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# **APPLICATIONS OF NUMBER THEORY IN ENGINEERING: A REVIEW**

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# ABSTRACT

Number theory is the foundation of all contemporary cryptography and is perhaps one of the most significant applications of mathematics in computer science. The study of integers was the initial focus of number theory. The foundational framework of number theory has been steadily enhanced by mathematicians throughout history, leading to the formation of a comprehensive and cohesive field of study. This study primarily examines the evolution and uses of number theory, with the goal of reviewing the discipline's history, examining its impact on production, our daily lives, and its applications in the engineering field. As a whole, number theory was used less in engineering than calculus geometry, etc. The inability to utilise it directly in any programme was the issue. However, the computational capability of contemporary computers, when paired with number theory, provides intriguing answers to practical problems. Numerous areas nowadays, including computing, cryptography, physics, chemistry, biology, acoustics, electronics, communication, graphics, and even musicology, use number theory extensively and comprehensively.

Keywords: Computers, musicology, cryptography, and number theory

## 1. INTRODUCTION

The field of mathematics known as number theory, often referred to as the "queen of mathematics," studies the positive integers 1, 2, 3, 4, 5, and 6, sometimes referred to as natural numbers, as well as their apparent characteristics. These natural numbers have been categorised since antiquity as odd, even, square, prime, Fibonacci, triangular, and other numbers. Number theory is important to mathematics since there are a lot of unanswered questions in the field. Number theory has recently been categorised as follows, based on the instruments used to solve related problems:

#### Number Theory

Classification	Explanation	
Elementary number theory	Elementary number theory is a branch of number theory based on elementary method. In essence, it applies divisible property to mainly study divisible theory and congruence theory. The typical Conclusion in this theory include the familiar Congruence theorem, Euler's theorem, Chinese residual theorem and so on.	
Analytic number theory	Analytic number theory studies the integers with calculus and complex analysis. Some analytic functions such as the Riemann function, which studies the properties of integers and primes.	
Algebraic number theory	Algebraic number theory is more inclined to study the nature of various rings of integers from the perspective of algebraic structure.	
Geometric number theory	Geometric number theory studies the distribution of the integers from the perspective of geometry.	
Computation number theory	Computational number theory studies questions in number theory with Computer algorithms.	

The scientific study of integers is really ascribed to the Greeks Later; however, a significant change in this theory took place with the publication of Euclid's "Elements," a renowned book that contains exact proofs of mathematical concepts. There are only few types of literature that examine number theory's applicability in engineering. Therefore, the goal of the current study is to conduct a critical evaluation of the current methods pertaining to the use of number theory in the engineering area.

#### 1. The Development of Number

Conceptualization The idea of numbers and arithmetic originated more than 3,000 years ago. Numerous problems in number theory have been presented and subsequently resolved, drawing an increasing number of researchers into the field. Over the lengthy history, many theories have been developed as well as new approaches and strategies for problem-solving. The growth of number fields and real-world applications have progressed algebraic number theory. This study investigates the origins of algebraic number theory by examining the major issues in the development of Fermat's theorem and two higher reciprocity laws, based on a collection of current data. This essay attempts to provide a more thorough study and thoughtful thinking from a fresh angle on the past.

#### 2. The stage of Arithmetic

Arithmetic symbols were not standard during the era from around 3800 to the third century, and algebra and geometry were kept apart. The greatest contribution to number theory came from the ancient Greeks, who are known for such notable works as the fundamental theorem of arithmetic, which was used in basic number theory, and Euclid's Euclidean algorithm in geometry, which suggested that the number of prime numbers is infinite.

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#### The Complete stage of number and equation theory

Irrational and imaginary numbers were found between the seventh and sixteenth centuries.

(a) The discovery of irrational numbers: The earliest known irrational number was found by Hipparchus of the Pythagorean school. The first mathematical crisis resulted from his proposal that all numbers might be written as the ratio of integers.

(b) Creations of arithmetic operators and solution to irrational equations: In The study of algebra was advanced to a new level by the mathematician Brahmagupta of India in the 7th century, who introduced a set of symbols used to express ideas and describe operations. Posgallo then presented the concept of negative square root, the solution to irrational equations, and the algorithm of irrational numbers in the 12th century.

(c) Establishment of imaginary number theory: The universal solution to the cubic equation was revealed in the book "The Great Art" written by the Milanese scholar Cardano in 1545. This answer was thereafter referred to as Cardano's formula. In mathematics, Cardano was the first to calculate the square root of a negative integer.

**3.** The Stage of Linear Algebra The tools for solving linear equations, matrices, determinants, and vectors arose between the 17th and the 19th centuries and provided essential services to the industrial civilization.

**4. The Stage of Abstract Algebra** The significance of form and method to the algebra structure was emphasised from the 19th century forward, providing benefits to the information society.

#### **Application of Number Theory**

The significance of form and method to the algebra structure was emphasised from the 19th century forward, providing benefits to the information society.

#### 1. Cryptography

In the current digital age, one of the most important areas is cryptography. When communicating online, there is a chance that a message transmitted from sender to recipient might be seen by an unauthorised individual if it is not properly secured. This issue is resolved by using the encryption decryption idea. A huge number, often prime, is used by the sender to "encrypt" or encode a message; this number is referred to as a "key," and in order for the recipient to "decrypt" or decode the message, they must also possess it. The creation of such big prime numbers is an example of number theory in action. Maurer used number theory to create an effective method that produces such numbers. When studying number theory, particularly cryptography, we prefer to study deterministic algorithms over probabilistic ones. If deterministic algorithms are unavailable, we will just reduce our needs and use probabilistic algorithms.

#### Application Fibonacci Series in Architecture as well as Engineering

According to Italian mathematician Leonardo Fibonacci, the term "Fibonacci sequence" describes a sequence of integers in which, starting with the third number in the sequence, each number is the sum of the two numbers that came before it. The formula for the nth number in the series is f(n) = f(n-1) + f(n-2). The Fibonacci Series is used in the simulation to represent the time dependency of moments and size distributions during consolidation. Some more important ideas about the Fibonacci Series. (a) The phi golden ratio If the ratio of any two quantities equals the ratio of their total to the larger of the two quantities, then those two quantities are said to be in the golden ratio. Algebraically expressed, x > y >0 for two numbers, x and y.

$$(x+y)/x = x/y = phi.$$

Numerous man-made and natural items' shapes are seen to follow the Golden Ratio[2]. The Parthenon, a renowned landmark, and the spirals seen in plant blooms are two examples of classical design. The Fibonacci sequence is often seen in nature and has several applications in both engineering and architecture. The behaviour of structural components utilised in engineering is explained by the phi code. In the stress analysis of beams, it is regarded as a defining parameter. The presence of the phi code in the relationship between normal and shear stresses was noted by Collins and Brebbia [3].

(b) Pascal Triangle The Fibonacci Sequence is increased by the numbers on the Pascal triangle's diagonals.

(c) Area of a rectangle The Fibonacci Sequence's first few numbers are seen as separate, little quadrilateral regions that may be merged to form larger quadrilateral areas.

#### **Computer Animation**

Computer animation may be created using linear transformation technology, which is often used to create visuals and computer graphics, which are created on display devices using algorithms and programmes. The three fundamental components of computer graphics are computing, storage, and picture representation. The usage of linear transformation techniques in computer animation has increased with the development of softer capabilities.



Machine Translation- With an accuracy rate of 90%, the primary machine translation algorithm is based on the statistical technique. Additionally, picture search technology makes use of this method. The fundamental idea behind this approach is the ability to express language units in both the source and destination languages using vectors, and to project lexical vectors from several languages onto a two-dimensional plan for analysis. It is important to categorise machine translation as a linear transformation since experimental findings demonstrate that the laxical vectors of various languages do have certain linkages resembling linear relations. Others Fields Surprisingly, number theory is also involved in other theories. The Hermite operator is one of the most fundamental ideas in quantum theory. The Pythagorean theorem is a well-known mathematical theorem. It discusses right-angled triangles and provides information on the relationships between the sides. It should come as no surprise that it has uses in any discipline using triangles. A few well-known instances include the "Delta Wing" wing arrangement used in contemporary jet aircraft. The theorem is important for the efficient and successful design of this kind of arrangement. An isosceles triangle in sectional view, the tios of rockets, has a similar purpose. Another example is the sectional study of the frustum of cones, which acts as a fairing in between the stages of a multi-stage rocket. The theorem is used in propeller and engine blade angle calculations. Aircraft This theorem is used by scientists and meteorologists to determine a range and sound source. As Manfred discusses, number theory may be used to enhance the acoustic quality of concert venues [4]. The construction of new musical scales to maximise sound dispersion in halls greatly enhances the practical quality of the acoustics. Jacobi's triple product has new polynomial counterparts that were provided by Krishnaswami Alladi and Alexander Berkovich[5]. In addition, number theory finds extensive application in fields other than mathematics, including computer science, quantum chemistry, theoretical physics, and so on. Robert and Howard reviewed Weights of Code words, an introduction to Coding theory in both its mathematical and technical aspects. The use of the Ramanujan sum in a single processing step has been seen in recent decades. In order to improve the decomposition of limited duration signals into the finite sum of orthogonal components, Vaidyanathan[6] described the Ramanujan Subspace in detail. Hence, the wide range of applications of number theory seen in many fields. Given the present circumstances, number theory plays a more significant role in solving cyber security issues.

### 2. CONCLUSION

The fundamental idea, theory, evolution, and applications of number theory were the key topics of discussion in this essay. Number theory's many engineering applications were covered in-depth. Number theory has made a substantial contribution to cryptography in recent years, which is why computer science engineering has taken notice. It was also acknowledged that the applications were versatile. This study seeks to provide readers with an understanding of the origins, development, and future trends of number theory in the field of computer science combinations by evaluating the field's application and development. In the modern world, number theory and even mathematics as a science will advance further due to the quick growth of the computer sector.

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