A LESSON ABOUT SINGULARITIES AND FLOW, FOR THE CLASSROOM OR A CLUB

Are there singularities in your coffee?

A 55-minute lesson for GCSE Foundation and Higher, and NCEA Level 1–2. It also works with curious students in Years 7–10, with an extension for those ready for more. It pairs with the short film *Maths in the News #2* and the student worksheet. The aim is a clear picture of "grows without bound," and a careful reading of a news claim — not exam technique.

What you will need

- The student worksheet (pages 1–4; keep page 5, the answers, for yourself)
- The Short, if it is available — or the spoken hook below
- Optional: scissors if you want students to cut the C1–C8 claims into cards (please do not have them cut the only copy of the worksheet)
- Optional: the lesson page at ilovemaths.app/lessons/singularities-navier-stokes

Objectives

- Explain what "grows without bound" means, and identify a vertical asymptote on the graphs of $y = 1/x$ and $y = 1/(t - T)$.
- Treat speed as a rate, and read the gradient of a distance–time graph as a speed of flow.
- Describe, in plain words, the difference between a forced and an unforced claim.
- Judge news claims as credible, unclear, misleading or false, and give a short reason.

Curriculum

GCSE Foundation and Higher (plots of $y = 1/x$; vertical asymptotes as a visual idea; speed as distance ÷ time; gradient of a straight-line graph as a rate of change). NCEA Level 1–2 (graphs, rates of change, and interpreting a mathematical claim in a news context). The extension, on finite-time blow-up versus "gets large eventually," is a natural step for Higher, NCEA Level 2, or a fast group.

The shape of the lesson

0–8 min — **Starter hook — play the Short if you can.** The film is about 75 seconds long. If it is not yet on YouTube, use the spoken hook: "This week a podcast said there are singularities in your coffee. That sounds like science fiction. In maths, the word means something much more precise — and more interesting. Before we find out what it means: what do you already think a singularity is?" Take two or three answers. Do not correct yet. Ask what questions the film (or the hook) left them with. Pronunciation, if you need it: Navier — NAH-vee-ay; Alpöge — roughly ALP-uh-geh.

8–22 min — **Main — grows without bound.** Pages 1–2 of the worksheet. Read the short definition together, then let students complete the $y = 1/x$ table (Q1) and talk about the asymptote (Q2–Q3). Circulate. If someone writes 1/0.01 as 10, ask "how many hundredths are in one whole?" rather than leading with "that's wrong." Then Q4–Q6, with the finite-time graphs. Linger on the idea that 5 seconds is a time you can point to on a clock. The two graphs $1/(t - 5)$ and $1/(5 - t)$ are mirrors — praise anyone who spots that before the extension.

22–34 min — **Rates of change and flow.** Page 3. Q7 and Q8 should feel familiar (speed, gradient). Q9 is there to contrast ordinary finite speed with the prize question. Q10 is the bridge: a "yes" would look like a speed–time graph shooting up a vertical asymptote at some finite time T. Keep the caveat in view: ideal fluid, not your coffee, and not the river in Q9.

34–48 min — **Activity — forced versus unforced, then the card-sort.** Page 4. Read the short news box together, then Q11–Q12. For C1–C8, students write Credible / Unclear / Misleading / False, with a one-line reason. You can also cut a spare copy into cards and sort them in pairs. Do not rush C6 and C7: those are the ones that reward a careful reading. If you have only 50 minutes, keep the sort to about 10 minutes and leave the extension for homework.

48–55 min — **Plenary.** In one sentence each, orally or on a mini whiteboard: "A singularity in this story means…" and "Why is this not about your coffee?" Listen for "grows without bound" or "a description breaking down," and for "ideal fluid" or "a metaphor, not a real cup." Then the official verdict of the film: **unclear**. Thank effort and good questions by name, specifically.

Discussion questions you can drop in

- If a graph shoots up a dashed line, has the quantity "reached infinity," or only got larger than any number we name?
- Why might "in a finite time" matter? What is the difference between "huge after a long time" and "blows up at 5 seconds"?
- Would a headline be enough for you to treat a million-dollar question as solved?
- Why might adding an outside force (a hand still stirring the cup) change the question being asked?

Misconceptions to listen for

- **A singularity is a black hole, or the "AI singularity" from podcasts.** In this lesson it means a breakdown in the description: a quantity growing without bound, or a solution stopping being smooth.
- **There are singularities of this kind in a real cup of coffee.** That wording is a vivid metaphor. The claimed blow-up is for a specially constructed ideal incompressible fluid, not everyday stirring.
- **1/0.01 = 10, or 1/0.001 = 100.** A useful check: 0.01 is one hundredth, so 1 ÷ 0.01 = 100. The tables are designed so the pattern 1, 2, 5, 10, 100, 1,000 becomes visible.
- **Gradient is "the steepness," with no units or meaning.** On the distance–time graph, the gradient is the speed, 2 m/s.
- **A news headline means the $1 million prize has been won, or the problem is officially solved.** Clay still lists Navier–Stokes as Active. OpenAI said it does not intend to claim the prize. This week's unforced claim has not been independently confirmed, and the key evidence had not been released as of 25 November 2026.
- **This is a DeepMind result.** The September announcement is OpenAI's; the November claim is Alpöge and Buckmaster's, with Claude.

Differentiation

If students need more support

Complete the first two rows of the $y = 1/x$ table as a class, then let pairs finish it. Sketch the axes together and only ask students to plot the points. For Q7, write "speed = distance ÷ time" on the board and let them do only the division. For the card-sort, discuss C1 and C2 together as a model, then let pairs try C3–C5. Pair work is better than a solo struggle with the verdict words.

If students are ready for more

The extension on page 4 (E1–E3) is for Higher, NCEA Level 2, or a fast Foundation / Level 1 group. E1 (the two graphs as mirrors) is a gentle start. E2 is the richest: doubling gets enormous, but it stays finite at every finite time — that is the contrast with $1/(5 - t)$. E3 is about why Clay waits (publication, at least two years, general acceptance). A further challenge: what happens to $1/(t - 5)$ as t approaches 5 from the left?

The November 2026 news — please keep this careful

Please do not tell students that the Millennium Problem has been solved, or that the prize has been awarded, and do not call the problem "conquered." The film's verdict is **unclear**. On 8 September 2026 OpenAI announced a proof that a smooth 3D Navier–Stokes flow can blow up in finite time, but only with a carefully constructed smooth external force, and said it does not intend to claim the prize. Many mathematicians called the forced case a loophole (Scientific American, 21 September 2026); later work suggested the method cannot be extended to the unforced problem. On 11 September Clay said the problem had "apparently been settled" and that its evaluation is "deliberately unhurried," but it still lists Navier–Stokes as Active, not solved. Prize rules require publication, at least two years, and general acceptance. On 20 November Levent Alpöge and Tristan Buckmaster claimed finite-time blow-up with no external force, written with help from Claude. As of 25 November 2026 the "certificate" was not public, a related interval-arithmetic check was not in the repository, and there was no independent confirmation. "Singularities in your coffee" is a metaphor, not a claim about a real cup: the blow-up is for a specially constructed ideal fluid. This is not a DeepMind result. Update this if the public picture changes.

Links

- This lesson: **https://ilovemaths.app/lessons/singularities-navier-stokes** · the tutor app: https://ilovemaths.app · Jane's channel: youtube.com/@getsussed-y4h
- Clay announcement, problems list (still Active), and prize rules: https://www.claymath.org/news/navier-stokes-announcement/ · https://www.claymath.org/millennium-problems/ · https://www.claymath.org/millennium-problems/rules/
- OpenAI, 8 September 2026: https://openai.com/index/navier-stokes-solution/
- Scientific American, 21 September 2026: https://www.scientificamerican.com/article/did-openai-solve-the-wrong-navier-stokes-problem/
- Alpöge and Buckmaster, 20 November 2026: https://github.com/tristanbuckmaster/navier-stokes/

For teachers: how students learn best with AI

The evidence is still early, and it is mixed. These points are here to be useful and honest — not to oversell I Love Maths, or AI in general. Links were checked in November 2026.

1. **AI is more likely to help when it supports understanding than when it does the work.** A November 2026 review by Stanford's SCALE Initiative (the AI Hub for Education) looked at 52 cause-and-effect studies. It found that using AI to understand new material is more promising than using it to produce the work — although neither use consistently improves learning. Using AI to offload the task can reduce what students later know.
2. **Treat sweeping "AI improves learning" claims with care.** An Education Week report (2 November 2026) covered an audit of 14 research reviews that all claimed positive effects. The audit found they failed basic research standards: they mixed very different studies, and often lumped together engagement, motivation or "how much students felt they had learned" with actual achievement.
3. **A few careful trials are encouraging, but they are still small.** In one randomised trial in Ghana, students who used Rising Academies' WhatsApp maths tutor Rori for two 30-minute sessions a week, over eight months, gained about 0.37 standard deviations in maths compared with a control group (around 1,000 students in grades 3–9, across 11 schools). That is a meaningful gain in education research, and the authors asked that these first-year results be interpreted carefully.
4. **Good design coaches step by step, rather than handing over the answer.** Google's Guided Learning mode in Gemini is built to ask questions and walk through the steps, rather than simply giving the answer. That is a design choice, in line with the idea above. It is not, by itself, independent proof that the tool improves results.
5. **When AI is used to mark work, human checks still matter.** NZQA uses automated text scoring for digitally submitted NCEA Literacy writing, and human markers check scripts around the Achieved / Not Achieved boundary (about 40% of assessments, in NZQA's published description). If the human mark differs, the human mark is used. This is about assessment marking, not tutoring — it is a reminder that AI works best as a support, with people still in the loop.
6. **The older findings about how people learn still apply, with or without AI.** Students generally learn more when they have to pull ideas out of memory (retrieval practice), explain their thinking (self-explanation), work through a genuine challenge rather than being rescued too quickly (productive struggle), and get feedback on their method, not only on the final answer.

How I Love Maths uses this

I Love Maths is built to support understanding, not to do the work for the student. The tutor asks questions before it gives answers. To reach "Mastered" on a topic, a student needs to type an explanation in their own words. If they send a photo of their working, it is marked for method — and the photo is not stored.

Sources (checked November 2026):

1. Stanford SCALE, "The Evidence Base on AI in K-12: A November 2026 Review" — https://scale.stanford.edu/ai/evidence-base-review/evidence-base-ai-k12-november-review
2. Stephen Sawchuk, "The Research on AI in Education Is a Mess", *Education Week*, 2 November 2026 — https://www.edweek.org/technology/the-research-on-ai-in-education-is-a-mess/2026/11
3. Owen Henkel, Hannah Horne-Robinson, Nessie Kozhakhmetova and Amanda Lee, "Effective and Scalable Math Support: Evidence on the Impact of an AI-Tutor on Math Achievement in Ghana" (arXiv, May 2024 version) — https://arxiv.org/abs/2402.09809
4. Google, "How Gemini's Guided Learning can help you study more effectively", 23 September 2025 — https://blog.google/products-and-platforms/products/gemini/guided-learning-google-gemini/
5. NZQA, "How we mark co-requisite assessments" — https://www2.nzqa.govt.nz/ncea/subjects/litnum/marking/
6. Retrieval practice: https://www.retrievalpractice.org/ · Michelene Chi and colleagues, "Eliciting Self-Explanations Improves Understanding", *Cognitive Science*, 1994 — https://onlinelibrary.wiley.com/doi/10.1207/s15516709cog1803_3 · Manu Kapur, "Productive Failure in Learning Math", *Cognitive Science*, 2014 — https://onlinelibrary.wiley.com/doi/full/10.1111/cogs.12107 · John Hattie and Helen Timperley, "The Power of Feedback", *Review of Educational Research*, 2007 — https://journals.sagepub.com/doi/10.3102/003465430298487

Jane, an experienced maths teacher
I Love Maths — a friendly maths tutor for GCSE and NCEA students who want maths to make sense again.
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