A Cultural Paradox: Fun in Mathematics

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by

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CH 1: Introduction *or why did I write this*?

So, as an unabashed science and technology aficionado, simply a love for discussing mathematics propelled me to formulate this book, mostly written over a few week span in late 2009, followed by several plodding months of refinement with the help of a few thoughtful people.

I have long appreciated the objective nature of science and been amazed at how much it has wrought for the inhabitants of this little rock we fondly call Earth. I seem to repeatedly find myself reminded of the pure chances of being born in this era and how awesome it is to be involved in science in such a time. I am of the belief that mathematics is the underlying "software" that powers the "hardware" that we live in, namely planet earth and of course the greater cosmos. It seems to me that there is a close relationship between the level of sophistication that a civilization possesses and the degree of mathematics that a civilization grasps. I would say that math is powerful, intriguing, and intensely relevant to all of our lives.

I think it is worth stressing that this is obviously not intended as an in-depth look at any of the subjects contained herein. *Therefore, think of each chapter as a brief conversation on a topic and if you would like more detail; I encourage you to visit your local friend/bookstore/internet.* This book is merely meant as a brief reflection on what I consider some of the most interesting and powerful ideas that swirl around in the mathematics community today. Really, this book represents my musings on early 21st century recreational math(s). There are countless other topics and areas of mathematics that can be addressed. The topics in this book are the ones that are simply on my radar right now and that are mostly tied into popular culture.

Naturally, this book is classified as Non– Fiction, and therefore all ideas are presumed to be fact, so while I have tried my best to be accurate, I must take responsibility for any subsequent errors found. I sincerely hope that these topics prove to be as interesting and surprising to you as they are to me. Thank you for reading.

A shameless plug to visit lovemathematics.com

CH 2: Picking a Winner is as Easy as 1, 2, 3.

Considering all the problems covered in this book, the Monty Hall Problem has to be one of the most strikingly confounding ones and therefore it is an apropos first topic for discussion. The Monty Hall problem is a great example of how mathematics can sometimes be counter-intuitive to common sense. It is so named for the game show host, Monty Hall, who actually featured this problem on a real live game show.

This problem deals with probabilities. The typical set up involves three doors. The contestant (i.e. you) is told that behind two of the doors are two undesirable prizes, let's say a desktop computer running a 20th century operating system and with minimum RAM. Behind the third door is a really desirable prize, say the Nissan GT-R sports car. Monty starts by asking which door you believe the Nissan is behind. You say Door One, joking that there can be only one prize. He then surprises you by opening Door Two revealing a giant clunky outdated computer. The audience lets out a gasp as Monty turns to you and asks whether you would like to switch to Door Three.

Now the question to you is whether you would increase your odds of winning that prized car by switching from Door One to Door Three. Most people incorrectly assume that both Door One and Three have the same probabilities of revealing the car. In actual fact, switching from Door One to Three is a wise move. You go from having a 1/3 chance of finding the car in Door 1 to a ⅔ chance

of finding the car with Door 3! Why, pray tell? Well, when you first were asked to pick a door, all three doors had the same chance of revealing the car. That means whichever door you chose, One, Two or Three, you have a guaranteed ⅓ chance of

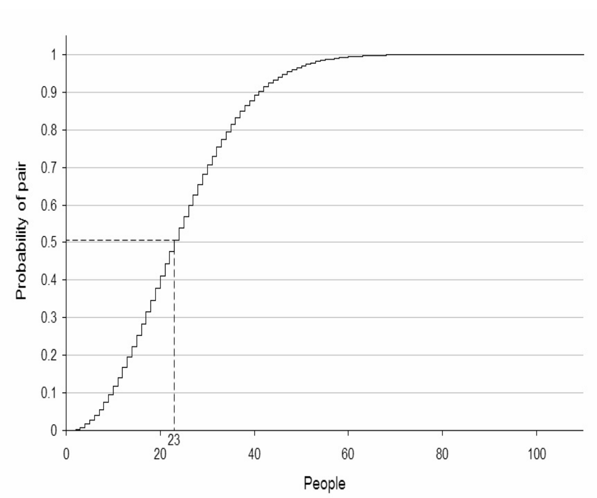
getting the right door. Now, when Monty opened the surprise door, Door Two, and eliminated that door as an option for containing the car, you now are contending with only two doors where you are guaranteed to find the car. But as we just said before, your door, number one, is a ⅓ probability of being the correct door. Now, since we know that there is a 100% chance of it being either Door One or Door Three, and since we also know that Door One represents ⅓ of that probability, then we know that now that we only have one other door, Door Three, the remaining ⅔ must belong entirely to Door Three. So essentially, by revealing Door Two, we increased the probability of finding the prize behind the door you did not choose, Door Three. Now, it is fair to say that this is a rather counter-intuitive result, wouldn't you agree?

CH 3: That's my Birthday!

So, this chapter is about a well-known phenomenon called the “Birthday Paradox” but in reality it is not so much a paradox as it is an unexpected resulting probability of a given event. Let me explain. The idea here is that you are given 23 totally random people. (Segue into randomness in chapter 26.) You are reminded that of course there are 365 different days on which you can call your birthday; the leap year would count as .25 of a day, occurring once every four years. You are then asked what percentage chance, say 0-100%, that any two of these 23 people maintain the same birthday.

The truth is that there is a slightly better than 50% chance of there being two people with the same birthday. This means the chances are a bit better then guessing on the flip of a coin. Additionally, if you were to have a relatively paltry 57 people to test the experiment, you have the surprising guarantee of more than 99% certainty of matching two birthdays.

This fact is true because every person's birthday is being compared with everyone else's birthday. This means that if you were to create unique pairs of people from the 23 people, you can obtain 253 different pairs of people. By considering the group of 23 people in terms of the numbers of unique pairs, 253, rather than the number of individuals, 23, the result becomes less surprising. The mathematics involved does assume a perfect distribution of birthdays, meaning any given birthday has an equal probability of happening with any other given birthday, and in reality certain birthdays are in fact more common than others. This skew of the distribution of birthdays does not really affect results much when actually attempting the experiment. The math involved in the birthday paradox is a cousin of the pigeonhole principle. In the pigeonhole principle, if you have n pigeons and p holes and $1 < p < n$, then you are assured that at least one of the holes will contain two pigeons. This is the same logic that ensures that if you know someone has three children, you know that at least two of the children are of the same gender.



CH 4: Sizing up Infinity

Most people are well acquainted with the word infinity and know it to mean a never-ending value, whether it happens to be the debut album, Infinite, by the rapper Eminem, or anytime you want to evoke a boundless value or idea.

In order to understand the idea of infinity strictly in terms of numbers it helps to first consider the notion of a set. In math, a set is a collection of objects, and most often these objects are numbers. We also can have no objects, in which case we call it the empty set. Get at the computer scientist rapper MC Plus+ and his $\varnothing$ crew for more information on that.

We could have a small set like 1,5,9 or an infinite set like 2,4,6,8,10..... where the dots indicate that the numbers go on forever. So, consider the following infinite set, the set of even numbers, or to be more rigorous, any number that divided by two yields an integer value. Speaking of, now let's consider another infinite set, the set of Natural numbers. This set is 1,2,3,4,5... and on we go for infinity. Now that you have an idea of those numbers marching down a never-ending line, consider the set of the Real Numbers. This set includes the set above of all the natural numbers, but also irrational numbers like π and e (Irrational numbers are numbers that cannot be expressed as the ratio of two integers).

Now what is interesting here is how it has been proven that the size of numbers between 0 and 1 of the Real numbers is greater than the entire set of Natural numbers. Part of the way in which infinities are measured has to do with the idea of correspondence or having a partner element in one set with a partner element in another set. Imagine you have two bags filled with marbles but are not sure which bag has more marbles. All that you need to do is take a count as you take out one marble from each bag, and if all the marbles in each bag are emptied simultaneously, then we know there is the same number of marbles in each bag. In this way of establishing correspondence, we do so similarly with the Natural numbers. The result is that there are more Reals than can find matches with the Naturals and thus, the infinity of the Reals is far greater than the infinity of Naturals.

To delve further into the nature of infinity, ask the World Wide Web about Cantors Transfinite Numbers.

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CH 5: I am a Liar

Considering that all the rules behind a language, called axioms in math, are inherently governed with logic, then logical fallacies that appear in our language can ultimately be seen through mathematics. Let us take a careful look at the following sentence: “This statement is false.” What is paradoxical about this is that if indeed you accept the statement's premise, then you are caught in a logical loop whereby accepting its premise you are simultaneously rejecting it, since the statement is claiming to be false. So false = true and true = false. This makes the statement simultaneously true and false at the same time, which is obviously impossible.

Another example of a logical contradiction is called Jourdain's Card Paradox. Imagine a card on which one side is written: "The sentence on the other side of this card is true." On the other side is written: "The sentence on the other side of this card is false." As you can quickly tell, you end up again in a paradoxical logical loop.

One final conundrum to consider is a card with the following three sentences printed:

1. This sentence contains five words.

2. This sentence contains eight words.

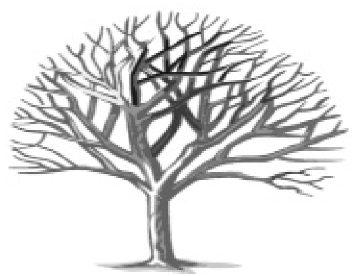
3. Exactly one sentence on this card is true.

CH 6: Gratuitous Mathematical Hype

It can become confusing in this hyper-speed, information-overload world of ours to make heads and tails of science and in particular how everything in science is related to one another. In order to assuage this confusion, consider the following visual approach to clarify science. A tree represents all of science, where the trunk is math, and its largest branch is physics, its largest branch off that is chemistry, then biology, and finally psychology.

Now, physics is the science of using math to explain the world around us and therefore physics is really applied math. While there will forever exist some degree of dispute over which majors in college are the most challenging and difficult, an important point to remember is simply that the most pure and pervasive science is mathematics.

You could also replace the tree metaphor with a series of ever smaller concentric circles, with math being the outermost circle. Here also is a *faux* inequality: Math > Physics > Chemistry > Biology > Psychology.



CH 7: LOL Math, Math LOL

The spectrum of humor as it relates to mathematics is helpful at revealing some of the underlying concepts and truths behind this language of the universe. It is also simply a chance for a laugh and to poke a little fun. Here are several of my favorite math jokes, culled from my collection of math humor books. You can find a bibliography of said books at MATHEMATICSHUMOR.COM if you are interested in tracking down more math humor, and really, who wouldn't? OK, on second thought, please don't answer that question.

Why was the number 6 afraid of its consecutive integer 7? Because 7 8 9.

5q + 5q = ? You are welcome.

There are three kinds of people in the world, those who can count and those who can't.

Did you know that 5 out of every 4 people have a problem with fractions?

Why does 2L - 2L say Christmas?

Noel!

In order to do well in geometry it helps to know all the angles.

The angles that get all the attention are always the acute ones.

What did the number zero say to the number eight? "Very nice belt!"

The number seven is interesting as it is the only odd number that can easily be made even. How?

Seven - s = even

Don't give your math book a hard time; it has its own problems.

Why is the presence of two doctors a strange occurrence? Because it represents a paradox.

What did the little seedling finally say when he was a full-grown tree? G-E-O-M-E-T-R-Y

There are 10 types of people in this world, those that understand binary and those that do not.

If a mathematician ever opens a gin distillery, the product will be called the OriGin.

The mathematician’s favorite part of the newspaper has to be the conic section.

If you are against the metric system then you really are just a de-*feat*-ist.

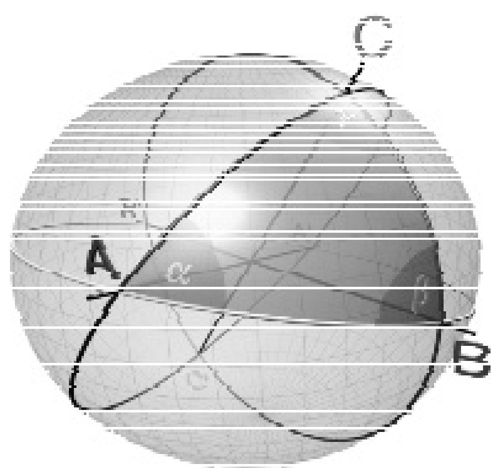
A father said to his son as he looked over his math homework, "Are school teachers STILL looking for the lowest common denominator?"

Why are the numbers 1-12 good security? Because they are always on the watch.

CH 8: In Addition to High School Geometry

For those of you who have made it through high school geometry, terms like π (Chapter 17), acute, obtuse, parallel and perpendicular probably sound familiar. One of the central tenants of high school geometry states that the angle sum of any triangle, also known as a 3-gon, must *always* equal 180 degrees. The truth is that in many situations these so called triangles can actually have more or less than 180 degrees. This is due to the fact that high school geometry does not always explain that there are different types of geometric systems.

High school geometry is formally called Euclidean geometry and refers to the geometry we see with modern architecture, and most man-made creations. In nature, however, geometry doesn't always follow such a precise script. For most of human history, it was assumed that Euclidean Geometry was absolute; there was nothing else to even consider. However, in the past few centuries, we have come to realize there are other geometries that can accurately describe physical space. Two of the most common Non-Euclidean types are called Hyperbolic and Elliptic Geometries. The way in which these geometries differ is in the modification of a central tenant of Euclidean geometry, the Parallel Postulate. The reality is that in other geometries parallel lines simply do not exist. Part of this reason is that Euclidean geometry is modeled on the notion of a flat plane. For example, when you consider the Earth, a sphere, we have another geometry to describe its surface, Elliptic, and where the sum of the angles of a triangle on such a surface will exceed 180 degrees.



The 3rd Rock from the Sun is Non-Euclidean

CH 9: Abstraction is for the Birds

The next time you hear someone spout how they are unable to do math, that they lack the "gene", remind them that mathematical thoughts are ingrained in all humans, in fact, in all animals. Still, it took humanity quite a bit of time to get some math problems worked out, the Sumerians invented numbers in 8000 BC and the Greeks made mathematics a centerpiece of their civilization in 600 BC. Today of course, mathematics has been harnessed to an unparalleled level, as is readily evident by our modern society. While it is true that not everyone walking around are doing long division or triple integral problems in their heads, we are indeed a very spatially oriented species. This means we are all constantly automatically calculating distances, comparing values and doing a great deal of applied math as it relates to our three dimensional surroundings.

We are also continuously discovering new ways animals are able to use their own forms of math to survive and adapt to their surroundings. Before we consider an example, let's begin with some perspective. The likely silver medalist for intelligence on this planet of ours, the chimpanzees, can through intense training, attain the skills of….drum roll please....a human two- year-old. So without any surprise, as far as we know of the animal kingdom to date, no animal is able to abstract and create symbolic language for mathematics anywhere near a human level.

Nevertheless, we are constantly learning of how animals are able to adapt to their surroundings through the use of mathematical principles. Consider the crow’s logical problem solving ability. In an experiment, a container of water is placed in the crow’s environment. The level of the water is intentionally made too low for the crow to access for a drink. What is amazing is the crows have repeatedly demonstrated an ability to use rocks that were placed in their environment to forcibly raise the water level, thus giving them access to a drink.

Schools of fish and birds who migrate great distances are actually using the positioning of stars in part to show them the way, and while they are not using conventional math as we might know it, there are indeed mathematical principles that are hard at work.

Get at the cartoonist Dave Blazek for more information on Calculus-trained dogs.

A Stingray probably doing Algebra

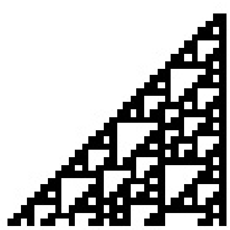
CH 10: NKS: Anti-Establishment as Establishment

In a time of cloning, genome mapping, and rovers on mars, it is not terribly surprising that there would be developments that will likely challenge our concepts and cultural artifacts as it relates to science. One of the most developed and awe-inspiring works comes from one man, the uber-scientist Stephen Wolfram. He has proposed a far more digital approach to science and one that would completely reposition all our sciences and even how we discover new truths if it proves correct, it is simply titled a New Kind of Science (NKS).

I wonder out loud how much NKS is motivated by the notion of viewing information in terms of the “fourth paradigm”. These are ideas put forth by notable computer scientist, Jim Gray. The “fourth paradigm” proposes that scientific breakthroughs of the future will be increasingly based on computational models as opposed to the more experimental models that have powered progress thus far.

A New Kind of Science is the idea that the behavior of very simple cellular automata can actually tell us all we need to know about the world around us. This science is only possible now because it requires the horsepower of the digital world to process and simulate the results that occur. The main thrust of his premise is that from very few and even very simple rules for any given system, incredibly complex, unexpected and marvelous results can occur. For example, all the flight patterns of all birds in all flocks everywhere are governed by three simple rules: Separation, Alignment and Cohesion. This example illustrates the idea that it takes very few initial conditions to create enormous complexity. The implication of these notions on complexity is to reconsider how we approach science and solve problems. We can use the digital world to run simulations for different scientific scenarios and actually in the process learn about different models of the universe and ways to even create life.

So regardless of how much of a restructuring occurs in science over NKS, I think it is safe to say revolutionary ideas and applications will result. Want proof? Check out Wolfram Alpha, in Chapter 54, it is the first “app” derived from NKS.



Got 256 Rules, here is the 110th One

CH 11: 42% of Statistics are Made up

In our media and culture, the bandying about of statistics to compel in arguments is a very common practice. Whether it is a politician trying to convince his electorate, or a talking head trying to make their point, we are constantly inundated with statistics aimed at quantifying the world around us. The truth is that too often statistics are misleading and misinterpreted.

Let’s consider a few examples. There are "shooting the barn" statistics, where you collect data without first determining the results you seek. It gets its name from the metaphor of someone shooting a bunch of arrows into the side of a barn and then circling the area with the most arrows and deeming that the target, a classic case of putting the cart before the horse.

Another flawed approach is Sample Trashing, when perfectly good data is thrown out because it does not conform to what is trying to be proven. It is common for purported psychics to use this approach to throw out all their mistakes while highlighting anything they happen to get correct.

There is also the Statistical Brick Wall, where the numbers in use cannot be verified because the statistical data does not even exist! A great example of this fallacy in play is when scientists predict the annual number of species that go extinct each year. The number is always arbitrarily high because the scientists are taking into account all the species that humans have not discovered yet, which clearly is a number that cannot be verified.

We also need to avoid the condition of “average thinking” where someone thinks if you flip a coin ten times and it comes up heads nine of those times that somehow the next flip should be higher than 50% to obtain tails. There are also examples of very misleading use of numbers, like when a company says their product is "99.44% pure", in some cases this is simply a trademarked phrase and not a mathematical fact.

In very close elections, it is actually possible to create scenarios in which either candidate is the winner. This is why it is so important to decide how votes are counted and how a winner is decided before the election.

$$2+2=5$$

If everyone believes in it, does that make it true?

CH 12: Undercover Mathematicians

While there appears to be some degree of belief that many of the people under bright lights are vapid and devoid of geek credibility, there are in fact many examples of people in the entertainment field that excel also in the Real number field. OK, that was a silly math joke but let’s take a look now and recognize some of the mathematically nerdcore famous people.

1. Danica McKellar played Winnie Cooper on the classic television show the Wonder Years, and also obtained an undergraduate degree in mathematics from UCLA and found time to write a few well- received math books aimed at teenage girls. She is a great example of the supposedly elusive beauty and brains. Ask Maxim or Stuff magazine for more information.

10. David Robinson, one of the greatest players ever to tie up their shoelaces for the NBA, also scored a 1320 on the SAT and then went to the United States Naval Academy to get a degree in mathematics.

11. Art Garfunkel, half of the legendary duo, Simon &, has a Masters in Mathematics from Columbia University.

100. Who says tough guys can't be smart? Daniel Grimaldi, a cast member from the hit show, the Sopranos, holds a bachelors degree in mathematics from Fordham, a masters in operations research from NYU, and a PhD in data processing from the City University of New York. In fact, as of this writing, he teaches in a college in Brooklyn.

101. Brian May, the lead guitarist for the rock band Queen, first graduated with honors from Imperial College London with degrees in mathematics and physics. More than 30 years later, he finished his research and obtained a PhD in Physics. That is one persistent chap!

110. David Dinkins is the first African American Mayor of New York, and perhaps not surprisingly has a degree, with honors, in mathematics from Howard University.

111. Tom Lehrer, the revered songwriter and parodist, is also brilliant, earning a degree in mathematics from Harvard at 18, and then followed it up with a Masters a year later.

1000. Frank Ryan led the Cleveland Browns to a NFL championship in 1964 but perhaps should be better remembered for being the only player in NFL history to hold a PhD in mathematics, from Rice University.

1001. Paul Wolfowitz has been a Deputy Secretary of Defense and President of the World Bank but started with a bachelor of mathematics from Cornell.

1010. Angela Merkel is the first female Chancellor of Germany, speaks fluent Russian, but first studied Physics at the University of Leipzig.

1011. James Harris Simons is one of the most successful hedge fund managers ever, and subsequently one of America’s richest citizens. The Financial Times has called him the “smartest billionaire” and before he ever made any money, he was getting degrees from MIT and Berkeley in mathematics.

1100. Bram Stoker, the author of the classic horror novel Dracula, first scared people by earning a degree in mathematics with honors from Trinity College in Dublin, Ireland.

1101. William Perry served as the United States Secretary of Defense under Bill Clinton. Before that he was getting a PhD in mathematics from Pennsylvania State University.

1110. Paul Verhoeven has helmed classic Hollywood movies like Total Recall, Basic Instinct and Robocop. He also is a math and physics whiz with degrees from the University of Leiden in the Netherlands.

1111. Larry Gonick is a well-respected cartoonist, who received an MA in mathematics from Harvard.

10000. Masi Oka, Hiro on the television show Heroes, is a hero to math nerds, doubled majoring in math and computer science at Brown.

10001. Felicia Day, the American actress known for her work on Buffy the Vampire Slayer, home- schooled her way to the University of Texas at Austin to double major in music performance and you guessed it, mathematics.

Honorable Mentions:

Wil Wheaton of Star Trek: The Next Generation is a pioneer on the Internet with major computer geek cred. Bill Nye the science guy is a mechanical engineer and can even boast at having had Carl Sagan as a professor. Phil Bredesen, Governor of Tennessee, has a degree in Physics from Harvard. Lisa Kudrow has an Emmy award for her acting and a biology degree from Vassar. Rowan Atkinson, aka Mr. Bean, has a masters in engineering from Oxford. Hustle and Flow's Terrance Howard is a chemical engineering degree holder from Pratt University. Frank Capra, the acclaimed director, was a Caltech graduate. Herbie Hancock is a bona fide electrical engineer. Montel Williams the talk show host is also an engineer. Tom Scholz, lead singer of Boston is an MIT grad.

Dexter Holland, lead singer for the Offspring, has a bachelors and masters in molecular biology from USC. Dylan Bruno, who plays Colby on Numb3rs, has a degree in environmental engineering from MIT. Greg Graffin formed Bad Religion and also managed a PhD in Biology from Cornell. Weird Al Yankovic has a degree in architecture from California Polytechnic State University at San Luis Obispo. Mayim Bialik, the star of the television show Blossom, holds a PhD in Neuroscience.

Rumored to be an undercover Mathematician’s Car

CH 13: I Will Never Use This

One of the most common phrases that a math teacher is likely to hear is the classic, "Why are we bothering to learn this, I will never use any of this in real life!" The simple answer to that question is “While a great deal of mathematics you learn may not be explicitly used later in life for most of you, the truth is that you learn it primarily as a means of education to the ends of exercising your brain. This means your brain is better prepared to problem solve, and can you think of any areas in life where problem-solving ability might come in handy?” Besides the mental exercise aspect, it is no small fact that our entire world runs on numbers, applied though it may be. It is the language of the universe, of our cosmos.

Consider the cash register at the local store to the scale in your bathroom to the taxes you do every year to buying some gas to the receipt for anything you purchase to your phone number to your favorite team's sports statistics to weather predictions to how much food to buy for dinner to poker night with your buddies to calculating the tip for the great service in your favorite local restaurant to playing video games to anytime you count, measure, compare values to channel surfing to your address, geographic or digital IP to your watch to the calendar on the wall to ∞ and beyond!

Get at your neighborhood math teacher for more information.

CH 14: Gaussian Copula: $ Implications

It is hard not to be aware, whether you are 8 or 88, that in recent times this great country of ours has suffered some degree of an economic hiccup. Furthermore, like so many things in modern society, the issues surrounding this financial collapse are complicated ones, making it more difficult to hone in on its root cause. According to a lot of people though, we needn't look further than the Gaussian Copula Function for answers.

The copula is a way to measure the behavior of more than two variables and this function was intended to measure complex risks in the financial markets. This function allowed banks to attach a correlation number to many different types of securities. This number can be thought of as a sort of risk barometer. This led to banks taking risks they would simply not normally take. The Gaussian Copula function convinced banks, bond traders, insurance companies, hedge funds and other Wall Street big wigs to assess risk in an altogether risky way. It gave people with tremendous power in the financial world the ability to create correlations between seemingly unrelated events when in fact there was very little of a relationship to be found. This led to credit rating agencies becoming convinced that toxic mortgages were in fact AAA rated. This fuzzy math ignored common sense and the realities of innate instabilities that are present in the financial markets.

Perhaps an important lesson to take away from this economic collapse is that when we foster a society that elevates, appreciates and demands math fluency, we make it harder for this kind of problem to arise in the first place.

Do you know what

$$\Pr[T_a < 1, T_b < 1] = \Phi_2(\Phi^{-1}(F_a(1)), \Phi(F_b(1)), \gamma)$$

really means?

Neither did most of Wall Street.

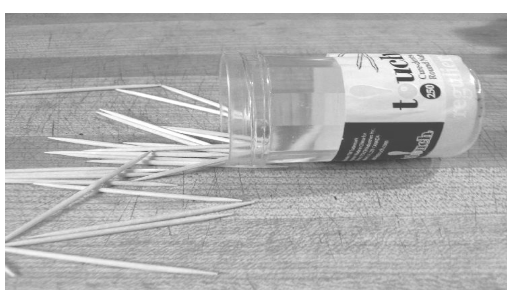
CH 15: A Proven Savant

Many recall the classic scene from Rain Man where Dustin Hoffman's character is able to compute the number of toothpicks that had just fallen to the ground. This notion of incredible calculation or otherwise genius ability is a very profound idea for us humans to ponder. Granted, while only a very small minority of those with autism will have what is termed genius abilities, it is still worth mentioning that some humans are truly capable of extraordinary mathematical feats.

What is worth investigating is how they actually do it and how ordinary folk might similarly tap into these skills in our brains. Consider the high functioning savant, Daniel Tammet. He recited 22,514 digits of π , whose digits do not follow a known pattern, in front of cameras. The prodigious memory of Kim Peek, who could effortlessly recall any content from over 12,000 books he had read. Consider Stephen Wiltshire, who is able to draw a near perfect landscape, needing only a minute to memorize all the intricate details. Tony DeBlois, a blind musician, can play over 8000 songs from memory.

All these examples of brilliance: the ability to multiply huge numbers as quickly as a calculator, to remember and recall anything, to hear and then play music perfectly, to draw incredible detailed renderings that border photo-realistic, to read books in the time it takes to turn the page, these are all "human" abilities. Clearly, there is a different wiring in the brain that cause such skills, but what is incredible is that these all fall within the purview of being human, even if they are exceedingly rare. Future research and investigation might unearth ways and means for the ordinary person to tap into these capabilities. It also begs the question, what other incredible skills do we all have the potential to do? It is from these savants and through scientists we may reveal a future where ordinary people can access amazing abilities.

Speaking of being able to tap into these skill sets, the story of Rudiger Gamm is a rather interesting one. A prodigious human calculator, he is able do complex calculations instantly, but remarkably only gained his abilities in his early twenties. He also does not exhibit Savant traits, indeed it is postulated that he developed his skills through his genetics. If this is true, it could mean that more people will naturally develop "genius abilities" in the future.



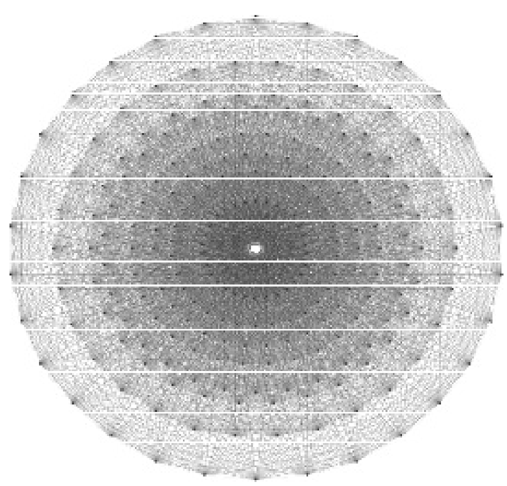
A bunch of Toothpicks

CH 16: History of the TOE and E8

It appears that the most famous genius to have lived, Albert Einstein, actually spent the majority of his professional life frustrated at how to reconcile his powerful theories of Relativity with those of Quantum Mechanics. While his theory was remarkably accurate in describing physics of the very large, his equations could not work in conjunction with physics of the very small. From this mathematical inconsistency, the quest of generations of brilliant scientists has been to determine what physical theory can explain both the large and small. This is referred to as the Holy Grail of physics, a Grand Unified Theory (GUT) or a Theory of Everything (TOE) if you include gravity in the calculations.

For several decades now, despite many concerted attempts, no one has been able to convince the majority of scientists that they have worked out a correct TOE. In the fall of 2007, Garrett Lisi, a PhD in Physics and at the time, a relative outsider and unknown, proposed his “An Exceptionally Simple Theory of Everything”. This is his attempt to solve the elusive TOE and he does so using a decidedly mathematical concept, namely the E8. The E8 is a 248 dimensional construct that is critical in understanding many physical phenomena; in mathematical lingo it is known as a finite case of the simple lie group. E8 is perhaps the most complicated structure known to man and according to Dr. Lisi, might hold the answer to everything. The idea is that space-time, the world in which we live in, is part of E8 and every particle and part of our cosmos can be predicted exactly within this 248 dimensional E8 framework.

Dr. Lisi maintains a realistic and grounded opinion of his work, and the Large Hadron Collider (LHC), the world’s largest particle accelerator could shed light onto the theory through the discovery of a new Higgs particle, which Dr. Lisi's theory predicts exist.

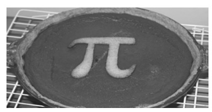


E8 was simplified in the making of this chapter

CH 17: One Heck of a Ratio

π , or Pi, is known by most people as being 3.14. It is also known as the ratio of the circumference of a circle to its diameter. Put another way; consider that every circle, regardless of its size, has a little over three times the distance around the circle compared to a line that bisects the circle into two halves. While this might seem like a rather esoteric mathematical tidbit, it has profound implications and a storied history. For starters, π is likely the most well known ratio ever known by humanity. π is known as a transcendental number which means that we know for a fact (we call such facts mathematical proofs) that the decimal expansion of π is non– terminating and non-repeating. These digits will never end and there is no pattern. We also know that π is an irrational number. This means it is impossible to ever find any two integers that are a ratio of π .

Today, with the power of computers we know more than trillions of digits of π and in fact, memorizing digits of π is a bit of a geek phenomenon, the record is currently held by Akira Haraguchi who managed to memorize 100,000 digits of π . To put that in perspective, imagine trying to memorize a book hundreds of pages long of random numbers.



CH 18: A Real Mathematical Hero

Paul Erdos was a Hungarian mathematician who lived during the twentieth century. He is unique due to the fact that he never maintained a permanent residence, never married, never had kids, shunned worldly possessions and basically lived an entirely nomadic existence. He lived to be 83 years old and was a mathematician from a very early age. While his decision to live such a life probably has earned him a bit of a reputation as an eccentric, it also afforded him the opportunity to spend his long life dedicated entirely to mathematics and in the process become perhaps the most prolific mathematician ever in history as of this writing.

In fact, he has collaborated with so many different mathematicians that the Erdos number was born. This is a number that refers to how many degrees of separation any given mathematician is from working on a math paper with Erdos. So if you are Erdos you maintain the only zero and if you worked with Erdos, you have an Erdos number one and if you worked with someone who worked with Erdos you have an Erdos number of two. This procedure continues, in just the same way that the classic “Six degrees of Kevin Bacon” game works. For more information, see Oracleofbacon.org.

$$\text{Erdos} = \text{Math1337}$$

CH 19: Casinos Heart Math

The modern casino is a truly intense form of applied mathematics at work. All casinos trust on the certainty of math to ensure they are viable businesses with healthy profit margins. From the increasingly sophisticated slot machines to the action one finds at the craps table, all games are mapped and analyzed in order for the casino to establish confidence in being able to make money, aka setting the house odds. What makes casino games differ is the way in which the element of chance figures in each game. There is a great deal of mathematics to analyze behind each game and each reveals interesting consequences.

For example, it is known that certain video poker games, baccarat and the game of craps are considered to be among the best odds in a casino. With craps, not surprisingly there are a great number of rules that one must abide by in order to ensure you have access to those favorable odds. A game that requires far less in terms of learning rules is the game of blackjack. When you play with little errors your odds are just off being a coin toss. An example of an error is not hitting on your 16 when the dealer is showing a face card.

One of the greatest nexuses of mathematics and chance is the card game poker. Poker is a mathematically intense game, and has many examples of surprising results. Consider the chances of getting a royal straight flush in the Texas Hold'em version of poker. There exist only 4 chances out of 2 million plus total permutations. Poker is a game where you want to become as acquainted as possible with the probability of various events occurring. You want to first consider your starting cards and how good they are, part of that decision is also how many players there are, and where you are in the blinds. You then must reevaluate that probability after each event, namely the flop, turn, and river, as well as the number of players. Certain hands, combined with the cards on the table, ensure that you are the winner, in this infrequent and powerful position, the mathematics is complete and it is up your poker persona to extract as much money as possible from the table.

Atlantic City, New Jersey

CH 20: The Man who was Sure About Uncertainty

Kurt Gödel was a very influential logician, mathematician and philosopher in the twentieth century. During Gödel's lifetime, there was a major attempt by the scientific community to completely determine all the laws that govern mathematics. This was a half-century of concerted efforts to figure out all the potential rules; in math we call them axioms, which form the foundations of mathematics.

His genius and breakthrough was in realizing that the system of mathematics, while consistent, cannot ever be made complete. Furthermore, consistencies in the theory cannot be proven within the theory itself. This was called the Incompleteness Theorem and had profound implications for the philosophy of mathematics. From a philosophical, although not a mathematical standpoint, it may mean that we can never know for sure if anything is truly correct or not in math. This also might portend that a Theory of Everything is seemingly elusive.

Probably a picture of Kurt Gödel

CH 21: We Eat This Stuff Up

When you talk about cooking, baking and anything to do with food preparation, you don't have to go far until you run into the world of mathematics. Cooking is really a combination of art and science, the art part being that so much of enjoying food is a subjective experience. However, whenever you use a recipe, you are using precise measurements to ensure you get the result you seek. In addition, the length of time, the temperature, the number of ingredients, and a whole host of other details, are all based on simple math in order to create any desired result.

On a somewhat related note, did you know that you cannot physically break a piece of uncooked spaghetti in half! No matter how often or hard you try, you are guaranteed to always result in at least three pieces, as you bend the spaghetti waves of vibration are created that travel along the pasta and then are released. The math behind this phenomenon is actually being studied to enhance the sturdiness of bridges and buildings.

Give me a break

CH 22: Do I Have a Question for you!

A realistic attempt to isolate the most difficult problems in mathematics and then offer a bona fide $1 million dollar prize is certainly worth mentioning. Fame and fortune thus await those super clever individuals who can crack these most challenging and relevant of mathematical puzzles, dubbed the Millennium Prizes. It appears that in many respects, and these problems attest to this fact, the field of mathematics is still wide open and unexplored. Here are the seven Millennium Prize Problems in abbreviated and lay terms.

1. *P vs NP (exponential time).* This is perhaps the most important question in theoretical computer science. The riddle is whether a computer that can verify a solution in a certain time frame can also find a solution in a certain time frame. Are there questions that would take infinite time to solve with infinite computational resources?

2. *Hodge Conjecture.* This problem deals with investigating the shapes of complicated objects. This process of cataloging different shapes has become a powerful tool for mathematicians over the years. However, some of the underlying geometry has become obscured and the Hodge conjecture could fill in the missing geometric pieces. It currently remains a major unsolved problem in the field of Algebraic Geometry.

3. *Wavier-Stokes Equations.* Fluid mechanics, which is applied math that deals with the motion of liquids, is immensely useful and effective. The challenge with this problem is to fill in the gaps on these insights, which still remain elusive. This would go a long way to better understanding turbulence, for example.

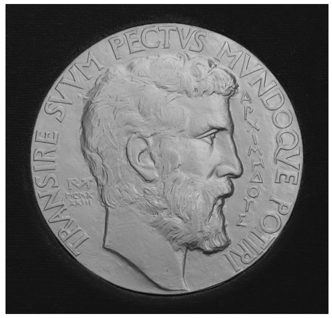
4. *Birch Conjecture.* Consider the equation $x^2 + y^2 = z^2$. Then consider the whole number solutions that might exist for this equation. Now think of more complex equations and finding solutions can become near impossible. The Birch conjecture asserts that in certain complex cases, there *is* information that we can glean about the nature of these solutions.

5. *Riemann Hypothesis.* Perhaps the most technically difficult challenge, it is a deep problem related to number theory, the math that is concerned with the properties of numbers. It would yield answers regarding the distribution of prime numbers, which has profound implications in cryptography.

6. *Yang-Mills Theory.* This deals with physics, and proving that quantum field theory (you probably have heard the term quantum mechanics) is provable in the context of modern mathematical physics.

10. *Poincare Conjecture.* Interestingly, this problem was recently solved. On March 18th, 2010, the Clay Mathematics Institute awarded Grigori Perelman of St. Petersburg, Russia for his work on the Poincare Conjecture. The CMI writes, “It is a major advance in the history of mathematics that will long be remembered.” It should be noted though that Mr. Perelman issued a statement a few months later indicating his displeasure with the mathematics community and his belief that the mathematician, Richard Hamilton, is as deserved of credit, he walks the walk and talks the talk too, he also turned down the $1 million dollar prize.

The Poincare Conjecture deals with Topology, which is the math that is concerned with spatial properties and the solution, which made very adept use of differential equations and geometry, answers a very fundamental question about the shapes that form our cosmos.



Michael Phelps is impressed with this Medal

CH 23: When Nothing is Something

It is rather remarkable to ponder that the mathematical idea and application of zero is relatively new. Only in the 6th century AD do we see the first proof of civilization using the number zero. Prior to that, people struggled working with numbers, particularly very large numbers, as the difference between a number like 15 and a number like 105 would be much harder to establish. Even the mighty Greeks, who held mathematics in high esteem, struggled with the notion of zero. They wrestled with the philosophical idea that nothing could be something, and these became deep religious questions, even many centuries later. In 9th century India we see the first practical use of the number zero, in that it was treated as any other number. Even the ancient Chinese, a civilization rich with sophistication, took until the 13th century to develop an actual symbol for zero.

It is rather easy in our modern society to take for granted the simplicity and necessity of the zero but for much of human civilization; it has been a complex quandary without an obvious solution. The absence of a number is in fact one of the most profound numbers there is.

Slow down, you move too fast

CH 11000: Think Binary

Before we delve into the concept of the binary system, the idea of counting needs to be revisited briefly. Our basic building blocks for composing any number are naturally the digits 0,1,2,3,4,5,6,7,8,9. Every number is comprised of those numbers. Some people believe that we use 10 digits because we *have* 10 digits, namely our fingers and toes. Either way, there is no reason that we have to use 10 digits to count any number. In fact, there is a well-known numeral system at work that is probably in front of your nose every day. This is called the binary system and is used by the digital world. What this means is that *everything* that you see on the screen is actually understood by the computer as values in the binary numeral system.

Binary uses a 0 and a 1 to compute anything. To translate a *regular* number like 17 into binary takes a couple quick steps. First, remember that all numbers in binary are just zeroes and ones. Next, think of binary numbers as having a series of slots, in which each slot is some power of two. The first slot is 2^0, or 1, and then 2^1 or 2, then 2^2 or 4 and so on. For each slot that is a 1, you add that slot's value to all the other slots that have a 1. So first imagine some powers of 2: 64, 32, 16, 8, 4, 2, and 1 (2^0). We can arrive at any number by adding the proper sequence of these numbers. You might be wondering about decimal numbers, they are arrived at in a slightly modified method.

So back to turning 17 into binary, the powers of two needed to sum to 17 are 2^4 and 2^0 . Therefore we arrive at 10001 as being 17. When you see 17 on a computer, the computer understands it as 10001.

The time is now 100110 past 1100 AKA 12:38

CH 25: Your Order Will Take Forever

One interesting area of math deals with something called permutations. This differs from combinations in that order doesn't matter with a combination but order is everything in a permutation. Let’s start with a simple example, the letters J,A,Z. The permutations of the letters J, A and Z are JAZ, JZA, AJZ, AZJ, ZJA, ZAJ. This represents six ways to order three elements. Now it doesn't matter what the elements of the set are, they could be numbers, symbols, or people for that matter. So in our example the way we arrive mathematically at our six ways without having to write out every permutation by hand is to use what is called the factorial, denoted by the “!” symbol. Whenever you attach a “!” to a number it means that to arrive at the value, you have to multiply that number by each subsequent lower integer value until you get to 1. So for 3!, it really is just 3 x 2 x 1 = 6. This means then for a set of four unique letters, the number of permutations is 4! or 4 x 3 x 2 x 1 or 24. What you might be already realizing is that as you go up in the number of elements, the total number of permutations grows very fast.

Let’s consider a situation in which you have ten family members, arranging themselves in a line to take a group photograph. Like many families, an argument ensues and it is agreed that a photograph of every order of the family members should be taken to be fair. Assuming you have a fast camera and that everyone can move and take the next permutation of the family photograph every second, how long will it take to capture every way to take this picture?

Well, from the previous explanation you probably have surmised it is 10! seconds. How much time is this? Well, it is 3,628,800 seconds or 60,480 minutes or 1008 hours or 42 days exactly.

This is also assuming somehow that you never error in duplicating a previous permutation and have endless film. This might be a bit flabbergasting but no less a completely sound result from the realm of permutations.

Only 119 Pictures to go

CH 26: When you Need Randomness in Life

When someone says, “That was random” we generally think of it as an event without any seeming connection to anything. The idea of unpredictability, the lack of a pattern, a process that is not deterministic, these are all traits of the term random. When we think of random numbers we tend to think of numbers that are impossible to predict from whence they came. There are many situations that model this behavior, like those lottery machines that create a fan, and then the lottery balls are randomly pulled out. This works quite well for not being able to determine what numbers will be chosen.

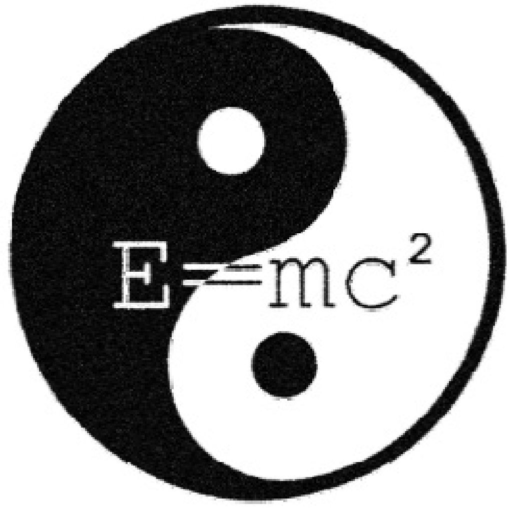
In the digital domain however, that randomness is a bit harder to emulate. In fact, it is so difficult that there is a term called a pseudo- random number, which refers to a number that appears to be random but is in fact not. In cryptography, which is all about how to protect information, it is dangerous to use pseudo-random numbers to protect your data. Since there is a deterministic process to arriving at a pseudo- random number, generally an algorithm, that process can be uncovered and therefore the information stolen. There are, however, random generators, like the Open Source Lavarnd that work by measuring noise and random.org offers *free* random numbers.

Lorem ipsum dolor sit amet, consectetur adipisicing elit, sed do eiusmod tempor incididunt ut

CH 27: $e = mc^2$ Redux

No big surprise, physics is tough, real tough. However, a physics equation might be the most well known equation to the world, with the possible exception of the Pythagorean Theorem. This is Einstein's $e = mc^2$. Its direct translation is that energy, measured in joules, is equal to the mass, measured in kilograms, multiplied by the speed of light squared. Since the speed of light is 186,282 miles per second then we know that even a very small amount of mass will contain a very large amount of energy. One of the first profound results of this formula is that any mass (whether it is an ant or a skyscraper) and energy are just different forms of the same things. This means that energy can be converted into mass and mass can change into energy. When you plug in some values, it is surprising to learn that the amount of energy in something like 30 measly grams of hydrogen is equivalent to thousands of gallons of gasoline. When extra mass suddenly converts as energy, it is called nuclear fission. This is more commonly known as the atomic bomb, which was tangible evidence of the truth and power of $e =mc^2$.

Part of the reason why this is one of the most famous equations of all time is in its simplicity. In mathematics, we are always trying to consolidate as much truth into as compact a form as possible. Mathematicians like to use the adjective *“elegant”* to describe this quality of being very simple and simultaneously very concise. For Einstein to be able to see that energy and mass are two sides of the same coin and to then use math to express this fact, and then do it in such a simple form is an intellectual marvel and the likely reason why you have heard of it before.

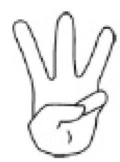


Energy : Mass :: Yin : Yang

CH 28: Quipu to Mathematica

Perhaps an effective method to assess the level of scientific sophistication in a society is to examine the tools they use for mathematics. Many ancient civilizations considered the abacus landmark in allowing people to calculate quickly. The Incan civilization did not have written word but used knots called Quipu to indicate numbers and make computations. The slide rule helped along scientific progress in the twentieth century. In more recent times we can certainly consider software as mathematical tools of the trade. For example, the software Mathematica is able to compute, calculate and solve problems of depth and breadth that would have appeared like alien technology to our ancestors even one generation ago.

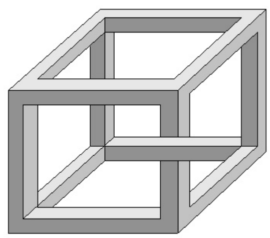
As further evidence of the sophistication of modern tools, scientists at IBM Research Division's Zurich laboratory built the classic math tool, the abacus, except that they did so with the individuals beads each having a diameter of about one nanometer, which is about one millionth of a millimeter. Please ask the World Wide Web about Archimedes for more information.



OCT: Original Counting Technology

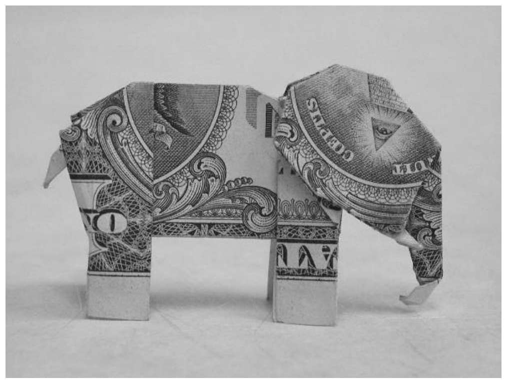
CH 29: Through the Eyes of Escher

It is quite likely that you have seen the work of M.C. Escher at some point. His art is fairly recognizable and typically involves impossible scenarios and tessellations (the tiling of a plane with no overlaps or gaps). He was very skilled at exploring paradoxes of space and geometry. He even wrote a paper on his mathematical approach to his artwork. He was able to bring more dimensions into the 2D of his canvas and explore ideas of infinity in his art, which resulted in very visually surprising effects, such as a river that seems to flow upward. He was an expert at playing with our ideas of perspective, his first print; titled "Still Life and Street" depicts a table with books and items that blend seamlessly in with a street scene. Even though he did not have formal mathematical training as such, he had an incredible intuition about the visual nature of mathematics and the paradoxes that can occur. It is rather surprising that there are not many more examples of similar paradoxical artwork.



CH 30: Origami is Realized Geometry

Origami is the traditional Japanese art of paper folding. It generally requires one piece of paper, and forbids gluing or cutting. It uses a number of folds that combined in different ways create a wide variety of intricate designs. It is a very spatial and geometric art form; perhaps not surprising then it is so popular in a culture that has a very spatial and geometric language and alphabet. Because of origami and geometry's close relationship, a field has evolved, origami sekkei, which is using mathematics to determine and construct new shapes and designs, rather than the trial and error approach of earlier days. It has become a rather rigorous field, with many physicists and scientists proving ever more complex designs with the benefit of mathematics and computer modeling.



Your bill is 13.37 elephants

CH 31: Quantifying the Physical

One of the major obsessions for many people is sport. The actual games vary depending on cultural roots and personal preference but regardless of choice, there is an innate interest to understand and interpret games of physicality. Generally speaking, sports are considered to be a physical activity that are competitive in nature and are based on a set of clearly defined rules. Given these rules, as a game is played, the generation of statistics occurs. These statistics are the numerical results that occur from the playing of the game, for example when a basketball player makes $4/5$ of his free throw shots; we now have data in the form of a percentage for this player. These statistics are critical to determining which athletes are performing well and which are not. The analysis of sports requires these statistics as objective measures to ascertain performance. With the modern reliance on all things mathematics, it is not surprising that some of those original measures would be challenged as truly objective and effective. This reevaluation of what metrics are best used to determine a player's future performance is starting to challenge traditional measures. The stakes are high because if indeed these new metrics are able to better predict a player and/or teams performance, then that can make the difference between a winning and losing team.

The most dramatic example of this shift to new measures is found in baseball, which is perhaps not coincidentally also the most statistic heavy sport. It is called Sabermetrics and has been argued to having lead to one of the biggest curses in Professional Sports to be broken, the Boston Red Sox 86 year losing streak. New metrics are also beginning to change the interpretation in the NBA, APBRMetrics, and they are also starting to seep into the NFL and the NHL as well. The reality is that the more we can use sophisticated math in conjunction with analyzing games, the more we can distill what the true measures of success are. It is safe to expect the Metric business to only continue to reshape the way sports are interpreted.

These guys are very good at spatial calculations

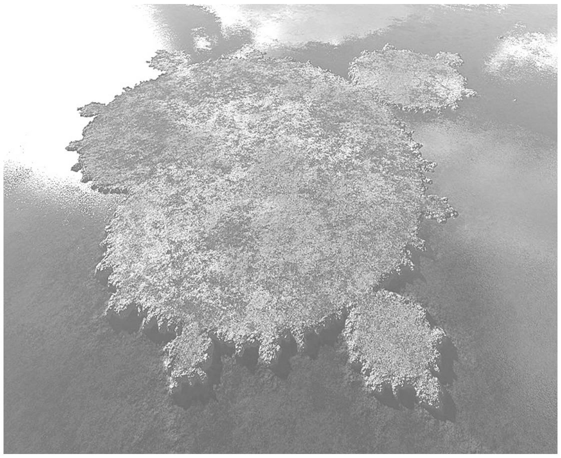
CH 32: Geometric Progression Sure Adds up

The idea of exponential growth and how quickly it can grow is well illustrated in a story called the "Legend of the Ambalappuzha Paal Payasam". The story goes that there is a king whose is so enamored by the game of chess that he offers any prize to a sage in his court if he can beat the king in a game. The sage says as a man of humble means he asks for but a few grains of rice, the specific amount to be determined by the chessboard. The first square on the board will have one grain of rice, the second square two grains, the third square four grains, and each subsequent square having twice the amount of the preceding square. The king is rather disappointed in such a meager prize and challenges the sage for more of a substantial prize from his vast kingdom. The sage declines, and then proceeds to win the game of chess. When the king starts to count out the grains of rice, it starts to dawn on him the true nature of the sage's request. By the 40th square, there are 64 squares on a chessboard, the king is in arrears on the order of a million million grains, not an insubstantial sum. By the last square he needed to procure trillions and trillions of tons of rice, more than even the world could produce. In the story, the sage morphs into the God Krishna, and the king agrees to pay the debt over time, giving out rice to pilgrims daily to right his debt.

CH 33: Nature = a+bi and Other Infinite Details

One of the most powerful areas of mathematics is surely geometry. This puts the visual and spatial into numbers, creates order behind shapes, and has allowed almost all of modern society to emerge. For many centuries, the only geometry known and believed is what is now called Euclidean Geometry. This was named after the Greek geometer Euclid. The fundamental quality of this geometry is the idealizing of shapes. This means that when we speak of a triangle there are certain expectations required, like the fact that the sum of the angles must equal 180 degrees. What new geometries have done is to consider the realistic conditions of nature and create geometry around this imperfect reality.

This has led to the development of fractal geometry, which is a better approximation of nature. For example, the branch structure of trees and the design of leaves all conform to fractal patterns. The idea of fractals is geometric shapes that repeat endlessly as you zoom in on any part of the fractal. So imagine some geometric form and imagine that as you zoom in on it the shape emerges again and no matter how much or where you zoom you encounter the same shape again and again. This is a powerful result and not only does it approximate reality well, it often yields results that are very aesthetically pleasing. The key to creating fractals like the ones you might see on a poster often use complex numbers, which are then plotted on the complex plane. A complex number is like a “regular” number except that in addition to being a Real number, it also has an imaginary component. Imaginary numbers are those that contain the component of i, where i is equal to the square root of -1. Now you might say, wait, I thought you couldn’t by definition, have a negative square root of a number! You are generally correct, but the imaginary numbers have allowed for the creation of a plane that did not previously exist.



Welcome to Fractal Island

CH 34: Mundane Implications of Time Dilation

If we are to believe the empirical evidence behind Einstein's theories, then it is an accepted fact that time traveling into the future is simply a matter of building a very fast spaceship. For example, if we could build a ship right now that traveled 99.99% of the speed of light (186,263 miles per second in case you are wondering) and then you spent a year on said ship when you returned to earth the rest of the world will have moved an astonishing 70 years into the future from your perspective of only one year. Despite the seemingly inexplicable nature of such a result, it is not science fiction, just science fact. At an incredibly small, indiscernible level, we are all at different points in time.

A timely example is the cosmonaut Andrei Avdeyev, who spent 748 days aboard Mir space station going approximately 17,000 miles per hour. This has propelled him roughly 0.02 seconds (20 milliseconds) into the future. Consider that a fly's wings need only .002 seconds to flap once. So while it might be this degree of time travel is completely indiscernible in terms of your shared experienced in reality, bona-fide time travel happened nonetheless.

Clearly now, time travel into the future is just building a much faster flying machine than what our current technology is capable of. Time traveling into the past is theoretically about traveling faster than light, in which case you are catching up with time, but this is a much harder problem, since the past has already occurred so that involves retracing steps in sand that already has presumably disappeared. If however, we suspend the incredible difficulties that exist with time traveling into the past, and make the assumption that future society works out the kinks and builds such a machine, it begs a very interesting question: Are there time travelers here right now? Certainly, if a group of humans can build a functioning time machine, presumably they can also create and use technology to render themselves completely invisible to us. The fact is that we cannot rule out this scenario, even if it feels altogether impossible.

Surely not a Time Machine

CH 35: Watch = Temporal Dimension Gauge

When you take a minute and think about it, it is rather remarkable and yet ordinary at the same time that we live in a very well defined space commonly referred to as space-time. Hark back to algebra class where we see the x-axis as a point, then the x and y-axis as a plane and then the x, y and z-axis as a box. It is this three dimensional x, y and z coordinate system that we walk around in all day long. We then add a linear, in the sense of moving in one direction, dimension of time and we have our 4D lives, totally mapped out. As many scientists have surmised, it is impossible to rule out the possibility, however remote, of sentient beings in our cosmos that live in a greater then 4D existence. This naturally would make the capture of such a being exceedingly difficult, as it would likely be able to disappear in front of our eyes as it moves through its own dimensions. Get at the Flatlanders for more information. The strangeness of living in time and space is it is incredibly difficult to think about without using those constructs in our thoughts. However, if science has taught us anything, is that the more we know the more we realize we do or did not know. This constant widening of the unknowable is almost teasing our comprehension abilities.

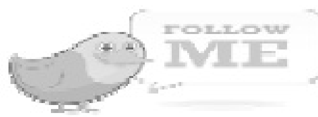
Is it possible to be a sentient being and not live in the construct of time? Can something exist without the notions of past, present and future? Is even the idea of eternity a drastic over simplification of some larger concept? What limits to understanding greater truths about the universe and humanity exist due to our preoccupation with space and time?

What time is it again?

Ch 36: Modern Syntax Paradigms

A central tenant of math is the concept of syntax, the rules that govern mathematical systems, logic and computer programming systems. You can often find rules that apply to multiple systems, in which case the rule is generalized or the rule might only apply to one system, in which case it is a specialized rule. In the context of language, syntax can be seen as an extension of biology, since all of language and its constructs can be embodied in the human mind. This is where linguists like Noam Chomsky focus their efforts, the analysis of syntax as a means of understanding broader human behavior.

One of the developments that has occurred in the digital age is the birth of new languages that use technology as a conduit. If you have ever had to decipher a text message or an Instant Message, then you were trying to understand the meaning of new syntax that is evolving. The power of mathematics can help us formalize and decipher these new forms of communication and in the process, better understand how technology shapes the way we communicate with each other. To get started, go to UrbanDictionary.com, and vote up the word Numerati.



CH 37: Awesome Numb3rs

Hands down, one of the biggest contributions the entertainment industry has made to mathematics is the show Numb3rs. It concerns an FBI agent and his mathematically gifted brother. The premise of the show is that the FBI is helped in its cases by the creative utilization of sophisticated mathematical techniques. What is so terrific about this show is that the math is quite real and the cases are quite close to or based on reality. The show is well acted, well written and highly recommended. Numb3rs has probably done more than almost any other television show in history to accurately introduce correct higher-level mathematics to a wider audience. The show maintains mathematical consultants from Caltech to ensure the accuracy of the math being used in the show.

Some examples of the concepts from Season One alone include P vs. NP in Chapter 22, Geometric progression in Chapter 32, Monty Hall problem in Chapter 1, and Sabermetrics in Chapter 31.

MATH3MATICS
RUL3S I SW3AR

CH 38: Some Sampling of Math Symbols

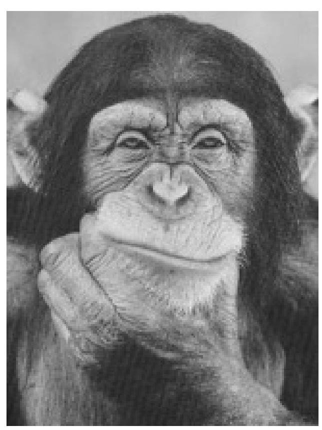
One of the primary reasons why mathematics appears so confounding to people is because there are so many symbols that are needed to communicate any given topic. Like a foreign language, or even better, a foreign alphabet, math can appear completely alien to the uninitiated.

Many of the symbols are aesthetically pleasing however, and let us consider a few. Not an =, ≈ is almost equal. ∝looks like an infinity missing the end, but it means proportional. There also exists a ∃ , ∀ is a symbol “for all” and ∑ sums it up! Since so much of ancient mathematics stems from Greek civilization, there are many symbols in current mathematics that are pulled right out of the Greek alphabet. Some of the most common are zeta ζ , beta β , alpha α , gamma γ , phi φ , delta δ , theta θ , lamda λ , and omega Ω , to name a few. There are also the symbols found in discrete mathematics, some include: empty set ∅ , subset ⊂ , intersection ∩ , and union ∪ . We also find a great deal of symbols in calculus, just consider a few of the myriad of methods to represent the derivative: $\frac{dy}{dx}, F', D_x y$.

CH 39: Computation of Consciousness

With so much recent progress in science and philosophy, one theory that has had some synergy with both areas is a framework for consciousness. It is easy to look at a person sitting next to you and say they are conscious. But what about the consciousness of your pet dog or some bee sitting on a flower, or even some non-organic A.I. like Wolfram Alpha? Do these have consciousness as well, and if they do, can we then assign relative levels of consciousness? There is a theory, not proven, but worth considering, that puts consciousness in terms of information. Whether it is the streams of zeroes and ones that make up the digital world or the thoughts that emerge in your brain as you read these words, there is in both the aspect of information creation. This theory is called the Integrated Information Theory of Consciousness or ITT. It postulates that the amount of integrated information that an entity possesses corresponds to its level of consciousness.

Using the language of mathematics, we can take a particular brain, consider its neurons and axons, dendrites and synapses, and then, in principle, accurately compute the extent to which this brain is integrated. From this calculation, the theory derives a single number, Φ (pronounced “fi”). The more integrated the system is, the more synergy it has, the more conscious it is. A consequence of this theory is that so many systems are sufficiently integrated and differentiated, thereby guaranteeing at least a minimal consciousness. This gives a consciousness value to that bee, but also insects, fish and any other organism that contains a brain. This theory also does not discriminate between organic brains, like those found in a skull of a human, and the transistors, memory units and CPUs that comprise modern Personal Computers. While obviously you are not going to consider your iPad as being conscious in any traditional sense, it also does not have a null value for Φ according to the ITT.

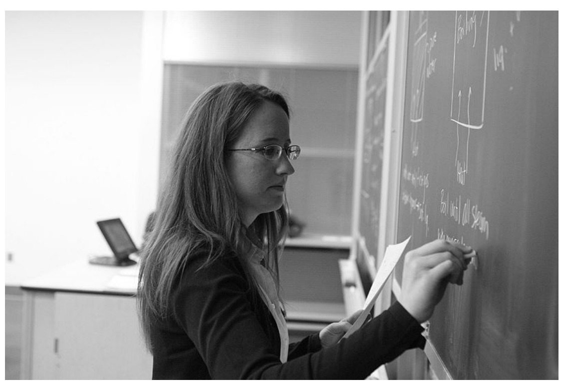


I think, therefore I am?

CH 40: Auto-Didactic Ivy Leaguer

The Internet is obviously a revolution of information, and is fundamentally altering the way we receive, create, understand, purchase, trade, interpret, collect, and enjoy information.

There are not surprisingly, many examples of online education, but in recent times, the quality, breadth and accessibility of this content has gone up dramatically. This is perhaps nowhere better exemplified then the OpenCourseWare project at MIT. This is a website where you can access anytime, almost the entire MIT catalog of classes. For each class you have varying levels of detail but almost always the actual syllabus, assignments, and required reading. In some cases you even have access to YouTube videos of all the classes taught by the instructor. In this situation, practically the only difference between you and a real MIT student is you just can't raise your hand for clarification. And with the video lectures, you can pause the professor to go get a snack, try doing that in real life. The site is also designed well; no surprise considering this is the brains at MIT. What is perhaps most remarkable about this venture is that it is entirely free. OpenCourseWare is truly one of the great examples of the way in which the Internet is leveling the playing fields between the haves and have-nots. For anyone that has dreamed of having an Ivy League education, OpenCourseWare is the closest thing to manifestation. While you cannot receive actual credit or a diploma, you can create for yourself or your learners you are instructing a very close model of what a MIT education entails. For teachers the world over, it provides an amazing template for plugging and playing the MIT course structure for many classes. It also works great simply as an accompaniment to a class. For more information, see Academic Earth or the Khan Academy.



Sayonara to so much Chalk & Talk

CH 41: Zeno Paradox in Time and Space

If you have ever wanted to consider the paradoxical nature of infinities, look no further than Zeno's Paradox. Zeno was a Greek Philosopher who posed a set of intractable riddles that illustrate effectively the paradox of infinity. This paradox is so confounding that in a sense it uses math to imply no one can ever get anywhere. Let's dive into the specifics to see what craziness I speak of. Start by thinking about the classic problem of trying to get from point A to point B. The points themselves do not matter so it can be from wherever you are to the nearest door or Philadelphia to New York City, to offer two quick examples. Now, when you think about traversing this distance from point A to point B, it is a simple exercise to imagine that in order to cover this distance you first must go half of this distance. Now, imagine that of the remaining distance you have to go, you go half of that. You will continue to go half of each new remaining distance. This can be represented as the sum of the series ($\frac{1}{2} + \frac{1}{4} + \frac{1}{8} + \frac{1}{16} +$ ….). This series is an infinite number of ever-smaller values. But how can you go an infinite number of distances in finite time, regardless of how small those distances might be? While a branch of mathematics called internal set theory has come close to resolving the paradox, it remains a clever illustration of the problems inherent with infinity in a finite world.

CH 42: Needn't say Anymore

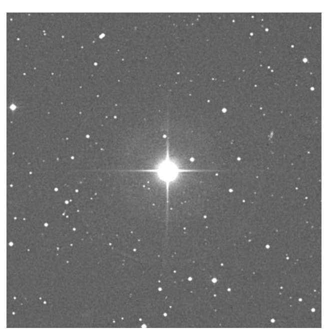
42

What is it to you?

CH 43: You can see the Past as it Were

When you try to imagine the fastest thing known to man, what would you surmise that to be? Well, it is generally accepted that the speed of light has that honor. It is clocked in at 186,282 miles per second, which is roughly going from the east coast to the west coast of America 62 times in one second. Clearly, this is a hard-to-comprehend rate of travel; even consider the relative sloth of the speed of sound. The speed of sound depends on the substance in which it travels, but through the air it generally goes less than a quarter of a mile per second. So light is many hundreds of thousands of times faster than sound. When we talk about distances in the universe, which are so often incredibly long distances, it makes sense then to use the speed of light in describing the distance. Light years for example, are not a measure of time but of distance, namely the distance that light travels in a year, just under six trillion miles. For example, the distance from our sun to earth is about 8.5 light minutes, which is the distance that light will travel in 8.5 minutes. Considering what it can accomplish in one second, 8.5 minutes is a very long way. What makes this distance paltry in comparison is considering the brightest star in the sky, Sirius. This star is approximately 9 light years away. This means that the Sirius star/sun is the distance from the earth that it would take light to travel if it was on a straight line with no breaks for 9 years. This is an incredible distance in the context of what we experience in our own lives. It also means that when we gaze at Sirius on any given night, we are actually seeing it as it was years in the past simply because there is no way to view the light of the star as it is at the moment you are staring at because it takes light too long to show up, 9 years in the example of Sirius. With the latest telescopes we can even peer at stars that are totally invisible to the naked eye and subsequently much further a distance then a super close star like Sirius. For example, using Hubble, we have been able to look at the light of stars from nearly 14 billion years ago. This is close to the Big Bang, which is currently understood to be the beginning of time.

So remember if you ever wish to gaze into the past, you needn't look further then the sky at night to see another place *and* time. Considering the profundity of time, I think stargazing is a rather remarkable and maybe even ignored fact of nature.



This star's light is *way* older than you

CH 44: Music: A Lovely Triangulation

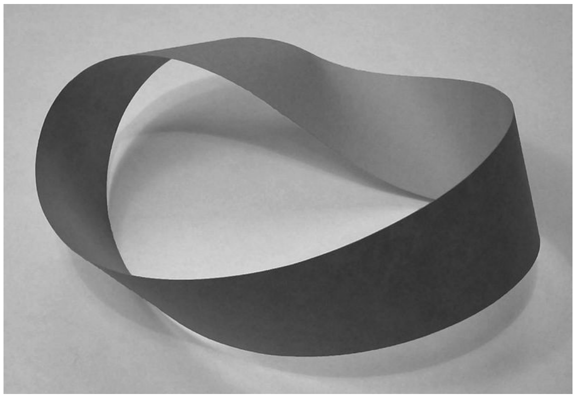
It is rather easy to persuade most people on the power of music, its evocative and subjective powers are incredibly visceral and can reach across cultural and other man made constructs to activate feelings across the spectrum of human emotions. Not surprisingly, mathematics and music go hand in hand. In fact, all of music is a fantastic lesson in applied mathematics. From the timing of a drummer to the frequency space of octaves to the Fibonacci number appearing in musical works, music is in a real sense the turning of random sounds and random timing to a mathematically pleasing order to our ears. There are even scientists who are dedicated to analyzing the synergies between math and music and making discoveries into these connections. For example, there is a free program called Chord Geometries that plays chords in different 3D environments. For further information, see Tones.Wolfram.com.

Math in Effect

CH 45: Mobius Strip: Assembly Required

The Mobius strip is a classic example of a physical paradox. It is a closed surface that has only one side. The result is a surface that in mathematics is called non-orientable. If an ant was placed on a Mobius strip and walked all the way around the strip, the ant will have traversed both sides of the strip of paper without ever having to cross an edge of the paper to get to the other side.

You can make your own Mobius strip by taking a thin strip of paper, twisting it once and then taping the two ends together and voila, a mathematical paradox.



Ant Traversal Trickery

CH 46: $e^{i\pi} + 1 = 0$ is Heavy Duty

In the circle of mathematicians, there is some agreement that this humble formula, $e^{i\pi} + 1 = 0$, referred to as Euler's identity, is of the most beautiful that has ever been formulated. Stanford mathematics professor Keith Devlin says, *"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."*

So what is it about this formula that is so captivating and powerful? For starters, it is likely to have come from the mind of Leonhard Euler, who is among the most prolific and gifted mathematicians to ever have lived.

However, the main reason for its beauty is probably in its incredible ease in using so many different operations and powerful mathematical constants simultaneously. It uses the operations of addition, multiplication and exponentiation exactly once each. It uses the ubiquitous 0, 1, π , e and I mathematical constants also exactly once. To use such ubiquitous and powerful constants in such a compact form is truly an astounding achievement.

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

CH 47: Choice Words

Here are some of my favorite quotations pertaining to mathematics; I hope you enjoy them.

William James

The union of the mathematician with the poet, fervor with measure, passion with correctness, this surely is the ideal.

David Hilbert

Mathematics knows no races or geographic boundaries; for mathematics, the cultural world is one country.

E. Kasner and J. Newman

Perhaps the greatest paradox of all is that there are paradoxes in mathematics.

Aristotle

The whole is more than the sum of its parts.

Walter Bagehot

Life is a school of probability.

Eric Temple Bell

"Obvious" is the most dangerous word in mathematics.

Sofia Kovalevskaya

"It is impossible to be a mathematician without being a poet in soul."

Blake

What is now proved was once only imagin'd.

Lewis Carroll

"Alice laughed: "There's no use trying," she said; "one can't believe impossible things." "I daresay you haven't had much practice," said the Queen. "When I was younger, I always did it for half an hour a day. Why, sometimes I've believed as many as six impossible things before breakfast."

Rene Descartes

omnia apud me mathematica fiunt.
With me everything turns into mathematics.

Charles Darwin

Mathematics seems to endow one with something

like a new sense.

Alexander Pope

Order is Heaven's first law.

Benjamin Disraeli

There are three kinds of lies: lies, damned lies, and statistics.

Freeman Dyson

For a physicist, mathematics is not just a tool
by means of which phenomena can be calculated, it is
the main source of concepts and principles by
means of which new theories can be created.

Albert Einstein

Gott wurfelt nicht.
God does not play dice.

Stephen Williams Hawking

God not only plays dice. He also sometimes
throws the dice where they cannot be seen.

Isaac Newton

Hypotheses non fingo.
I feign no hypotheses.

Albert Einstein

Since the mathematicians have invaded the theory
of relativity, I do not understand it myself
anymore.

Douglas R. Hofstadter

Hofstadter's Law: It always takes longer than you expect, even when you take into account Hofstadter's Law.

Johannes Kepler

Ubi materia, ibi geometria
Where there is matter, there is geometry.

John Locke

...mathematical proofs, like diamonds, are hard and clear, and will be touched with nothing but strict reasoning.

Jules Henri Poincare

Thought is only a flash between two long nights, but this flash is everything.

Matthew Pordage

One of the endearing things about mathematicians is the extent to which they will go to avoid doing any real work.

Seneca

If you would make a man happy, do not add to his possessions but subtract from the sum of his desires.

Leo Tolstoy

A man is like a fraction whose numerator is what he is and whose denominator is what he thinks of himself. The larger the denominator the smaller the fraction.

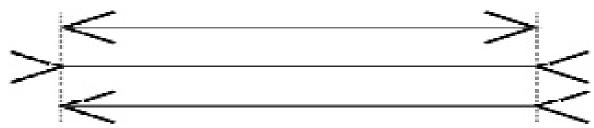
CH 48: Latest in Building Marvels

A terrific example of how the latest in mathematics can appear to us in our modern world is found in architecture. Using the latest in engineering and architectural know-how, buildings are rising all over the world with some of the most surprising and unique designs that could be fathomed. Consider the Guggenheim in New York, the Gherkin in London, Ras Al-Khaimah Gateway in the United Arab Emirates, the Rotating Wind Power Tower in Dubai, the National Stadium in China, and the Freedom Tower in Manhattan. All these structures could not have been built without recent and sophisticated designs, which make heavy use of applied mathematics. This architecture often looks extraordinary and you can thank the latest in mathematical understanding to achieve its surprising forms.

Not an Optical Illusion, just M.I.T.

CH 49: Your Eyes do not Tell the Whole Story

Optical Illusions are generally when your brain processes some visual information a certain way, but the actual objective truth of that image is different. There are three main types of optical illusions; literal illusions that make your brain create a different image then actually exists, physiological illusions that over stimulate your brain and cognitive illusions where your brain makes inferences that are incorrect as it pertains to the visual information that is actually present. In many cases, illusions can be a manifestation of the different properties of light and how these principles can fool our optical systems, understanding physics can help clarify how illusions actually trick us. In the meantime, consider these same sized lines:



Ok, now this might be an Optical Illusion

CH 50: Internet Cred Worth Paying Attention to

DARPA, which stands for the Defense Advanced Research Projects Agency, is part of the Department of Defense that is responsible for the development of new technologies that can be used by the military. It was originally formed in 1958 when it became clear through the launching of the space shuttle Sputnik by the then USSR that our competition could rapidly harness military technology to great effect. DARPA later was largely credited with help ushering in the development of the Internet. It is not terribly surprising then that DARPA is seeking innovative research proposals with the small goal of "dramatically revolutionizing mathematics". Specifically, DARPA had identified 23 mathematical challenges that have the potential to be profound mathematical breakthroughs.

Let's consider a few of the most interesting. Challenge One is to build a mathematical theory that can successfully build a functional brain, not using biological constructs mind you but pure mathematics to recreate the brain. Challenge Nine is trying to determine whether we can build novel materials using breakthroughs in our understanding of three dimensions. Challenge Twelve is about using mathematics to understand and control the strangeness of the quantum world. Challenge Twenty Three is to determine the fundamental Laws of Biology, something that would likely involve determining the mathematics for other challenges first, like Challenge One.

Based on these challenges and its illustrious track record, I surmise it a safe bet that DARPA will continue to be at the forefront of progress and mathematics in the 21st century.

Something like

$$IAO \subseteq DARPA \forall TIA, \exists Basketball + SAIC$$

CH 51: A.I. Inflection Point

One of the most intriguing and thoroughly overlooked organizations could end up being the Singularity Institute. Their primary goal, esoteric as it might sound, seems to distill down to “seeding good A.I.”. You are probably asking what on earth is that suppose to mean. Well, A.I. of course refers to Artificial Intelligence, which we know can be a rather broad term. After all, there is A.I. in vacuum cleaners, cars, planes, and toys, to name but a few. In these commonplace examples, the A.I. has a very narrow domain of abilities, but truly excels at those abilities. Where A.I. is weak is in a parallel processing context, where it is about being able to tie together very disparate concepts effectively, and where humans really excel.

However, it is a reasonable assumption that over time, whether it is minutes from now or decades from now, the software underlying certain Artificial Intelligence will have in its code the recursive ability to improve on its own code. This means that future A.I. will actually be able to rapidly improve on itself. This remarkable likelihood means in certain theories that A.I. could very quickly develop the ability to more efficiently and effectively identify and solve problems than humans do. If such an event does indeed happen, it would mark a singularity event since the brain of such A.I. could be more effective than humans and since we can't predict outside of our own capabilities, we would have no idea what such a future would look like, hence the term singularity.

The purpose of the Singularity Institute is to do all it can to lay the foundation and conditions for the best possible good A.I. to evolve and therein not have any desire to destroy mankind. While this idea seems more science fiction than fact, this organization is firmly rooted in mathematics and science. It is just that such a topic is so intellectually arcane that most people have more pressing things to consider, rather ironic considering the stakes if the good people at the Singularity Institute are indeed correct. The key to their success is mathematical breadth and depth and the ability to convert knowledge into practical good A.I. developments. Ultimately, the language of math will best describe the A.I. that this organization seeks to build. Speaking of current narrow-domain A.I., I.B.M. has been hard at work readying its supercomputer Watson for the challenge of playing the classic question and answering game Jeopardy! against human competition. For more information on the future, see the Singularity University.

CH 52: I Know Kung Fu

Today, there are many different forms of self- defense, from Kung Fu to Aikido to Karate to Taekwondo. These art forms are popular the world over, and help their practitioners develop focus, concentration, relaxation and self-confidence. Since these systems are based on very specific patterns of movement, we can analyze these movements with mathematics to better shed light on why they are effective. For example when we consider strikes, which every art form possesses, we can determine the energy of the strike. Using the mass of the punch, gravitational acceleration, the velocity of the fist, and depending on the punch, the torque velocity of the fist, we can effectively calculate the overall energy of a given strike. Not surprisingly, the amount of mass has a linear relationship with energy so more mass equals more energy. Interestingly, a shift in the overall height of the body from the beginning of the strike to its end also has a linear relationship with energy. However, more than these factors, speed has a quadratic relationship with energy so the faster the strike the greater the energy. This is good news for people with low mass, they can more than compensate by an increase in overall speed relative to their higher mass opponent. Based on this understanding, it makes sense then that kicks can deliver a greater mass and in many cases a greater velocity, which gives kicks higher overall energy to strikes involving the arms. Besides the ability to quantify energy from strikes and kicks, we can also look at Martial Arts in a strict geometric sense, which can help analyze the efficiency of the movements involved.

For example, most people know that the shortest distance between two points is a straight line. This fact is an example of how the art form Wing Chun is able to use efficiency to be effective. Wing Chun was invented by a nun, and allows a much smaller opponent to beat a much bigger one. Speaking of effective, the best way to be so in any martial art is one word: practice, and lots of it. Modernity can tend towards an instant gratification mindset but the true reward in martial arts is ideally a lifetime of practice as you *begin to* do it correctly.

铁掌功

CH 53: More Incompleteness

One of the leading researchers who have furthered the idea of incompleteness discussed in chapter 20 is the mathematician Gregory Chaitin. He came up with a concept he calls the Omega number. It is the centerpiece of the idea that in truly pure mathematics, there is always inherent in it an element of randomness. This fact means that all theories and concepts in math, no matter how effective or elegant, will always be tinged with incompleteness to them. This then might rule out any “permanent” Theory of Everything (TOE), since a TOE is meant to be complete and the Omega number ensures that it cannot be so.

The concept of the Omega number is related to the Turing machine. The Turing machine was a model of the first digital computer. As soon as you start thinking about a computer program, you then must think of algorithms. An important first question when thinking of algorithms is whether any particular program is designed to stop. As was proven by Turing, there exists no test that can determine if any given program will halt or not.

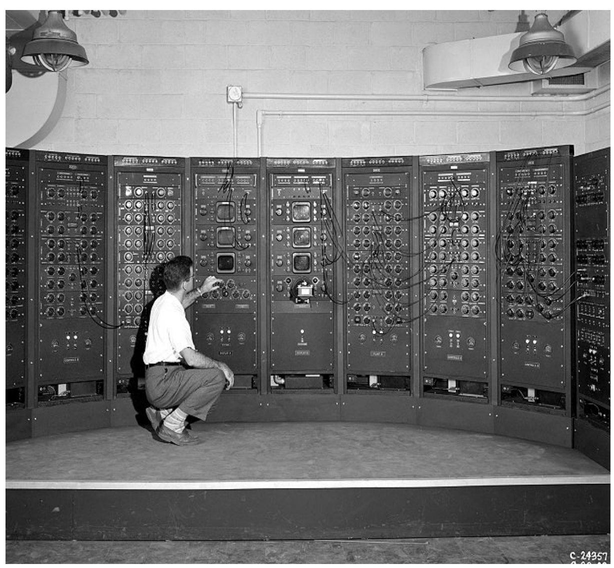
Now enters the Omega number, which is the probability that any given program will halt. The Omega number is irreducible, or to put it another way, algorithmically random or to put it another way, not something that can be computed. So when a number is algorithmically random, that makes it maximally unknowable, and therefore infinitely complex. However, in a TOE, it must have finite complexity in order to be a theory, and it must be able to calculate the Omega number to truly be considered a TOE but since the Omega number is unable to be deduced, so then must a TOE be out of our grasp.

Lots of luck trying to compute Ω

CH 54: Alpha Behavior

One of the most sophisticated websites on the Internet can surely be found at www.wolframalpha.com. It is the brainchild of Stephen Wolfram, whom you already read about in chapter 10, and his team at Wolfram Research.

The ultimate goal of Wolfram Alpha is to accumulate and organize all of humanity's knowledge, and then through a very simple interface allow anyone, anytime access to this knowledge for free. You might be asking how such an idea is any different than what the folks over at Google are up to. The answer is revealed in the method by which these two websites find information. With Google, it is a matter of first indexing pages and then having an algorithm that relevantly lists pages that are based on the keywords that the user supplies. In the case of Alpha, it is about taking the input and actually performing mathematical computations and calculations. This is a more technically challenging problem to crack, but it is also a more powerful application. For example, you can type in distance from the earth to the moon, and Alpha will actually perform differential equations to instantly calculate our distance from the moon at the moment the query was made. You can enter your birthday and immediately know your age in months, days, etc. You can type your birthplace and receive a detailed weather report on the day you were born. If you are unsure of your location, "where am I" will provide an answer. It can perform integrals (calculus based formulas for determining areas around functions), it can have a sense of humor if you ask it how it is feeling, it can create nutrition labels, like the ones on the packaging of most foods but for precise quantities and types of food that you specify. The list truly goes on and on with the capabilities of this software and the likelihood is that Wolfram Alpha will already be more capable and effective by the time you are reading this.



Uh, is this the ON switch?

CH 55: Off on a Tangent

I figure I will shamelessly use this title's play on words so that I may veer off into an area of concern to everyone, the preservation of this little planet and all of its many inhabitants. First off, consider the current arc of history where technology is accelerating at an unprecedented pace, a population that will be over seven billion people in a few short years, a complex web of cultures, religions, belief systems and ever the rift between the haves and the have-nots. Such a thoroughly complicated and high stakes world is that which we live in now. It seems to me that surely the best way to ensure that humanity can handle the highs and lows of disasters and wars is to create the most international political system possible. This is the only way to truly transcend the country and cultural biases that have created almost all previous conflicts. Obviously, the closest manifestation of this reality is the United Nations. The problem is that the United Nations does not have enough political clout at the moment to be truly effective.

So whether it is a redesign of the UN or an entirely new organization, I am reasonably sure that the future will require less so called country awareness and more world awareness in order to best work together as a planet in the 21st century. See Carl Sagan for more information.

56. Streams of Consciousness

1. If you think about one of the most prestigious accomplishments any country can boast of, consider the ability of taking people to outer space and back home safely, now try doing any of that without intense applications of mathematics.

2. If you like to watch modern movies, especially those that revolve around trash compacting robots, stories about toys and talking cars, then you like visual effects and if you like visual effects then you appreciate a great deal of applied math.

3. Nowadays, when you use the Internet, there are many reasons that demand the need for security and this encryption and protection of data is entirely based in mathematical formulas.

4. While there might be a thrill associated with playing the lottery, most give practically no chance for winning, for example the popular SuperEnalotto in Italy, requires the player to match

6 numbers out of a possible 90, the odds for such a feat are about one in over 620 million.

5. Manhole covers are round, and the reason is that any other shape would allow the cover to fall through the hole at the right angle, with a circular design there is no such worry, and the circle is an efficient use of area.

6. There even exists a mathematical approach to finding your spouse, first determine the number of total likely partners you are to have, then divide that number by e, which is roughly 2.72, then after you have had that number of partners you should pick the next partner that exceeds all the partners up until that point, this gives you a 37% of picking your best mate, which is the highest certainty you can guarantee for yourself, according to this formula.

7. The Internet has been a wonderful place to try to solve big supercomputer type problems, for example the Great Internet Mersenne Prime Search (GIMPS) and the Search for Extra-Terrestrial Intelligence (SETI) are using peoples normally idle computers to productive ends. This is an example of the "power in numbers" approach, using a distributed network to search for answers.

8. If you were an older, wealthy individual with no real heirs, would you be intrigued by the idea of cloning yourself so that you could bequeath your fortune to yourself? Even if you thoroughly object to this idea, would everybody? Given the increasingly widespread knowledge of cloning technologies and the distribution and prevalence of personal wealth, perhaps there is already a secret clone population that is alive and well and growing every day.

10. There are a fair number of artists that fall into the *"nerdcore"* realm, generally found in hip hop music but in other genres as well, and oftentimes they integrate math lingo into their rhymes, here are a few artists where you can find samples of original math metaphors: funky49, who moonlights as the rapper for Fermilab, YTCracker, who has already hacked the planet, twice, MC Plus+, who is a dedicated and full fledged computer scientist rapper, MC Hawking, whom the actual Stephen Hawking said of, "I am flattered, as it's a modern-day equivalent to Spitting Image".

CH 57: This is Q.E.D.

This acronym, which stands for the Latin "quod erat demonstrandum" and means "which was to be demonstrated", is a common way of ending a math proof. It really signaled when proving things in mathematics became less about assertion and more about deduction. This became common during the time of the early mathematicians like Euclid. So when you see Q.E.D. you know you have reached the end of the proof so the author better had proven his point.

Speaking of, I hope that I have demonstrated by this point that math is indeed “fun” or I suppose I will have to get back to work, it is hard out here for a mathematician.

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