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The Types of Math Used in Modern Computer Science

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ABSTRACT: Because math is a foundational part of computer systems, every programmer and computer scientist needs to have basic mathematical knowledge. The type and level of math you need depends on what areas of computer science you want to work in. Some computer science career tracks require only minimal mathematical knowledge. For example, as long as you know basic programming languages and can do simple arithmetic, you can develop basic mobile apps. But if you want to go further with your computer science career, perhaps exploring advanced fields like computer security or operating systems, you'll need to understand some higher-level math concepts. No one expects computer scientists to be mathematicians, but studying high school and college level math can open doors. Math is fundamental to computer science, but an affinity towards math is not a prerequisite for success in the field. For example, the final course in the Python program Joyner is an instructor for, Computing in Python IV: Objects & Algorithms, covers object-oriented programming, a popular paradigm that Joyner likens to philosophy. "Object oriented programming speaks to my general desire to make people aware that computer science isn't just for the people who were really good at math in high school. It's an area of programming that has a surprisingly deep conjunction with philosophy. One thing that people often underestimate about careers in computer science, is they are very creative kinds of areas."

KEYWORDS: math, computer science, concepts, philosophy, object, creative, mobile apps

1. INTRODUCTION

Computer scientists use all different types of math. Those who work with advanced algorithms and matrices, like the kind involved in image recognition for medical diagnostics, need to understand higher-level concepts like differential equations. But for aspiring and first year professionals, it's more important to master number theory and basic equations. Here are some topics to explore.¹

Binary and Hexadecimal Counting

The binary number system uses only two digits, 0 and 1, to express all mathematical concepts. Computers use the binary system instead of the more common decimal system, so computer scientists need to know how it works. Computers can read binary, but it can be inconvenient for humans to deal with. As an alternative, computer programming has turned to a system called hexadecimal, which uses all nine decimal digits and the letters A through F. It makes more sense to humans and converts electronically to binary. Don't let the unfamiliarity of these languages scare you away. Computer science programs tend to cover them early on, so you can start practicing right away.

Discrete Mathematics

Discrete math is tangible math. It analyzes the relationship between things that are distinct and separate. The concepts of discrete math include:

- Probability
- Combinatorics
- Logic
- Number theory
- Graph theory

The problem-solving processes of discrete math are the basis of modern computer engineering. They power both simple and complex disciplines such as:

- Computer architecture
- Functional programming
- Distributed systems

- Machine learning and artificial intelligence

As a computer science professional, you might use discrete math to test out multiple algorithms and learn which is the most efficient. Meanwhile, the logical thinking you develop as a discrete math student will help you to approach programming and development tasks more methodically.²

Statistics

Data has become an increasingly important aspect of scientific computing in the past few years, from machine learning to personalized app performance. This increased reliance on data has made statistics an important topic of study for all computer science students. Statistics allow computer programs to deliver accurate generalizations and predictions based on available information. Understanding statistics can make it easier to grasp concepts like:

- Data mining
- Machine learning
- Future modeling
- Speech recognition
- User responsiveness
- Computer graphics analysis

The more you learn about statistics, the more adept you'll become at managing and using complex data structures. This lets you write more advanced algorithms and push the envelope in software customization.³

Linear Algebra

Computer science and software engineering rely on algorithms. An algorithm is a formula that takes you from a specific input to the correct output. If that sounds familiar, it may be reminding you of middle school or high school algebra.

Algebra includes concepts like:

- Exponents
- Polynomials
- Linear equations
- Quadratic equations

Each of these concepts has real world computer science applications. Understanding exponential relationships can help you to adapt visuals so they appeal to the eye. Solving linear equations helps with analysis of algorithms because it helps you to spot inaccuracies. You can get by in software development without knowing much algebra, but learning it can help you to reach greater heights.⁴

Calculus

If you plan to get a computer science degree, you'll probably take a calculus course at some point. There are two different types of calculus: integral calculus and differential calculus. Together, these disciplines help you to figure out rate of change, which is an important ingredient in many algorithms and programs.⁵ Differential equations are particularly important. A differential equation calculates how something changes and how fast that happens, so a computer can predict future outputs. This helps with:

- Designing simulations
- Improving problem-solving programs
- Creating effective algorithms
- Developing accurate graphs

The word "calculus" scares some computer science students, but it's much less intimidating than most people think. The key is to find a course that will lead you through what you need to know to work in your field.⁶

II.DISCUSSION

1. Binary Math

Binary math is the heart of computer operation and among the most essential types of math used in computer science. Binary is used to symbolize every number within the computer. The binary number system is an alternative to the decimal system. Using this system simplifies computer design. Reading and simple mathematical operations are vital for hardware low-level programming. Knowing how to work with a hexadecimal number system is necessary for various programming functions, including setting the color of an item. Standard arithmetic is utilized in numerous

functions of computer programming. In nearly every written program, addition, subtraction, multiplication, and division area used.⁷

2. College Algebra

College algebra covers various concepts, including linear equations, operations, factoring, exponents, polynomials, quadratic equations, rational expressions, radicals, ratios, proportions, and rectangular coordinates. It focuses on algebraic relationships, graphs, and functions and students learn to solve for one or two unknown variables in various complex equations. Students also learn how to graph algebraic functions. Algebra is used in computer science in the development of algorithms and software for working with mathematical objects. It is also used to design formulas that are used in numerical programs and for complete scientific computations.⁸

3. Statistics

Statistics is a form of math used in computer science that uses quantified models, representations, and synopses for a provided collection of experimental data or actual studies. The field studies methodologies to obtain, review, evaluate, and form conclusions from data. Some statistical measures include mean, skewness, regression analysis, variance, analysis of variance, and kurtosis. Statistics plays a fundamental part in computer science as it is used for data mining, speech recognition, vision and image analysis, data compression, traffic modeling, and even artificial intelligence, as shared by Medium. It is also used for simulations. A background in statistics is needed to understand algorithms and statistical properties of computer science.⁹

4. Calculus

Calculus is the examination of continuous change and the rates change occurs. It handles the finding and properties of integrals and derivatives of functions. There are two types of calculus, differential calculus, and integral calculus. Differential calculus deals with the rate of change of a quantity. Integral calculus determines the quantity where the change rate is known. Calculus is used in an array of computer science areas, including creating graphs or visuals, simulations, problem-solving applications, coding in applications, creating statistic solvers, and the design and analysis of algorithms.¹⁰

5. Discrete Math

Discrete math examines objects that can be represented finitely. It includes a variety of topics that can be used to answer various tangible inquiries. It involves several concepts, including logic, number theory, counting, probability, graph theory, and recurrences. Discrete math provides an important foundation for all areas of computer science. Discrete math is used in various areas including computer architecture, algorithms, computer systems, databases, functional programming, distributed systems, machine learning, operating systems, computer security, and networks. The problem-solving methods taught in discrete math are needed for composing complicated software. Students who enjoy computers and possess strong problem-solving skills will find a career in computer science lucrative and rewarding, with the Bureau of Labor Statistics providing key data on this field. Completing courses in binary math, college algebra, statistics, calculus, and discrete math is an ideal way of gaining a solid foundation in the different types of math used for computer science.¹¹

III.RESULTS

Mathematics has been the bane of many students' lives (including mine!!!) since arguably it's inception. On the other hand, Computer Science is quite interesting and students study it in hopes of becoming the next programming whizz-kid!!! But hold on...is it really that simple?!! No, my friends, it isn't....Computer Science is in fact quite closely linked to Mathematics. For many years, there has been much debate about the Importance of Mathematics in Computer Science. Some believe that it adds only little value in Computer Science while others (mostly in the majority!) think it is the foundation on which Computer Science is built. According to the University of Oxford:

Mathematics is a fundamental intellectual tool in computing, but computing is also increasingly used as a key component in mathematical problem-solving.¹²

1. Discrete Mathematics is the Foundation of Computer Science

Ever heard of Logic Notation, Set Theory, Combinatorics, Graph Theory, Probability, Number Theory, Algebra, etc.? Don't be overwhelmed, these are all a part of Discrete Mathematics and also a basic foundation for Programming and Computer Science (And that means you need to study these for Computer Science!!!).

A prime example of this is Algebra. While Boolean Algebra is used in Logic Gates, Relational Algebra is used in Databases. In case you need another example, Number Theory has multiple applications in Cryptography and Cryptanalysis.²

2. Mathematics Teaches the Usage of Algorithms

Algorithms are a fundamental part of Computer Science and all of you must have heard of them one way or another (If not...you need to study again!!!). They are basically a set of instructions that demonstrate the implementation of a program or an application.

Now, where did you first use an algorithm? It was not the Computer Science class but actually the Mathematics class! Don't believe me?!! Well, " $2 + 3 = 5$ " is a basic algorithm you learned in Mathematics class that demonstrates the sum of 2 and 3. Mathematics is actually very important in learning the basic usage of algorithms that are utilized in an advanced form in Computer Science.⁴

3. Mathematics Provides the Analytical Skills Required in Computer Science

Analytical skills are necessary for problem-solving and data analyzation. And guess where you first use these skills? Mathematics!!! Yeah, Mathematics always forces you to analyze your equations and understand the derivation flow in case a mistake is made. This mistake needs to be fixed in order to obtain the final solution.

This provides lots of analytical skills that can be used later in finding and fixing bugs!!! Even though there are modern tools that can do this job automatically, the experience and knowledge gained about the program flow and debugging is invaluable.⁶

4. Mathematical Concepts are Required in many Disciplines of Computer Science

Computer Science is an umbrella term that contains many disciplines like Operating Systems, Databases, Networking, Artificial intelligence, Embedded systems, Data analytics....need I go on?!!! And while there are some disciplines that you can handle with minimal knowledge of Mathematics, most of them require at least some level of competency. For example, fields like Artificial Intelligence and Machine Learning require a thorough knowledge of Mathematical concepts like Linear algebra, Multivariable Calculus, Probability Theory, etc. (And that makes Maths pretty important!!!) Is Mathematics really necessary Computer Science? Well, some would say that it depends on the job. For Example: Creating a blog on food does not necessarily require any knowledge of mathematics. But creating a successful blog is another thing entirely. It requires a focus on audience preferences, topic popularity, article ratings, etc. And guess what...Mathematics is required for all of this. So yes...Mathematics is present in the foundation of Computer Science. And if you want to succeed in any discipline of Computer Science, it is much better to inculcate a love of Mathematics as that will help you tremendously.⁸

IV. CONCLUSIONS

Coding is all about dealing with numbers and building logic around them. Mathematics is one of the most important tools for programmers to develop sophisticated applications. Without the knowledge of mathematics, a programmer is basically handicapped. Therefore, it is important for all programmers to be well-versed in certain topics in mathematics that are central to programming. As a complicated field, there are various types of math in computer science. Computer science examines the principles and use of computers in processing information, designing hardware and software, and using applications. Possessing a strong foundational knowledge of mathematics is vital to gaining an understanding of how computers work. Mathematics is a fundamental scholarly tool in computing. The field of cryptography, which is the study of how to create security structures and passwords for computers and other electronic systems, is based entirely on discrete mathematics. This is partly because computers send information in discrete — or separate and distinct — bits. Number theory, one important part of discrete math, allows cryptographers to create and break numerical passwords. Because of the quantity of money and the amount of confidential information involved, cryptographers must first have a solid background in number theory to show they can provide secure passwords and encryption methods. Programming and mathematics go hand-in-hand. Eventually, every programming problem is an underlying mathematics problem where programming has been used simply as a tool to perform computation and obtain the output. Therefore, all programmers who aim to be successful should be well-versed in the mathematics-related topics.¹²

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