SLC (University of Delhi)
Shyam Lal College

Saraswati IKS Centre

Project Title: An Action based Study to Explore & Connect Select IKS in Contemporary Discourses & Practices

Comparison between Current and Ancient Indian Mathematics

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Abstract

This research paper includes various concepts of mathematics that are developed by the ancient Indian mathematicians. This paper gives the insight to the readers about the various topics that have been described and provides the clear understanding of these topics. Moreover this paper presents a link between the elementary and secondary level and compare the topics developed by the ancient Indian mathematicians to the present context. The paper is being designed so that students can get a better understanding about the topics and recognize the work developed by the Indian scholars.

1. Introduction

Ancient Indian Mathematicians such as: Aryabhata, Varahamihira, Brahmagupta, BhaskaraI, Mahavira, Bhaskara II, Madhava of Sangamagrama, and Nilakantha Somayaji give broader and clearer shape to many branches of mathematics. This research paper includes various topics those were developed by ancient Indian mathematicians. Such topics include Quadratic equations, permutation, and combination, and Weighted mean. These are some of the topics that are of great significance to the students who are learning. Also, these topics are derived much earlier but are not put forward for basic conceptual clarity. Students are still being ignored by the relevance of the topics developed by our Indian mathematicians. More than 10 million manuscripts are available and barely 5% have been studied. The remaining 95% of scripts are waiting to get explored. IKS is not only spiritual but contains mainly applicable-oriented knowledge system for all types.

Thus, this research paper includes such topics to enhance the better learning of students and also to recognize the work done by these ancient Indian mathematicians.

This paper is divided into two sections: First section deals with the elementary level particularly include the basic clarity of Vedic mathematics that provides the easiest way to calculate lengthy problems and section-2 deals with the secondary level to help the student to get a better understanding of the concepts developed by ancient Indian mathematicians.

2. Vedic Mathematics for Elementary level

Vedic Mathematics is a collection of Methods or Sutras to solve numerical computations quickly and faster. It consists of 16 Sutras called Formulae and 13 sub-sutras called Sub Formulae, which can be applied to the solving of problems in arithmetic, algebra, geometry, calculus, conics, etc. This section discussed about the basic concept for elementary mathematics with the help of Vedic Mathematics such as addition, subtraction, multiplication and division. Further, a comparison between traditional method (Vedic method) and present method are shown by with help of numerical examples.

2.1: Addition: The addition of two and more than two numbers in Vedic mathematics are solved by one of the Vedic Mathematics formula "**Ekadhikena Purvena**" means that by one more than the previous one.

Compute 879+466+587

Steps to solve:

Step 1: - Rearranging the numbers in the row and columns as shown below:

879

466

587

Step 2: in the above numbers, if we look at in units place, from the bottom, we find the digits 7, 6, 9. If we start adding in that sequence, first we have to add 7+6=13.

This 13 can be visualized as 10+3. To indicate the number 10, we put a dot on 6. Temporarily we can forget about 10. Then we take remaining 3 and add this with 9, 3+9=12.

Again, this can be visualized as 10+2. To indicate the number 10, we once again put the dot on 9. The remaining digit 2 is written at the unit place as the answer.

87**9**°

46**6**°

587

_ _ 2

Step 3: Now, we have to add the digits 8, 6, 7 of the 10's place. Before this we have to count the number of dots that we put in the unit's place earlier. So, there are 2 dots that we put on 6 and 9 earlier in the unit's place. These 2 dots have to be added to digit 8.

2+8=10. To indicate this 10, we put a dot on 8. Remaining digit 0 has to be added to 6, 0+6=6. Again, we proceed further, 6+7=13.

We can visualize this 13 as 10+3. To indicate this 10, we put a dot on 7 and the remaining digit 3 is written in 10's place as the answer.

This can be shown as:

8**7**°**9**°

46**6**°

5**8**°7

_ 3 2

Step 3: Following the same procedure, we count the number of dots in 10's place. There are 2 dots, so we add these 2 dots to the digit 5 in the 100's place i.e. 2+5= 7. Moving further, 7+4=11 and 11 can visualize as 10+1 and indicate 10 by putting a dot on 4. The remaining digit 1 is added to 8, 1+8=9. This 9 is written in the 100's place as answer.

Since there are no digits in the 1000's place. So, we count the dots in 100'place and write that in the 1000's place as the answer. There is 1 dot in the 100's place. So, we write 1 in the 1000's place as the answer.

So, the final answer is 1932.

8**7**°**9**°

4°6 **6**°

5**8**°7

1932

Comparison of above method and present addition method:

Vedic Method	**Present Method**
	122 (Carries)
8**7**°**9**°	879
4°6 **6**°	466
5**8**°7	+ 587
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1932	**1932**
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Here, we can see that, in Vedic method, students can add two or more numbers, if they know the counting up to 20. But in today's scenario, which method we are using consumed more than 20 and timing whereas which method is being described above is easy to calculate the lengthy calculations and to save time.

2.2: Subtraction : The subtraction of two numbers in Vedic mathematics are solved by one of the Vedic Mathematics formula "**Ekadhiken Purvena"** means that by one more than the previous one.

Compute: 300-168

Step 1: Rearranging the numbers in the row and columns as shown below:

300

168

Step 2: We need to subtract 0 from 8 (biggest to smallest) i.e., 8-0 = 8. Now we need to find 10's complement of 8. (8+2 = 10). Here we put a dot on the digit which is lying on the LHS of the digit being subtracted.

So, 8-0 = 0. We put a dot on 6 as it lies on the LHS of 8. Since 2 is the complement for 8 as (8+2 = 10). This 2 is added with 0. 2+0 = 2.

Thus digit 2 is written in the unit's place as the answer.

300

1**6**°8

_ _ 2

Step 2: Now we have to subtract 0 from 6 (6-0). Before subtracting we need to add 1 to 6 as there is a dot on 6. So, 6+1=7

Now subtract 7 from 0, 7-0=7 (biggest to smallest). But we need to find the complement for 7 i.e., 7+3=10

Now we put a dot on 1 which lies on the LHS of the digit 6. Remaining 3 is subtracted from 0 (3-0=3). This 3 is written at the ten's place as answer.

300

1°**6**°8

_ 3 2

Step 3: Since there is a dot on 1, so we add 1 to 1, 1+1=2.

Now we need to subtract 3 from 2 (smallest to biggest), 2-3=1

(We'll ignore the minus sign). Now this digit 1 is written at the 100's place as the answer.

300

$\mathbf{2}^{\circ}\,\mathbf{6}^{\circ}8$

132

Comparison of above method and present substation method:

Vedic Method	**Present Method**
	9
	2 10 10 **(borrows)**
300	300
$2^{\circ}6^{o}\,8$	268
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132	**132**
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Here we can see that, in Vedic method, students can subtract two numbers without any borrow process and it's easy to calculate the lengthy calculations as well as save time.

2.3 Multiplication: The multiplication of two numbers in Vedic mathematics are solved by the Vedic Mathematics formula "**Ekadhiken Purvena"** means that by one more than the previous one and "Ekanyunena Purvena" means that by one less than the previous one.

Compute: Multiply 63 and 67 by "Ekadhiken Purvena".

Step1: Check, Sum of unit digits = 3 + 7 = 10

Step2: Digits in tens places in both numbers are same

Step3: We can write the multiplication as:

$63 \times 67 = 6 \times (6 + 1)/3 \times 7$

$= 6 \times 7/3 \times 7$

$= 42/21$

$= 4221$

Note: - This method is used when both the digit's ten's place has the same number and the sum of the unit digits must be 10.

Compute: Multiply 876 and 999 by "Ekanyunena Purvena"

This formula is used if one of these numbers is having only 9's then we can apply this method.

Multiply 876 and 999.

Step 1: Subtract 1 from 876.

876 – 1 = 875

Subtract 875 from 999.

999 – 875 = 124

Thus,

876 × 999 = 876 – 1/999 – 875

= 875/124

= 875124

Multiplication in current scenarios

$$\begin{array}{r} \boxed{\begin{array}{l} 1 \\ \quad 2 \end{array}} \text{ Carries} \\ 63 \\ \times 67 \\ \hline 441 \\ +3780 \\ \hline 4221 \\ \hline \end{array}$$

Comparison: Here we can see that, in Vedic method, students can multiply two numbers without any tables. It's easy to calculate the lengthy calculations as well as save time.

2.4: Division: The Division in Vedic mathematic are solved by the Vedic formula "**Nikhilam "** means that all from nine and last from ten.

Compute: 23 ÷ 8

We use some abbreviations,

R = Remainder, Q = Quotient

Diff. = Difference

Step 1: Identify Base & Difference

As divisor is 8, which is near to 10, so Base = 10, Difference = base – number = 10 – 8 = 2.

Step 2: Split the dividend in to two parts (Q & R) in such a way that Number of digits in remainder side is equal to number of zero in base.

Base: 10

Divisor = 8

Difference = 2

2 | 3

Q | R

As here Base 10 have 1 zero so in remainder side, we take 1 digit.

Step 3: Take 2 down as it is at quotient place. This is our first digit of Q.

2 | 3

2 | R

Step 4: Now multiply this 2 with diff. 2. So, 2 x 2 = 4 & add this 4 in next digit of dividend i.e., 3 & write down the total at R place.

2 | 3

| 4 [2 *2 (diff.) =4]

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2 | 7

Answer, Q = 2 & R = 7

Division in current scenarios

23 ÷ 8

8	23	2 Quotient
	16	
	07 Remainder	

Comparison: Here, we can see that, in Vedic method, students can division without any tables and it's easy to calculate the lengthy calculations as well as save time.

3. Ancient mathematics for Secondary level

In this section, we discuss the some basic concept for secondary level such as quadratic equation, weighted mean, Permutation and Combination. These topics are already discussed by our Indian

Mathematician in thousand years ago. Comparison of these topics between ancient method and present method are shown by with help of numerical examples.

3.1: Quadratic equation: An equation is said to be a quadratic if the highest degree of the variable occurring in this equation is 2.The solution of this type of equation had invented by famous Indian Mathematician Aryabhata *in the Sutra [10, Sutra25] of Aryabhata.*

This sutra states the rule on how to calculate the interest amount on the principal. This is the solution of a quadratic equation.

Step 1: Multiply Amount (A), time (t) and principal(p) andthen add half of principal square.

$\mathrm{Apt} + \left(\frac{\mathrm{p}}{2}\right)^2$.

Step 2: Take the square root and subtract half of the principal

$\frac{-\mathrm{p}}{2} \pm \sqrt{\mathrm{Apt} + \left(\frac{\mathrm{p}}{2}\right)^2}$

Step 3: Step two is divided by time; we get roots of given second order equation

$$= \frac{\frac{-\mathrm{p}}{2} \pm \sqrt{\mathrm{Apt} + \left(\frac{\mathrm{p}}{2}\right)^2}}{\mathrm{t}}$$

Formula

Aryabhata's considered this quadratic equation is given as: -

$\boldsymbol{tx^2 + px - Ap = 0}$

For this equation, the solution is: -

$$\mathrm{x} = \frac{\frac{-\mathrm{p}}{2} \pm \sqrt{\mathrm{Apt} + \left(\frac{\mathrm{p}}{2}\right)^2}}{\mathrm{t}}$$

Comparison of this formula with that of current formula

In today's world, we use determinant as D = $b^2 - 4ac$ of second order equation $ax^2 + bx + c = 0$.

Solution of this equation is as:

$\mathrm{X}=\frac{-b\pm\sqrt{b^2-4ac}}{2a}$

3.2: Weighted Average Mean: Weighted average mean was first given by the renowned Indian mathematician "**Brahmagupta"**(598-665 CE). He had given various examples and then derived the weighted arithmetic mean which is being used today all over the world. He was one of the earliest Indian mathematicians in whose text the concept of arithmetic mean occurs explicitly in this statistical sense. He has mentioned this weighted average mean in Chapter 12 of ganitadhyayah, verse 44, in Brahma sputa Siddhanta.

When he was studying how to find the depth of the region where the top and the base are identical to each other but the depth varies. So, to find the varied depth, he subdivided the region so that the depth was taken uniformly throughout each section. Then he derived the principle of the weighted average mean. So, in an excavation whose face and base have the same measurements, the mean depth is given by the sum of the products of the lengths and depths of the sections divided by the total length.

In symbols: He noted that the excavated region of uniform length comprises of n section such as l_1, l_2, l_3……., and depths such as

d_1, d_2, d_3,..,d_n respectively, then the mean depth of the region is defined as:

Formula

d= $\boldsymbol{l_1 d_1} + \boldsymbol{l_2 d_2} + \boldsymbol{l_3}\mathbf{d_3} +\ldots\ldots, + \boldsymbol{l_n}\,\mathbf{d}_{\boldsymbol{n}} / \boldsymbol{l_1} + \boldsymbol{l_2} + \boldsymbol{l_3}\ldots\ldots, +\boldsymbol{l_n}$

Comparison of this formula with that of current formula

In today's world we denote the weighted mean by $\bar{x}$=(x_1w_1+ x_2w_2+,…...,+ x_nw_n/(w_1+w_2+w_3 +,…,+w_n).

Where, x is the subject and w is the weightage of the marks.

3.3: Permutation and Combination: Pascal's triangle or quick computations and of $\mathbf{n_{C_r}}$ it was described by Halayudha in the 10th Century AD as Meru-Prastara 700 years before it was stated by Pascal; and Halayudha's Meru-Prastara was only a clarification of a rule invented by Pingala more than 1200 years earlier (around 200 BC).

The formula of the combination was given by the Indian mathematician Pingala in his Chandah sutra which contains a great description of Meru prastaar (aka pascal's triangle). This Meru prastaar is explained by the Indian mathematician Halayudha in

Mṛtasañjīvanī, a commentary on Pingala's Chandah sutra.

Halayudha (Sanskrit: हलायुध) was a 10th-century Indian mathematician who wrote the Mṛtasañjīvanī, a commentary on Pingala's Chandah sutra. The latter contains a clear description of Pascal's triangle (called meru-prastāra).

It was only through Halayudha Bhatt's commentaries on Chandah shastra in his work Mritasanjeevani (composed in the 10th century CE) that people were able to understand this sutra.

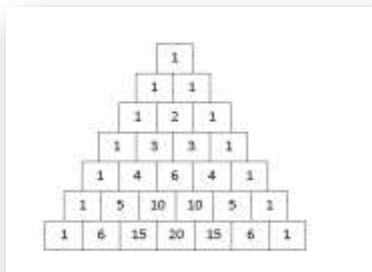
Halayudha has explained how to create a table of numbers which he called मेरु प्रस्तार.

प्रस्तारे मित्र गायत्र्याः स्युः पादे व्यक्तयः कति।

एकादिगुरवश्चाशु कथ्यतां तत्पृथक् पृथक ॥

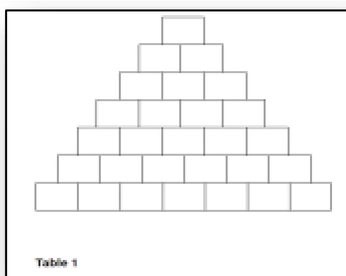
This verse implies that -

How many meters with r Gurus (or Laghus) are possible in a prastaar for n syllables?



PINGALA'S MERU PRASTAAR

Step 1: -



Put one square in the first row.

Then put 2 squares below it in the second row. Below this put 3 squares in the third row.

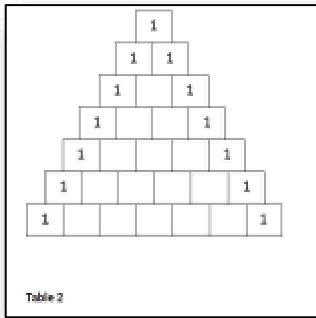
In the fourth row put 4 squares and so on.

If you want the combinations for a meter having n syllables then create a table having n + 1 rows.

Write 1 in the square in the first row.

Then put 1s in the squares at the ends of each row.

Step: - 2

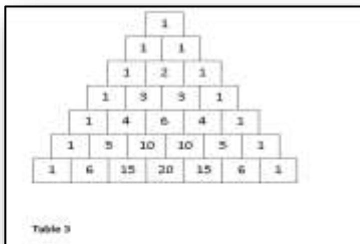


1						
1	1					
1		1				
1			1			
1				1		
1					1	
1						1

Table 2

Numbers in the inner squares are got by adding the numbers in the two squares just above them.

Step 3: -



1						
1	1					
1	2	1				
1	3	3	1			
1	4	6	4	1		
1	5	10	10	5	1	
1	6	15	20	15	6	1

Table 3

Let us understand this by calculating the number for the middle square of the third row.

Both the squares above this square contain 1, hence we get 1 + 1 = 2.

Thus, the number in this square gives a number of meters having 1 Guru in a prastaar for 2 syllables.

Now let us calculate the value for the second square of the fourth row. The number in this square gives us the number of meters having 1 Guru in a prastaar for 3 syllables. The numbers in the two squares just above this square are 1 and 2.

Hence, we get 1 + 2 = 3.

Now let us calculate the value for the third square of the fourth row. The number in this square gives us the number of meters having 2 Guru in a prastaar for 3 syllables. The numbers in the two squares just above this square are 2 and 1.

Hence, we get 2 + 1 = 3.

Now let us calculate the value for the second square of the fifth row. The number in this square gives us the number of meters having 1 Guru in a prastaar for 4 syllables. The numbers in the two squares just above this square are 1 and 3. Hence, we get 1 + 3 = 4.

If we observe figure 3 closely, we can realize that the numbers in the squares are the binomial coefficients, ${}^{n}C_{r}$. Hence the number of metrical forms containing r Gurus (or Laghus) in a prastaar for n syllables is given by ${}^{n}C_{r}$.

Comparison of this method with that of the current method

In today's world, we use a formula for combination problems.

$$^{n}_{r}C = \frac{n!}{r!\,(n-r)!}$$

Conclusion

This paper includes various concepts that were first introduced by ancient Indian scholars. There are many more such concepts, so it becomes essential to read their verse and understand them to bring these concepts forward for better understanding and to give the credit they deserve and show the 'Indian way' to the world. The noble vision of the IKS is to train generations of scholars who will show the 'Indian way' to the world. If we intend to become the knowledge power of this century and be the 'Vishwa Guru', it is imperative that we understand our heritage and teach the world the 'Indian way' of doing things.

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