MATH COUNTS

Peter B. Henderson

Programming and Mathematical Thinking

Editor's Note:
Peter B. Henderson and
Allan M. Stavely
co-authored this column

OUR GUEST CONTRIBUTOR for this Math CountS column is Allan Stavely, who recently wrote Programming and Mathematical Thinking: A Gentle Introduction Featuring Python [2], which will be available in early 2014. In this column, Allan gives his motivation for writing this book, shares his insights on the role mathematics can play in the curricula, and provides some guidelines for achieving these goals.

I'd like to second a statement that the editor of this column made previously, but push it farther. In his September 2013 column Dr. Henderson, speaking of the current state of mathematics in undergraduate computer science, said:

The mathematical foundation concepts are not used or reinforced effectively in most computer science courses, the relevant connections between these mathematical concepts and the fundamental concepts of computer science are not made, and the importance of mathematics as a tool for reasoning, problem solving and analysis, and solution verification are lost for many students.

To the last point, I would add: the importance of discrete-mathematics struc-

tures in day-to-day programming is lost for many students.

The courses in my department have long followed a familiar pattern: introductory programming in the first semester, data structures and algorithms in the second semester, and a discrete mathematics course in the second year as a prerequisite to several courses in the third and fourth year. Many of my students never saw the point of the discrete math course at the time they were taking it; students call the course "Weird Math." Courses like the third-year analysis-of-algorithms and formal-languages-and-automata courses would use discrete-math structures, of course, so that when the students hit my fourth-year compiler-writing course they could cope with the sets and trees and directed graphs used in compiler writing. However, I suspect that many of the students left the course thinking that discrete structures are used only in such advanced and exotic computer science topics.

On the contrary, I claim that concepts of discrete mathematics are enormously useful in even the most basic kinds of programming. Let me quote from a forthcoming textbook of mine. The example is adapted from my book Toward Zero-Defect Programming [3].

Many experienced programmers approach the design of a program by describing its input, output, and internal data objects in the vocabulary of discrete mathematics: sets, sequences, mappings, relations, and so on. This is a useful habit

for us, as programmers, to cultivate. It can help to clarify our thinking about design problems; in fact, solutions often become obvious. And we inherit a well-understood vocabulary for specifying and documenting our programs and for discussing them with other programmers.

For example, consider this simple programming problem. Suppose that we are writing software to analyze web pages, and we want some code that will read two web pages and find all of the URLs that appear in both. Some programmers might approach the problem like this:

First I'll read the first web page and store all the URLs I find in a list. Then I'll read the second web page and, every time I find a URL, search the list for it. But wait: I don't want to include the same URL in my result more than once. I'll keep a second list of the URLs that I've already found in both web pages, and search that before I search the list of URLs from the first web page.

But a programmer who is accustomed to thinking in terms of discrete-mathematical structures might immediately think of a different approach:

The URLs in a web page are a set. I'll read each web page and build up the set of URLs in each using set insertion. Then I can get the URLs common to both web pages by using set intersection.

Either approach will work, but the second is conceptually simpler and it will probably be more straightforward to implement. In fact, once the problem is described in mathematical terms, most of the design work is already done.

Programmers can exploit the properties of sets and relations and other discrete structures in their work even before they study those structures formally and learn how to construct proofs using them. Beginning computer science students can often do their work more skillfully and professionally, as in the example above, if they think in terms of the discrete structures when formulating designs. So can programming students who aren't computer science majors.

Programming And Mathematical Thinking

Anthony S. Fauci

Programming And Mathematical Thinking:
   Programming and Mathematical Thinking Allan M. Stavely,2013   *Mathematical Thinking* Howard Karloff,2023-08-09 This textbook invites readers to explore mathematical thinking by finding the beauty in the subject With an accessible tone and stimulating puzzles the author will convince curious non mathematicians to continue their studies in the area It has an expansive scope covering everything from probability and graph theory to infinities and Newton s method Many examples of proofs appear as well offering readers the opportunity to explore these topics with the amount of rigor that suits them Programming exercises in Python are also included to show how math behaves in action Mathematical Thinking is an ideal textbook for transition courses aimed at undergraduates moving from lower level to more advanced topics as well as for math recruitment and invitational courses at the freshman or sophomore level It may also be of interest in computer science departments and can be used as a supplemental text for courses in discrete mathematics and graph theory   *A Case Study* Hyunjung Woo,2014   Duality in 19th and 20th Century Mathematical Thinking Ralf Krömer,Emmylou Haffner,2024-07-01 This volume brings together scholars across various domains of the history and philosophy of mathematics investigating duality as a multi faceted phenomenon Encompassing both systematic analysis and historical examination the book endeavors to elucidate the status roles and dynamics of duality within the realms of 19th and 20th century mathematics Eschewing a priori notions the contributors embrace the diverse interpretations and manifestations of duality thus presenting a nuanced and comprehensive perspective on this intricate subject Spanning a broad spectrum of mathematical topics and historical periods the book uses detailed case studies to investigate the different forms in which duality appeared and still appears in mathematics to study their respective histories and to analyze interactions between the different forms of duality The chapters inquire into questions such as the contextual occurrences of duality in mathematics the influence of chosen forms of representation the impact of investigations of duality on mathematical practices and the historical interconnections among various instances of duality Together they aim to answer a core question Is there such a thing as duality in mathematics or are there just several things called by the same name and similar in some respect What emerges is that duality can be considered as a basic structure of mathematical thinking thereby opening new horizons for the research on the history and the philosophy of mathematics and the reflection on mathematics in general The volume will appeal not only to experts in the discipline but also to advanced students of mathematics history and philosophy intrigued by the complexities of this captivating subject matter   **Computing and Combinatorics** Yong Chen,Xiaofeng Gao,Xiaoming Sun,An Zhang,2025-02-12 This three volume set LNCS 15161 15162 and 15163 constitutes the refereed proceedings of the 30th International Conference COCOON 2024 held in Shanghai China during August 23 25 2024 The 90 full papers and 6 short papers were carefully reviewed and selected from 277 submissions COCOON 2024 provided an excellent venue for researchers working in the area of algorithms theory of computation computational complexity and combinatorics related to

computing   *Artificial Intelligence for Supporting Human Cognition and Exploratory Learning in the Digital Age* Pedro Isaias,Demetrios G. Sampson,Dirk Ifenthaler,2024-08-08 The Cognition and Exploratory Learning in the Digital Age CELDA conference focuses on discussing and addressing the challenges pertaining to the evolution of the learning process the role of pedagogical approaches and the progress of technological innovation in the context of the digital age In each edition CELDA gathers researchers and practitioners in an effort to cover both technological and pedagogical issues in ground breaking studies Some of CELDA s main topics include assessment of exploratory learning approaches and technologies educational psychology learning paradigms in academia and the corporate sector student centered learning and lifelong learning The CELDA 2023 conference selected and published a selection of papers that focus on the use of Artificial Intelligence and Learning Analytics in the educational context   **Emerging Research in Intelligent Systems** Miguel Botto-Tobar,Henry Cruz,Angela Díaz Cadena,Benjamin Durakovic,2022-02-02 This book constitutes the proceedings of the XVI Multidisciplinary International Congress on Science and Technology CIT 2021 held in Quito Ecuador on June 14 18 2021 proudly organized by Universidad de las Fuerzas Armadas ESPE in collaboration with GDEON CIT is an international event with a multidisciplinary approach that promotes the dissemination of advances in science and technology research through the presentation of keynote conferences In CIT theoretical technical or application works that are research products are presented to discuss and debate ideas experiences and challenges Presenting high quality peer reviewed papers the book discusses the following topics Artificial Intelligence Computational Modeling Data Communications Defense Engineering Innovation Technology and Society Managing Technology Sustained Innovation and Business Development Security and Cryptography Software Engineering   Orchestration of Learning Environments in the Digital World Dirk Ifenthaler,Pedro Isaías,Demetrios G. Sampson,2022-01-31 This volume focuses on the implications of digital technologies for educators and educational decision makers that are not widely represented in the literature The chapters contained in the volume are based on the presentations at the 2020 edition of the CELDA conference and cover multiple developments in the field such as deploying learning technologies proposing pedagogical approaches and practices to address digital transformation and presenting case studies of specific technologies and contexts The chapters form a lively debate and provide a comprehensive analysis of the contribution of learning technologies designed to improve the learning process and the experience of the students as well as to develop key competences   **Proceedings of CECNet 2021** Antonio J. Tallón-Ballesteros,2022-01-15 It is almost impossible to imagine life today without the electronics communications and networks we have all come to take for granted The 6G network is currently under development and some chips able to operate at the Terahertz THz scale have already been introduced so the next decade will probably see the consolidation of 6G based technology as well as many compliant devices This book presents the proceedings of the 11th International Conference on Electronics Communications and Networks CECNet 2021 initially planned to be held from 18 21 November 2021 in Beijing China but ultimately held as an

online event due to ongoing COVID 19 restrictions The CECNet series is now an established annual event attracting participants in the interrelated fields of electronics computers communications and wireless communications engineering and technology from around the world Careful review by program committee members who took into consideration the breadth and depth of those research topics that fall within the scope of CECNet resulted in the selection of the 88 papers presented here from the 325 submissions received This represents an acceptance rate of around 27% Providing an overview of current research and developments in these rapidly evolving fields the book will be of interest to all those working with digital communications networks **Great Currents of Mathematical Thought: Mathematics in the arts and sciences** François Le Lionnais,1971 Python for Mathematical Thinking Pradeep Singh,Balasubramanian Raman,2025-12-13 This book offers a rigorous yet approachable pathway to applying Python for mathematical problem solving spanning foundational concepts to advanced theoretical frameworks It bridges the gap between abstract mathematics and computational execution guiding readers through a logically structured step by step journey Emphasizing mathematical reasoning symbolic computation and real world problem modeling it equips readers to analyze simulate and visualize complex structures with clarity and efficiency Ideal for students researchers and professionals in Mathematics Data Science AI Physics and Computational Science it cultivates both programming skill and deep mathematical intuition **The Journal of Computer Game Design** ,1988 *Information Processing* ,1983 **Information Processing** International Federation for Information Processing,1983 *Mathematical Programming and the Analysis of Capital Budgeting Problems* H. Martin Weingartner,1967 **Mathematical Thinking Skills Needed by First-year Programming Students** Carla Coetzee,2016 **University Senate Minutes, Twin Cities Campus Assembly Minutes, Faculty Senate Minutes, Student Senate Minutes** University of Minnesota. Senate,2006 **Matematica: insegnamento e computer algebra** Michele Impedovo,2004-03-29 Esiste oggi un potente strumento didattico che pu essere utile per rinnovare contenuti e metodi dell insegnamento ora che la COMUPTER ALGEBRA disponibile su calcolatrici di piccole dimensioni l insegnante e lo studente hanno l opportunit di rendere il proprio insegnamento apprendimento pi efficace Questo libro mostra percorsi didattici provati in classe nell ambito della sperimentazione LABCLASS del M P I che partendo da attivit di ricerca sperimentale hanno lo scopo di rafforzare la valenza semantica degli oggetti matematici e innestare su un terreno pi solido definizioni e teoremi Il volume destinato ai docenti delle scuole medie superiori e dell universit e agli studenti curiosi di fare matematica non solo con carta e penna *Proceedings* ,1975 *Undergraduate Catalog* Illinois Teachers College Chicago North,1966

This book delves into Programming And Mathematical Thinking. Programming And Mathematical Thinking is a crucial topic that must be grasped by everyone, ranging from students and scholars to the general public. The book will furnish comprehensive and in-depth insights into Programming And Mathematical Thinking, encompassing both the fundamentals and more intricate discussions.

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   - Chapter 4: Programming And Mathematical Thinking in Specific Contexts
   - Chapter 5: Conclusion

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