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Research Article

A Short Note on Kaprekar's Constant 6174

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Abstract. Kaprekar's constant 6174 is one of the most celebrated numbers in recreational mathematics. Starting with any four-digit number having at least two distinct digits, a simple procedure involving the rearrangement of digits and subtraction eventually produces the number 6174. Once reached, the value remains unchanged under further applications of Kaprekar's operation. In this note, we introduce Kaprekar's procedure, present several illustrative examples, establish the fixed-point property of 6174, prove a basic divisibility property of the procedure, and discuss the convergence phenomenon that makes 6174 so remarkable. The topic provides an attractive example of how elementary arithmetic can lead to unexpected and fascinating numerical phenomena.

Keywords. Kaprekar's Constant, Recreational Mathematics, Number Patterns, Iterative Processes, Digit Manipulation, Mathematical Curiosities.

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1. Introduction

Recreational mathematics contains many surprising numerical patterns that can be discovered using only elementary arithmetic. Such patterns often arise from simple procedures and calculations, yet they reveal unexpected regularities and mathematical structure. Because of their accessibility and elegance, numerical curiosities have long been a central topic in recreational mathematics. Among the most remarkable examples in recreational mathematics is

$$6174,$$

known as *Kaprekar's constant.* Named after the Indian mathematician D. R. Kaprekar, who discovered its remarkable property in 1949 [1], this number arises from a surprisingly simple digit-manipulation process. Starting with any four-digit number containing at least two distinct digits, one repeatedly rearranges the digits and subtracts the smaller arrangement from the larger. Remarkably, the resulting sequence eventually reaches

$$6174.$$

Once this value is obtained, it remains unchanged under further applications of the procedure.

To illustrate, consider the number

$$3524.$$

Arranging its digits in descending and ascending order gives

$$5432 - 2345 = 3087.$$

Repeating the procedure,

$$8730 - 0378 = 8352,$$

and then

$$8532 - 2358 = 6174.$$

Applying the procedure once more yields

$$7641 - 1467 = 6174,$$

showing that 6174 remains unchanged under further applications of the procedure.

The appearance of a single number from such a wide variety of starting values is both surprising and aesthetically appealing. Although the procedure requires only elementary arithmetic, it exhibits behaviour reminiscent of more sophisticated iterative processes encountered throughout mathematics. The study of Kaprekar's constant, therefore, provides an excellent example of how simple numerical experiments can lead to interesting mathematical questions.

The purpose of this article is to present an accessible introduction to Kaprekar's constant and its associated procedure. We describe the algorithm, provide illustrative examples, establish several elementary properties, and discuss related observations that make 6174 one of the most fascinating numbers in recreational mathematics.

2. Kaprekar's Procedure

The remarkable behaviour of Kaprekar's constant arises from a simple iterative algorithm applied to four-digit numbers.

Definition 2.1. Let n be a four-digit number (regarded as a four-digit string, allowing leading zeros when necessary). Construct two new numbers using the digits of n:

1. Arrange the digits in descending order to form the number $D(n)$.
2. Arrange the digits in ascending order to form the number $A(n)$, allowing leading zeros when necessary.
3. Compute
$$K(n) = D(n) - A(n).$$

The transformation K is called *Kaprekar's operation*. For the study of convergence to 6174, we restrict attention to numbers containing at least two distinct digits.

Remark 2.2. Throughout this article, numbers occurring in Kaprekar's procedure are regarded as four-digit strings. If necessary, leading zeros are added so that every intermediate value contains exactly four digits. For example,

$$378 = 0378, \qquad 25 = 0025, \qquad 999 = 0999.$$

This convention ensures that Kaprekar's operation is well defined at every step.

Example 2.3. Consider the number

$$4210.$$

The digits arranged in descending order give

$$4210,$$

while the digits arranged in ascending order give

$$0124.$$

Therefore

$$K(4210) = 4210 - 0124 = 4086.$$

Thus, a single iteration of Kaprekar's operation transforms the number 4210 into 4086.

The number 6174 possesses a remarkable fixed-point property.

Proposition 2.4. *The number* 6174 *is a fixed point of Kaprekar's operation.*

Proof. Arranging the digits of 6174 in descending order gives

$$7641,$$

while arranging them in ascending order gives

$$1467.$$

Hence

$$K(6174) = 7641 - 1467 = 6174.$$

Therefore, the value remains unchanged under Kaprekar's operation. □

The proposition shows that once the sequence reaches 6174, all subsequent terms are equal to 6174. In other words,

$$6174, \quad 6174, \quad 6174, \quad \dots$$

is a constant Kaprekar sequence.

3. Numerical Examples

One of the most appealing aspects of Kaprekar's procedure is that it can be explored using nothing more than elementary arithmetic. A few examples quickly reveal the surprising tendency of the process to converge to the same number.

Example 3.1. Consider the number

$$1234.$$

Applying Kaprekar's operation, we obtain

$$4321 - 1234 = 3087.$$

Continuing,

$$8730 - 0378 = 8352,$$

and

$$8532 - 2358 = 6174.$$

Figure 1 illustrates the convergence of the Kaprekar sequence starting from 1234.

$$1234 \longrightarrow 3087 \longrightarrow 8352 \longrightarrow 6174 \longrightarrow 6174$$

Figure 1: Iteration of Kaprekar's operation starting from 1234. After three applications of the procedure, the sequence reaches the fixed point 6174.

Example 3.2. Starting with
$$2005,$$
we obtain
$$5200 - 0025 = 5175.$$
Next,
$$7551 - 1557 = 5994,$$
$$9954 - 4599 = 5355,$$
$$5553 - 3555 = 1998,$$
$$9981 - 1899 = 8082,$$
$$8820 - 0288 = 8532,$$
and finally
$$8532 - 2358 = 6174.$$
Thus, the sequence again reaches the fixed point 6174.

Example 3.3. Consider the number
$$9831.$$
Then
$$9831 - 1389 = 8442,$$
$$8442 - 2448 = 5994,$$
$$9954 - 4599 = 5355,$$
$$5553 - 3555 = 1998,$$
$$9981 - 1899 = 8082,$$
$$8820 - 0288 = 8532,$$
and
$$8532 - 2358 = 6174.$$
Therefore, the sequence converges to 6174.

The preceding examples suggest a remarkable phenomenon. Although the starting numbers are quite different, each sequence eventually reaches the same value. This observation naturally leads to the question of whether every four-digit number behaves in the same way.

Before addressing this question, it is useful to note that some numbers must be excluded from consideration.

Example 3.4. Suppose that all four digits are equal, for example

$$1111.$$

Then

$$1111 - 1111 = 0000.$$

Similarly,

$$2222 - 2222 = 0000,$$

and in general, any four-digit number with all digits equal immediately produces

$$0000.$$

Once this occurs, the process remains at

$$0000.$$

Consequently, Kaprekar's procedure is usually applied only to four-digit numbers having at least two distinct digits.

4. Properties of Kaprekar's Constant

The number 6174 possesses several interesting arithmetic properties. The following proposition shows that every nonzero output of Kaprekar's operation is divisible by 9.

Proposition 4.1. *Let n be a four-digit number. Then the value produced by Kaprekar's operation is divisible by* 9*.*

Proof. Let the digits of n, arranged in descending order, be

$$a \geq b \geq c \geq d.$$

Then

$$D = 1000a + 100b + 10c + d$$

is the number formed by arranging the digits in descending order, and

$$A = 1000d + 100c + 10b + a$$

is the number formed by arranging the digits in ascending order.
Hence

$$\begin{aligned} D - A &= (1000a + 100b + 10c + d) - (1000d + 100c + 10b + a) \\ &= 999(a - d) + 90(b - c). \end{aligned}$$

Since

$$999 = 9 \times 111$$

and

$$90 = 9 \times 10,$$

it follows that

$$9 \mid (D - A).$$

Therefore, every value obtained from Kaprekar's operation is divisible by 9. $\square$

Corollary 4.2. *Kaprekar's constant* 6174 *is divisible by* 9*.*

Proof. We have

$$6 + 1 + 7 + 4 = 18,$$

and

$$18 = 9 \times 2.$$

Hence

$$9 \mid 6174.$$

$\square$

The divisibility by 9 helps explain why many different starting values eventually enter the same collection of numbers during the iteration process. Although the initial number may not be divisible by 9, every subsequent value produced by Kaprekar's operation is divisible by 9.

These observations suggest that the repeated application of Kaprekar's operation is highly restrictive. In the next section, we discuss the remarkable fact that every admissible four-digit number eventually reaches the fixed point 6174.

5. Convergence to 6174

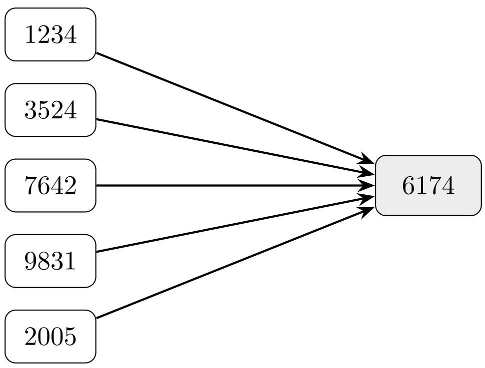

Figure 2: Different starting values eventually converge to the fixed point 6174 under repeated applications of Kaprekar's operation.

The examples of the previous section suggest that many different starting values eventually lead to the same number. Remarkably, this phenomenon is not accidental.

Theorem 5.1 (Kaprekar [1])**.** *Let n be a four-digit number containing at least two distinct digits. Repeated application of Kaprekar's operation eventually produces the number*

$$6174.$$

Moreover, at most seven applications of Kaprekar's operation are required.

Remark 5.2. A complete proof of Theorem 5.1 requires a systematic analysis of all admissible four-digit configurations and is beyond the scope of this introductory article. Computer verification also provides an accessible way to confirm that every admissible four-digit number reaches 6174 in at most seven applications of Kaprekar's operation.

The theorem was established by Kaprekar and is one of the most famous results in recreational mathematics. It shows that 6174 is the unique attracting fixed point of Kaprekar's procedure on the set of admissible four-digit numbers.

Figure 2 illustrates the convergence of several different starting values to the fixed point 6174.

To illustrate the theorem, consider the number

$$7642.$$

Applying Kaprekar's operation repeatedly gives

$$7642 \to 5175 \to 5994 \to 5355 \to 1998 \to 8082 \to 8532 \to 6174.$$

Thus, starting from 7642, seven applications of Kaprekar's operation produce the fixed point 6174. Once 6174 is reached, all subsequent applications of the procedure leave the value unchanged.

Although the intermediate values may differ from one starting number to another, every admissible four-digit number eventually reaches the same fixed point.

The theorem excludes numbers whose digits are all equal. For example,

$$1111 - 1111 = 0000,$$

and therefore

$$0000$$

remains fixed under further applications of Kaprekar's operation. Consequently, such numbers do not converge to 6174.

One way to understand the convergence phenomenon is to observe that Kaprekar's operation dramatically reduces the number of possible outcomes. After only a few applications of Kaprekar's operation, many distinct starting values merge into the same intermediate numbers. This repeated merging causes the trajectories of different starting values to become increasingly similar until they eventually reach the fixed point 6174.

The existence of an attracting fixed point arising from such a simple arithmetic procedure is one of the reasons why Kaprekar's constant continues to fascinate students, teachers, and recreational mathematicians.

6. Historical Note

Kaprekar's constant was discovered by D. R. Kaprekar in 1949 [1]. Although Kaprekar worked largely outside the mainstream mathematical community, he discovered several remarkable numerical phenomena that continue to attract attention in recreational mathematics. Among his best-known contributions are Kaprekar numbers, the Kaprekar routine, and the constant 6174 discussed in this article.

The enduring popularity of Kaprekar's constant illustrates how elementary arithmetic can produce surprisingly rich mathematical structures. More than seventy years after its discovery, the phenomenon continues to appear in books, articles, classrooms, and mathematical recreations [2, 3, 4].

Kaprekar's constant remains one of the most widely discussed examples in recreational mathematics. Its combination of simplicity and unexpected behaviour has made it a favourite topic for mathematical exploration, classroom demonstrations, and computational investigations. Discussions of Kaprekar's constant and related recreational number patterns may be found in the works of Gardner and Pickover [2, 3]. Additional historical information, computational examples, and related references are available in the MathWorld article on Kaprekar's constant [4].

7. Exercises for the Reader

The study of Kaprekar's constant provides many opportunities for experimentation. The following exercises invite the reader to explore additional properties of the Kaprekar process.

Exercise 7.1. Apply Kaprekar's operation repeatedly to the number

$$7642.$$

Verify that the resulting sequence reaches 6174. How many applications of Kaprekar's operation are required?

Exercise 7.2. Apply Kaprekar's operation repeatedly to the number

$$5431.$$

Verify that the resulting sequence eventually reaches 6174.

Exercise 7.3. Find a four-digit number that reaches 6174 after exactly one application of Kaprekar's operation.

Exercise 7.4. Find a four-digit number that requires exactly five applications of Kaprekar's operation before reaching 6174.

Exercise 7.5. Show that every value produced by Kaprekar's operation is divisible by 9.

Exercise 7.6. Verify directly that

$$6174$$

is a fixed point of Kaprekar's operation.

Exercise 7.7. Investigate what happens when Kaprekar's procedure is applied to three-digit numbers. Does there exist a constant analogous to 6174?

Exercise 7.8. Experiment with five-digit numbers. Do all starting values converge to the same number? What patterns can you observe?

Exercise 7.9. Write a computer program that implements Kaprekar's operation and test all four-digit numbers having at least two distinct digits. Verify that each sequence eventually reaches 6174.

These exercises illustrate how a simple numerical process can lead to many interesting questions. Some can be answered using only elementary arithmetic, while others invite computational exploration and further investigation.

8. Concluding Remarks

Kaprekar's constant 6174 is a striking example of how simple arithmetic procedures can produce unexpected and beautiful mathematical phenomena [2, 3]. Beginning with any four-digit number having at least two distinct digits, repeated application of Kaprekar's operation eventually leads to the fixed point 6174. The universality of this behaviour makes the constant one of the most celebrated curiosities in recreational mathematics.

Although the procedure involves only elementary digit manipulations, it exhibits several interesting mathematical features, including iteration, convergence, divisibility properties, and fixed points. These ideas appear throughout mathematics in both elementary and advanced settings, demonstrating how recreational problems can provide insight into broader mathematical concepts.

The study of Kaprekar's constant also illustrates the value of experimentation in mathematics. A few numerical examples quickly suggest a pattern, which can then be investigated more systematically. Such explorations encourage curiosity and problem-solving while requiring only a modest mathematical background.

More than seventy years after its discovery [1], Kaprekar's constant continues to fascinate students, teachers, and mathematicians alike. Discussions of Kaprekar's constant and related recreational number patterns may be found in [2, 3], while additional historical information and computational details may be found in [4]. It remains an elegant reminder that remarkable mathematical structures can arise from the simplest of numerical processes.

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Conflict of Interest

The author declares that there is no conflict of interest regarding the publication of this paper.

Data Availability Statement

No data were used to support this study.

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