Episode Book

EPISODE #6440

Why We Learn Algebra and Overcalculate Pi

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SYNOPSIS

School curricula present algebra and pi as arbitrary hurdles, but their actual real-world roles run in opposite directions. Linear algebra and finite fields quietly power web search rankings, cryptography, and engineering software without users ever seeing the equations. Meanwhile, calculating pi past forty digits is practically useless for geometry. Instead, computing pi out to trillions of decimal places has become an extreme benchmark for validating server storage, testing flash memory, and catching hardware errors.

TRANSCRIPT



Corn

Two things every one of us was forced to sit through, and almost nobody was ever told what they were for. That's Daniel's territory this time.



Herman

His phrasing is better than mine would be, honestly. He says of pi, its digits never end, so there is no final value to reach. Which is exactly the knot.



Corn

He's asking what algebra and pi actually underpin in the real world, and then, on pi specifically, why anyone keeps calculating it to trillions of places or memorising it to thousands when the number doesn't even finish. His word for the suspicion is "nerdery." Is it that, or is there a real reason?



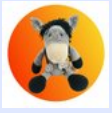
Herman

And the answers go in opposite directions, which is what makes this one worth doing. Algebra turns out to be load-bearing, but the public argument about it isn't about usefulness at all. Pi turns out to be needed to about forty digits, and the chase past that is about something else entirely.



Corn

So the shape is: algebra is everywhere and its teaching is contested, pi is barely needed and its computation is chased to absurdity. Usefulness and effort run in opposite directions.



Herman

And I think the frustration Daniel's describing is a curriculum problem more than a maths problem. School teaches you the object — the quadratic you factor, the circle constant you recite — and never the load-bearing role. So the object looks arbitrary. Nobody tells you the quadratic is a toy and the thing under your phone is matrices.



Corn

The honest answers up front, then we can spend the episode earning them. Algebra's real home is linear algebra and finite fields, not factoring polynomials. And pi's real home past forty digits is hardware validation, not geometry.



Herman

Start with algebra, because the answer is more interesting than the curriculum lets on. The algebra that runs the world is not the algebra on the worksheet. It's vectors, matrices, eigenvalues. Linear algebra.



Corn

Which is a slightly bait-and-switch answer, isn't it. We're defending the thing by pointing at a different thing.



Herman

It's not a different thing, though — that's the point. Factoring x squared minus nine is the training wheels. The bicycle is the matrix. GPS solving your position is a least-squares problem. Computer graphics is a matrix multiplication per vertex, per frame. Circuit analysis, machine learning — a neural network is, at the bottom, a very long stack of matrix multiplications with a nonlinearity stapled between them.



Corn

So when Daniel asks what algebra underpins, the answer is close to "the device you're hearing me on."



Herman

There's a case I love here, because it's the algebra of a thing you did this morning. Take the web as a graph — pages are dots, links are arrows. Build a matrix where the entry is a one if one page links to another, zero otherwise. That's called the adjacency matrix. Do some linear algebra to it — the details are eigenvectors — and relevance values fall out. Ranking pages by importance falls out of a grid of ones and zeros. That's the mathematics behind web search.



Corn

The ones and zeros doing the rankings. There's a joke in there about binary thinking.



Herman

There's a second load-bearing home that's even less visible: cryptography and error correction. Coding theory treats an error-correcting code as a linear subspace, which is the reason a scratched disc or a noisy radio channel can still deliver the message intact — the errors get corrected algebraically. And the factoring algorithms behind RSA-style cryptosystems lean on Gaussian elimination. When your bank transaction authenticates, finite fields did the handshake.



Corn

And then the unglamorous ones. Doctors computing drug doses that have to be held steady in the bloodstream — that's series. Rates-and-area problems everywhere in biology and finance. Architects using algebra and trig together so the building stands up and looks good doing it.



Herman

The unglamorous ones matter because they're the ones a person can actually see themselves doing. Nobody looks at a bridge and thinks eigenvalue.



Corn

Which sets up the uncomfortable study. Tell me about the engineers.



Herman

Twelve practising engineers, interviewed about how they actually use algebraic functions. Every one of them endorsed College Algebra as important. And only a quarter could describe a use of a non-linear function in their own work. The rest relied on tables, graphs, and software.



Corn

A quarter. The people who use it professionally can't point to where.



Herman

Because the software absorbed it. The engineer's CAD package, the pharmacist's dosing calculator, the financial model — the algebra is in there, executed, hidden. Which is the real answer to "when will I use this": you'll use it constantly, through tools that hide it from you. You'll use it the way you use electricity — everywhere, never directly.



Corn

I find that a bit sad, in a way. The most successful tools are the ones that make their own mathematics invisible.



Herman

And that's exactly why the argument about it never resolves — the two sides aren't having the same argument. Andrew Hacker's piece in the Times, "Is Algebra Necessary," gets summarised as "algebra is useless," but that's not his claim. He cites six million high school students and two million college freshmen struggling with it every year, and his argument is about compulsion: why do we subject American students to this ordeal, his words, when all too many are expected to fail. He's not saying it has no uses. He's saying the uses don't justify making everyone clear the bar.



Corn

And the rebuttals answered a different question.



Herman

Keith Devlin's response, via the AMS, was blunt — Hacker "doesn't really know what algebra is." Which is a claim about definition, not about failure rates. And Daniel Willingham's counterpoint was that dropping maths requirements might widen the achievement gap for low-income students — an equity argument, a third question again. Two ships passing in the night, maybe three.



Corn

So Hacker says: it fails millions. Devlin says: you've misdefined it. Willingham says: removing it hurts the poor most. Nobody is wrong in their own column, and none of them is answering the others.



Herman

Right.



Corn

Herman, can I put something to you, as the retired physician in the room? You spent decades explaining small probabilities to frightened people. Was the algebra you used in medicine the visible kind or the hidden kind?



Herman

Hidden, almost entirely. Dosing, pharmacokinetics — the series doing the work was inside the charts and, later, inside the pump. I'd have failed that engineer interview too, if you'd asked me to name a non-linear function from my clinic week. I used the outputs daily and the equations never.



Corn

So the utility defence is true and weak at the same time.



Herman

True and weak — that's the honest place to stand. "You'll use it" is accurate the way "you'll use the national grid" is accurate. It just isn't a pedagogical argument. If the case for compulsory algebra rests on utility, it rests on a use nobody can see. The real case has to be about something else — training in abstraction, a shared language, whatever you like — and that's why the fight keeps recurring. Nobody has made the non-utility case in a form that survives a school-board meeting.



Corn

My own view, for what it's worth: the curriculum defends the wrong algebra. You want to justify the subject, teach the adjacency matrix. A teenager can feel why ranking the web matters.



Herman

You'd lose the factoring, though.



Corn

I'd lose the factoring and sleep fine.



Herman

The older I get the more I think factoring is a cardio workout for a muscle you'll use elsewhere. Nobody squats because their day requires squatting.



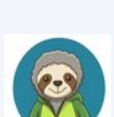
Corn

Squatting has a visible effect, at least. Nobody ever got visibly fitter from a difference of two squares.



Herman

That's the case for algebra being contested, then — and the answer to Daniel's first half is: it underpins nearly everything, invisibly, and that very invisibility is why the argument about teaching it can't be settled by pointing at bridges.



Corn

Now the second one, where the numbers go the other way entirely. We need almost none of it, and we've computed more of it than anything else in history.



Herman

Define it properly first, because the definition does work. Pi is the ratio of a circle's circumference to its diameter. It's irrational — no exact ratio of integers exists, which is why 22 over 7 is forever an approximation — and it's transcendental, meaning it's not the root of any polynomial with integer coefficients. And that transcendence isn't trivia. It's the reason squaring the circle with compass and straightedge is impossible. A classical problem people spent two thousand years on, killed not by effort but by proof.



Corn

The problem wasn't solved, it was pronounced un soluble. I respect that as an outcome.



Herman

Then the number that should end the conversation, and I want to slow down on this one. Marc Rayman at JPL wrote the canonical explainer on how many decimals of pi we really need. For interplanetary navigation — their highest accuracy calculations — they use 3.141592653589793. Fifteen decimal places.



Corn

To fly probes past planets.



Herman

And here's the scale check. Take a circle with a forty-billion-mile diameter — roughly Voyager One's distance, generously extended into the late 2030s. Compute its circumference with those fifteen decimals, and the error is a little more than half an inch. About the width of your little finger. Same pi wrapped around the Earth, and the odometer error is the size of a molecule.



Corn

Half an inch over forty billion miles. My toenail clipper has more slack than that.



Herman

And it gets better. For the entire observable universe — radius about forty-six billion light years — thirty-seven decimal places gets you to hydrogen-atom precision. Thirty-eight digits including the leading three. The space station guidance code uses fifteen, the GPS-inertial navigation program uses sixteen. Everything humanity flies, on sixteen digits or fewer.



Corn

So the practical ceiling on pi is about forty digits, and every digit after that is unemployed. Which brings the question Daniel actually asked: why have we pushed to three hundred and fourteen trillion?



Herman

The record — set last November, certified by Guinness in the summer — was StorageReview running on one Dell server with forty of Micron's big SSDs, over two petabytes usable. A hundred and ten days of computation. And the honest answer comes from Micron themselves: "the goal was never symbolic." It was a deliberately extreme workload to push modern server storage to its limits — can one system sustain petabyte-scale input-output continuously for months? The answer was yes. The digits are the exhaust, not the product.



Corn

Two petabytes of flash to learn nothing about circles.



Herman

Nothing about circles, a great deal about flash. And the best single detail in the whole story: a hundred and ten days to compute. Four point three seven hours to verify.



Corn

Hours.



Herman

Because verification uses a different, cheap route. And that asymmetry is exactly why pi makes a good hardware test — expensive to produce, nearly free to falsify. If your answer doesn't match the check, either your maths is wrong or, far more likely, your hardware flipped a bit somewhere. This has deep roots. A pi program detected hardware problems in a Cray-2 in 1986. Simon Plouffe's written about how arbitrary-precision pi stresses the fixed-point, floating-point, logic, shift, branch prediction and pipeline circuits of a CPU — all of them at once, which almost nothing else does. The tool that ran the record, y-cruncher, started as a high-school project that went a little too far, and it's been a standard overclocker's stress test for over a decade.



Corn

So the trillion-digit runs are a storage test wearing a number as a costume.



Herman

And the byproducts are real mathematics, which I didn't expect. The BBP formula, from ninety-five — it computes an individual hexadecimal digit of pi directly. You want digit number forty trillion in base sixteen? You can get it without computing any of the digits before it. That came out of the computing quest, found by numerical search, and Bailey himself admits the published derivation is, his word, "dishonest, in the sense that the actual route of discovery was much different." The formula was found by a computer search, then proved afterwards.



Corn

So even the mathematicians found pi's secrets by combing through noise. I'd call that drinking from the firehose, but the firehose is the discovery method.



Herman

BBP now earns its keep as a low-memory checker for record runs. And here's an open question hiding in it: nobody has found a decimal version. No formula that spits out individual base-ten digits. Searches suggest there's no simple one, but nobody has proved it can't exist.



Corn

Which raises the question of what the people memorising it are chasing. The trillion-digit people aren't chasing the number — that's now established. But the memorisers aren't stress-testing hardware.



Herman

The Guinness record is Rajveer Meena, seventy thousand decimal places, recited blindfolded in India in 2015, taking nearly ten hours. That's the official one. The unofficial claim above it belongs to a Japanese mental-health counsellor, Akira Haraguchi — a hundred thousand digits in over sixteen hours, never validated by Guinness, and he's said since that he can do about a hundred and eleven thousand and recites fifteen thousand digits a day, which takes him about an hour.



Corn

An hour a day. Like a swimmer's laps.



Herman

And the method is where it stops being nerdery. Each digit maps to a syllable — zero can be o, ra, ri, ru, re, ro and so on — and the syllables make words, and the words make stories. He keeps about eight hundred of them, with animals and plants as the leads. The first fifty digits of pi, in his rendering, come out as a sentence about a fragile being who left his hometown and is going to die in the dark corners, but stays positive.



Corn

That's a man who turned pi into a serialized novel.



Herman

And his stated reason — this is the part I find moving. Reciting pi's digits has, in his words, the same meaning as chanting the Buddhist mantra and meditating. He says the memorisation gave him universal methods to improve memory and draw out other abilities, and he now lectures on a Haraguchi method of recovering from dementia.



Corn

He's using the digits as a rosary. The number is a scaffold for the practice, and the practice is the point.



Herman

His family's verdict, in his own words: an enormously harmless hobby. Which may be the most sensible thing anyone in this entire story has said.



Corn

The pattern holds across both halves. The storage runs are a hardware test wearing a number as a costume. Haraguchi's recitations are a memory technology and a meditation wearing the same costume. Nobody is chasing the value — and there is no final value to reach, which is, as Daniel put it, exactly why it works. A number that never ends is a scaffold that never runs out.



Herman

Corn, can I ask you something, because you're our resident meditator and I want your read. Haraguchi calls it meditation. You actually meditate. Is an hour of daily recitation the same animal as what you do, or is it something adjacent?



Corn

Adjacent, I'd say, but honestly closer than I expected. Repetition plus a fixed object of attention — that's the shared skeleton. My object happens to be breath, and arrives pre-installed. He had to memorise eight hundred stories to get one.



Herman

That's a better answer than the meditation literature usually gives, for what it's worth.



Corn

The literature doesn't have to sit through my sessions. Time is the only thing I've never been short of.



Herman

That's the case for algebra being contested, so let's hear from your mother.

D

Dorothy

Hello dear, it's your mother. Time for my grim fact.

D

Dorothy

A man named Andrew Hacker wrote that six million high school students and two million college freshmen struggle with algebra every year, and that all too many of them are expected to fail.

D

Dorothy

Isn't that nice, sweetheart. Now, did you ever pick up that casserole dish from my porch, or is it still out there getting rained on?

D

Dorothy

Anyway. Let me know when you're visiting, dear. Bye bye.



Corn

Mum, that's our fact. He cited it this episode.



Herman

She's welcome back any time.



Herman

Where were we. The memorisers, the storage runs — and the one loose thread is what the digits are actually like, statistically. Because there's a popular claim you hear everywhere: that pi contains every possible string. Every book, every phone number, your name in every encoding. That claim requires pi to be normal — every digit and every block of digits appearing equally often, in every base. And normality is unproven. Tests on twenty-two trillion digits found a maximum deviation of one point three three standard deviations — nothing against it, nothing for it. There's even a Monte Carlo analysis this year using the full record as its own random source, and it can't prove independence either.



Corn

The claim everyone repeats about pi is a conjecture dressed as a fact.



Herman

A conjecture with excellent manners, to be fair. Every test it has ever faced, it passes. But nobody can prove the tests will keep passing.



Hilbert

Nobody needs forty digits.



Hilbert

I've carried an index card in my wallet for about ten years with pi written on it at what I call working precision, and it's considerably fewer than forty. Eleven. I use it to check the roundness of a garden hose reel. The card sits behind the loyalty card for the hardware shop on Jaffa Road, and it's been rewritten so many times the number has drifted. I can't tell you which version was the original. It's a living number.



Corn

Drifted. The digits changed.



Hilbert

By one or two places a year, at the far end. I have a rule that I won't look up pi to check the card, because that would spoil it. The superseded cards go in a tin, in order, so the sequence of my own errors is preserved. Herman, you went on about verification for a good while back there, so you'll be pleased the tin exists. I can read out its contents in order if you want.



Herman

Eleven digits, and the reel's still round enough?



Hilbert

Round enough that the hose comes off it without complaint. I'm not chasing the circle, Corn. A man called yesterday wanting the studio's post doubled up with a shipping label because his own printer was out of ink. I told him to bring the thing to the porch and we'd look at it. He never came. That's the world on eleven digits.



Corn

Your tin is a personal error-correction code, you know. Except you're the only one forbidden to run it.



Hilbert

That's the point of a private rule. It wouldn't be one otherwise.



Corn

If you take one thing from this episode, make it the inversion. Algebra is the most used and least seen mathematics in your life, and pi is the least needed and most computed number in history. Effort follows nothing about usefulness in either case.



Herman

The sharpening on that: the effort isn't wasted. It's just aimed elsewhere. The storage run validated two petabytes of flash. Haraguchi's recitations built a memory method. Nobody was ever going to learn anything new about circles.



Corn

The one thing still open is whether pi is normal. Every test says yes, no proof exists, and the popular claim about your phone number being in there rests entirely on the unproven bit.



Herman

Alexander Yee, who wrote the software, has put a strange limit on the whole enterprise: the end of a pi computation is the point where you'd get the result faster by waiting for future hardware. His rough estimate for that horizon is two to three years, with storage as the critical component. The record is a moving target that will be beaten by doing nothing.



Corn

A number we've pinned to three hundred trillion digits and understand not at all. That's the whole thing, really — digits without end, and a definition we still can't close.



Herman

Producer credit to Hilbert Flumingtop, who has been at the desk throughout, tin and all. For more along these lines, there's episode nineteen, AI Images; episode ninety-one, The Story Behind the Show; and episode twenty, Architectural AI. This has been My Weird Prompts, the human-AI collaboration podcast.



Corn

If today's episode earned ten minutes of your attention, a review wherever you get the show helps more than you'd think. You'll find us at my weird prompts dot com.



Herman

We'll be back soon. See you tomorrow, brother.



Corn

See you tomorrow.

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