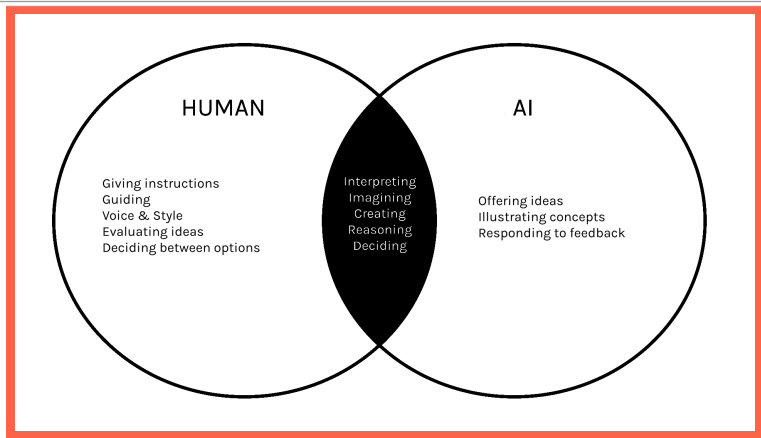


AI for the working mathematician - part 1?

Or: Introduction

What is everyday AI for math?



- ▶ **Everyday AI for math** = LLMs + small tools folded into research
- ▶ **In 2025 (caveat: this may age fast)** They speed up reading, coding, drafting, organizing, but you remain the supervisor
- ▶ **Guardrail** Treat AI as a bright but unreliable collaborator; verify everything

What about mathematics?

AI can produce
perfect proofs
of well-known results
but that is not
what this series is about

ChatGPT 5 ▾

Can you prove that pi is irrational?

Thought for 53s

Sure—here's a clean, self-contained proof (often attributed to Niven) that π is irrational.

Proof by contradiction

Assume π is rational. Write $\pi = \frac{a}{b}$ with coprime positive integers a, b .

For a positive integer n , define the polynomial

$$P_n(x) = \frac{(bx)^n (a - bx)^n}{n!}.$$

Note that P_n has integer coefficients (binomial expansion in the integer variables bx and $a - bx$), and that P_n vanishes to order n at both endpoints $x = 0$ and $x = \pi = \frac{a}{b}$.

Consider the integral

$$I_n = \int_0^\pi P_n(x) \sin x \, dx.$$

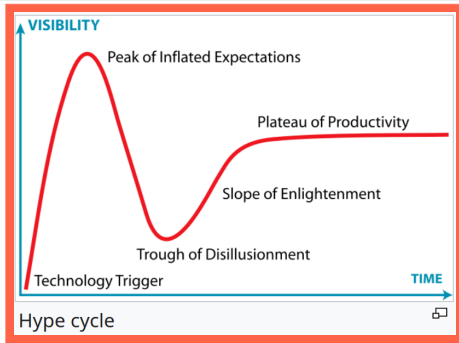
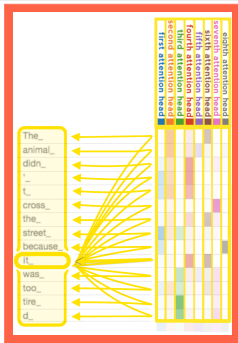
Step 1: $0 < I_n < 1$ for n large

On $[0, \pi]$ we have $0 \leq x(\pi - x) \leq \pi^2/4$, hence

$$0 \leq P_n(x) \leq \frac{(b^2\pi^2/4)^n}{n!} = \frac{(a^2/4)^n}{n!}.$$

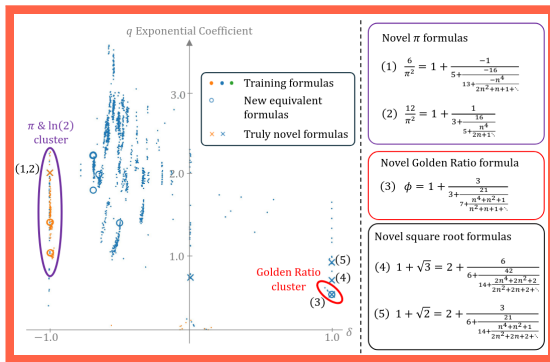
- ▶ Simulating rigorous reasoning is unsolved; proofs still need supervision
- ▶ Good news AI still helps: structure, search, (counter)examples, edits, ...
- ▶ This series Examples of how to use AI in research, how not to use it, and the “Why does it work?”

Everyday AI = LLMs



- ▶ Large language models (LLMs) are trained on huge corpora of text/code to predict the next token
- ▶ They are good at supporting workflows we will cover: reading (summaries, glossaries), coding (snippets, datasets), writing (abstracts, whole passages), and reproducibility (templates, notes)
- ▶ They are not particularly good for reasoning, guarantees, and originality (but we will still see how they can be used for these tasks)

What it can do for you well (general)



- ▶ **Example** “Unsupervised Discovery of Formulas for Mathematical Constants” (2024, <https://arxiv.org/abs/2412.16818>, not an LLM)
- ▶ **Good at** exploring millions of expressions and rediscovering known formulas for π , e , $\ln(2)$ and friends
- ▶ **Striking** the system also found new identities, later verified by mathematicians

What it can do for you well (LLM)

Efficient infinite series [\[edit \]](#)

$$\sum_{k=0}^{\infty} \frac{k!}{(2k+1)!!} = \sum_{k=0}^{\infty} \frac{2^k k!^2}{(2k+1)!} = \frac{\pi}{2} \text{ (see also [Double factorial](#))}$$

$$\sum_{k=0}^{\infty} \frac{k!}{2^k (2k+1)!!} = \frac{2\pi}{3\sqrt{3}}$$

$$\sum_{k=0}^{\infty} \frac{k! (2k)! (25k-3)}{(3k)! 2^k} = \frac{\pi}{2}$$

$$\sum_{k=0}^{\infty} \frac{(-1)^k (6k)! (13591409 + 545140134k)}{(3k)! (k!)^3 640320^{3k}} = \frac{4270934400}{\sqrt{10005}\pi} \text{ (see [Chudnovsky algorithm](#))}$$

$$\sum_{k=0}^{\infty} \frac{(4k)! (1103 + 26390k)}{(k!)^4 396^{4k}} = \frac{9801}{2\sqrt{2}\pi} \text{ (see [Srinivasa Ramanujan](#), [Ramanujan-Sato series](#))}$$

- ▶ The formulas from the previous slide are **very restricted in scope** – not quite human-level formulas
- ▶ Expect **the same** from everyday AI: it can generate new results, but usually only small leaps
- ▶ **Takeaway** In 2025, use LLMs for workflow boosts, not breakthroughs

Thank you for your attention!

I hope that was of some help.