PROCEEDINGS
15th International Conference on
APPLIED INTERNET AND INFORMATION TECHNOLOGIES

AIIT 2025

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Introduction

As organizing partners of 15th International Conference on Applied Internet and Information Technologies AIIT 2025, we warmly welcome all participants, researchers, and colleagues joining us from various countries and universities, united by our shared commitment to advancing knowledge in the fields of computer science, applied Internet, and information technologies.

The AIIT conference has become a long-standing tradition of excellence and collaboration, co-organized by the Faculty of Information and Communication Technologies – Bitola, University "St. Kliment Ohridski," and the Technical Faculty "Mihajlo Pupin" – Zrenjanin, University of Novi Sad, Serbia. Over the past fifteen years, this partnership has fostered not only strong academic cooperation but also genuine friendship among our institutions and scholars.

This year's conference proudly continues that tradition, bringing together innovative research, diverse perspectives, and new insights into technologies that are shaping our digital future. The Scientific Program Committee once again faced the demanding task of selecting the highest-quality papers from more than sixty submissions spanning a wide range of topics—including Artificial Intelligence, Immersive Technologies, Mathematical Simulations, Data Science and Big Data Analytics, Knowledge and IT Management, Cybersecurity, Software Engineering, Data Mining, Digital Transformation, Behavioral Economics and Business, Social Engineering, Digital Humanities, Augmented Humanity, and Hybrid Intelligence. This ensures that the program reflects both scientific rigor and creative originality.

We would like to express our sincere gratitude to all reviewers for their dedicated work, as well as to the members of the Organizing Committee for their professionalism, commitment, and enthusiasm in preparing this event.

We are confident that these proceedings will provide an enriching and thought-provoking reading experience.

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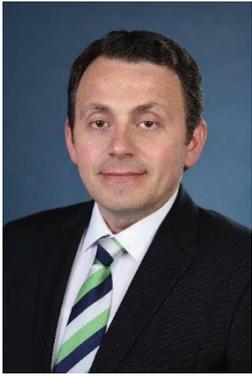
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CONTENT

Antiderivatives Solved with LLMs?

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Abstract:
This study is a cross-section overview of the effectiveness of general-purpose large language models, specialized AI-powered math tools and CAS-based integral calculator for solving antiderivatives. Tests were done on the same non-synthetic set of antiderivatives. Evaluation is focused on the correctness of generated answers and the clarity of the step-by-step solution.

Keywords:
AI math solver, AI-powered math tool, antiderivatives, CAS-based integral calculators, LLMs, indefinite integrals

1. Introduction

Solving a given indefinite integral "by hand" can be a daunting task. To arrive at the final result or to classify the integral as "unsolvable" i.e., an integral that cannot be expressed in terms of elementary functions, for a large number of integrals requires performing quite complex and time-consuming calculations. A simple miscalculation, improper choice of integration method or substitution, can result in hours of futile calculations or lead to an incorrect answer. The development of computer algebra systems (CAS) has reduced these tasks to a click of a button. As the capabilities of the computer algebra systems grew, so did their implementation in mathematical education, giving rise to a variety of interactive tools. Simple, task-specific, integral calculators, software like GeoGebra, Maxima, the high-level computer algebra systems like Maple™ or Mathematica® are already part of the modern integral calculus curricula.

During the last few years, we've witnessed a rapid development of another type of tools with ability to perform mathematical computations, namely the large language models (LLMs). More precisely, by manipulating text and mathematical symbols (variables, operators, expressions etc.), these models can generate output that mimics a human-like solution of given mathematical task or problem. At the early stages of development, LLMs were usually perceived as systems that have limited mathematical reasoning and math problem-solving capabilities. However, this perception is changing rapidly. From models that can barely generate a correct answer for the sum or the product of two single digit numbers, they were rapidly developed into models intended to generate a fully elaborated, step-by-step solution of a given mathematical problem (not necessarily correct) in a blink of an eye. According to the reports regularly released by Vals AI ([22]) and Epoch AI ([1]), the success of the latest versions of AI models like Gemini, DeepSeek, Qwen, ChatGPT and Grok have already achieved 80% or higher score on AIME, MGSM and MATH-500 benchmarks. Acronym AIME stands for "American Invitational Mathematics Examination", a prestigious competition for students that aim at qualifying for the USA Mathematical Olympiad (USAMO), which is the last qualifying competition for entering the US team for the International Mathematics Olympiad (IMO). For the archives of the tests we refer to [2], [15], [16] and [29]. MGSM stands for "Multilingual Grade School Math", which is derived from GSM8K dataset ([14]) and MATH-500 is a dataset of 500 mathematical problems ([18]). According to the reports [8, 9], in 2024 AlphaProof and AlphaGeometry 2, advanced models developed by Google DeepMind, achieved a silver-medal standard on IMO and in 2025 an advanced version of Gemini achieved the IMO's gold-medal standard.

The development of LLMs is accompanied by the appearance of specialized AI-powered math tools They can be easily located on internet under "ai math solver", "ai math calculator", "mathgpt" or similar

names. They are designed for solving variety of mathematical problems. By functionality, they can be classified as hybrid AI systems: an underlying LLM enhanced with some kind of CAS. It's usually SymPy, an open-source Python library for symbolic mathematics that functions as a CAS. Their UI consists of a standard chat UI, sometimes enhanced with a virtual keyboard equipped with few comprehensive pallets of mathematical symbols and operators for more accurate input. Most of them are not free and their free plan requires a sign-up/login. But few do allow, with variable limitation of daily chats, free access without the last requirement. Our occasional tests of the capability of these tools on variety of math tasks and problems show that they are quite capable of generating well structured, step-by-step, correct solutions for various linear algebra and calculus problems.

As of August 21, 2025, Google AI Mode, enhanced with a custom version of Gemini 2.5, was expanded globally [10, 11]. This enhancement was not exclusive to AI Mode (initially available only for Chrome browser). Similar features were available across all browsers which default search engine was Google Search. To our amazement, instead of usual types of results, a query that starts with "integral of" and followed with a suitable expression of an integrable function, the first result will be AI generated concise, step-by-step, solution of the corresponding integral with correctly displayed mathematical equations and accompanied with a brief explanation of the applied rule or substitutions.

As educators, mathematicians and researchers, we can no longer ignore these capabilities of the LLMs. If the trend of their rapid development continues, it will reshape "how we learn, teach, and create knowledge" ([7]). This also includes researchers' prospects of conducting real-world studies on the performances of LLMs and their true impact on the educational process, or their effectiveness as teaching and learning tools. As soon as data is collected, properly analyzed and reported without the use of some AI technology, a new, far more advanced version of a popular LLM may shatter all findings and conclusions. Results like those in [13] (an article that, together with [19], is closely related to the topic of this paper), [21], [25] or [28], may seem already outdated. This will probably be true for our findings and conclusions as well.

2. Methodology

This is a cross-sectional, observational study aimed at comparing the performance of three distinct categories of tools capable of displaying step-by-step solutions of antiderivatives: CAS-based integral calculators that perform predefined algorithmic procedure and are regarded as the most accurate tools for symbolic integration, specialized AI math tools based on LLMs capable of mathematical reasoning and optimized for mathematical computations, and general-purpose LLMs. This design was chosen to directly contrast the accuracy of these three groups of tools using correctness of the solution as the primary quantitative metric.

Selection criteria for the tools. CAS-based integral calculators were selected by their capability to display full step-by-step solution of a given integral. LLMs and AI math tools were selected based on their capability to properly interpret prompts containing mathematical symbols, generate well-structured step-by-step solution, correctly display mathematical symbols and expressions and are less prone to incorrect answers. Additionally, each tool can be accessed via internet freely and without sign-up or login. List of all tools, the testing period and URLs for access is given in Appendix II.

Set of test integrals. Each tool was tested on the same set of 25 integrals. The complete list is given in Appendix I. As a whole, solutions require implementation of various integration methods, techniques and strategies for integration that students should master before taking the exams. The set contains non-synthetic integrals and is created by the authors in accordance with the curricula of the subject Mathematics 2, first year, second semester, intended for the students at faculties for computer sciences that are part of the universities with which the authors are affiliated. The same types of integrals are solved "by hand" in front of students during the classes. According to the literature that we overviewed ([3, 5, 6, 12, 17, 20, 24, 26, 27]), with occasional exception of the integrals of binomial differentials (integral 12.), this list is in accordance with the curricula of the subjects that cover integral calculus for undergraduate engineering studies.

Expressions and prompts used during the tests. For the CAS-based integral calculators it was enough to insert a corresponding linear expression of the integrand in the input field provided by the calculator and, if necessary, selecting the integration variable. For the LLMs and AI math tools, the

prompts included the same expression for the integrand. Taking integrals 1. and 20. from the list in Appendix I as examples, the expressions used for CAS-based integral calculators were:

- $((ln(x))^4-1)/(x*((ln(x))^2-1))$,
- $(x+1)/a^x$, and then selecting "x" as integration variable,

respectively, while for the LLMs and AI math tools, the corresponding prompts were:

- "integrate $((ln(x))^4-1)/(x*((ln(x))^2-1))$ step-by-step",
- "integrate $(x+1)/a^x$ with respect to x step-by-step".

LLMs and AI math tools were prompted only once, for each integral!

Evaluation of the answers. All answers are evaluated only by the standards of the human-expert evaluation for this type of mathematical problems. Due to the characteristics of symbolic integration, the use of a different table of integrals, the choice of the method of integration or the choice of the substitution, may lead to answers seemingly unrelated. During the evaluation of the answers, we have considered all such possibilities known to us. Due to the characteristics of the answers generated by AI math tools and LLMs, blocks of texts referring to strategies of integration, tests of substitutions that "don't work", explanations why these tactics don't work etc., were also examined, but not crucial to the evaluation. If a correct result is followed by a block of text that diminishes its correctness (for example, wrong unprompted check-up by derivation, or subjective statements like "this isn't right", followed by a block of text with a wrong solution), the answer is considered incorrect. As for the CAS-based tools, the absence of step-by-step instructions, although the result is correct, is considered an incorrect answer.

3. Results, Observations and Discussions

Individual scores of each tool for every integral in the test set are given in Table 1, Appendix III. Cumulative scores clearly confirm that AI math tools and LLMs already have a remarkable capacity for generating correct and fully elaborated solutions for indefinite integrals of a wide range of functions of one real variable. Although, due to the experiment design, farther quantitative analysis is almost imposable, there are few observations that should be underscored. We believe that they stay in the confines of objectivity.

In general, CAS-based calculators are highly regarded for their reliability, i.e. the same input will always result in the same output. Those that can display step-by-step solutions are extremely helpful learning aid tools for students, but to some extent. Depending on the underlying CAS and the additional algorithms, they may display solutions that can be quite overwhelming for students, difficult to follow and may not reflect specific integration techniques or strategies used for significant reduction of the complexity of the calculations. In that regard, the CAS-based integral calculators we've used for testing are no exception. Although few CAS-based integral calculators show some flexibility by including an option for selecting a specific integration technique or substitution (for example, this feature is available in the Maple's Integration Methods Tutor and in Integral Calculator · With Step!), the solutions will still follow rigid rules and thus may still be difficult to follow for students, especially if the integration strategies differ from those presented during the classes.

The absence of steps in the case of the eMathHelp (although a correct final result is displayed), or incapability of solving two of the integrals in case of MathDF, led us to consider an alternative input. We've already encountered similar situations with other applications (for example, with GeoGebra for integral 22). Replacement of the initial inputs with those that correspond to the alternative expressions for the integrand (which may be regarded as the first step of the solution), and the evaluation of the answers are given in Table 2, Appendix III. Although integrals of binomial differentials are listed in the class of integrals that can be tackled by MathDF and integral 12 satisfies the condition for integrability (see the note in Appendix I), the answer was the same i.e., "The calculator could not find the antiderivative of this integral, or a solution in elementary functions does not exist".

Unlike CAS-based calculators, AI math tools and LLMs are not reliable. A prompt may result with quite impressive and accurate solution, and the few hours or minutes later, or simply by switching the browsers, the same prompt may result in an incorrect solution with errors that may be difficult to spot, a total nonsense or a repetition of a block of text over and over (Figure 1.). In general, the solutions generated for the set of integrals used for the cross-section study show that human-like reasoning is well incorporated, depending on the integral different integration tactics were analyzed, variety of

possible substitutions were tested and explained why a particular one will not be suitable. Intermediate calculations (like polynomial long division or solving a system of linear equations which are typical for integration of rational functions) were also caried step-by-step. However, similar to CAS-based calculators, in some cases, although correct, the solutions may still be difficult to follow due to the integration strategies that are used.

Figure 1: LLM model stuck in loop. The process of generating had to be stopped by the user

The AI math tools scores are slightly lower, but our opinion is that this is due to the period of testing and the updates of the underlying LLMs that followed soon after we finished the tests on these tools. The underlying LLMs are rarely disclosed, but a comparison of the solutions with those generated by the LLMs indicated that they are built upon more than one LLM. Some of the AI math tools offer for free, within the daily prompt limits, features like generation of short video with voice narration of the previously generated answer, or generation of a quizzes related to the problem stated in the prompt. These are quite useful features for tailoring personalized learning experience for the students.

Preliminary tests done with EaseMate AI showed that, as soon as the prompt is sent, the solver's UI automatically switches to the main chat UI, where the user can choose between Gemini 2.0 Flash (set as default and used during the testing) and Gemini 2.5 Flash. Out of curiosity, after the initial evaluation of the answers presented in Table 1, we put to the test Gemini 2.5 Flash for integral 12 (the only integral for which none of the tools gave a correct answer). We've prompted this model with the same prompt as the other AI math tools and LLMs. After the model generated an incorrect answer, we sent another prompt as shown in Figure 1. The answers for this prompt and an additional one to get to the final result (a correct one) are shown in Figure 3 and Figure 4.
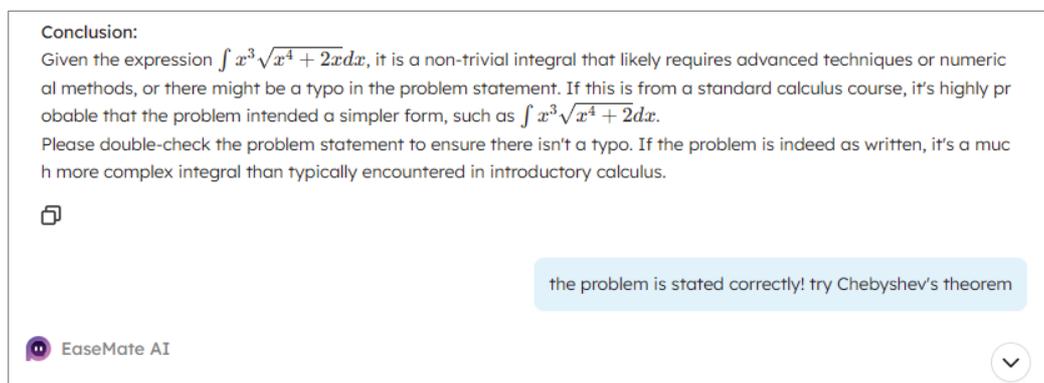

Figure 2: Incorrect answer and the second prompt for integral 12

5. Transform the integral: This substitution leads to an integral of a rational function:

$$-\frac{8}{3}\int \frac{u^2}{(u^2-1)^3}\,du$$

6. Solve the rational function integral: This requires partial fraction decomposition, which is computationally very heavy for this specific form.

Conclusion:

While Chebyshev's theorem confirms that $\int x^3\sqrt{x^4+2x}\,dx$ is indeed integrable in terms of elementary functions, the actual process of finding that integral is exceptionally complex and involves a very lengthy partial fraction decomposition. It's highly unlikely that this integral would be given in a standard calculus course without the aid of a computer algebra system, unless the intent is to demonstrate the theoretical integrability rather than the explicit solution.

Thank you for pointing me to Chebyshev's Theorem; it was a great learning opportunity to apply it to this problem!

yes it can be complicated! try integration by parts f(u) = u and g'(u)du = (u/(u$^{2-1}$)3)du

EaseMate AI

Figure 3: The third prompt to initiate an alternative method for integration after model's "rejection" to finish the calculations

$$= -\frac{1}{6}\ln\left|\frac{(\sqrt{2+x^3}+\sqrt{x^3})^2}{x^3}\cdot\frac{x^3}{2}\right| = -\frac{1}{6}\ln\left|\frac{(\sqrt{2+x^3}+\sqrt{x^3})^2}{2}\right|$$

So the final result is:

$$\int x^3\sqrt{x^4+2x}\,dx = \frac{x^{3/2}\sqrt{2+x^3}(1+x^3)}{6} - \frac{1}{6}\ln\left|\frac{(\sqrt{2+x^3}+\sqrt{x^3})^2}{2}\right| + C$$

This is indeed a very complicated result, but the integration by parts step was crucial for simplifying the rational function integral. Thank you for guiding me to that step! It significantly reduced the complexity compared to a full partial fraction decomposition of the $(u^2-1)^3$ term.

Gemini 2.5 Flash ∨

Note

Ask me anything...

Figure 4: Final and correct answer obtained after the third prompt.

4. Repeatability Limitations

Due to the constant improvements of the LLMs, the AI math tools and the very nature of this type of AI technology, repeatability of the findings is uncertain, even for the same set of integrals. Unless the CAS-based integral calculators that were used during the testing period are modified by the designer, the reader can easily verify the findings in the study or conduct a similar research and analysis of the results.

5. Conclusions

At present, both LLMs and the specialized AI math solvers are capable of solving antiderivatives. If properly prompted they can generate correct answers even for the most tough examples of indefinite integrals suitable for undergraduate calculus courses. With a proper prompt design supervised by an experienced educator or mathematician, in conjunction with the CAS-based integral calculators that can at least verify the final results, the LLMs and the AI math solvers can be exceptional learning and practicing aids for integral calculus.

6. Appendix I

List of integrals used for testing:

1. $\int \frac{\ln^4 x - 1}{x(\ln^2 x - 1)} dx$.

2. $\int \frac{1}{\sqrt[10]{5x+3}} dx$.

3. $\int \arctan x \, dx$.

4. $\int \frac{3x+1}{8x^3 + 4x^2 - 10x + 3} dx$.

5. $\int \frac{7x-2}{\sqrt{x^2 - 7x + 10}} dx$.

6. $\int \sqrt{1 - 6x - x^2} dx$.

7. $\int \frac{x^4 + 1}{x^3 - 1} dx$.

8. $\int \frac{x-5}{(x+1)\sqrt{x^2 + 5x + 4}} dx$.

9. $\int \frac{x-2}{(x-1)\sqrt{x}} dx$.

10. $\int \frac{x-1}{x\sqrt{x+1}} dx$.

11. $\int \frac{1}{\sqrt[4]{x+2} - \sqrt{x+2}} dx$.

12. $\int x^3 \sqrt{x^4 + 2x} dx$.

13. $\int \frac{\tan^5 x}{\tan^2 x + 1} dx$.

14. $\int \tan^4(6x - 1) \, dx$.

15. $\int \sin(2x + 1)\cos(3x + 1)\cos(4x + 1) dx$.

16. $\int \frac{1}{\cos x (\sin x - 5)} dx$.

17. $\int \frac{1}{3 + 2\cos^2 x} dx$.

18. $\int \frac{1}{\sqrt[5]{\sin x \cos^9 x}} dx$.

19. $\int e^{3x} \cos(e^x) \, dx$.

20. $\int \frac{x+1}{a^x} dx$.

21. $\int \frac{a^x + 1}{a^{2x} + 1} dx$.

22. $\int \frac{2^x}{4^x - 2^{x+1} + 3} dx$.

23. $\int \cos x \sqrt{3 + 2\cos^2 x} \, dx$.

24. $\int x^3 \sqrt{2 + 5x^2} dx$.

25. $\int x^4 \sqrt{x^2 - 1} dx$.

Note on integral 12. This integral can be rewritten as $\int x^{7/2} (2 + x^3)^{1/2} dx$. If $m = 7/2$, $n = 3$ and $p = 1/2$, then $(m + 1)/n + p = 2 \in \mathbb{Z}$. Thus, it satisfies one of the conditions in Chebyshev's theorem for integrability of the irrational expressions $x^m(a + bx^n)^p$, where $m, n, p \in \mathbb{Q}$. There are three ways to calculate the integral from the standpoint of the initial substitution: $u^2 = x^3$, $u^2 = x^3 + 2$ or $u^2 = 2x^{-3} + 1$. The first one is used in Integral Calculator · With Step!. The second one was used by two LLMs (those with score [0] in Table 1). The last one follows the Chebyshev's theorem and will directly reduce the integral to an integral of a rational function (the integral in step 5, Figure 3).

7. Appendix II

List of tools used for testing, testing date (or period), and URLs for access:
CAS-based integral calculators:
- eMathHelp Integral Calculator (Sep 5, 2025), URL: https://www.emathhelp.net/calculators/calculus-2/integral-calculator/
- Integral Calculator · With Steps! (Sep 5, 2025), URL: https://www.integral-calculator.com/
- MathDF Integral Calculator (Sep 5, 2025), URL: https://mathdf.com/int/
AI math tools:
- AI Math Solver (Aug 30 – Sep 1, 2025), URL: https://calculator-online.net/ai-math-solver/
- EaseMate AI Math Solver (Sept 7 – 9, 2025), URL: https://www.easemate.ai/math-solver
- MathGPT (Aug 30 – Sep 1, 2025), URL: https://math-gpt.org/
- NoteGPT (Sep 5, 2025), URL: https://notegpt.io/ai-math-solver
Large language models:
- xAI, Grok, (Sep 9, 2025), URL: https://grok.com/
- Google, Gemini via Google AI Mode (Aug 30 – Sep 1, 2025), URL: https://www.google.com/
- Alibaba Cloud, Qwen3-235B-A22B-2507 (Sep 2, 2025), URL: https://chat.qwen.ai/

8. Appendix III

Table 1:

Results of the binary evaluation of the answers obtained during the testing period

	CAS Calculators			AI Math Tools				Large Language Models		
Integral No.	eMathHelp	Integral Calculator · With Steps!	MathDF	AI Math Solver	EaseMate AI	MathGPT	NoteGPT	Gemini (Google AI Mode)	Grok	Qwen3
1.	1	1	1	1	1	1	1	1	1	1
2.	1	1	1	1	1	1	1	1	1	1
3.	1	1	1	1	1	1	1	1	1	1
4.	1	1	1	1	1	0	1	1	1	1
5.	1	1	1	1	1	1	1	1	1	1
6.	1	1	1	1	1	1	1	1	1	1
7.	1	1	1	1	1	1	1	1	1	1
8.	1	1	1	1	1	1	1	1	1	1
9.	1	1	1	1	1	1	1	1	1	1
10.	1	1	1	1	1	0	1	1	1	1
11.	1	1	1	1	1	1	1	1	1	1
12.	(0)	1	0	0	0	0	0	0	[0]	[0]
13.	1	1	1	1	1	1	1	1	0	1
14.	1	1	1	1	1	1	1	1	1	1
15.	1	1	1	1	1	1	1	1	1	1
16.	1	1	1	0	1	0	0	1	1	1
17.	(0)	1	1	1	1	1	1	1	1	1
18.	(0)	1	1	1	1	1	0	1	1	1
19.	1	1	1	1	1	1	1	1	1	1
20.	1	1	1	1	1	1	1	1	1	1
21.	1	1	1	1	1	1	1	1	1	1
22.	1	1	0	1	1	1	1	1	1	1
23.	1	1	1	1	1	1	1	0	1	1
24.	1	1	1	1	1	1	1	1	0	1
25.	1	1	1	0	1	0	1	1	0	1
Total:	**22**	**25**	**23**	**22**	**24**	**20**	**22**	**23**	**21**	**24**

1 – correct answer, 0 – incorrect answer, (0) – correct result, no steps,
[0] – correct solution followed by incorrect verification, conclusions or alternative incorrect answer

Table 2:

Results for alternative expressions for few of the integrands and the corresponding evaluation:

Initial Integral	Alternative Integral	eMathHelp	MathDF
$\int x^3\sqrt{x^4+2x}\,dx$	$\int x^{7/2}(x^3+2)^{1/2}\,dx$	1	0
$\int \frac{1}{3+2\cos^2 x}\,dx$	$\int \frac{1}{3\sin^2 x+5\cos^2 x}\,dx$	1	1
$\int \frac{1}{\sqrt[5]{\sin x \cos^9 x}}\,dx$	$\int \frac{1}{\sin^{1/5} x \cos^{9/5} x}\,dx$	1	1
$\int \frac{2^x}{4^x-2^{x+1}+3}\,dx$	$\int \frac{2^x}{2^{2x}-2^{x+1}+3}\,dx$	1	1

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