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SUNGKA MATHEMATICS OF THE PHILIPPINES

PAUL MANANSALA

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The Sungka Board, as it is known in the Philippines, is known over a wide area of the Malayo-Polynesian world from Madagascar to Polynesia, and also through Southeast Asia, India and even mainland Africa.

Its main purpose in modern times is to serve as a sedentary game. In the Philippines, and possibly elsewhere, the Sungka Board is also still occasionally used for popular divination, especially by elders enquiring on whether travel by youths is auspicious on a certain day, or by girls interested in finding out whether and when they will get married. This practice is not as common as it was before, particularly before World War II.

Occasionally, the Sungka Board is still used by "professional" seers and prophets who are known by names such as *maghuhula*, *bailan*, etc.

An older usage of this board is for computational purposes using cowries known as *sigay* in Tagalog, or as a substitute, tamarind seeds, pebbles, or other bits.[1] As cowries were once a widespread form of currency in the surrounding regions in ancient times, their usage with the Sungka board attests to its connection with monetary and other types of calculation.

Also, like other types of divination devices, *mahjong* and playing cards, for example, the Sungka Board became a popular game, and may, at one time, even have been a game of chance. In the modern game, the winner often takes the cowries or other bits from their opponents.

Our main focus here, though, will be on the mathematical usages of the Sungka Board. Documentation of this usage is very hard to come by. The Spaniards made mention of computation using pebbles, cowries and other bits, but few details can be found in the available English translations. There is a fairly good amount of material available on native types of mensuration,[2] but the material can hardly be considered exhaustive. However, as the amount of material in Spanish, much of it only found in libraries in Spain, there may be some documentation that will turn up as these works are translated.

It is difficult to say how much the Sungka Board is used for computation today. Probably, this knowledge is confined to a few, being passed on for purposes of cultural preservation, but the board still may be in use by some of the more isolated tribal people. In the modern Philippines, hand calculators and other modern devices have become available to high school and even elementary school students in most areas.

Another type of computation system in the Philippines is that of the runo stalk counters of the Igorots in Northern Luzon.[3] This type of calculation bears some resemblance to the old counting rods of China. Probably there are also many other systems of which the author is unaware.

3633, Comanche Way, Antelope, CA 95843, USA

NUMERATION AND COMPUTATION

The general method of computation and counting in ancient and modern India is based on the number eight. The rupee, composed of sixteen *annas,* is an 8-based system. The Santali, *pan* "80 *kauri* (cowries)" has its correspondence in the Sanskrit, *pana* "80".[4] The general method of the Munda and Sanskrit uses the factor four as the multiple :

$4 \times 1 = 4$, $4 \times 5 = 20$, $4 \times 20 = 80$.

This type of system is prevalent throughout the Austric regions. For example, here is a system of numerical computation used by the Ifugao of the Northern Philippines:[5]

Unit	Number	Multiples	Amount in other units
boto	1	1-9	
hongol	5	1, 3	5 *boto*
nad'op	10	1	10 *boto*
napulu	20	1	3 *hongol* + 5 *boto*
dalan	25	1-9	1 *napulu* + 5 *boto*
bongle	125	1	5 *dalan*
upu	250	1-9	10 *dalan*
bukul	2500	1	10 *upu*

There are two types of factors working in this mensuration system. One is based on the factor five:

5 × 1 *boto*	= 1 *hongol*	= 5 × 1	= 5 *boto*
5 × 1 *hongol*	= 1 *dalan*	= 5 × 5	= 25 *boto*
5 × 1 *dalan*	= 1 *bongle*	= 5 × 25	= 125 *boto*

A type of decimal system also exists :

1 *nad'op*	= 10 *boto*
1 *upu*	= 10 *dalan*
1 *bukul*	= 10 *upu*

The other factor is a combination of the unit 2.5 and 10 :

10 × 2.5 *boto*	= 1 *dalan*	= 10 × 2.5	= 25 *boto*
10 × 1 *dalan*	= 1 *upu*	= 10 × 25	= 250 *boto*
10 × 1 *upu*	= 1 *bukul*	= 10 × 250	= 2500 *boto*

This system is used mostly with volume measurement, but also in calculation of abstract numbers. Tallies are made with the help of runo stalk counters in a manner which appears to resemble the counting rod method of the Chinese. More frequently in the Austric regions a counting system using cowries, or *kauri, kuri,* etc. as known in India, was used. This, of course, is a trait of maritime people, and the connection of the rupee/*kauri* system based on the number eight with the cowries shells may give some idea of its origin. A similar type of computation as that used by the Igorots can be found in the lowlands of the Philippines, also utilized in volume measurement. Although the quantities vary from place to place, the nomenclature is usually the same. One system used in Pampanga uses this standard :

1 × 2.5 *gatang*	= 1 *pati*	= 2.5 *gatang*	
10 × 2.5 *pati*	= 1 *kaban*	= 25 *pati*	= 62.5 *gatang*

Another standard has 5 *gatang* to a *pati*, and 25 *pati* to a *kaban*, while another has 6 *gatang* to a *pati*, and 36 *pati* to a *kaban*. The old Tagalog system shows signs of the eight-based system as :

1 *salop* (*ganta*) = 8 *kaguiian* (*pitis*)

The term *ganta, gantang, gatang* used mostly for cubic-type measurement in the Philippines resembles the monetary measurement, *ganda (ka)*,[6] used in Sanskrit and in the Munda languages. In both areas this unit can be based on eight. Referring to the "salop" mentioned above, the old Tagalog monetary system was based on the *salapi* which was sort of a binary system based on halves :

Gold and Silver reckoning

1 *salapi*	= 2 *kahati*
1 *kahati*	= 2 *saikapat*
1 *saikapat*	= 2 *saikabalo*
1 *saikabalo*	= 2 *aliu*
1 *aliu*	= 2 *kuding*

Thus,

1 *salapi* = 2 *kahati* = 4 *saikapat* = 8 *saikabalo* = 16 *aliu* = 32 *kuding*. This obviously, then, is also an eight-based system resembling the binary code of the I Ching which is also eight based, since 8^2, or 64, equals the total number of hexagrams in the I Ching notation of China. A similar type of monetary system could be found throughout the Philippines. It is known in Tagalog as *talaro*. Another type of measurement used exclusively for gold which also was a type of binary system :

2 *sapaha*	= 1 *tinga*	
2 *tinga*	= 1 *tahel*	
1 *tahel*	= 2 *tinga*	= 4 *sapaha*

A system used with steelyards for bulkier items was a combination of halves and decimal fractions:

1 *sinatan*	= 2 *banal*	= 10 *kate*
1 *banal*	= 5 *kate*	= 10 *soko*
1 *kate*	= 2 *soko*	= 100 *piko*
1 *soko*	= 50 *piko*	

So, 1 *sinatan* = 2 *banal* = 10 *kate* = 20 *soko* = 1000 *piko*.

In relation to the eight-based counting systems, the Sungka Board of the Philippines particularly draws our attention. This board has two large wells at each end, with each large well having a corresponding row of seven smaller wells. These two rows of seven are parallel and thus the board has a total of 16 wells divided into two group of eight. There is no doubt that this board was once used as a counting board when counting by heaps was still in vogue.

It is generally used with cowries shells showing its Oceanic provenance, but tamarind seeds and other bits, or *guti* as known in the Indic, can also be used. The Sungka Board is both binary and eight-based like the counting system of China.

Benedict[7] has shown that China owes many of its numerals over 100 to the Austro-Thai. It is difficult to say what relation exists between the counting systems of China and the Austrics. The Dravidians of India also appear to have had an eight-based counting system. Mark Collins has explained the Tamil, *om-pattu* "nine," as really being Tamil, *pattu* plus *una*, or 10 - 1 = 9. In like manner, the Telugu, *tommidi* is explained as "broken ten."[8] These indicate that at one time eight was the highest number in the Dravidian system. It may be that the Austronesian *siwa*, *savo*, etc. are a contraction of *sa* "one," and *walu* "eight," and thus 1 + 8 = 9, as suggested by Fornander. In the Tagalog language, the word *waluhan*, denoted counting by eights, or a capacity of eight. Mostly, though, the Philippine, Malay, and Oceanic systems are decimal with secondary eight-based, vigesimal (*dalawanpuan*, Tag.) and quinary.

The Indic numeral system shared with Austric the habit of placing the names of the numerals in descending order of value, that is, with place notation. For example, here are the numbers as spoken in Tagalog :

1	– *isa*
2	– *dalawa, dalwa*
3	– *tatlo*
4	– *apat*
5	– *lima*
6	– *anim*
7	– *pito*
8	– *walo*
9	– *siyam*
10	– *sampu*
11	– *labing-isa* (*labi* means "excess" over 10)
12	– *labing-dalawa*
20	– *dalawampu* (*dalawa-sampu*, two-tens)
21	– *dalawamput-isa*
22	– *dalawamput-dalawa*
70	– *pitumpu* (seven-tens)
72	– *pitumpu-dalawa* (seven-tens, two)
100	– *sandaan*
108	– *sandaa't-walu* (one-hundred, eight)
125	– *sandaa't-dakawanput-lima* (one-hundred, two-tens, five)
200	– *dalawandaan*
225	– *dalawandaan dalwampu't lima* (2 100's, 2 10's, 1 5)
1000	– *sanlibo*
10,000	– *laksa* (sanlaksa)
100,000	– *yuta* (sangyuta)
1,000,000	– *angaw* (sang angaw)
1,000,000,000	– *sanlibong angaw* (excess over million)
1,000,000,000,000	– *angaw-angaw* (million millions)

Another correlation between the Indic numeration and that of the Dravidians and Austrics is the use of words for objects that express certain numbers. For example, in Indonesia the word for "eyes," means "two," while that for "teeth," means "thirty-two," after the number of teeth in our mouth. Practically, every Austronesian language uses *lima*, *rima* "hand," for the number five, and the word for numeral is often *bilang* or related terms meaning "finger."

Sometimes, the words are more obscure such as the use of *umi* in Polynesia for "ten;" the word having the meaning of "whiskers, beard." This same thing occurs in the Indic system and it used to ease the requirements of memorization. For example, Vasu, a class of eight deities, stands for the number eight, and 'mountain' stands for number seven after the seven legendary mountain chains.[9]

The ordering of word numbers occurs not only in the case of ordinary numbers, but also in other measurement systems. For example, Conklin gives this example for the Ifugao mensuration system detailed above :

duwanupu ya tulundalan ta hiyam di'abto'na = two *upu* + three *dalan* + nine *boto* = 2(250) + 3(25) + 9(1) = 584 *boto.*[10]

In the alphabetic systems of the Greeks no place value appears to be used, and although the Sumerians used place value with their cuneiform symbols, they did not seem to extend past their successors in Mesopotamia. The Roman numerals, which dominated Europe until the introduction of numbers from India, were based on a system of addition and subtraction and not on place value:

IV	= 5 - 1	= 4
VI	= 5 + 1	= 6
XC	= 100 - 10	= 90

Computation with Abstract Quantities

The Ifugao system is a good one to show how these quantities can help reduce and facilitate calculations. In many ways they resemble techniques used with the decimal system, and as such, they augment the regular decimal-based counting. For example, if we wish to divide a quantity of *upu* or *bukul* by 25, we simply use the fact that 10 *dalan* equal 1 *upu*, and 100 *dalan* equals 1 *bukul* :

23,669,201 *upu*	= 236,692,010 *dalan*
5,889 *bukul*	= 588,900 *dalan*

Of course, one *dalan* equals 25 units, or boto. If we wish to divide 30,555,000, or 12,222 *bukul*, by 125, we can use the fact that 1 *bukul* = 100 *dalan*, and 5 *dalan* = 125 :

12,222 *bukul* = 1,222,200 *dalan*, or 30,555,000

5 *dalan* = 125

so, 30,555,000/125 = 1,222,220 *dalan*/5

This system also allows us to divide by multiplication :

We wish to divide 6,060,000, or 2424 *bukul*, by 20, or one *napulu*.

1 *bukul* = 125 *napulu*,

so 6,060,000/20 = 2424 × 125 = 303,000.

By extracting known quantities we can also facilitate operations :

We wish to divide 55,280 by 250,
first we take 50,000 and convert into 20 *bukul*
then we take 5,000 and convert into 2 *bukul*
we add one zero to 20 + 2 *bukul* = 220 *upu*
the remainder is 280 from which we draw one
one *upu* and 30 *boto*.
So the answer is 221 *upu* and 30 *boto*.

A difficult number like 24,384,982 can be reduced to 9,739 *bukul*, 5 *upu*, 1 *bongle*, 4 *dalan* and 7 *boto*, or more conveniently to 9,000 *bukul*, 7000 *upu*, 700 *bongle*, 400 *dalan*, 70 *napulu*, 82 boto. This can facilitate computations :

50 *upu*, 20 *dalan*, 10 *napulu*, 3 *boto*

× 30 *upu*, 10 *dalan*, 5 *napulu*, 2 *boto*

is the same as : 13,203

× 7,852

The reader will see that the first problem can be figured out totally in the head, and the quantities even temporarily memorized without much difficulty. The modern operation is difficult to do without mnemonic aids. The same can be said, to a lesser extent, for the operation of addition, as little carrying is needed with our quantities. Even the operation of division with fractions as remainders, or with decimal fractions of a few places, can be carried out in the head after a little practice. Here is another example :

40 b, 20 u, 30 bn, 40 d, 20 n, 8 bt

× ÷ + − 20 b, 40 u, 25 bn, 20 d, 10 n, 2 bt

the abbreviations are b = *bukul*, u = *upu*, bn = *bongle*, d = *dalan*, n = *napulu*, and bt = *boto*. In ordinary numbers :

110,158

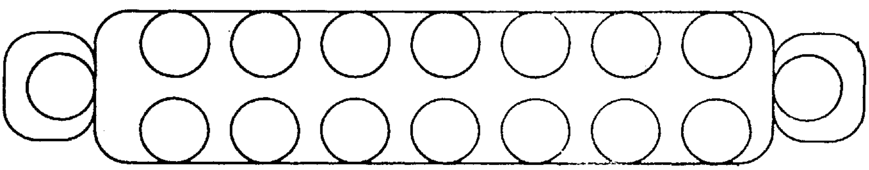
× - + ÷ 63,827

After one gets used to the quantities above, it will be found that the operations can be done all in the head using the first method, but that this becomes almost impossible using the modern method, without mnemonic aids like scratch paper, etc.

The Sungka Board

It may be that the place notation system of numerals was devised by persons who counted with the help of the Sungka Board, or its equivalents in India or Southeast Asia. Numbers are placed on the Sungka Board either from right to left or *vice-versa*. There are two rows of seven wells each, other than the two large wells on each end. Each well in a row can stand for a place value such as one's, 10's, 100's, etc. up to one million.

The wells can also stand for abstract values such as the one shown in the Infugao system. Thus, from left to right, the seven wells plus one larger well can represent the *bukul, upu, bongle, dalan, napulu, nad'op, hongol* and *boto,* respectively or they can represent any of these or other values in powers of tens, so when using the *dalan,* for instance, the far left well stands for a million *dalans,* the next to the right, hundred thousand *dalans,* and so on.



1,000,000	100,000	10,000	1,000	100	10	1	
bukul	*upu*	*bongle*	*dalan*	*napulu*	*nad'op*	*boto*	Fractions
bukul, etc.	*bukul*, etc.	*bukul*, etc.	⟶				
(1,000,000)	(100,000)	(10,000)	(1,000)	(100)	(10)	(1)	

Diagram I

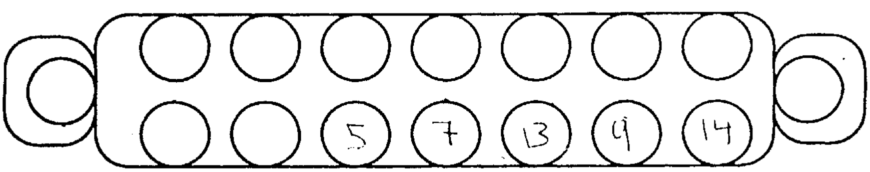


Diagram II

In the preceding diagram of the Sungka Board is shown a simple addition problem. These five numbers are being added: 233, 464, 1200, 1301 and 55,206. The place value will be arranged from left to right as in the modern Western system. At the extreme right, next to the large well is the place for the 1's with the other places ascending by 10's towards the left. Along the bottom row, the counter places the numbers of cowries, tamarind seeds, runo stalks or whatever device is used for each number given above in the proper place. Thus, for the number 233, three cowries are placed in the 1's well, three in the 10's well to its left, and two in the 100's well. This is done for all five numbers. The quantities shown in the bottom row are the sum of cowries in each place for all five numbers.

In this diagram, the next step is illustrated. The counter counts 10's from each

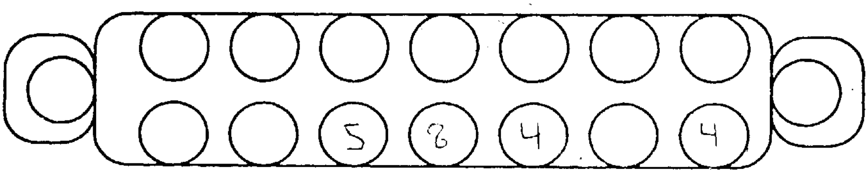


Diagram III

well and places one cowrie for each ten cowries removed from a well in well immediately to its left. In the first row of 1's, there are 14 cowries, so one cowrie is placed in the 10's place to its left. The remainder of four cowries is left in its original well, and the rest are placed in one of the large wells which both hold cowries for use in the calculations.

Then, the same is done for the 10's well using any additional cowries contributing from the 1's well, and so on for each well containing cowries. The final results are shown above and the number read from left to right is 58,404, which is correct.

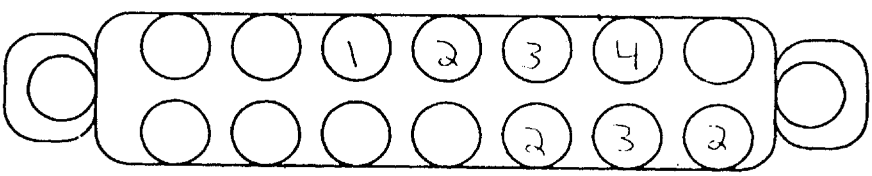


Diagram IV

In this diagram, simple subtraction is illustrated. The number to be subtracted from is placed in the upper row. The subtrahend is placed in the lower row. The following problem is 12,340 - 232. In the 1's column it is seen that there is nothing to subtract from, so one cowrie is taken from the 10's well and 10 are placed in the 1's well. Thus, any time there is an empty well in the upper column, one cowrie is removed from the well to the left, and ten are placed in the empty well. The quantity of the lower well is then subtracted from the upper well, and the remainder is left in the bottom well. If there is no remainder, the lower well remains empty. When there is no subtrahend, in our example, in the 1000's and 10,000's place, the cowries in the upper row are simply transferred to the lower row. The result after performing these calculations is 12,108. Only two numbers may be used at a time, so one should first add up all the subtrahends.

Multiply Left to Right →

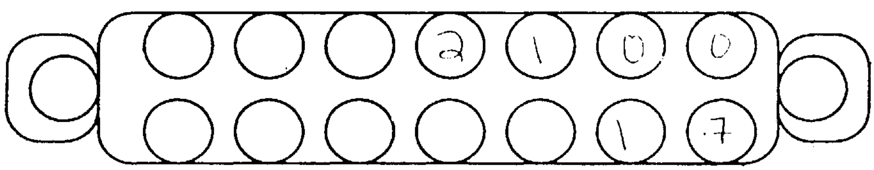
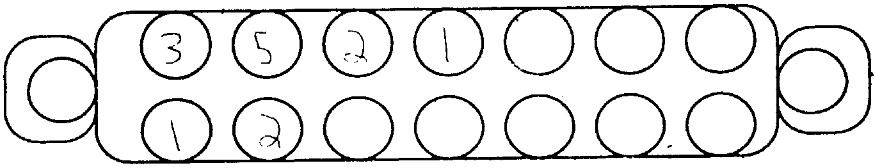


Diagram V

The next diagram shows a multiplication problem. First of all, simple multiplications can be solved and eventually memorized for use in larger problems. For example, 5 x 8; the quantity of five cowries is placed in eight wells and the sum of all the cowries is counted indicating 40.

Our problem above is 2,100 × 17.

The higher number is placed in the upper row, and the lower one at the bottom. The process is from left to right for multiplication. Therefore, we first multiply the two in the 1,000's row by the one in the 10's row of the lower row, 2 × 10 = 20. Any quantity of ten adds one cowrie to the well to the left of the row in question, so we place two cowries in the 10,000's row. Now, we multiply the seven in the 1's row with the two in the 1,000's row, 2 x 7 = 14. From this product we expunge 10 and place one cowrie in the 10,000's row and leave the remainder of four cowries in the 1,000's row. If the result is under 10 we leave the whole amount in the place being multiplied. After completing these calculations for each well we read the result shown on the top row.



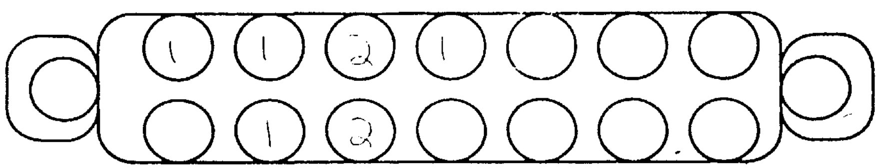
→ move divisor to right

Diagram VI

Simple division can be learned by taking the number of cowries as the number to be divided and then alloting to a well the amount of the divisor until all the cowries are used. So, for 24/4, one takes 24 cowries and places four cowries in each well until all 24 are used up. Then the total wells are counted giving the quotient. For a problem like 24/5, you will have four full wells, but one well with only four cowries rather than five. Thus, you will have a fraction of four/fifths, which is known as "bahagi".

The problem given above is 3,521/12. In division, the numbers are placed at the extreme left of the Sungka Board. Again, the problem is worked out starting at the left. Twelve is first divided from the 35 of the first two wells, 2 × 12 = 24 – 35 = 11. Thus, we place the quotient of two cowries on the ground in line with the lower well from which we divided, i.e. the 100's place.

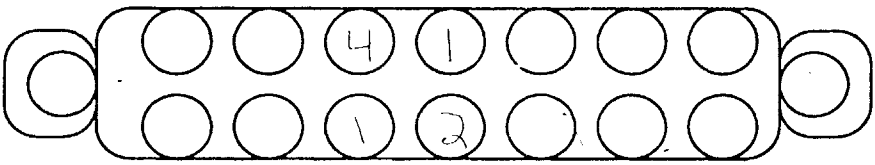
The remainder of eleven is placed in the first two wells as shown in the next diagram :



2 (quotient)

Diagram VII

We then divide the number all the way to the next well, i.e., the first three wells, which equates to: 112/12. Our nearest quotient is 9 × 12 = 108 – 112 = 4. Thus, we add 9 to the 10's spot of the quotient, and place the remainder, 4, in the 10's well.



2 9 (quotient)

Diagram VIII

Then we divide the remaining number, 41, by 12 and get a quotient of 3, with a remainder of 5. Thus, our final answer is 293 with a *bahagi*, or fraction of 5/12. If we wish a decimal fraction, or *bahagdan*, we simply move the divisor (in two wells) over one well to the right, and then begin dividing the remainder until there is no remainder left, or we are satisfied with accuracy of the decimal fraction.

PERMUTATIONS AND COMBINATIONS

Let us a assume a progression by two's so that at each step, the product increases by two:

$1 = 1 \times 2 = 2$

$2 = 1 \times 2 + 2 \times 2 = 4$

$3 = 1 \times 2 + 2 \times 2 + 3 \times 2 = 12$

$4 = 1 \times 2 + 2 + 2 + 3 \times 2 = 16$

On the Sungka Board, if we place two cowries in each well for each progression, we will find that up to the 4th step, all the wells will have two cowries each. Thus, up to three steps, the equation for this type of combination is :

$n^2 + n$

where n = the number of the step. Thus, for the third step :

$3^2 = 9$

$9 + 3 = 12$

for the fourth step :

$4^2 = 16$

Thus, for the fourth step we do not add n. However, after the fourth step, the formula again takes validity :

$8^2 = 64$

$64 + 8$	=	72
8×2	=	16
7×2	=	14
6×2	=	12
5×2	=	10
4×2	=	8
3×2	=	6
2×2	=	4
1×2	=	+2
	=	72

Thus, our formula may be adjusted to:

$$n^2 + \frac{(n \times 4 - n)}{4 - n}$$

Notice how if n = 4, the quantity to be added becomes 0. This formula takes on practical importance when we realize that this type of progression pertains to squares :

Number	Square	Difference
1	1	
		3
2	4	
		5
3	9	
		7
4	16	
		9
5	25	

It will be noticed that the differences between the squares of each succeeding whole number increases by two. Because of this progression we find that factors of

2^2, or 4, tend to double :

Number		**Square Root**
1	$\times 4 = 4$	2
4	$\times 4 = 16$	4
16	$\times 4 = 64$	8
64	$\times 4 = 256$	16
256	$\times 4 = 1024$	32
1024	$\times 4 = 4096$	64

A similar type of progression can be made concerning cube roots. First, we will study the progression of combinations of three's :

Steps 3 :

$$\begin{aligned} 3 \times 3 &= 9 \\ 3 \times 2 &= 6 \\ 3 \times 1 &= 3 \\ \hline &\ 18 \end{aligned}$$

so: $n^2 + n \times 3$, or $3^2 + 3 \times 3 = 18$

This only holds for the third step, as for higher steps one must factor in halves for each whole number :

Step 4

$$\begin{aligned} 4 \times 3 &= 12 \\ 3 \times 3 &= 9 \\ 2 \times 3 &= 6 \\ 1 \times 3 &= +3 \\ \hline &\ 30 \end{aligned}$$

and, $4^2 + 4 \times 3.5 = 30$.

Step 5

$5 \times 3 = 15 + 30$ (Step 4) $= 45$

and, $5^2 + 5 \times 4 = 45$

Thus, our formula for numbers higher than three looks like this :

$n^2 + n \times [.5(n - 3) + 3]$

This will hold true for numbers also, as (n − 3) will give a negative number :

Step 2

$$\begin{array}{lcr} 2 \times 3 & = & 6 \\ 1 \times 3 & = & +3 \\ \hline & & 9 \end{array}$$

$$2^2 + n \times .5(n - 3) + 3 = 4 + 2 \times .5(2 - 3) + 3 = 4 + (2 \times (-.5 + 3) = 9$$

Cube roots double according to factors multiplied by eight :

Number		**Cube Root**
1	× 8 = 8	2
8	× 8 = 64	4
64	× 8 = 512	8
512	× 8 = 4096	16
4096	× 8 = 32,768	32

The permutations for the Sungka Board as an instrument of divination, and as a game of chance or otherwise, are hard to calculate because of the variant number of cowries that may be used. Generally, its binary permutations are 72^2, or 5,184. The trinary permutations are 96^2, or 9,216.

The two large wells at both ends represent a positive or negative answer in divination, the wells of opposing players, and symbolically, the Sun and Moon, hot and cold, and other forms of polarity. Each of these wells has its corresponding row of seven wells, and symbolically the whole board can represent the cycle of the lunar fortnight. The well of the Sun represents the Full Moon, and the corresponding row, the waning Moon as it approaches the Sun.[11] The well of the Moon, the New Moon and the waning Moon as it departs from the Sun. Thus, as an instrument of divination, similar to the I Ching oracle, which follows the 12 seasons of the year. But the Sungka, as seen, is luni-solar in orientation.[12]

Notes and References

1. Prof. Das Gupta, in his article, 'A Few types of Indian Sedentary Games', *Journal of the Asiatic Society of Bengal* XXII (1926), pp. 142-148 and 211-213, comments on various games which end in the word, *guti*, which the Professor gives the meaning "pieces". For example, *do-guti, tre-guti, nao-guti, bara-guti* The word may be the same as the Santali, *guti*, as noted by P.C Bagchi, and is related to the *ganda guti* of the counting system.
2. There is some good material on the subject of the pre-Hispanic mensuration system of the Tagalogs, and to a lesser extent, of some of the other people of the Philippines in the chapter, 'Native Peoples and Customs.' See Blair and Robertson. *The Philippine Islands*, vol. 40.
3. A good picture of the runo stalk counters in use can be found in Harold Conklin and Pugguwon

Lupaih, *Ethnographic Atlas of Ifugao: a Study of Environment, Culture, and Society in Northern Luzon*. Yale University Press : 1980, p. 11.

4. Bagchi, P.C. *Pre-Aryan and Pre-Dravidian in India*. Calcutta University : 1929; pp. xv-xvi.
5. Conklin, p. 11.
6. Bagchi, p. xvi.
7. Benedict, Paul K., *Austro-Thai Language and Culture: with a Glossary of Roots*. HRAF Press : 1975. pp. 81-85 and pp. 214-218.
8. Chatterji, S.K. 'Race Movements and Prehistoric Culture'. *The Vedic Age*. Bharatiya Vidya Bhavan, Bombay : 1951, p. 104.
9. See Burgess (ed. and tr.). *The Sūrya Siddhānta*. Motilal Banarsidass, Delhi : 1989; p. 28.
10. Conklin, p. 11.
11. The practice of counting fortnights is found over wide areas of the Austric domain from Madagascar to outer Polynesia. The words for "new" and "full moon" in Polynesian, in fact, even have correspondence in similar Vedic words for those days. I have discussed the matter of Austric connections between India and the extra-Indian Austro-Asiatic and Austronesian regions in my book, *The Naga Race*, (Firma KLM Pvt. Ltd, 1994) and in my upcoming book, *The Origin of the Brahmana and Rishi Traditions* by the same publisher.

In the matter of Austronesian time-reckoning, James Frazer, in vol. VII of *The Golden Bough* discusses the practices of various Malayo-Polynesian tribes in reckoning the year. Among the methods for reckoning the tropical year, he cites: (1) The use of gnomons known as *togallan* (measurers) to measure the Sun's shadow, or for direct observation of declination. (2) The use of native "observatories" consisting of small huts with levelled roofs into which a hole is punched. (3) The space between the hole and the spot on the levelled floor caused by the Sun's rays are measured to determine declination. (4) The point at which the Sun casts no shadows on upright objects. (5) The use of markers like stones to gauge the declination of the rising Sun. The Igorot stone agricultural calenders are also a type of astrolabe by which the tropical year can be measured.

The sidereal year was most often reckoned by the rising of certain stars like the Pleiades and Orion. Sometimes these constellations had to reach angles like 25°, 45° or 90° degrees, and the gnomon hand measure and other aids were often used in aiding observations. According to the journals of Captain Cook's companion, James Banks, the Polynesians were able to reckon the rising of the fixed stars to a degree of accuracy that European astronomers would find hard to believe. Other Western commentators stated that the Oceanic people could distinguish between planets by their times of rising, both diurnal and helical.

In the book, *An Ocean in Mind*, by Will Kyselka, (University of Hawaii Press, 1987) a famed Micronesian celestial navigator of modern times, when questioned about a conjunction involving Jupiter, is said to have counted for a while with his hands, and then confirmed the correct time. There are also accounts of Fijian navigators who kept track of the helical risings of Venus, as it was that star by which they made their regular navigations.

In some cases, intercalation of the lunar and solar year was done primarily mathematically as among the Igorots, whose intercalation generally does not involve observation. Among many of the tribes of the southern Philippines, on the other hand, the direct observation of stars rising from their conjunction with the Sun, or taking certain angles in the sky before sunrise, or after sunset, is required.

In South-East Asia, the ancient Indian system of time reckoning has a very old history. Records in Cambodia, near the time of the astronomer, Varāhamihira, gives dates in terms of Indian *nakshatras*, *tithis*, *yogas*, etc. and the time in terms of the rising ascendant. The knowledge of the daily *yoga* and the ascendant suggest that a fair amount of Indian astronomical knowledge had passed into this region.

In the Laguna Copper-Plate Inscription found in the Philippines, we find the dating "in the Saka-year 822: the month of March-April; according to the *jyotiṣa;* the fourth day of the dark half of the moon on Monday": Antoon Postma. 'The Laguna Copper-Plate Inscription'. *Philippine Studies*, vol. 40, 1992, p. 187. This type of dating is widespread in the Malay Archipelago and South-East Asia.

The Chinese luni-solar calender also enters into South-East Asia at a very early date, although it seems to have taken root principally on the mainland.

In addition to the regular lunar month, the sidereal revolution of the Moon was also noted, with the tail of the constellation Scorpio most often used as the point of conjunction. Time was kept by means of the Sun in the day, and by the stars at night. In the Philippines, the *pawit* star was the one which was used to keep the Sun's place at night.

12. A type of divination system is known among the Malagasy people of Madagascar as *Sikidy*. Western scholars have tried to find an Arabic origin for this system, but this does not agree with the native tradition, which claims Sikidy as a system of their ancestors that was used secretly until it was decided by consensus to reveal it for public use. It may be that the early Arab sea-faring merchants picked up this system from the Malagasy people, and from them it entered into Europe where it became the principle form of geomancy.

The Arabic etymologies given for some of the terms in Sikidy are extremely problematic at best, and the majority of the related-words are of undoubted Malagasy origin. It seems that in the crediting of divination systems in Madagascar and Africa to Arabs, we only have another example of the "Aryan myth" extended to the "Europoid" elements among the Arabs. See Lars Dahle, 'Sikidy and Vintana'. *The Antananarivo Annual and Madagascar Magazine*. Antananarivo : 1886-88.