uranus
Down
1. Comets 2. Neptune 3. Sun 7. Asteroids 10. Saturn

Jumble
1. SPRING 2. WINTER 3. SUMMER 4. AUTUMN 5. SEASON
Neil Armstrong, Buzz Aldrin, Michael Collins.
Ans: ASTRONAUTS .

Sudoku

EASY

6	3	5	2	1	4
2	1	4	5	3	6
4	5	3	1	6	2
1	6	2	4	5	3
5	4	6	3	2	1
3	2	1	6	4	5

MEDIUM

4	1	2	3	5	6
6	3	5	1	4	2
5	4	3	2	6	1
2	6	1	4	3	5
3	2	6	5	1	4
1	5	4	6	2	3

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The Copper Pod or The Yellow Flame Tree

This tree is widely grown in tropical regions as an ornamental tree particularly in India, Bangladesh, Thailand, Australia, Pakistan, Nigeria, etc. Its natural habitat is actually the teak forests of Java in Indonesia but it is grown all over because of its beauty.

In India, these trees have been planted alternately with the red-flowering G**ulmohar** tree as a road-side tree. Its official name is ***Peltophorum Pterocarpum*** and it is also called the yellow Gulmohur and the rusty shield bearer.

Like the Gulmohar to look at, the copper pod has a much smoother bark and its leaves are similar too, with several “leaflets” on a leaf, and bigger too (each leaflet is oval and about 1-2 cm long). The easiest way to spot it is to look for the tell-tale yellow-gold carpet made by its copiously falling yellow flowers. Walking on such a carpet gives you that really royal feeling. Contrasting with the red Gulmohar, these red and yellow colours brighten up our roads in summer, though, unlike the Gulmohar, its leaves do not all fall off when it is in bloom.

The flowering season begins at the end of February and reaches its peak in the middle of April so look out for it now.

The flowers are bright yellow coloured, with several clustered together at the end of branches. The wrinkled-looking flowers in fact fall off the trees when they are still fresh and account for the amazing colour of the “carpet”.

Trees begin to flower after about four years. The fruit is a seed pod 5-10 cm long and 2.5 cm broad, containing one to four seeds. The large pods are very visible since they remain on the tree till the next flowering season which can even be in September. In most cities in India, this tree bears flowers throughout the year, although not in such copious amounts. In colour, the pods are a rich coppery-red or rusty brown gold when young, maturing to a full copper colour and finally turning black. This gives them their name ‘copper pod.’

The bark of the tree has medicinal uses as a tonic or an astringent to cure or relieve liver and intestinal disorders, sprains, bruises and swellings or as a lotion for eye infections, muscular pains and sores.

The root, on the other hand, is traditionally used in sickness during pregnancy and also in treating tuberculosis. The tree itself traps dust and suspended particles; hence their popularity as avenue trees that line busy city roads.

These trees are not only excellent shade providers but are also home to many birds and animals such as golden orioles, coppersmith barbers, spotted doves, mynas, squirrels, bats and lizards. Can you spot the squirrel in the picture?! The pollen and nectar attract bees and insects in turn attract insectivorous birds. However, the pollen can cause allergic disorders in sensitive patients.

– Based on several sources