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Applicability of Vedic sutras to study the recurring decimals

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Abstract: *The applicability of Vedic sutras is shown in this paper to convert the vulgar fraction into recurring decimal digits. It is shown that the traditional method is too long to convert the vulgar fraction into the decimal recurring compared to the Vedic method. Further, the Vedic methods are studied to convert the vulgar fractions whose denominator ends with nine into the recurring decimal form. Vedic Method I and Method II studied to solve the vulgar fraction whose denominator ends with nine into the decimal form. Moreover, method I is studied to convert the vulgar fraction with denominator not end in 9. In our study, it is investigated that method II is also applicable to convert the vulgar fraction whose denominator ends with other than a 9 number. The present method explores the applicability of Vedic methods in the field of mathematics. This increased the beauty of Vedic mathematics.*

Key Words: *Recurring decimals, Aanurupyena Sub-sutra, Ekadhika Sutra.*

1. INTRODUCTION:

Veda is commonly defined as knowledge**.** In terms of both Ancient Indian culture and Hinduism, it is the earliest and most ancient type of text. There is a belief that the Vedas are divine revelations from God and that they are divine in origin. There are four Vedas in the world: the Yajur Veda, the Rig Veda, the Athar Veda, and the Sama Veda. Vedic texts are ancient texts whose exact dates are uncertain, but they are believed to date back to the early centuries of B.C. Vedic literature was widely known long before printing was invented and was freely available. Through word of mouth, this has been passed down through the centuries. Recent studies have shown that the Vedas are highly organized internally and in their relationships. Between 1911 and 1918, Krishna spent eight years in the Shringari pine forest, where he practiced Brahma Sadhana and learned advanced Vedanta Theory. His dedication resulted in the discovery and reconstruction of Vedic from stray allusions in the Atharvaveda's appendices. There are sixteen formulae and thirteen subformulae in Vedic Mathematics, each with a basic rule and concept. Vedic mathematical processes use both modern and ancient mathematical systems. Each procedure describes a mental working concept for solving various mathematical problems.

During the early twentieth century, Vedic Mathematics was popularized based on Veda. In addition to their sixteen equations, many subformulae with basic principles and regulations make it a very independent, efficient, and complex mathematical system [1-4]. Specifically, Archana V Katgeri states that Jagad guru Shri Bharathi Krishna Tirtha developed Vedic Math between 1911 and 1918. A Vedic Mathematics book was published later by Tirthaji Maharaj, also known as Bharati Krsna. Bharati Krsna lived between 1884 and 1960 and was a devotee of Lord Krsna. In addition to his excelling in mathematics, Sanskrit, English, Philosophy, Science, and History, he was an outstanding student. Mathematical problems can be solved quickly and easily with Vedic Mathematics. An algebra, conics, arithmetic, geometry, and calculus problem may be solved using sixteen Sutras and thirteen Sub-Sutras [9-13].

It is a methodology of mental mathematics that is based on Vedic principles. For example, it is easy to think of division as the reverse of multiplication. Compared to the current system, this would be in direct opposition to it. Sometimes, solving issues with traditional mathematical methods can be challenging and time-consuming [16]. Numerical computations can be done quickly and accurately using Vedic Mathematics' General and Specific Techniques.

Inspired by the above literature, we have discussed the recurring decimal digits with traditional and Vedic methods. We also discuss two Vedic methods for converting the vulgar fraction into recurring decimal digits.

1.1 Preliminaries:

Recurring decimals- Recurring decimals are numbers, that are repeated with the same values after the decimal point. For example 5.232323…, 21.123123…, 0.1111…
Some Vedic Sutras-
There are some Vedic sutras that are useful for studying recurring decimals.
Aanurupyena subsutra- Means "According to the ratio".
Ekadhika Sutra-Which means "by the preceding one increased by one".

1.2 Applications of Vedic sutras in recurring decimals:

Conversion of the vulgar fraction into their equivalent decimal form

In this section, we convert the vulgar fractions to decimal form.
Let us consider the vulgar fraction $\frac{1}{13}$.
We simply follow the usual division process to convert the vulgar fraction into decimal form by traditional mathematics.
For example,

```
13)1.00 (0.0̇76923̇
 -0
 ----
   10
  - 0
  ----
   100
  - 91
   ----
     90
    -78
    ----
     120
    -117
     ----
       30
      -26
      ---
        40
       -39
       ---
         1
```

In the whole division process, 1, 10, 9, 12, 3, and 4 are successive remainders.

This traditional division method is too long. Vedic mathematics provides us with an easy way to solve division problems. By the Vedic mathematics procedure, we can find the remainder by using Aanurupyena Sub-sutras. Which means "proportionality." Here we observe that the ratio between the first and second remainder is 1:10. According to this ratio, the third remainder will be, $10 \times 10 = 100$ and 100 is greater than 13; therefore, we further divide 100 by 13 and get the remainder 9. Hence the third remainder is 9. Similarly, the fourth reminder is $10 \times 9 = 90$ and 90 is greater than 13; therefore, with the division of 90 by 13 we get 12 as the fourth remainder.
Further, for the fifth remainder, we multiply 10 by 12 and get the remainder of 120 which is again greater than 13; therefore, with the division of 120 by 13, we get 3 as the fifth remainder. The Sixth remainder is $10 \times 3 = 30$, which is greater than 13. Hence after the division of 30 by 13, we get 4 as the sixth remainder. Similarly, we find 4 as the seventh remainder.

This way, we get 1, 10, 9, 12, 3, and 4 as the successive remainder.
From the remainders, we calculate the quotient digits. The Vedic mathematics provides two procedures for calculating the quotient digits from the remainders.

Procedure I- Each remainder digit gives dividends. Corresponding to each remainder digit, we have the consecutive dividend digits 10, 100, 90, 120, 30, and 40. Divide these digits mentally by 13. We get the quotient digits 0, 7, 6, 9, 2, and 3. Hence, $0.\dot{0}769\dot{2}$ is required recurring decimal.

Procedure II- Vedic mathematics provides an excellent way to find quotient digits without doing little division work. And we can put the quotient digits automatically. Here the most relevant sutra, "Sesanyankena Caramena," is used, which means, "The remainder by the last digit."
First, write the remainder in order 10, 9, 12, 3, 4, 1. (Here, we put first remainder 1 in the last place). We also see that the last digit of denominator 13 is 3. Therefore we multiply remainders by 3 and put the right hand most digit.
10, 9, 12, 3, 4, 1
Multiply 10 by 3 we have 30; put down only 0
Multiply 9 by 3 we have 27; put down only 7
Multiply 12 by 3 we have 36; put down only 6
Multiply 3 by 3 we have 09; put down only 9
Multiply 4 by 3 we have 12; put down only 2

$$\frac{10, 9,\ 12, 3, 4, 1}{0, 7, 6, 9,\ 2\ (Quotient\ digits)}$$

Hence the required recurring decimal digit is $0.\dot{0}769\dot{2}$.

Number ending in nine

Here we will deal will the fractions whose denominator end with nine.
Let us consider fraction $\frac{1}{19}$. In the denominator, the first digit is 1. According to the Ekadhika Purva sutra, we take 2 (one more than 1) for the required multiplication or division, which is applicable.
To solve this further, we have two methods: the multiplication method and the division method.

Method I- By multiplication
The following steps are given to solve the above problem by multiplication method.
Step 1: Take the last digit of the numerator, i.e., 1, and put it into the right end.
Step 2: Now multiply it by 2, and we get 2. Put it left to the preceding digit.
For example 2 1

Step 3: Now multiply 2 by 2; we get 4. Put 4 down as the next previous digit.
4 2 1
Step 4: Next, multiply 4 by 2; we get 8. Write it as shown below.
8 4 2 1
Step 5: Multiply 8 by 2; we have 16. This has two digits therefore put the 6 down left to the 8 and keep 1 on hand to be carried over to the left at the next step.
6 8 4 2 1
1
Step 6: Multiply 6 by 2 and add 1; we have 13. . Write it as shown below.
3 6 8 4 2 1
1 1
Step 7: Multiply 3 by 2 and add 1; we have 7. Write it as shown below.
7 3 6 8 4 2 1

0 1 1
Step 8: Multiply 7 by 2; we have 14. Write it as shown below.
4 7 3 6 8 4 2 1
1 0 1 1

Step 9: Multiply 4 by 2 and add 1; we have 9. Write it as shown below.
9 4 7 3 6 8 4 2 1
0 1 0 1 1

Step 10: Multiply 9 by 2; we have 18. Write it as shown below.
8 9 4 7 3 6 8 4 2 1
1 0 1 0 1 1

Step 11: Follow the same procedure continuously.
Step 12: When we find that the whole decimal has begun to repeat itself, we stop the process here.
Hence, we get the required recurring decimal digit $0.\dot{0}5263157894736842\dot{1}$.

Method II- By division.
In this method, we do division instead of multiplication by Ekadhika Purva sutra. Because the division process is just the opposite of the multiplication, the operation in the division process will be left to right, just opposite direction to the multiplication (i.e., the right to left). Further steps are given as follows:
Step 1: Choose the last digit of the numerator, which is 1. Divide it by 2; we get quotient 0 and remainder 1. Write it as shown below.

0
1

Step 2: Now we have 10 as the next dividend. Divide 10 by 2; we get the quotient 5. Put 5 down the right side to the first quotient.

0 5
1

Step 3: Now, we have 5 as the next dividend. Divide 5 by 2; we have the quotient 2 and the remainder 1. Write it as shown below.

0 5 2
1 0 1

Step 4: Similarly, now we have 12 as the quotient. Divide 12 by 2; we get the quotient 6 and the remainder 0.

0 5 2 6
1 0 1 0

Step 5: Now we have 6 as the next dividend. Divide 6 by 2; we have the quotient 3. Write it as shown below.

0 5 2 6 3
1 0 1 0 0

Step 6: Now we have 3 as the next dividend. Divide 3 by 2; we have the quotient 1 and the remainder 1. Write it as shown below.

0 5 2 6 3 1
1 0 1 0 0 1

Step 7: Now we have 11 as the next dividend. Divide 11 by 2; we have the quotient 5 and the remainder 1. Write it as shown below.

0 5 2 6 3 1 5
1 0 1 0 0 1 1

Step 8: Now we have 15 as the next dividend. Divide 15 by 2; we have the quotient 7 and the remainder 1. Write it as shown below.

0 5 2 6 3 1 7
1 0 1 0 0 1 1

Step 9: Now we have 17 as the next dividend. Divide 17 by 2; we have the quotient 8 and the remainder 1. Write it as shown below.

0 5 2 6 3 1 7 8
1 0 1 0 0 1 1 1

Step 10: Now we have 18 as the next dividend. Divide 18 by 2; we have the quotient 9. Write it as shown below.

0 5 2 6 3 1 7 8 9
1 0 1 0 0 1 1 1 0

Step 11: Follow the same procedure continuously.
Step 12: When we find that the whole decimal has begun to repeat itself, we stop the process here.

Hence, we get the required recurring decimal digit $0.\dot{0}5263157894736842\dot{1}$.

Number with other ending

Now we will deal with the fractions whose denominator is not ending with nine.

Method I- By multiplication.
Let us consider fraction $\frac{1}{7}$. To calculate $\frac{1}{7}$ in the recurring decimal form we have the following steps:
Step 1: First, we convert $\frac{1}{7}$ in form $\frac{1\times7}{7\times7}=\frac{7}{49}$. (Denominator ends with 9)
Step 2: In the denominator, the first digit is 4. According to the Ekadhika Purva sutra, we take 5 (one more than 4) for the required multiplication or division, which is applicable.
Step 3: - Take the last digit of the numerator, i.e., 7 and put it into the right end.
Step 4: Now multiply it by 5, and we get 35. Take 5 from 35 and put 3 as the remainder. Write it as shown below.

For example,

5 7
3

Step 5: Now multiply 5 by 5; we get 25. Add the previous remainder 3 with 25 we get 28. Put 28 as shown below.

8 5 7
2 3

Step 6: Next, multiply 5 by 8 and add 2; we get 42.

2 8 5 7
4 2 3

Step 7: Multiply 5 by 2 and add 4; we have 14.

4 2 8 5 7
1 4 2 3

Step 8: Multiply 5 by 4 and add 1; we have 21.

1 4 2 8 5 7
2 1 4 2 3

Step 9: Multiply 5 by 1 and add 2; we get 7. If we multiply 5 by 7 we will get 35, and the whole process will repeat. Therefore we stop the process here.
Hence, we get the required recurring decimal digit $0.\dot{1}4285\dot{7}$

Method II- By division.
Again, we consider fraction $\frac{1}{7}$. In the second method, as shown above, we first convert $\frac{1}{7}$ in form $\frac{1\times7}{7\times7}=\frac{7}{49}$. (Denominator ends with 9). Next, we do division instead of multiplication by Ekadhika Purva sutra. Because the division process is just the opposite of the multiplication, the operation in the division process will be left to right, just opposite direction to the multiplication (i.e., the right to left). Further steps are given as follows:

Step 1: In the denominator, the first digit is 4. According to the Ekadhika Purva sutra, we take 5 (one more than 4) for the required division.
Step 2: Choose the last digit of the numerator, which is 7. Divide it by 5; we get quotient 1 and remainder 2. Write it as shown below.

1
2

Step 3: Now we have 21 as the next dividend. Divide 21 by 5; we get the quotient 4 and the remainder 1. Put the quotient right side to the first quotient and put 3 down right to the remainder digit 1.

1 4

2 1

Step 4: Now, we have 14 as the next dividend. Divide 14 by 5; we have the quotient 2 and the remainder 4. Write it as shown below

 1 4 2
2 1 4

Step 5: Similarly, now we have 42 as the quotient. Divide 42 by 5; we get quotient 8 and remainder 2.

 1 4 2 8
2 1 4 2

Step 6: Now, we have 28 as the next dividend. Divide 28 by 5; we have the quotient 5 and the remainder 3. Write it as shown below

 1 4 2 8 5
2 1 4 2 3

Step 7: Now, we have 35 as the next dividend. Divide 35 by 5; we have the quotient 7 and the remainder 0. Write it as shown below

 1 4 2 8 5 7
2 1 4 2 3 0

Step 8: Now we have 7 as the next dividend. Divide 7 by 5; we have the quotient 1 and the remainder 2, and the whole process will repeat. Therefore, we stop the process here.

Hence, we get the required recurring decimal digit $0.\dot{1}4285\dot{7}$

2. CONCLUSION:

In this paper, we have discussed the application of Vedic sutras to study recurring decimals. First, we compare the traditional method for converting the vulgar fraction into a recurring decimal. Moreover, we study the Vedic method to convert the vulgar fractions whose denominator ends with nine into the recurring decimal form. We solve the vulgar fraction whose denominator ends with nine into the recurring decimal form by Vedic method I and method II. Further, by method I, we convert the vulgar fraction whose denominator does not end with nine into recurring decimal form. We also find that method II is also applicable to convert the vulgar fraction whose denominator not end with nine into the recurring decimal form. This increase the applicability of Vedic sutras in the field of Vedic mathematics.

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