Wouter & Michael's Solo Newsletter
Monday 10 Jan 2022

What's On

Coming Up

Tue 1 Feb Chinese New Year

The News This Week

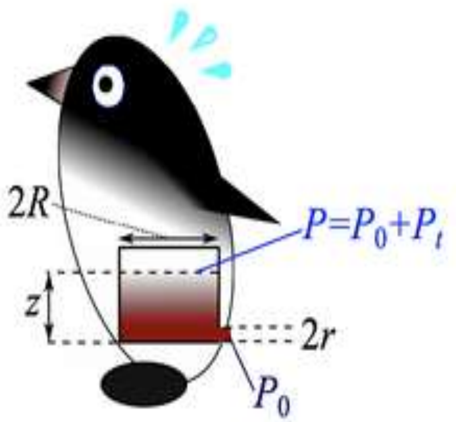
Penguin Poop Bombs

If the Olympics awarded medals for long-distance pooping, penguins would take home the gold.

When penguins are pooping, you'd better stand back

These tubby, aquatic birds can squirt arcing jets of poop to distances nearly twice their own body length, and scientists recently calculated just how much force their tiny rectums produce in order to do so - and how far the poop can fly.

Over a decade ago, scientists had explored the pressure needed for chinstrap and Adelie penguins to expel poop along a mostly horizontal path, which they identified as penguins' most common poop direction. For a new study, which appeared on the preprint site arXiv on July 2 and has not been peer-reviewed, another team of researchers analyzed a different fecal trajectory in Humboldt penguins (*Spheniscus humboldti*), which often poop in a descending arc away from their nests on higher ground.



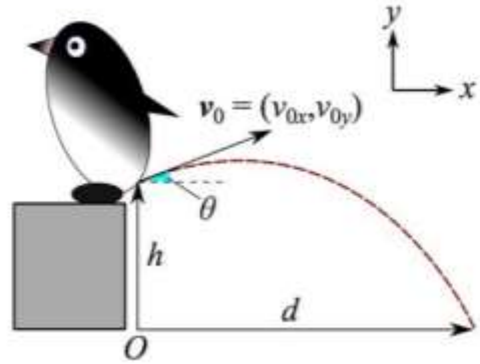
The team of scientists who first addressed the penguin poo puzzle published their results in 2003, in the journal Polar Biology; that pioneering study won the authors an Ig Nobel Prize in 2005 for fluid dynamics. When a new team of researchers revisited the question, they expanded on the earlier results by recalculating internal pressures inside the penguin's gut and rectum, correcting for viscosity of the poo, and factoring in air resistance along an arcing trajectory. They then discovered that the forces at work were even more extreme than previously suggested.

To estimate penguins' pooping prowess, researchers examined variables such as stomach pressure (P = P0+Pt), atmospheric pressure (P0 = 1013 hPa) and rectal pressure (Pt).

Pressure is measured in units called kilopascals (kPa), where 1 kPa is 1,000 newtons per square meter. In the new study, the scientists calculated that the pressure generated in the rectums of pooping penguins was as much as 28.2 kPa - about 1.4 times the estimate in the 2003 study. "I was surprised by the extremely strong penguin's rectal pressure," said lead study author Hiroyuki Tajima, an assistant professor in the Department of Natural Science at Kochi University in Japan.
Though Humboldt penguins stand only 71 centimeters tall, the scientists discovered that the birds can generate enough poo-propelling energy to send fecal bombs flying at speeds of nearly 8 km/h, landing up to 134 cm away. This achievement would be comparable to an adult human shooting their feces to a distance of more than 3 meters, said Tajima.

Victor Benno Meyer-Rochow, lead author of the 2003 study, declared that he was "very pleased that other researchers have taken up our ideas to look into penguin pooping," according to Improbable Research, the humorous science organization that awarded Benno Meyer-Rochow the 2005 Ig Nobel Prize.

The new study described the penguins expelling a fecal arc that curved upward before descending, which Benno Meyer-Rochow and his colleague had not seen in Adélie penguins. Nevertheless, "it is of course possible that either we missed that or that these penguins sometimes do that when they stand on an uneven rock and/or bend forward more than what we had observed," Benno Meyer-Rochow told Improbable Research. Birds that eat meat or fish typically poop with more force than seed-eaters, likely because their waste contains higher amounts of irritating uric acid, Benno Meyer-Rochow wrote in a 2019 blog post.



The physics of penguin pooping

While blasting poop jets helps penguins keep their nests tidy, their high-pressure pooping poses an occupational hazard for penguin caregivers in zoos and aquariums, the study authors reported. Their findings therefore have a practical side: helping wildlife experts who care for penguins to establish a foolproof safety zone, so they can keep well out of range during the birds' explosive bathroom breaks, Tajima said.

5 Seriously Mind-Boggling Math Facts

Mathematics is one of the only areas of knowledge that can objectively be described as "true," because its theorems are derived from pure logic. And yet, at the same time, those theorems are often extremely strange and counter-intuitive. Some people find math boring. As these examples show, it's anything but.

torus ring (Image credit: public domain)

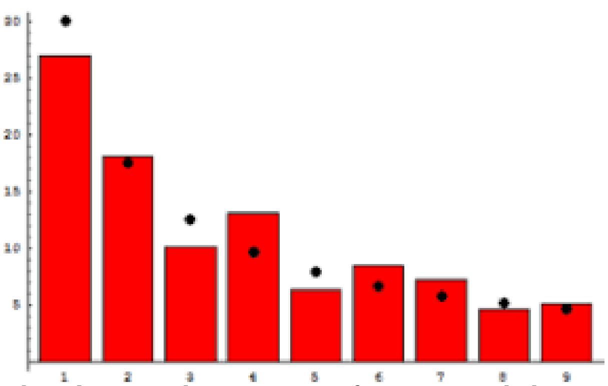


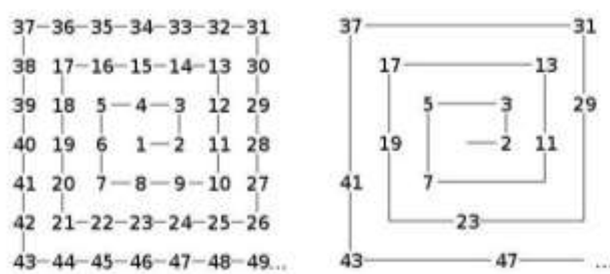
Chart depicting the percentage of countries with the corresponding digit as the first digit of their population (red bars). Black points indicate what is predicted by Benford's law.

1. **Random Patterns**

Weirdly, random data isn't actually all that random. In a given list of numbers representing anything from stock prices to city populations to the heights of buildings to the lengths of rivers, about 30 percent of the numbers will begin with the digit 1. Less of them will begin with 2, even less with 3, and so on, until only one number in twenty will begin with a 9. The bigger the data set, and the more orders of magnitude it spans, the more strongly this pattern emerges.

2. **Prime Spirals**

Because prime numbers are indivisible (except by 1 and themselves), and because all other numbers can be written as multiples of them, they are often regarded as the atom" of the math world. Despite their importance, the distribution of prime numbers among the integers is still a mystery. There is no pattern dictating which numbers will be prime or how far apart successive primes will be.



An Ulam spiral

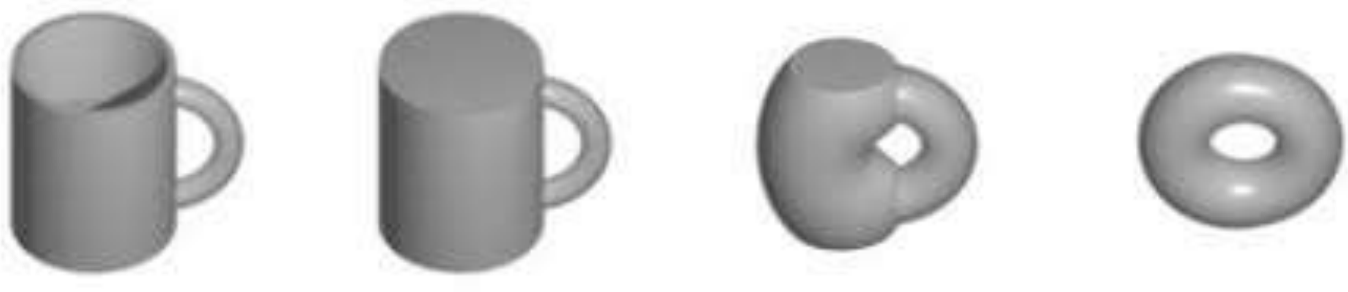
The seeming randomness of the primes makes the pattern found in "Ulam spirals" very strange indeed. In 1963, the mathematician Stanislaw Ulam noticed an odd pattern while doodling in his notebook during a presentation: When integers are written in a spiral, prime numbers always seem to fall along diagonal lines. This in itself wasn't so surprising, because all prime numbers except for the number 2 are odd, and diagonal lines in integer spirals are alternately odd and even.

Much more startling was the tendency of prime numbers to lie on *some* diagonals more than others - and this happens regardless of whether you start with 1 in the middle, or any other number. Even when you zoom out to a much larger scale, as in the plot of hundreds of numbers below, you can see clear diagonal lines of primes (black dots), with some lines stronger than others. There are mathematical conjectures as to why this prime pattern emerges, but nothing has been proven.

3. Sphere Eversion

In an important field of mathematics called topology, two objects are considered to be equivalent, or homeomorphic, if one can be morphed into the other by simply twisting and stretching its surface; they are different if you have to cut or crease the surface of one to reshape it into the form of the other.

Consider, for example, a torus - the dougnut-shape object shown here. If you turn it upright, widen one side and indent the top of that side, you then have a cylindrical object with a handle. Thus, a classic math joke is to say that topologists can't tell their doughnuts from their coffee cups.



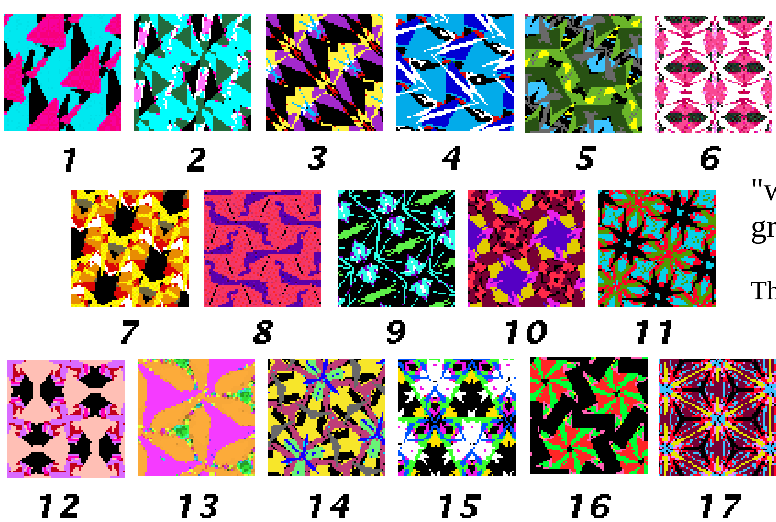
A mug turning into a donut

On the other hand, Moebius bands - loops with a single twist in them - are not homeomorphic with twist-free loops (cylinders), because you can't take the twist out of a Moebius band without cutting it, flipping over one of the edges, and reattaching.

Topologists long wondered: Is a sphere homeomorphic with the inside-out version of itself? In other words, can you turn a sphere inside out? At first it seems impossible, because you aren't allowed to poke a hole in the sphere and pull out the inside. But in fact, "sphere eversion," as it's called, *is* possible. Incredibly, the topologist Bernard Morin, a key developer of the complex method of sphere eversion, was blind.

4. Wallpaper Maths

Though they may be decorated with an infinite variety of flourishes, mathematically speaking, there's just a finite number of distinct geometric patterns.



All Escher paintings, wallpapers, tile designs and indeed all two-dimensional, repeating arrangements of shapes can be identified as belonging to one or another of the so-called "wallpaper groups." And how many wallpaper groups are there? Exactly 17.

The 17 different wallpaper designs

5. The Sonnet

"Like a Shakespearean sonnet that captures the very essence of love, or a painting that brings out the beauty of the human form that is far more than just skin deep, Euler's Equation reaches down into the very depths of existence." Stanford mathematician Keith Devlin wrote these words about the equation in a 2002 essay called "The Most

Beautiful Equation." But why is Euler's formula so breath-taking? And what does it even mean?

$$e^{i\pi}+1=0$$

Euler's Equation

First, the letter "e" represents an irrational number (with unending digits) that begins 2.71828... Discovered in the context of continuously compounded interest, it governs the rate of exponential growth, from that of insect populations to the accumulation of interest to radioactive decay. In math, the number exhibits some very surprising properties, such as - to use math terminology - being equal to the sum of the inverse of all factorials from 0 to infinity. Indeed, the constant "e" pervades math, appearing seemingly from nowhere in a vast number of important equations.

Next, "i" represents the so-called imaginary number: the square root of negative 1. It is thus called because, in reality, there is no number which can be multiplied by itself to produce a negative number (and so negative numbers have no real square roots). But in math, there are many situations where one is forced to take the square root of a negative. The letter "i" is therefore used as a sort of stand-in to mark places where this was done.

Pi, the ratio of a circle's circumference to its diameter, is one of the best-loved and most interesting numbers in math. Like "e," it seems to suddenly arise in a huge number of math and physics formulas.

A bit of mathematical magic

Putting it all together, the constant "e" raised to the power of the imaginary "i" multiplied by pi equals -1. And, as seen in Euler's equation, adding 1 to that gives 0. It seems almost unbelievable that all these strange numbers - and even one that isn't real - would combine so simply. But it's a proven fact.

Rewards For Getting This Far

Quote: “Love is composed of a single soul inhabiting two bodies.” – Greek philosopher Aristotle

Thought for the week: Sex on television can’t hurt unless you fall off.

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