THEORY OF COMPUTATION SIPSER SOLUTIONS 2ND EDITION Latest Edition

theory of computation sipser solutions 2nd edition is a comprehensive resource widely used by students and educators to understand fundamental concepts in automata theory, formal languages, and computational complexity. This authoritative textbook, authored by Michael Sipser, offers detailed explanations, rigorous proofs, and practical problem-solving strategies, making it an essential guide for mastering the core principles of the theory of computation. The second edition enhances clarity, introduces new exercises, and aligns with modern curriculum standards, making it an invaluable tool for both self-study and classroom instruction.

Overview of the Theory of Computation Sipser Solutions 2nd Edition

What is the Theory of Computation?

The theory of computation is a branch of computer science and mathematics that deals with understanding the capabilities and limitations of various computational models. It explores questions such as:

- What problems can be solved by algorithms?
- How efficiently can these problems be solved?
- Which problems are inherently unsolvable or undecidable?

The second edition of Sipser's textbook provides a structured approach to these questions, covering a wide range of topics from automata theory to complexity classes.

Key Features of the 2nd Edition

This edition offers several enhancements over the first:

- Improved explanations and illustrations
- Additional exercises with solutions
- Clarified proofs and concepts
- Updated content reflecting recent developments in the field
- Focus on problem-solving strategies

Core Topics Covered in the Sipser Solutions 2nd Edition

The book systematically covers foundational topics in the theory of computation, including:

Automata Theory

Automata are abstract machines that recognize patterns within input strings. The solutions in the book delve into various types:

- Finite Automata (FA)
- Deterministic Finite Automata (DFA)
- Nondeterministic Finite Automata (NFA)
- Equivalence of DFA and NFA
- Regular expressions and their relation to automata

Formal Languages

Formal languages are sets of strings over an alphabet. The solutions explore:

- Language definitions
- Operations on languages (union, intersection, concatenation, Kleene star)
- Closure properties
- Pumping Lemma for Regular Languages

Context-Free Grammars and Pushdown Automata

This section covers:

- Context-Free Grammars (CFGs)
- Parse trees
- Chomsky Normal Form
- PDAs and their equivalence to CFGs
- Applications in compiler design

Turing Machines and Computability

The solutions explain the most powerful abstract computational model:

- Definition and operation of Turing Machines
- Variants (multi-tape, nondeterministic)
- Decidability and semi-decidability
- The Halting Problem
- Reductions and their role in proving undecidability

Computational Complexity

This section addresses the resources required for computations:

- Time and space complexity
- Complexity classes (P, NP, NP-complete, PSPACE)
- Reductions and completeness
- The significance of P vs. NP problem

How the Solutions in Sipser 2nd Edition Aid Learning

Step-by-Step Problem Solving

The solutions provide detailed, step-by-step approaches to solving problems, helping students grasp complex concepts.

Proof Techniques and Strategies

The book emphasizes proof methods such as:

- Induction
- Contradiction
- Construction
- Pumping Lemma applications

Practice and Reinforcement

A wealth of exercises, with solutions, solidify understanding and prepare students for exams.

Why Choose the Sipser 2nd Edition for the Theory of Computation?

Authoritative Content

Michael Sipser's clear writing style and rigorous approach make complex topics accessible.

Comprehensive Coverage

The book covers the entire spectrum of the theory of computation, making it suitable for various course levels.

Practical Problem-Solving Focus

Solutions and exercises are designed to develop analytical skills necessary for both academic and industry applications.

Updated and Relevant

The second edition reflects recent advances and pedagogical improvements, ensuring current relevance.

How to Use the Solutions Effectively

Active Practice

Attempt problems independently before consulting solutions to maximize learning.

Focus on Understanding

Use solutions as guides to understand problem-solving techniques, not just for answers.

Review Key Proofs

Pay special attention to proofs and derivations to build a strong theoretical foundation.

Benefits of Mastering the Theory of Computation with Sipser Solutions

- Develops analytical and problem-solving skills
- Prepares students for advanced topics like complexity theory
- Enhances understanding of algorithm limitations
- Builds a solid foundation for research in theoretical computer science
- Supports success in competitive programming and technical interviews

Conclusion

The **theory of computation sipser solutions 2nd edition** stands as an essential resource for students aiming to master the core principles of automata, formal languages, and computational complexity. Its detailed solutions, clear explanations, and comprehensive coverage make it an invaluable guide for navigating the complexities of theoretical computer science. Whether used as a textbook companion or a standalone reference, this edition equips learners with the necessary tools to understand the theoretical limits of computation, develop rigorous problem-solving skills, and prepare for advanced academic or professional pursuits in computer science. By leveraging the solutions provided, students can deepen their understanding, solidify their grasp of challenging concepts, and excel in their studies of the theory of computation.

Theory of Computation Sipser Solutions 2nd Edition: An In-Depth Guide for Students and Enthusiasts

The Theory of Computation Sipser Solutions 2nd Edition is an essential resource for students delving into the foundational aspects of computer science. This textbook, authored by Michael Sipser, provides a rigorous yet accessible approach to formal languages, automata theory, computability, and complexity theory. Its comprehensive problems and solutions serve as a crucial aid in mastering the core concepts, especially when supplemented with detailed analysis and structured review. In this guide, we will explore the key topics covered in Sipser?s second edition, analyze common solution strategies, and offer tips for effectively using this resource to deepen your understanding of computational theory.

Understanding the Significance of the Second Edition

Before diving into the core content, it?s important to appreciate what makes the 2nd Edition of Sipser?s Theory of Computation particularly valuable:

- Updated Content and Clarifications: The second edition refines explanations, clarifies complex ideas, and incorporates additional exercises that challenge students to think critically.
- Enhanced Problem Sets: The solutions are designed to reinforce learning, offering step-by-step reasoning and alternative approaches.
- Broader Scope: It expands on topics like nondeterminism, reductions, and complexity classes, ensuring students gain a well-rounded understanding.

This edition acts as both a textbook and a problem-solving companion, making it an indispensable resource for coursework, self-study, and exam preparation.

Core Topics Covered in the Book

The Theory of Computation Sipser Solutions 2nd Edition spans several fundamental areas:

- Formal Languages and Automata

- Regular Languages and Finite Automata
- Context-Free Languages and Pushdown Automata
- Decidability and Recognizability

- Computability Theory

- Turing Machines and Their Variants
- Decidability and the Halting Problem
- Reductions and Rice?s Theorem

- Complexity Theory

- Time and Space Complexity
- NP-Completeness
- Hierarchy Theorems

Each chapter builds upon the previous, creating a layered understanding of how simple models lead to powerful computational frameworks.

Approaching the Solutions: Strategies and Insights

The solutions provided in Sipser?s textbook are crafted to help students develop problem-solving intuition. Here?s a structured approach to understanding and leveraging these solutions:

- Read the Problem Carefully

- Identify what is being asked.
- Note any constraints or special conditions.
- Determine which definitions or theorems are relevant.

- Recall Relevant Concepts

- Automata types (DFA, NFA, PDA, TM)
- Closure properties
- Decidability results
- Complexity classes

- Break Down the Solution

- Step-by-step reasoning: Solutions typically decompose problems into manageable subproblems.
- Constructing models: For automata or grammars, the solutions often involve explicit constructions.
- Proof techniques: Use of direct proofs, contradiction, reduction, or induction.

- Verify and Reflect

- Check each step for correctness.
- Think about alternative solutions or generalizations.
- Consider the implications of the result in broader contexts.

Common Problem Types and Solution Approaches

Below are some frequent problem categories from Sipser?s book, along with typical solution strategies:

Automata Construction Problems

Sample Problem: Design a DFA that accepts strings over {0,1} with an even number of zeros.

Solution Approach:

- Recognize the pattern: tracking parity of zeros.
- Use states to represent the current parity status.
- Construct transitions accordingly.

- Verify that the accepting state corresponds to an even count.

Language Closure and Decision Problems

Sample Problem: Show that the class of regular languages is closed under union.

Solution Approach:

- Use automata constructions: Given automata for L? and L?, build a new automaton that accepts the union.
- For DFAs, create a product automaton with accepting states defined appropriately.
- Prove that the construction preserves regularity.

Turing Machine Decidability and Recognizability

Sample Problem: Prove that the Halting Problem is undecidable.

Solution Approach:

- Assume a hypothetical decider for the Halting Problem.
- Show how this leads to a contradiction via diagonalization.
- Use a reduction from a known undecidable problem to establish the impossibility.

Reductions and NP-Completeness

Sample Problem: Reduce 3-SAT to CLIQUE to show CLIQUE is NP-hard.

Solution Approach:

- Construct a graph from a 3-SAT formula such that the graph contains a clique of a certain size if and only if the formula is satisfiable.
- Carefully map variables and clauses to vertices and edges.
- Prove the equivalence between satisfiability and clique existence.

Tips for Using Sipser?s Solutions Effectively

- Don?t Just Copy: Use solutions as a learning tool, not just a shortcut. Attempt problems

independently before consulting the solutions.

- Analyze Each Step: Pay attention to the reasoning behind each step. Understand why a particular construction or proof technique is used.
- Practice Variations: Modify problems slightly and try to adapt the solutions. This enhances flexibility.
- Summarize Key Ideas: After studying a solution, write a brief summary of the core concept or technique involved.
- Discuss with Peers: Explaining solutions to others can solidify your understanding.

Common Challenges and How to Overcome Them

Many students encounter difficulties with certain topics in the Theory of Computation. Here are common hurdles and recommended strategies:

Understanding Automata Constructions

- Challenge: Visualizing complex automata or grammars.
- Solution: Draw diagrams step-by-step, simulate strings, and verify acceptance criteria.

Grasping Decidability and Reductions

- Challenge: Following intricate reduction proofs.
- Solution: Break reductions into smaller parts, write out the mapping explicitly, and verify correctness with examples.

Comprehending Complexity Class Relationships

- Challenge: Internalizing hierarchy theorems and class separations.
- Solution: Create diagrams illustrating class inclusions and separations; revisit definitions frequently.

Final Thoughts: Mastering the Theory of Computation

The Theory of Computation Sipser Solutions 2nd Edition stands as a cornerstone for students aiming to master computational theory. Its detailed solutions demystify complex proofs and constructions, fostering a deeper understanding of the fundamental limits and capabilities of computation. By approaching problems systematically, engaging actively with solutions, and consistently practicing, students can develop both confidence and competence in this challenging

yet rewarding field.

Remember, the journey through automata, languages, and complexity is not just about passing exams?it?s about cultivating a logical mindset that underpins all of computer science. Use Sipser?s solutions as a guiding light, but also challenge yourself to explore beyond the solutions to truly internalize the principles of the theory of computation.

QuestionAnswer What are the main topics covered in Chapter 2 of Sipser's 'Theory of Computation' 2nd edition? Chapter 2 primarily discusses regular languages, finite automata, regular expressions, and their interrelations, including proofs of equivalence and closure properties. How does Sipser define a deterministic finite automaton (DFA) in the solutions manual? A DFA is defined as a 5-tuple consisting of a finite set of states, an input alphabet, a transition function, a start state, and a set of accept states, with the transition function being deterministic. What is the key method used in solving problems involving regular expressions and finite automata in Sipser Solutions? The key method involves converting regular expressions to finite automata using Thompson's construction, and vice versa, to demonstrate their equivalence and solve related problems. How are closure properties of regular languages proved in Sipser's solutions manual? Closure properties are typically proved by constructing automata or regular expressions that represent the combined languages, such as using union, concatenation, and Kleene star operations, to show the resulting language is regular. What strategy is recommended in Sipser Solutions for proving that a language is not regular? The common strategy involves using the Pumping Lemma for regular languages to show that the language does not satisfy the necessary conditions, thus proving it is not regular. In the solutions manual, how is the equivalence between regular expressions and finite automata demonstrated? Equivalence is demonstrated through systematic conversions: converting regular expressions to finite automata via Thompson's construction and converting finite automata to regular expressions using state elimination methods. What are the common pitfalls highlighted in Sipser's solutions manual when constructing automata for complex regular expressions? Common pitfalls include incorrectly handling epsilon transitions, omitting necessary states, and failing to ensure the automaton accepts the correct language, especially when dealing with union, concatenation, and Kleene star operations. How does Sipser's solutions manual approach the proof of the Pumping Lemma for regular languages? The manual presents a step-by-step proof, selecting a suitable pumping length, decomposing strings into parts, and demonstrating that pumping the middle section either produces strings outside the language or violates the language's properties, thus confirming the lemma. What is the significance of minimal automata in the context of Sipser's solutions, and how are they constructed? Minimal automata are significant because they provide the simplest automaton recognizing a language. They are constructed by merging equivalent states using partition refinement algorithms, ensuring the automaton has the smallest possible number of states.

Related keywords: computational theory, automata theory, formal languages, Turing machines, decidability, complexity theory, algorithms, computational models, Sipser textbook solutions, automata and languages

SIPSER SECOND EDITION SOLUTIONS

Sipser Second Edition Solutions is a comprehensive resource that provides detailed explanations and step-by-step solutions to the exercises found within the popular textbook "Automata Theory and Computability" by Michael Sipser. Designed for students, educators, and enthusiasts in theoretical computer science, these solutions serve as an invaluable supplement to the textbook, helping readers deepen their understanding of automata, formal languages, Turing machines, and complexity theory.

Understanding the Importance of Sipser Second Edition Solutions

Enhancing Comprehension and Learning

The primary purpose of Sipser Second Edition solutions is to facilitate a better grasp of complex concepts. Automata theory and formal languages involve intricate proofs, constructions, and problem-solving techniques. Having access to detailed solutions allows learners to verify their approaches, understand different problem-solving strategies, and clarify misconceptions.

Supporting Self-Study and Course Preparation

For students preparing for exams or working through coursework independently, these solutions act as a reliable guide. They enable self-assessment and help in identifying areas that require further review. Instructors can also utilize these solutions to create effective teaching materials and problem sets.

Ensuring Academic Integrity

While solutions are a valuable learning aid, they should be used responsibly. They are intended to complement active engagement with the coursework, encouraging learners to attempt problems independently before consulting the solutions.

Scope of Contents in Sipser Second Edition Solutions

Automata and Formal Languages

Solutions cover topics such as:

- Finite automata (DFA and NFA)
- Regular expressions and their equivalence to automata

- Closure properties of regular languages
- Pumping Lemma for regular languages

Context-Free Languages and Pushdown Automata

Problems and solutions include:

- Context-free grammars (CFGs)
- Pushdown automata (PDAs)
- Chomsky Normal Form transformations
- Parsing algorithms and ambiguity

Turing Machines and Computability

Key topics addressed are:

- Design and simulation of Turing machines
- Decidability and undecidability proofs
- Halting problem analysis
- Recursive and recursively enumerable languages

Complexity Theory

Solutions delve into:

- P vs NP problem
- Reductions and NP-completeness
- Time and space complexity classes
- Hierarchy theorems

How to Use Sipser Second Edition Solutions Effectively

Active Problem Solving

To maximize learning, students should attempt problems on their own before reviewing the solutions. Use the solutions to verify your reasoning, understand alternative approaches, and clarify any misunderstandings.

Step-by-Step Breakdown

Solutions often include detailed step-by-step explanations, which are crucial for grasping complex proofs and constructions. Pay attention to the logical flow and reasoning to develop problem-solving intuition.

Supplementary Study Resource

Instructors can incorporate solutions into their teaching by assigning problems for homework and then discussing the solutions in class. This approach encourages active participation and critical thinking.

Focus on Key Concepts

While reviewing solutions, focus on understanding the core concepts and techniques used. This will help you apply similar strategies to new problems and different contexts.

Benefits of Using Sipser Second Edition Solutions for Exam Preparation

- Identify common pitfalls and mistakes made by students
- Gain insight into problem-solving strategies adopted by experts
- Build confidence by practicing with solutions for various difficulty levels
- Develop a deeper understanding of proofs and theoretical arguments

Where to Find Sipser Second Edition Solutions

Official Resources

While the textbook itself does not include solutions, publishers or associated academic websites may provide instructor solutions or supplementary materials. Always ensure to access legitimate resources to maintain academic integrity.

Online Platforms and Forums

Several educational platforms, forums, and communities host discussion threads and unofficial solutions. Websites like GitHub repositories, Chegg, or Course hero sometimes offer solutions, but users should verify the accuracy and reliability of these resources.

Study Groups and Peer Collaboration

Forming study groups allows for collaborative problem-solving and peer review of solutions. Sharing approaches and discussing solutions enhances understanding and retention.

Legal and Ethical Considerations

When using solutions, always respect copyright laws and academic honesty policies. Use solutions as a learning aid rather than a shortcut to completing assignments dishonestly.

Conclusion

Sipser Second Edition solutions serve as an essential resource for mastering automata theory and computability. They provide clarity on complex topics, facilitate effective self-study, and support academic success. By engaging with these solutions thoughtfully and ethically, students and educators can significantly enhance their understanding of theoretical computer science concepts, paving the way for further exploration and research in the field.

Additional Tips for Mastering Automata and Computability

- Practice regularly to develop problem-solving skills
- Focus on understanding proofs rather than rote memorization
- Use solutions to learn alternative methods and strategies
- Engage with online communities for discussion and clarification
- Review foundational concepts before tackling advanced problems

By integrating the use of Sipser Second Edition solutions into your study routine, you'll be well-equipped to conquer the challenging topics of automata theory and computability, ultimately strengthening your theoretical computer science expertise.

Sipser Second Edition Solutions: An Analytical Overview of Its Educational Value, Content, and Practical Applications

Introduction: The Significance of Sipser's Second Edition in Automata Theory and Formal Languages

In the realm of theoretical computer science, Michael Sipser's "Introduction to the Theory of Computation" stands as a cornerstone textbook that has shaped generations of students' understanding of automata, formal languages, computability, and complexity theory. The second edition, in particular, released to incorporate updates and refinements, continues to serve as a critical resource. Alongside the core text, the availability of solutions manuals enhances its pedagogical utility, providing students and educators with comprehensive answer keys and detailed

explanations.

This article aims to offer an in-depth analysis of the Sipser Second Edition Solutions, exploring their role in learning, the structure of these solutions, their benefits and limitations, and best practices for utilizing them effectively.

The Role of Solutions Manuals in Learning Automata and Formal Languages

Why Are Solutions Manuals Important?

Solutions manuals serve multiple functions in the educational journey:

- Clarification of Concepts: They demystify complex proofs, algorithms, and problem-solving strategies.
- Guidance for Self-Study: Especially useful for students working independently or in online courses.
- Assessment and Feedback: Provide immediate feedback on problem-solving approaches, helping students identify misconceptions.
- Preparation for Exams: Offer a resource for practicing and mastering key topics.

In the context of Sipser's book, which covers abstract and theoretical material often deemed challenging, solutions manuals act as a bridge from rote memorization to deep understanding.

The Specifics of Sipser Second Edition Solutions

The solutions are meticulously crafted to mirror the textbook's problem set, covering topics such as:

- Finite automata and regular expressions
- Context-free grammars and pushdown automata
- Turing machines and decidability
- Complexity classes such as P, NP, and beyond

They typically include step-by-step reasoning, diagrams, and sometimes alternative approaches, enriching the student's comprehension.

Structure and Content of the Sipser Second Edition Solutions

Problem Categories and Their Solutions

The solutions are organized according to chapters and problem types:

- Conceptual Questions: Definitions, theoretical properties, and proofs.
- Constructive Problems: Designing automata, grammars, or algorithms.
- Proof-based Problems: Formal proofs of properties like undecidability or complexity bounds.
- Application Problems: Real-world-inspired questions applying theoretical principles.

Each solution generally follows a structured approach:

- Restatement of the Problem: Clarifies what is being asked.
- Outline of Approach: Summarizes the strategy, such as induction, reduction, or construction.
- Detailed Solution: Step-by-step reasoning, including diagrams, formal proofs, or pseudo-code.
- Conclusion and Insights: Summarizes the key takeaways and potential extensions.

Examples of Detailed Solutions

For example, in problems involving the design of a finite automaton for a given language, solutions often include:

- Formal definitions of the automaton's states, alphabet, transition function, start, and accept states.
- State diagrams illustrating the automaton.
- Verifications demonstrating correctness.

Similarly, for undecidability proofs, solutions include:

- Construction of reductions from known undecidable problems.
- Formal proofs showing the impossibility of certain decision procedures.

Analytical Perspectives on the Solutions: Strengths and Limitations

Strengths

- Depth and Clarity: The solutions are crafted to elucidate complex reasoning, often including multiple approaches.
- Alignment with the Textbook: They stay faithful to the concepts and methodology presented in

the book, reinforcing learning.

- Pedagogical Value: They help bridge the gap between theory and problem-solving skills, especially for students new to the subject.
- Preparation for Advanced Topics: Solutions often hint at or lay the groundwork for more advanced research topics.

Limitations

- Potential Over-Reliance: Excessive dependence on solutions may hinder independent thinking.
- Lack of Alternative Strategies: While solutions are detailed, they may not always present alternative methods or shortcuts.
- Assumption of Prior Knowledge: Some solutions presume familiarity with prior concepts, which could be challenging for absolute beginners.
- Accessibility Issues: Official solutions manuals are sometimes restricted or expensive, leading students to seek unofficial sources that may vary in quality.

Best Practices for Using Sipser Second Edition Solutions Effectively

To maximize the educational benefits of solutions manuals, consider the following strategies:

- Attempt Before Consulting Solutions: Engage with problems thoroughly before reviewing solutions to develop problem-solving skills.
- Use Solutions as a Learning Tool: Instead of passively reading, analyze each step, understand the reasoning, and replicate the solutions independently.
- Compare Different Approaches: If available, explore multiple solutions to a problem to appreciate different methodologies.
- Identify Weak Areas: Use solutions to pinpoint topics or problem types where understanding is incomplete.
- Integrate with Classroom Learning: Use solutions to complement lectures, discussions, and collaborative study sessions.

The Impact of Solutions on Mastery of Automata, Languages, and Computability

Reinforcing Core Concepts

Solutions manuals serve as an integral supplement that enables students to internalize key principles such as:

- Closure properties of regular languages
- Pumping lemmas and their applications
- Construction of Turing machines for specific languages
- Reductions demonstrating undecidability

Enhancing Problem-Solving Skills

Through detailed explanations, students learn to:

- Break down complex problems into manageable parts
- Recognize patterns and common proof techniques
- Develop formal reasoning skills essential for research

Preparing for Research and Advanced Study

A solid grasp of solutions builds a foundation for tackling research-level problems in computational complexity and formal verification.

Final Thoughts: The Value and Caution in Using Solutions Manuals

While the Sipser Second Edition Solutions are invaluable educational aids, they should be leveraged thoughtfully. They are best used as a supplement rather than a shortcut, enabling learners to verify their understanding and deepen their insights into automata theory and formal languages.

In the rapidly evolving landscape of computer science education, combining the authoritative explanations in the solutions with active engagement and critical thinking fosters a robust mastery of the material. As educators and students navigate the challenges of mastering the theoretical underpinnings of computation, solutions manuals like Sipser's play a vital role?when used responsibly and strategically?in cultivating the next generation of computer scientists.

Conclusion

The Solutions to Sipser Second Edition stand as a testament to the importance of clarity, precision, and pedagogical intent in teaching complex theoretical topics. They serve as both a compass and a map?guiding learners through intricate proofs and constructions while encouraging independent exploration. By understanding their structure, strengths, and limitations, students and educators can harness these resources to achieve a more profound and comprehensive understanding of automata theory, formal languages, and the fundamental limits of computation.

QuestionAnswer Where can I find the official solutions for Sipser's Second Edition? Official solutions for Sipser's Second Edition are typically provided to instructors; however, some university course pages or online educational resources may offer supplementary solutions or guidance. Always ensure you're using authorized materials to support your studies. Are there any reliable online resources or forums for discussing Sipser Second Edition solutions? Yes, platforms like Stack Exchange, Reddit, and dedicated automata theory forums often have discussions and shared solutions related to Sipser's Second Edition. Be cautious to verify the accuracy of shared solutions and use them as study aids rather than definitive answers. How can I effectively use the solutions manual for Sipser Second Edition to improve my understanding? Use the solutions manual to check your work after attempting problems independently. Study the step-by-step solutions to understand problem-solving strategies, and try to replicate the reasoning process without looking at the answers to reinforce learning. Are there any recommended study guides or supplementary materials for mastering Sipser Second Edition problems? Yes, many students find supplementary textbooks on automata, formal languages, and computational theory helpful. Additionally, online lecture notes, tutorial videos, and problem sets from university courses can complement your study of Sipser's material. Can I find practice problems with solutions similar to those in Sipser Second Edition online? Yes, numerous educational websites and textbooks provide practice problems with solutions that align with the topics covered in Sipser's Second Edition. These resources can help reinforce concepts and prepare for exams or assignments.

Related keywords: Sipser, second edition, solutions, automata theory, formal languages, complexity theory, computational theory, textbook solutions, computer science, automata solutions

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