

Supplement

Gaṇitapañcavimśī

Introduction, English Translation with Edited Sanskrit Text

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*Ganitapañcavimśī** English Translation with Introduction

INTRODUCTION

The Sanskrit text of the *Ganitapañcavimśī* was first edited by Professor David Pingree and published in 1979 in Ludwich Sternbach Felicitation Volume of the Journal *Rtam* of the Akhila Bharatiya Sanskrit Parishad, Lucknow. The single manuscript used for this edition was discovered in London. It was incomplete as a number of verses about the middle of it which dealt with inverse proportion, barter of commodities, separation of mixtures, simple interest, partnership, alligation and mensuration of triangle and quadrilateral were missing from it. Instead there were some interpolatory verses, of which

$\frac{8}{2}$ belonged to the *Lilāvatī* of Bhāskara II (1150 CE) and $\frac{1}{2}$ to the *Ganitatilaka* of Śrīpati (1039 CE). There was also a rule ascribed to Nārmada (ca. 1375 CE) and an example in illustration of it.

The present edition of the *Pañcavimśatikā* was prepared at the request of late Shri G C Sinha, Secretary, Akhila Bharatiya Sanskrit Parishad, Lucknow, who wanted revision of Professor Pingree's edition with the addition of notes and comments where necessary or an altogether a new edition of it on the basis of complete manuscripts if possible. Fortunately a complete manuscript of the *Pañcavimśatikā* was discovered in the library of Mithila Sanskrit Research Institute, Darbhanga, Bihar. A zerox of this manuscript was acquired and was used for the present edition, besides of Professor Pingree's edited text (which has been referred in the Sans. text).

The manuscript acquired from the Mithila Research Institute Accession No. 3444 may be

described as follows:

Extent 6 folios, 9 lines to a page and 40 letters to – a line, approximately 97 lines or 121 *granthas* in all; character—modern devanāgarī; script—good, pagination on both margins, on one side of each folio as usual; the beginning and end as follows:

Beginning: ॥ श्रीगणेशाय नमः ॥ ॥ हरि ऊँ३८ ॥ शिवप्रणम्य etc.

End: वेदांगोदधिम् १४६४ तूपे शुभकृन्नाप्रिसंस्थि ल ॥ आयंनचोत्तरे जात चैतेपक्षे च बाहुले ॥१॥ ॥४॥ ॥५॥ श्रीः ॥ इति श्रीपंचविंशतिका श्रीधराचार्य विरचिता समाप्ता ॥ ॥ ग्रंथसंख्या १२१ ॥

The text exhibited by the manuscript

contains $53\frac{1}{2}$ verses, excluding three verses at the end, of which two are in appreciation of the work and praise of its author and the third, the last one, which is due to the scribe, mentions the time of writing the manuscript. Of these $53\frac{1}{2}$ verses, $45\frac{1}{2}$ are in *anuṣṭubh* metre, 2 in *āryā*, $\frac{1}{2}$ in *indravajrā*, 2 in *upajāti* (*indravajrā* plus *upendravajrā*), $1\frac{1}{2}$ in *upendravajrā*, 1 in *dodhaka*, and 1 in *bhujangaprayāta*. These verses are distributed as follows:

Introduction and rules: 25 verses

Definitions and examples: $28\frac{1}{2}$ verses

* Manuscript is edited, translated with introduction by Late Professor K S Shukla of Lucknow University. The manuscript was received in 2016 from his son Ratan Shankar Shukla (48-2 Argara, Hussainiganj behind Bata Co., Lucknow-226001) after the expiry of Professor Shukla on 22 August 2007 for publication.

The name *Pañcavimśatikā* or *Pañcavimśi* was given to the work evidently on the basis of the 25 verses which constitute the introductory verse and the verses embodying the rules. These indeed form the kernel or nucleus of the work.

The subject matter of the work is divided as usual into two major sections, one containing the arithmetical operations (*parikarma*) and the other the determinations (*vyavahāra*), although such division is not actually made and is only implied. The operations dealt with are addition, subtraction, multiplication, division, squaring, cubing, square-root, and cube-root, both for whole numbers and fractions. Four classes of fractions viz. $a/b \pm c/d$, a/b of c/d , $a \pm b/c$ and $a/b \pm c/d$ of a/b as also operations with zero are also dealt with. Besides this, rules for certain specific problems involving arithmetical operation resulting in a number called the "visible" (*dr̥ṣya*), and those for direct and inverse proportion and barter of commodities are also given. The determination dealt with are those pertaining to mixtures (*miśraka*), arithmetic series (*średhī*) plane figures (*kṣetra*), excavations (*khāta*), piles of bricks (*citi*), sawing of wood (*krakaca*), heaps of grain (*rāśi*), and brief, concise & quite suitable for the beginners for whom the book was written.

In the opening verse and the colophon at the end we are told that this work is the composition of the well-known Indian mathematician Śridharācārya and that it constitutes the essence of his *Pāṭīganita*. This, however, is not substantiated by the contents of the work. To us it seems that this work is based on the *Līlāvatī* of Bhāskara II rather than on the *Pāṭīganita* of Śridharācārya. The unit of gold, grain, money and land measures defined in the beginning are exactly the same as given in the *Līlāvatī*. Of these measures, some are either different from those defined and used in the *Pāṭīganita* or quite new. The rules too are in most cases based on those given in *Līlāvatī* rather than those given in the *Pāṭīganita*. It is noteworthy that whereas the *Pāṭīganita* and the *Pāṭīganita-sāra* (or *Triśatikā*

of Śridharācārya both make use of $\pi = \sqrt{10}$, or $\pi = 3.16$, the present work following the *Līlāvatī* uses $\pi = 22/7$. Another noteworthy point is that whereas Śridharācārya in his *Pāṭīganita* finds fault with, and in his *Triśatikā* ignores, the rule area of triangle or quadrilateral = $\frac{1}{2}(a+c) \times \frac{1}{2}(b+d)$, the author of the *Pañcavimśatikā* prescribes it and sets an example on it.

Exploitation of the name of Śridharācārya is evidently made to gain popularity for the work, for Śridharācārya and his writings were held in the highest esteem throughout the length and breadth of India. Survival of manuscripts of the *Pañcavimśatikā* or *Pañcavimśi* clearly shows that this work was indeed popular. But we do not hear of this work before the fourteenth century CE. The earliest quotations from this work have been discovered so far in the works of Padmanābha (ca. 1400 CE), son of Nārmada (ca. 1375 CE), and Gaṇeśa (1520 CE), the commentaries of the *Līlāvatī* and his father Keśava.

We are therefore inclined to believe that the author of the *Pañcavimśatikā* lived posterior to Bhāskara II (1150 CE) and composed this work on the basis of the *Līlāvatī* which was then in more popular use. Mention of the name of Nārmada in one of the rules in Pingree's edition seems to suggest some relationship of that writer with this work.

A commentary *Pañcavimśatikā*, entitled *Bālabodha*, written by Sambhūnātha is known to exist in the Central Library of the Oriental Institute, Baroda. We wished to consult this manuscript and the present secretary of the Akhila Bharatiya Sanskrit Parishad, Dr J P Sinha, requested the authorities of that library to supply us a zerox of that manuscript but no reply was received. A reminder was then sent but it also fell on deaf ears.

I am grateful to Dr J P Sinha, Secretary, Akhila Bharatiya Sanskrit Parishad, Lucknow for his keen interest in the publication of the present work.

HOMAGE AND INTRODUCTION

- Having paid obeisance to God Śiva, Śridhara gives the essence of the *Pāṭī (ganita)*¹ composed by himself, in twenty-five verses with clear meaning.

DEFINITIONS

2-3 (a-b) [Gold -measures]:

(i)²

5 <i>guñjā</i>	= 1 <i>māṣa</i>
16 <i>māṣa</i>	= 1 <i>karṣa</i>
1 <i>karṣa</i> of gold	= 1 <i>suvarṇa</i>
4 <i>suvarṇa</i>	= 1 <i>pala</i>
	(ii) ³
3 <i>guñja</i>	= 1 <i>valla</i>
16 <i>valla</i>	= 1 <i>gadyāṇaka</i>

3(c-d)-4: [Grain-measures (*Dhānya-māna*)⁴]:

1 *kudapa* (or *kudava*) = $3 \times 3 \times 1\frac{1}{2}$ cu. *aṅgulas*

$$= \left(\frac{1}{4}\right)^5 \text{ cu. cubits}$$

4 <i>kuḍupa</i>	= 1 <i>prastha</i>
4 <i>prastha</i>	= 1 <i>ādhaka</i>
4 <i>ādhaka</i>	= 1 <i>drona</i>
16 <i>drona</i>	= 1 <i>khārī</i> (of Magadha)
	= 1 cu. cubit.

5. [Money-measures]⁵:

20 *varāṭaka* (cowries) = 1 *kākiṇī*

4 *kākiṇī* = 1 *pana*

16 *pana* = 1 *dramma*

16 *dramma* = 1 *niṣka*

6-7 [Land-measures]⁶:

3 vertical *yava*⁷ = 1 *aṅgula* (digit)

24 *aṅgula* = 1 *kara* (cubit)

4 *kara* = 1 *danda*

2000 *kara* = 2 *krośa*

4 *krośa* = 1 *yojana*

10 or 8 *kara* = 1 *vamśa* (bamboo)

Area of a square field on the side of 20 *vamśa*

(200 or 160 cubits)⁸ = 1 *nivartana*.

The above definitions agree with those given in the *Lilāvatī* of Bhāskara II. They agree only partially with those given in the *Pāṭīganita* of Śridharācārya. Śridharācārya mentions *purāṇa* in place of *dramma*, but does not mention *valla*, *gadyāṇaka*, *niṣka*, *vamśa* and *nivartana*. So the author's assertion in the opening stanza that he is setting out in the present work the essence of Śridharācārya's *Pāṭīganita* is not true. This also throws doubt as to its author being Śridharācārya. The rules that follow are also mostly based on the *Lilāvatī* of Bhāskara II, sometimes even the words used are the same. They are certainly not based on the *Pāṭīganita* of Śridharācārya.

NAME OF PLACES

8-9. *Eka*, *daśa*, *śata*, *sahasra*, *ayuta*, *lakṣa*, *prayuta*, *koṭi*, *arbuda*, *padma*, *kharva*, *nikharva*, *mahapadma*, *śanku*, *jaladhi*, *antya*, *madhya* and *parārdha* - these are the denominations of places whose values increase in the ratio⁹ of 10.

¹ Work on *Pāṭīganita* deals with arithmetic and mensuration.

² Cf. L (= *Lilāvatī*), Ānandāśarma Sanskrit Series edition, vs. 4; PG (*Pāṭīganita* of Śridharācārya)

³ Cf.L, vs. 3. This table does not occur in PG.

⁴ Cf. L vss. 7-8; PG, 11

⁵ Cf. L, vs. 2; GT(= *Ganitatilaka* of Śrīpati , H R Kapadia's edition, p.2 vs.4 PG has *purāṇa* in place of *dramma* but *nicka* is not there.

⁶ Cf. L, vss. 5-6; PG, 12 does not mention *vaAṣa* and *nivartana*.

⁷ frFkZX;oksnjk.;'Vk v(okZ ok czhg;L=%A %Le'fr%/%

⁸ 200 cubits according to *Lilāvatī* and 160 cubits according to *Ganitatilaka*.

⁹ Cf. L, vss. 10-11; PG, 7-8

This list of names of places is the same as given in the *Lilāvatī* with *abja* in place of *padma*. The *Pāṭīganīta* has *abja* in place of *padma*, *mahāsaroja* in place of *mahāpadma*, and *saritpati* in place of *jaladhi*.

Section One: Operations (*Pakikarma*)

Addition and Subtraction

10 (a, b). Addition and subtraction are performed (starting from the unit's place on the right towards the left; or from the last place on the left, towards the right).¹⁰ When zero is added to or subtracted from a number, the number remains unchanged.¹¹

Example. What is obtained when 60, 9 and 12 are added together, and what results when the sum obtained is subtracted from 100? (Answer: sum 81; remainder 19).

Multiplication

10 (c, d). Multiply the digit of the multiplicand standing in the last and other places by the multiplier.¹²

Example. What is obtained when 127 is multiplied by 24, and what when 16132 is multiplied by 123? (Answer: 3048 and 1984236.)

Division

11(a, b). In the case of division, the quotient is the (greatest possible) number by which the divisor being multiplied the resulting product is subtractable from the dividend.¹³

Example. What will be the result when the dividend is 3048 and divisor 24; and when dividend

1984236 and divisor 123? Results are 127 and 16132.

Square and Cube

11 (c, d). The product of two equal numbers is the square¹⁴, and the (continued) product of three equal numbers is the cube.¹⁵

Example. Friend, What are the squares and cubes of 9 and 123. (Answer: squares 81 and 15129; cubes 729 and 1860867)

Square-root

12-13 (a-b). Having subtracted from the last odd place (the greatest possible) square number (and then having set down twice its square-root in a line), divide the next even place by twice the square-root (which has been set down in a line); then subtract the square of the resulting quotient from the next odd place and set down twice that quotient in the line. Now starting with "divide the next even place" repeat the process (until all the digits of the given number are exhausted). Half of the number (standing in the line) is the (required) square-root.¹⁶

Example. What is the square root of 81 and 15129?; The square root is 9 and 123.

Cube-root

13 (c-d)-15 (a-b). To begin with, divide the digits starting from the unit's place into periods of one cube (*ghana*) and two non-cube (*aghana*) places. Then from the last cube place subtract (the greatest possible) cube and set down the cube-root of that separately (in line). Then by thrice the square of that divide the next (non-cube) place; and put down the quotient in the line (of the cube-root).

¹⁰ Cf. L.vs. 12. There is no such rule in PG.

¹¹ Cf. L.vs. 45 (a,b); PG vs. 21 (a,b).

¹² Cf. L.vs. 14 (a,b). There is no such rule in PG.

¹³ Cf. L. vs. 18 (a,b). There is no such rule in PG.

¹⁴ Cf. L.vs. 19 (a).

¹⁵ Cf. L.vs. 24 (a).

¹⁶ 1. Cf. L. vs. 22. for details see PG, English translation, p.10.

Then subtract the square of that quotient, multiplied by thrice the last (i.e. the cube-root), from the next (non-cube) place. Then subtract the cube of that quotient from the next (cube) place. (The number in the line of the cube-root gives the required cube-root.) (If there are more places), repeat this process (until all the places are exhausted) to get the cube-root of the given number.¹⁷

Example. What is the cube root of 729 and 1860867?; the result is 9 and 123.

Fractions

Addition and subtraction of simple fractions

15 (c-d)-16 (a-b). To reduce the (two) given fractions to a common denominator, multiply the numerator and denominator of each fraction by the denominator of the other. Then add or subtract (as the case may be) the numerators of the fractions with equal denominators. It shall be noted that the denominator of a whole number is 1.¹⁸

Example. What is obtained when the unit fractions $1/2, 1/3, 1/4$ are added together and what they are subtracted from 3? [Answer: sum is $13/12$ (or $1\frac{1}{12}$) and difference is $23/12$ (or $1\frac{11}{12}$)].

Reduction of “Fraction of a Fraction” and Multiplication of Two Fractions

16 (c-d). In the case of simplification of a fraction of a fraction or multiplication (of two fractions), divide the product of the numerators (of the fractions) by the product of the denominators (of the fractions).¹⁹

That is, a/b of $c/d = a/b \times c/d = ac/bd$.

Example. What is $1/3$ of $1/2$ of $1/4$ and what $1/2$ multiplied by $1/3$? (Answer: $1/24$ and $1/6$).

Division of one fraction by another

17 (a-b) Invert the numerator and denominator of the divisor and then multiply (the two fractions).²⁰

Example. What is obtained by dividing than previous result ($1/6$) by $1/3$?; dividend $1/6$ divisor $1/3$, result $1/2$.

Square and square-root of a fraction

17 (c-d) To find the square (of a fraction), square the numerator and the denominator; to find the cube, cube the numerator and the denominator; to find the (square or cube) root, extract the (square or cube) root of the numerator and the denominator.²¹

Example. What are the square and cube of $3\frac{1}{2}$ and what are the square - root and cube-root of those (square and cube)?²²

(Answer: square $49/4$ and cube $343/9$; square-root $7/2$ and cube-root $7/2$.)

Simplification of $\left(a + \frac{b}{c}\right)$ (*rūpabhāgānubandha*) or
 $\left(a - \frac{b}{c}\right)$ (*rūpabhāgāpavaha*)

18 (a-b) The numerator of the (given) fraction should be added to or subtracted from (as the case may be) the (given) whole number multiplied by the denominator of the (given) fraction. This is the case when one fraction is a whole number.

¹⁷ Cf. L, vss. 28-29, for details see PG, English Translation, pp. 13-14

¹⁸ Cf. L. Vss. 30 and 37. Also see PG. rule 32.

¹⁹ 2. Cf. PG. rule 33a.

²⁰ Cf. L. vs. 41.

²¹ Cf. L. vs. 43

²² Same example occurs in L, vs. 41.

a
b
c
d

Simplification of $a/b + c/d$ of a/b written as

(*bhāgabhaṅgānubandha*) or $a/b - c/d$ of a/b written

as

a
b
c
d

 (*bhāgabhaṅgā, unāha*)

Example. What is 3 plus $1/3$ and 3 minus $1/3$?; result is $10/3$ and $8/3$. What is $3/1+1/3$ of $3/1$ and what is $3/1-1/3$ of $3/1$?; result is 4 and 2.

18 (c-d) Multiply the denominator (of the upper fraction) by the denominator of the lower fraction, and the numerator (of the upper fraction) by the same denominator (of the lower fraction) increased for decreased (as the case may be) by its own numerator; (and then rule out the lower fraction).²³

That is, $a/b + c/d$ of $a/b = a(d+c)/bd$
and $a/b - c/d$ of $a/b = a(d-c)/bd$.

Example. What is the value of $3\pm1/3$ and of $3\pm1/3$ of 3? (Answer: $10/3$ and $8/3$; 4 and 2).

Operations with Zero

19 (a-b). Multiplication by zero yields zero; the square and cube etc. of zero are also zero.

Rule of Inversion

19 (c-d)-20(a-b). Starting from the visible quantity (backward), reverse the operation of addition and

subtraction, multiplication and division, square and square-root, cube and cube-root, and if there is increase or decrease by a fraction of itself, divide by one plus minus the fraction.²⁴

Example. What is that number which being diminished by 2, then multiplied by 3, then squared, then increased by $1/3$ of itself, and then divided by 3 yields 16? (Answer: 4.)

Miscellaneous Types of Problems

(1) The visible type (*drśyajāti*)

20 (c-d). The visible quantity divided by 1 multiplied, divided, or increased or decreased by the fraction, in the manner stated in the (given) problem, (yields the desired result).²⁵

Example. What is that number which multiplied by 3, then divided by 5, then increased by one-fifth of the same number, and then divided by 4, yields 2?²⁶ (Answer 10)

$$\text{The required number} = \frac{2}{\frac{3}{5} + \frac{1}{5}} = 10$$

(2) The remainder type (*śesajāti*)

For rule vide Sripati's *Ganitalilaka* ed. M.R. Kapadu, p 44.

Example. One-sixth (of the parrots), one half of the remainder, and one-third of those left thereafter having gone away, there remain 10 parrots. (Find the number of the parrots.) (Answer: 36 parrots.)

²³ Cf. this rule and the previous one with *L*, vs. 31 and *PG*, rules 39, 40

²⁴ Cf. *L*, vs. 48.

²⁵ Cf. *GK* (=*Ganita-Kaumudi*) Part I, p. 17, rule 37 (c-d)-38. *L*, vs. 51 gives a more general rule. But *PG* does not contain this rule.

²⁶ After this example P (*Pāṭīganita*) adds:

Example on the “visible” type. One-sixth of a number of parrots went to the sky, one-third to the water, and the remaining 6 are visible. What was the number of those parrots?

Rule for the “remainder” type. Divide the “visible” number by the product of the denominators, each diminished by the corresponding numerator, as divided by the product of the denominators.

[Applying this rule to the problem given above under the remainder type, we get $\frac{10}{\frac{(6-1)(2-1)(3-1)}{6 \times 2 \times 3}} = 36$.]

In view of 20 b above, this rule is irrelevant:

(3) The difference type (*viślesajāti*)

Example. What is the strength of a herd of cow, if the difference of and there of having been lost 6 cows are to be seen? (Answer: 9 cows.)

(4) The visible, square-root and fraction type (*drśyamūlāṁsa-jāti*)²⁷

21. Rule: Multiply the result obtained by adding or subtracting (the multiple of) the square-root by 4, to that add the square of (the multiple of) the square-root, then extract the square-root of that, then diminish or increase that by (the multiple of) the square-root, then reduce that to half, and then square it: what is thus obtained is the (required) result.²⁸

This rule gives the solution of the quadratic equation

$$x \pm m\sqrt{x} = n,$$

where m is the multiple of the square-root. The solution is correctly stated as

$$x = \left[\frac{\sqrt{m^2 \mp 4n \mp m}}{2} \right]^2$$

Example. What is the number which diminished by its square-root, then diminished by one-sixth of the remainder, and then added to the square-root of the remainder, yeilds 30?²⁹ (Answer: 36).

²⁷ P calls this type *mulajāti* instead of *drśyamūlāṁsa-jāti*.

²⁸ Cf. L, vs. 65. Also see PG, rule 75.

²⁹ After this P adds the following:

Rule for *drśyamūlāṁsa-jāti*:

When some quantity is stated to be increased or decreased by a fraction, then it should be obtained by dividing the “visible” number by 1 increased or decreased by that fraction. If that is increased or decreased by its square-root also, one should proceed as stated before.

Example. O proficient mathematician, quickly say the number which when increased by $1/27$, $1/3$ and $1/9$ of itself and also by its square-root, becomes 129.

[Let the number be x . Then

$$x(1+1/27+1/3+1/9) + \sqrt{x} = 129$$

$$\text{or } x + \frac{\sqrt{x}}{1+1/27+1/3+1/9} = \frac{129}{1+1/27+1/3+1/9}$$

$$\text{or } x + \frac{27}{40}\sqrt{x} = \frac{27 \times 129}{40} \quad [\text{vide rule of vs. 13}]$$

Rule for *māḍajāti*:

On the floors of the multiple-storeyed structure write down a series of equal numbers (one above the other). (Starting from the lowest number) divide by the *iṣṭa* plus 1, successively (increasing in the ratio of itself). (The equal numbers are to be chosen in such a way that after this division there is 1 in the last but one storey.) Then the lowest number gives the number of people in the lowest storey; this number multiplied by *iṣṭa* and added to the number above it gives the number of people in the second storey; and so on. Listen to this unique rule propounded by Narmada. Example. O pupil, listen. On every floor of the king’s seven-storeyed beautiful gate-pyramid there were people.

For fear of collapse of the building, people in each lower storey cried aloud and said to those in the next upper storey said: “Come as many people as we are here to this storey.” The number of people in each storey then became equal. Tell me. O friend, the equal number of the people (and also the number of people who were in the seven storeys in the beginning).

The equal number of people = $2^{7-1} = 64$. The number of people in the seven storeys in obtained as follow

	Series of equal number	After successive division	People in the seven storeys
Seventh Storey	64	64	127
Sixth Storey	64	1	63
Fifth Storey	64	2	62
Fourth Storey	64	4	60
Third Storey	64	8	56
Second Storey	64	16	48
First Storey	64	32	32

Let x be the required number. Then

$$x - \sqrt{x} - \frac{1}{6}(x - \sqrt{x}) + \sqrt{x - \sqrt{x}} - \frac{1}{6}(x - \sqrt{x}) = 30$$

which can be written as

$$x - \sqrt{x} = y \quad (1)$$

$$y - \frac{1}{6}y = z \quad (2)$$

$$z + \sqrt{z} = 30 \quad (3)$$

Solving (3) we get $z = 25$; then solving (2) we get $y = 30$; and finally solving (1) we get $x = 36$.

Rule of Three etc.

22-23. In the case of (problems on proportion involving) three, five, seven or more quantities, the argument and the requisition are of the same denomination. (Set down the quantities associated with the argument on one side and those associated with the requisition on the other and then) carry the fruit and the denominators (if any) from one side to the other; when the proportion is inverse, the fruit is not to be transposed. Then the product of the quantities on the side having larger number of quantities divided by the product of the quantities on the side having lesser number of quantities, gives the (desired) fruit.³⁰

Example 1. If 100 mangoes are obtained for $6\frac{1}{2}$ paṇas, how many of them will be obtained for 1 *drama* (or 16 paṇas)?

Indian method of working: argument side requisition side

$$\begin{array}{rcl} 13 & & 16 \\ & 2 & \\ \hline 100 & & x \end{array}$$

Transposing fruit and denominator to the other side:

$$\begin{array}{rcl} 13 & & 16 \\ & & 2 \\ \hline x & & 100 \end{array}$$

Hence the required number of mangoes =

$$\frac{16 \times 2 \times 100}{13} = 246\frac{2}{13}$$

Example 2. If the interest on 100 for $1\frac{1}{2}$ months is 5, what will be the interest on 60 for 1 year?

Indian method of working:

argument side	requisition side
100	60
<hr/>	<hr/>
3	12
2	<hr/>
<hr/>	<hr/>
5	x

Transposing fruit and denominator:

$$\begin{array}{rcl} 100 & & 60 \\ & 3 & \\ \hline & 12 & \\ & 2 & \\ \hline x & & 5 \end{array}$$

Therefore, the required interest =

$$\frac{60 \times 12 \times 2 \times 5}{100 \times 3} = 24$$

Therefore example of *Pañcarāśika*, *saptarāśika* in the original but not translated into English.

Inverse rule of three

Example. When $1/2$ *māṣa* of 8 *varṇas* is given, how much of 10 *varṇas* will be obtained in exchange? (Answer: $2/5$ *māṣa*)

³⁰ Cf. L, vss. 73a, 82; PG, 45,

Barter of commodities

Example. If 30 camels are obtained for 100 horses, how many camels will be obtained for 30 horses? (Answer : 9 camels.)

SECTION TWO: DETERMINATIONS (*VYAVAHĀRA*)

1. Separation of mixed Quantities (*Miśraka*)

1. Simple Interest

24. By the time corresponding to the argument multiply the argument, and by the time past (severally) multiply the interest etc.; divide (each product) by their sum and multiply by the mixed amount. Then are obtained the capital and interest etc. separately.³¹

Example 1. Find the capital and interest when their sum amounts to 8 in a year, the rate of interest being 5 percent (per months).

Here argument = 100, corresponding time = 1 month, other time = 12 months, fruit = 5, amount = 8.

Hence

$$\text{capital} = \frac{100 \times 1 \times 8}{100 \times 1 + 5 \times 12} = 5$$

$$\text{interest} = \frac{5 \times 12 \times 8}{100 \times 1 + 5 \times 12} = 3.$$

Example 2. On 100, the monthly interest is 10, the commission of the broker 1/2, and the fee of the scribe 1/3. If a certain sum amounts to 495 in half a year, give out the capital and interest etc. (separately).

$$\text{Capital} = \frac{100 \times 1 \times 495}{100 \times 1 + 6(10 + 1/2 + 1/3)} = 300$$

$$\text{Interest} = \frac{10 \times 6 \times 495}{100 \times 1 + 6(10 + 1/2 + 1/3)} = 180$$

$$\text{Brokerage} = \frac{1/2 \times 6 \times 495}{100 \times 1 + 6(10 + 1/2 + 1/3)} = 9$$

$$\text{Scribes fee} = \frac{1/3 \times 6 \times 495}{100 \times 1 + 6(10 + 1/2 + 1/3)} = 6$$

2. The Jewel problem

25 (a-b). Diminish the denominators by their own numerators and reduce them to their lowest common denominator. Then the resulting numerators are the values of the fractional parts of the men's own capitals.³²

Example. One (man) said $\frac{1}{2}$ (of his capital), the other $\frac{1}{3}$ (of his capital), and the other $\frac{1}{4}$ (of his capital). Each of these (severally) increased by the capitals of the other two brothers is the price of a jewel. How is this equality possible?

The fractions associated with the three men are

$$1/2, 1/3, 1/4$$

Diminishing the denominators by their own numerators, we set

$$1/1, 1/2, 1/3$$

Reducing them to their lowest common denominator, we get

$$6/6, 3/6, 2/6$$

Therefore,

$$\frac{\text{capital of first man}}{2} = 6$$

$$\frac{\text{capital of second man}}{3} = 3$$

$$\frac{\text{capital of third man}}{4} = 2$$

³¹ Cf. L, vs. 90; PG, 47.

³² A similar rule occurs in BM (= Bakshali Manuscript), ed. Svami Satya Prakash Sarasvati and Dr.Usha Jyotismati, p.10, sutra (iii). But there is no such rule in PG

Hence the capitals of the three men are 12, 9 and 8 respectively, and the price of the jewel is 23.

3. The fruit problem

25 (c-d). The number of men plus 1 gives the number of fruits with the last man and that increased (successively) by 2 with the men (successively) ahead of him.

Example. Four men going one behind the other are carrying fruits. Each man gives one fruit, out of his own fruits, to each man behind him (if any). When the fruits have been taken in this way, all men possess equal fruits. Tell the number of fruits with them. (Answer : 5,7,9, 11 fruits.)

4. Partnership

26 (a-b). The investments (of the partners) (severally) divided by their sum and multiplied by the mixed profit give the individual profits (of the partners).³³

Example. If the total produce be 63 (*prasthas*), what are the (individual) shares (of the partners) who sowed 2, 3 and 4 *prasthas* (of grain)? (Answer: 14, 21 and 28 *prasthas*.)

5. Alligation

26 (c-d) The sum of the products of weight and *varṇa* of the several pieces of gold, being divided by the sum of the weights (of those pieces of gold), gives the *varṇa* (of the alloy).³⁴

Example. What is the *varṇa* of the alloy formed by melting together two pieces of gold whose weights are 2 and 8 *māṣas* and *varṇas* 8 and 12 (respectively)? (Answer: $11\frac{1}{5}$)

27 (a-b). The sum of the products of *varṇa* and weight of the several pieces of gold) when divided by the *varṇa* of the refined gold gives the weight of the refined gold, and when divided by the weight of the refined gold gives the *varṇa* of the refined gold.³⁵

Example. The two pieces of gold of the previous example are melted together and refined. If the weight of the refined gold is 8 (*māṣas*) what is its *varṇa*; if the *varṇa* is 16 (lit. devoid of *kṣaya*), what is its weight? (Answer: *varṇa* 14, weight 7 *māṣas*)

27 b-28 (a-b). Find the product of the *varṇa* of the refined alloy (of all the pieces of gold) and the sum of the weights (of all those pieces of gold whose weights are known) also find the sum of the products of *varṇa* and weight (of those pieces of gold whose *varṇa* and weight both are known). Their difference divided by the weight of the piece of gold of unknown *varṇa*, gives the unknown *varṇa*.³⁶

That is, if n pieces of gold of weights w_1, w_2, \dots, w_n and *varṇas* v_1, v_2, \dots, v_n are mixed up with another piece of gold of weight w but of unknown *varṇa* and refined and the *varṇa* of the refined alloy is found to be e , then the unknown *varṇa* v is given by the formula

$$v = \frac{(w_1 + w_2 + \dots + w_n + w)v' - (w_1v_1 + w_2v_2 + \dots + w_nv_n)}{w}$$

28 (c-d) (The same difference) divided by the difference of the *varṇa* of the refined alloy and the *varṇa* of the unknown weight, gives the unknown weight.³⁷

That is, if n pieces of gold of weights w_1, w_2, \dots, w_n and *varṇa* v_1, v_2, \dots, v_n are mixed up

³³ Cf. L, vs. 94.

³⁴ Cf. L, vs. 103 (a-b); PG, 52 (c-d).

³⁵ Cf. L, vs. 103 (x-d); PG, 53;

³⁶ Cf. L, vs. 106; PG, 54.

³⁷ Cf. L, vs. 108; PG, 55.

with another piece of gold for *varṇa* *v* but of unknown weight and refined and the *varṇa* of the refined alloy is found to be the unknown weight *w* is given by the formula

$$w = \frac{(w_1 + w_2 + \dots + w_n + w)v' - (w_1v_1 + w_2v_2 + \dots + w_nv_n)}{v - v'}$$

Let the weight and *varṇa* of two pieces of gold and those of the refined alloy, be

weight	2	8
<i>varṇa</i>	x	12 $11\frac{1}{5}$

Then

$$x = \frac{(2+8) \times 56/5 - 8 \times 12}{2} = 8$$

And if the weight and *varṇa* of the two pieces of gold and those of the refined alloy be

weight	y	8
<i>varṇa</i>	8	12 $11\frac{1}{5}$
$y = \frac{8 \times 56/5 - 8 \times 12}{8 - 56/5} = 2$		

29. Divide the weight of the gold-stick by the difference of the *varṇas* of the two pieces of gold and multiply by the difference of the higher *varṇa* and the desired *varṇa*: the result is the measure of weight of the lower *varṇa*. The weight of the stick diminished by that gives the measure of weight of the higher *varṇa*.³⁸

Two pieces of gold are mixed up and a gold stick of given weight is formed out of the alloy. The *varṇas* of the two pieces and the *varṇa* of the gold stick being known, the rule tells how to find weights of the lower and higher *varṇas* in the gold stick.

Example. The *varṇas* of two pieces of gold are 15 and 6. (The weight of the gold stick is 6.) If the *varṇa* is reduced by 1/4m find the weights of gold of the lower and higher *varṇas* (in the stick).

$$\text{Weight of lower } varṇa = \frac{6 \times 1/4}{15 - 6} = 1/6$$

$$\text{Weight of higher } varṇa = 6 - \frac{1}{6} = 5\frac{5}{6}$$

2. Series (*Sredhī*)

30. Diminish the number of terms by 1, then multiply by half the common difference, then add the first term, and then multiply by the number of terms: the result is the sum of the series in arithmetic progression.³⁹ That is if *a* be the first term, *d* the common difference and *n* the number of terms, then the sum of the sets is given by

$$s = n \left[\frac{d}{2} (n-1) + a \right]$$

Example. The initial sum is 8, and the daily increment is 5. What will be the amount at the end of a month? (Answer: 2415.)

3. Plane Figures (*Kṣetra*)

1. Triangle and quadrilateral

31 (a-b). In triangle etc. (i.e. in triangle and quadrilateral), the product of half the sum of sides and countersides gives the area.³⁹

That is, if *a*, *b*, *c*, *d* be the sides of a quadrilateral, taken in order, then

$$\text{Area} = \frac{a+c}{2} \times \frac{b+d}{2}$$

Similarly, if *a* be the base of a triangle and *b*, *c* the other two sides, then

³⁸ Cf. L, vs. 110.

³⁹ This rule is the same as stated in *BrSpSi* (= *Brāhma-sphuṭa - siddhānta*), xii. 21 (a-b), but criticized by Śridharācārya in *PG*, rule 112-114.

$$\text{area} = \frac{a}{2} \times \frac{b+c}{2}$$

These results are gross.

Example. What is the area of the triangle whose sides are 13, 14 and 15; of the square whose sides are each 5; and of the quadrilateral whose sides are 5, 7, 9 and 8? (Answer: 98, 25 and 105/2.)

31 (c-d). Set down half the sum of the (four) sides (of the quadrilateral) in four places, then diminish them (respectively) by the (four) sides (of the quadrilateral) and then take the square-root of their product: the result is the accurate area of the quadrilateral (if it is cyclic).⁴⁰

Example. What is the accurate area of the quadrilateral whose base is 60, face 25 and the lateral sides 3×13 and 4×13 . (Answer: 1764.)

2. Circle

32 (a-b). The diameter and the square of the semi-diameter, when divided by 7 and multiplied by 22, give the circumference and the area (respectively).⁴¹

It is noteworthy that Śridharācārya in his *Pāṇiganitasāra* or *Trisatikā* takes $\pi = \sqrt{10}$, whereas in above rule use has been made of $\pi = 22/7$.

Example. What is the circumference of the circle having 10 for its diameter, and what is its accurate area?⁹ (Answer : circumference $31\frac{3}{7}$ and area $78\frac{4}{7}$).

3. Segment of a Circle

32 (c-d). In the case of the segment of a circle, the area is equal to the arrow as multiplied by half the sum of the *jyā* and arrow increased by one-twentieth of itself.

That is, area of the segment of a circle

$$= (1+1/20) \times \text{arrow} (\text{jyā arrow})/2.$$

This formula seems to have been derived from Śridharācārya's formula⁴²

Area of the segment of a circle

$$= \frac{\sqrt{10}}{3} \text{ arrow} (\text{jyā arrow})/2$$

by replacing $\sqrt{10}$ by $22/7$ and ultimately taking the round figure 1/20 in place of 1/21.

Example. What is the accurate area of the segment of a circle in which *jyā* = 13 and arrow = 3?⁴³

$$(\text{Answer} : 25\frac{1}{5}).$$

⁴⁰ Cf. PG, rule 117 (a-b); L, vs. 169

⁴¹ Based on L, vs. 199 (c-d).

⁴² See *Trisatikā* (ed. S. Dvivedi), p. 35, rule 47

⁴³ After this P adds the following rules and examples which are taken from Bhāskara II's *Lilavatī* (vss. 204, 205, 135-137): Rule for finding the arrow: Take the square-root of the product of the sum and difference of diameter and chord, diminish the diameter by that: one –half of it is the arrow. Diminish the diameter by the arrow and then multiply by the arrow: the square root of that multiplied by 2 is the chord. The square of half the chord divided and increased by the arrow is said to be the measure of the diameter in the case of circle.

Example. A circle of diameter 10 has a chord equal to 6. Tell the corresponding arrow. Also derive the arrow from the chord and the diameter from the chord and the arrow.

Rule of right - angled triangle:

The side which is adjacent to the base (*bhūja*) but is another (orthogonal) direction is the other side. In a right angled triangle or rectangle, it is called the upright (*koṭi*) by the learned. The square root of sum of their squares is the hypotenuse; the square root of the difference of the base and the hypotenuse is the upright; and the square-root of the difference of the squares of the upright and the hypotenuse is the base.

Example. What is the hypotenuse when the upright is 4 and the base 3? Also tell the upright from the base and the hypotenuse and base from the upright and hypotenuse.

4. Excavations (*Khāta*)

33 (a-b). In the case of excavation, the area of the transverse section multiplied by the depth gives the volume in terms of cubic cubits.

Example. What are the volume in cubic cubits of excavations of depth 3 (cubits) whose transverse sections are the previously stated triangle and rectangle ? (Answer: 294 and 75 cu. cubits.)

5-6. Piles of Bricks and Sawing of Wood (*Citi* and *Krakaca*)

33 (c-d). In the case of piles of bricks, multiply the (base) area by the height;⁴⁴ and in the case of sewing, multiply the (sectional) area by the number of sections.⁴⁵

Example 1. What are the volumes of the piles of bricks of height 2.when the bases are the previously stated triangle and rectangle? (Answer: 168 and 50.)

Example 2. If the length (of the section) is 10 and breadth 3 and the number of sections 6, what is the total area sown? (Answer: 180.)

7. Heaps of Grain (*Rāśi*)

34 (a-b). In the case of heaps of grain, multiply

one-ninth of the circumference by the square of one-sixth of the circumference.⁴⁶

Example. The circumference of the base of a heap of grain is 36 cubits. How many cubic cubits is its volume? (Answer: 144 cu. cubits or *māgadhakhārīs*.)

8. Shadow (*Chāyā*)

34 (c-d). Half the gnomon divided by gnomon plus its shadow is the day elapsed or to elapse.

Example. How much of the day has or is to elapse when the shadow of the eight- digit (*aṣṭāṅgula*) gnomon is 24 digits (*aṅgulas*)?⁴⁷ (Answer : $\frac{1}{8}$.)

Appreciation of the Work and its Author

35. That you may not fall into the trap laid by the cunning authors of imitative compositions, you should read this chapter in arithmetic composed by the poet Śridhara and delightful to men of taste.
36. From the abode of the gods in the north to the Malaya mountain in the south and between the oceans in the east and west there exists no mathematician other than Śridhara.

⁴⁴ Cf. *Triśatikā*, p.41, rule 58 (a-b); L, vs. 220 (a-1)

⁴⁵ Cf. *Triśatikā*, p.42, rule 59 (a-b).

⁴⁶ Cf. L, vs. 227. The above rule is for heaps of bearded grain in which the height of the heap is supposed to the one-sixth of the circumference of the base.

⁴⁷ Here P adds the following rules and examples which are taken from Bhāskara II's *Līlāvatī* (vss, 234-237):

Rule for knowing the shadow:

The gnomon multiplied by the distance between the foot of the lamp-post and the foot of the gnomon and divided by the height of the lamp minus the height of the gnomon gives the shadow.

Example. If the space intervening between the gnomon and the lamp-post is 3 cubits and the height of the lamp 3 cubits, say quickly how much is the shadow of that gnomon which is 12 digits (*aṅgulas*) in length.

Rule for knowing the height of the lamp:

The gnomon divided by the shadow and multiplied by the distance between the foot of the gnomon and the lamp-post, when increased by the gnomon, gives the height of the lamp.

Example. If the space between the lamp-post and the gnomon is 3 cubits and the shadow (of the gnomon) equal to 16 digits (*aṅgulas*), tell me what is the height of the lamp and therefrom the distance between the lamp-post and the gnomon.

गणितपञ्चविंशी

[मङ्गलाचरणम्]

शिवं प्रणम्य स्वकृतं पाठ्याः सारं प्रवस्थति ।
श्लोकाना पञ्चविंशत्या श्रीघरः प्रकटार्थया ॥१॥

[परिभाषा]

पञ्चगुन्जो भवेन्माषो माषैः कर्षौ नृपप्रमैः ।
स सुवर्णः सुवर्णश्च¹ तैश्चतुर्भिः पलं स्मृतम् ॥२॥

वल्लस्त्रिगुन्जस्तैर्गद्याणकः षोडशार्भः स्मृतः ।
सार्द्धं वेघोऽङ्गुलं त्रीणि कुडपे दैर्घ्यविस्तृती ॥३॥

चतुर्भिः कुडपैः प्रस्थः प्रस्थैश्चतुर्भिराढकः ।
चतुर्भिराढकैर्द्रोणः खारी द्रोणैर्नृप प्रमैः ॥४॥

वराटकानां विंशत्या काकिणी तच्चतुष्टयम् ।
पणस्ते षोडश द्रम्मस्ते षोडश च निष्ककः ॥५॥

त्रयोऽङ्गुलं यवा ऊर्ध्वास्तच्चतुर्विंशतिः करः ।
दण्डश्चतुष्करः क्रोशस्सहस्रं द्वितयं भवेत् ॥६॥

योजनं स्याच्चतुः क्रोशं व वशो हस्ता दशाष्ट वा ।
निर्वर्तनं तद्विंशत्या क्षेत्रं बद्धं चतुर्भुजम् ॥७॥

[स्थानसंज्ञा]

एकं दशं शतं तत्मात् सहस्रमयुतं ततः ।
लक्षं च प्रयुतं कोटि रुद्धं पदयंमेव च ॥८॥

खर्वं निरर्वर्वं महापदयं शङ्कुः जलधिरित्यपि ।
अन्त्यं मध्यं परार्द्धं स्जुः संज्ञा दशगुणोत्तराः ॥९॥

इति संज्ञाः ॥ १०००००००००००००००००००० ॥

¹ Ms reads सुवर्णश्च

अथ सङ्कलितव्यवकलितयोः सूत्रम्—

योगान्तरे यथास्थानं चेत्तवेना विकृतो भवेत् ॥१०॥ (a, b)

उदाहरणम्—

षष्ठिनवार्काः किं युक्ताः स्यात् शताद्वा विशोधिताः ।

न्यासः ॥६०॥६॥१२॥ योगे जातं ॥८॥ शता
द्विशोध्य शेषं १६॥

॥ इतिसङ्कलितव्यव कलिते ॥

गुणने सूत्रम्—

गुण्यस्यांत्या दिकानङ्कान् गुणयेद् गुणकेन तु ॥१०॥ (c, d)

उदाहरणम्—

जिनैनगार्काः किं निष्णास्त्र्यर्कः किं दन्तभून्तपाः ।

न्यासः ॥ गुण २४ गुण्य १२७ । गुण १२३ गुण्य १६९३२ ।

गुणनाज्जाते फले ॥३०४८॥ १६८४२३६॥

॥ इति प्रत्युत्पन्नम् ॥

भागे सूत्रम्—

भागे भाज्याद्वरो येन हतः शुद्धयेत् फलं तु सः ॥१९॥ (a, b)

उदाहरणम्—

प्राग्लब्धं गुणफलयोः स्वगुणच्छेदयोर्मार्गार्थं न्यासः ।

भाज्यः ॥३०४८॥ हरः ॥२४॥ भाज्यः ॥१६८४२३

६॥ हरः ॥१२३॥ लब्धे फले ॥१२७॥ १६९३२॥

॥ इति भागहारः ॥

वर्गधनयोः सूत्रम्—

समद्विघातो वर्गः स्यात् समत्रयहतिर्धनः । ॥१९॥ (c,d)

उदाहरणम्—

कौ नवानां त्रिसूर्याणां स्यातां वर्गधनौ सखे ।

न्यासः ॥६॥१९२३॥ जातौ वर्गौ ॥८॥१५१२६॥

घनौच ॥७२६॥१८६०८६७॥

॥ इति वर्गधनौ ॥

वर्गमूले सूत्रम्—

त्यक्त्वाऽन्त्याद्विषमाद्वर्गं द्विघमूलहते समे ।

लब्धवर्गं तदाऽद्योनात् त्यक्त्वाऽप्तं द्विगुणं न्यसेत् ॥

पद्मक्त्यां भक्ते समे पद्मक्येति मुहुस्त दूलं पदम् । ॥१२॥

उदाहरणम्—

प्रागवर्गौ ॥८॥१५१२६॥ लब्धे मूले ॥६॥१९२३॥

॥ इति वर्गमूलम् ॥

घनमूले करणसूत्रम्

आद्यं धनोऽघनद्वच्छमित्यन्त्याद् घनतो पदम् ॥१३॥ (a, b)

त्यक्त्वा पृथक् पदं कृत्या त्रिच्याऽस्याद्यं भजेत् फलम् ।

पद्मक्त्यां न्यसेदस्य वर्गं तदाद्यात् यन्त्यताङ्गितम् ॥

जह्याद् घनं तु तत्पूर्वात्मूलायैवं पुनर्विधिः । ॥१३ (c, d)-१५ (a, b) ॥

उदाहरणम् ॥ [प्राग्] घनौ ॥७२६॥१८६०८६७॥

लब्धे धनमूले ॥६॥१९२३॥

इति घनमूलम् ॥

॥ इति परिकर्मष्टकम् ॥

भागजातौ भिन्नसङ्कलितव्यवकलितयोः सूत्रम्—

समच्चेदार्थमन्योन्यद्वयां हन्याद् हरांशकौ ।

समच्छिदोऽशा युतोनाः स्याद्रूपमहरे हरः । ॥१५ (c, d)-१६ (a, b) ॥

उदाहरणम्—

अर्ध—त्र्यंश—चतुर्थांशः किं युक्ता वा त्रयाच्युताः ।

न्यासः	१	१	१
	२	३	४

जाता: समच्चेदम्

६	४	३
१२	१२	१२

योगे	१३
	१२

एतत्प्रयाद्विशोध्य	शेषम्	२३
		१२

॥ इति भागजातौ भिन्नसङ्कलितव्यवकलिते ॥

प्रभागजातौ भिन्नगुणने करणसूत्रम्

भाग प्रभागे गुणेऽशाद्यातोत्भूतहत्यां ॥१६ (c, d) ॥

उदाहरणम्—

अङ्गेऽर्द्धतृतीयांशः किं त्र्यंशहतं दलम् ।

न्यासः	१	१	१
	४	२	३

प्रभागे	जातं	१
		२४

१	१
३	२

गुणिते	जातं	१
		६

॥ इति प्रभागजाति भिन्नगुणनम् ॥

भिन्नभागे सूत्रम् —

परिवर्त्य लवक्षेदौ हरस्य गुणनं ततः । ॥१७॥ (a, b)

उदाहरणम् —

प्रागलब्धगुणफलस्य भागार्थं न्यासः ॥ भाज्य

१	६	हर	१
२			३

लब्धम्

॥ इति भिन्नभागहारः ॥

भिन्नवर्गादौ वर्गमूलादौ सूत्रम् —

छेदांशयोः कृती वर्गं घने घनौ पदे पदे ॥१७॥ (c, d)

उदाहरणम् —

सार्वत्रयस्य कौ वर्गधनौ ताम्यां च के पदे ॥

न्यासः	३	जातो वर्गः	४६	वर्गमूलं	७
	१		४		२

घनः ३४३ घनमूलं १०
८ २

॥ इति भिन्नवर्गादिचतुष्टयम् ॥

भागानुबन्धभागापवाहयोः सूत्रम् –

छेद्रध्रूपेष्वंशः स्वमृण चैकस्य चेल्लवा : |
हतो हरोऽधिश्छदोशस्त्या स्वांशयुतोनया ॥१८॥

उदाहरणम् –

त्र्यंशाढयोनास्त्रयः किंच स्वत्र्यंशाढचोनितास्त्रयः |

३	३
१	१
३	३

जातं

१०	८
३	३

३	३
९	९
९	.
३	९
	३

जातं ॥४॥१२॥

॥ इति भागानुबन्धभागापवाहजातिः ॥

शून्ये सूत्रम् –

खेन वधे शून्यं स्यात् खं खस्य वर्गधनादिषु ॥१६॥ (a,b)

॥ इति शून्यजातिः ॥

व्यस्तोदेशे सूत्रम् –

व्यस्ते स्वर्णे गुणहारो दृष्टे वर्गपदे अपि ।।
स्वर्णे स्वांशे सति स्वांशा ढयोनरूपेण भाजयेत् ॥५
(c-d) - २० (a-b) ॥

॥ इति व्यस्तोदेशजातिः ॥

उदाहरणम् –

द्वयूनस्त्रिघो वर्गितः कः स्वत्र्यंशाढ चस्त्रिहन्तुपः ॥
न्यासः ॥१, २ गुण ३, वर्ग, स्व (त्र्यंशाठयः), ९ भाग
दृश्य १६ | जातो राशिः ॥४॥

९
९
९
९

दृश्यजात्यादिषु सूत्रम् –

आलापवद्हतहतांशयुतोनैकहन्ददृश्यः ॥२०॥ (c,b)

उदाहरणम् –

कस्त्रिधनः पञ्चहृद्राशोः पञ्चांषाढयो ऽन्धिहृदद्वयम् ।
न्यासः ॥ गुण ३ भाग ५ राश्यंशधनं ९ भाग ४ दृश्य
२ । जातो राशिः १० |

५

॥ इति दृष्यजातिः ॥

(१) अथ दृश्यजात्युदाहरणम् (B)

रवं षष्ठोऽशाज्जलं त्र्यंशः षड् दृष्टाः कति ते शुकाः ।
न्यासः ० ० ० दृश्य ६ | जाताः शुकाः १२

६
३

(२) शेषजातौ उदाहरणम्

षष्ठे शेषार्द्धे तच्छेषनयंशे याते शुका दश ।

न्यासः ० ० ० दृश्यः ७० | जातो राशिः ३६ ॥

६	२	३
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॥ इति शेषजातिः ॥

(३) विश्लेषजातौ उदाहरणम् –

षडंशार्धान्तरं नष्टं दृष्टाः षड् योग्युतिः कति ।

न्यासः ० ० ० दृश्यः ६ | जाता गावः ६ ॥

६	२
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॥ इति दृष्यजातिः ॥

(४) दृश्यमूलांशजातौ सूत्रम् –

मूलाढयोनाच्चतुर्निर्धात् मूलवर्गयुतात्पदम् ।
मूलोनयुतं दलितं वर्गितं जायते फलम् ॥२१॥

उदाहरणम् –

मूलोनितः शेषषडंशहीनः कः शेषमूलेन युतः खरामाः ॥१५॥
न्यासः ॥ मूल । ७ शेष शेषमूलधनं ९ दृश्य ३० । जातो
राशि । ३६ । ६

। इति दृश्यमूलांशजातिः ॥

दृष्ट मूलांशजातौ सूत्रम् ॥

अथ लवयुतोनिवौत्तौ लवान्वितोषैक भाजिताद् दृश्यात्
तस्यानयनं प्राग्वन् मूलादपि यदि लवो राशे ॥

उदाहरणम् ॥

यो भांशत्र्यंशनन्दांशैर्निजैर्युक्तः पदेन च ।
राष्णिर्वार्कतुल्यः स्यात् तं द्राक्कीर्त्य कोविद ॥

न्यासः । ९ । ९ । ९ । मूल । ७ हश्य १२६ । जातो राशि: ८९ । १

इति दृष्टमूलांशजातिः समाप्ता ॥

अथवा भागापवाहविधिना वल्लीरूपर्णन भागाः ॥ (B)

न्यासः । ९ । ९ । . । ९ । ६ । . । ९ । २ । . । ९ । ३ ।
हतो हरो ५ घश्वदांश इत्यादि करणेन
सर्वर्णनाज्जातम् । ५ । एतेन दृष्टभत्कं
जाताः शुकाः ३६ ॥ विलोमसून्नेण वा
सिद्धयति ॥

माडजातौ सूत्रम् –

माडस्य भूमौ सदृशांङ्कपंक्तिरिष्टैःसरूपैः क्रमशो विभक्ता ।

दृष्टघ्नलब्धं सहित । तदर्थे सूत्रं विचित्रं श्रृणु
नार्मदोक्तम् ?

उदाहरणम् –

शिष्याकर्णय गोपुरे क्षितिर्भृतः सप्तकणे सुन्दरे ।
तत्रासन्मनुजाः क्षणं क्षणमधस्तिष्ठन् जगादोच्चगीः ॥
यावन्तो वयमत्र पातनभयात्तवन्त एते क्षणाद् ।

आयाताः प्रतिभूमिकां वद सरवे संख्या नराणां समा ॥

न्यासः ॥ पथवक्षणे क्षणे जाता नराः समाः ६४ । ६४ ॥

१२६
६३
६२
६०
५६
४८
३२

इति माडजातिः ॥

इति श्री श्रीधराचार्यविरचिता जातिः समाप्ता ॥

★ ★ ★

अथ त्रैराशिकादिशु सूत्रम् –

त्रिपञ्चसप्तादिकराशिके स्तः प्रमाणमिच्छा च समान
जाती ॥

अन्योन्यपक्षे फलहारकाणां विधाय मान, न फलस्य
वामे ।

वह्नशपक्षाङ्कवधो उल्पकांशपक्षाभ्कघातेन हृतः फलं
स्यात् ॥ २२-२३ ॥

उदाहरणम् –

(१) साद्वैः षड्भिः पणैराप्रशतं द्रम्मेण ते कति ।

न्यासः । । ६ । १६ । लब्धमाप्राः । २४६
९ । २ । १३
२ ।
१०० ।

। इति त्रैराशिकम् ॥

(२) पञ्चराशिके उदाहरणम् –

साधर्दे मासे शते पञ्च वर्षे षष्ठ्या फलं तु किम् ॥८॥

न्यासः । । ३ । १२ । लब्धं (फलम्) २४ ।
२ ।
१०० । ६०
५ । ०

मूलधने अज्ञाते लब्धं मूलधनं ६०।
न्यासः

३	९२
९	
२	
५	२४
९००	०

अज्ञाते कालेष्वेवमेव।

॥ इति पच्चराशिकम् ॥

(३) सप्तराशिके उदाहरण् –

दशायामा त्रिविस्तारा पटी द्रम्माष्टकेन चेत्।
लभ्यते द्वे त्रिविस्तारे अर्कायामे किमान्जुतः ॥६॥

न्यासः ॥ लब्धं दुम्मा: ९६
९ २
९० ९२
३ ३
८ ०

॥ इति सप्तराशिकम् ॥

व्यस्तेत्रेराशिके उदाहरणम् –

दत्ते इष्टवर्णमाषाढ्वे दशवर्णं तदा कियत्।

न्यासः ॥ लब्धन् २
८ ९००
९ ०
२

॥ इति व्यस्तत्रैराशिकम् ॥

भाण्डप्रतिभाण्डके उदाहरणम् –

शतेनाश्वैस्त्रिंशतुष्ट्राः कत्यश्वत्रिंशतोष्ट्रकाः ॥

न्यासः ॥ लब्धोष्ट्राः ६ ।
९०० ३०
९ ९
३० ०

॥ इति भाण्डप्रतिभाण्डकम् ॥

मिश्रक व्यवहारे करणसूत्रम् –

प्रमाणकालेन हतं प्रमाणं
गतेन कालेन हताः फलाद्याः।
स्वयोगभक्ताश्च विमश्रनिधाः
पृथक्पृथक् मूलफलादयः स्यः ॥ २४ ॥

(१) उदाहरणम्—पञ्चकेन शतेनाद्वे फलमूलयुतिर्गजाः ॥ ११ ॥

न्यासः ९०० । १२ । मिश्रधनं ।८ । लब्धं मूलधनं ।५ ।

वृद्धिधनं ।३ । इति

(२) उदाहरणम् – मासि शतस्य फलं दश शिष्टे
रूपदलं त्रिलवो लिपिकर्तुः।

पञ्चशती विशराङ्गदलेऽभन्
मिश्रधनं वद मूलफलादीन् ॥ १२ ॥

न्यासः ॥ ९ ६ ६
९०० ९ ९
९० २ ३

लब्धं मूलधनं ।३०० । वृद्धिधनं ।१८० । शिष्टधनं ।६ ।
लेखके ।६ ।

(रत्नजातौ) करणसूत्रम् –

व्यंशच्छेदाः समीभूताः स्युः पुसां स्वा निजांशकाः २५ (a, b)

उदाहरणम्–

एको दलं परं त्र्यं चतुर्थां परोऽवदन्।
भ्रातरद्वयवित्तादयं रत्नमौल्यं कथं समम् ॥

न्यासः ॥ ९ ९ ९
२ ३ ४

सममौल्यं रत्नस्य २३।

करण सूत्रम्–

नृसंख्यैकयुताङ्गत्यस्थे तदाद्ये द्वियुते विदुः ॥ २५ ॥

उदाहरणम्–

फलानि नृहणां नयतां चतुर्णमाद्यैर्दत्तेऽन्त्ये स्वफलप्रमाणैः।
फले गृहीते ५ खिलमेव एवं कृते समाः स्युः वद
तत्फलानि ॥१४ ॥

न्यासः ॥ नराः ४ । जातानि फलानि ॥३ ॥ ॥११ ॥
॥ ६ ॥ ॥७ ॥ ॥५ ॥

[प्रक्षेपके] करणसूत्रम् –

प्रक्षेपकाः स्वयोगाप्ता मिश्रहनाः स्यात् पृथक् फलम् ॥
२६ (a-b)

उदाहरणम् :

फले त्रिषष्टिर्भागे किं [द्वित्र्यन्धियप्रस्थवापिनाम्] ।
न्यासः ॥२॥३॥४॥ फलं ६३। लक्षं भागे
१४ ॥२१॥२८।

[स्वर्णव्यवहारे] सूत्रम् –

स्वर्णध्वं वर्णयौगे स्याद्वर्णः स्वर्णेक्यभाजिते ॥२६(c-d)॥

उदाहरणम् –

आवर्तवर्णः कोऽष्टाकं वर्ण यो द्वर्यष्टमाषयोः ॥१५॥

न्यासः $\begin{array}{|c|c|} \hline ८ & १२ \\ \hline २ & २ \\ \hline \end{array}$ आवर्त वर्ण लक्षं $\begin{array}{|c|c|} \hline १६ & \\ \hline २ & \\ \hline ५ & \\ \hline \end{array}$

[अन्यत्] करणसूत्रम्

भक्ते शुद्धेन वर्णेन तौल्यं तौल्येन वर्णकः ॥२७ (a-b)॥

उदाहरणम् –

शूद्धौ तौल्येऽष्टके वर्णः कः कावर्णक्षये मिति: ।

न्यासः $\begin{array}{|c|c|} \hline ८ & १२ \\ \hline २ & ८ \\ \hline \end{array}$ शूद्धौ तौल्ये ८ ष्टके ॥८॥ जातो
वर्णः ॥१४॥ अथवा शूद्धौ वर्णक्षये ॥१६॥ जात ।
तौल्यं ॥७॥

[अन्यत्] सूत्रम् –

पक्ववर्णध्वतौल्यैक्यं वर्णतौल्यवधैक्यकम् ॥२७ b-२८

(a-b)॥

तदन्तरमविज्ञातो वर्णस्ततोल्यहृदभवेत् ॥

अज्ञात तौल्यं तद्वर्णं पक्व वर्णन्तरोद्घतम् ॥ २८ c-d ॥
तंत्राष्टके वर्णं इज्ञाते न्यासः $\begin{array}{|c|c|} \hline ० & १२ \\ \hline २ & ८ \\ \hline \end{array}$ पक्ववर्णः $\begin{array}{|c|c|} \hline ११ & \\ \hline १ & \\ \hline ५ & \\ \hline \end{array}$ लक्ष्ये
वर्णः ८ ॥

माषद्वयेऽज्ञाते न्यासः $\begin{array}{|c|c|} \hline ८ & १२ \\ \hline ० & ८ \\ \hline \end{array}$ पक्ववर्णः $\begin{array}{|c|c|} \hline ११ & \\ \hline १ & \\ \hline ४ & \\ \hline \end{array}$ समफललक्ष्यौ
माषौ ॥२॥

[अन्यत्] सूत्रम् –

शलाकामितिर्वणविश्लेशभक्ता
विनिध्ना वृहद्वर्णसाध्यान्तरेण ।

भवेत् स्वल्पवर्णस्य तौल्यप्रमाणं ।
तदूना शलाका वृहद्वर्णमानम् ॥२६॥

उदाहरणम् –

तिथिषङ्गवर्णयोर्माने के तत्तौल्येऽङ्ग्नहानितः ॥१६॥

न्यास ॥ वर्णौ ॥१५॥६॥ शलाकामानं ६ हानिः $\begin{array}{|c|c|} \hline ९ & \\ \hline ४ & \\ \hline \end{array}$
लक्ष्यं स्वल्पवर्ण – वृहद्वर्णमाने $\begin{array}{|c|c|} \hline ९ & ३५ \\ \hline ६ & ६ \\ \hline \end{array}$

॥ इति स्वर्णक्यवहारः ॥

अथ श्रेढीसूत्रम् –

व्येकं पदं चयाद्वद्धं साद्रिगच्छहतं घनम् ॥३०॥

उदाहरणम् –

आदिरष्टं चयः पञ्च फलं मासेन किं भवेत् ।

न्यासः । आ ८ च ५ ग ३० घनं २४९५ ।

॥ इति श्रेढीव्यवहारः ॥

अथ क्षेत्रे सूत्रम्!

फलं दोः प्रतिदोयोर्गीर्द्धघातस्त्र्यस्त्रादिपूर्वके ॥ ३६ a-b ॥

उदाहरणम् –

विश्वेन्द्रद्युभुजे त्र्यस्त्रे फलं कि स्याच्चतुर्भुजे ॥

शरदोस्यथवा पञ्चसप्तनंदाष्टवाहुके ॥

न्यासः $\begin{array}{|c|c|c|} \hline १३ & १४ & ५ \\ \hline १५ & & \\ \hline \end{array}$ $\begin{array}{|c|c|} \hline ८ & ५ \\ \hline & ५ \\ \hline \end{array}$ $\begin{array}{|c|c|} \hline ८ & ६ \\ \hline & ६ \\ \hline \end{array}$

लक्ष्यानि फलानि ॥६८॥ ॥२५॥ $\begin{array}{|c|c|} \hline १०५ & \\ \hline २ & \\ \hline \end{array}$

[अन्यत्] सूत्रम् –

भुजयुतिदलं चंतुःस्थं भुजोनघातात्पदं स्पष्टम् ॥३९ (c-d)
॥

उदाहरणम् –

भूमिः षष्ठिःमुखं पञ्चविंशति स्त्र्यव्यियसङ्गगुणे ॥

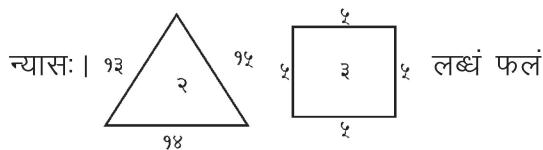
। इति खातव्यवहारः ॥

अथ चितिक्रकचौ सूत्रम् –

उच्छ्रयेण चितौ मार्गः क्रकचे फलमाहतम् । ॥३३(c-d) ॥

चितौ उदाहरणम् –

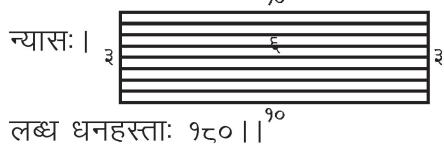
१) त्रिस्त्रे च चतुरस्त्रे च द्वचुच्छ्रये किं फलं चितौ ।



१६८ ॥५० ॥

२) क्रकचे उदाहरणम्

दशदैर्घ्ये त्रिविस्तारे मार्गः षड्भिः फलं तु किम् । ॥२९ ॥



इति चितिक्रकचो ॥

अथ राशि सूत्रम् –

राशौ नवांशः परिधिः षड्भागकृतिताडिल्ले । ॥३४ (a-b) ॥

उदाहरणम् – षट्क्रिंशत् परिधी राशैः कति स्युधनबाहवः ।

न्यासः | परिधिः ३६ ॥ लक्ष्य

घनहस्ता: ॥१४४ । एत्रवन्तो मागधरवार्ओः ।

॥ इति राशिव्यंवहारः ॥

अथ छायासूत्रम् –

सशङ्कुमाभाप्ते शङ्कवर्द्धे गत शेषदिनं भवेत् । ॥३४ (c-d) ॥

उदाहरणम् –

[सि] द्वाभाऽष्टाङ्गुलेशङ्कौ किं द्युशेषं गतं तदा ॥

न्यासः | शंकुः ८ छाया ८४ | लक्ष्यं दिनगतशेषं ॥९ ॥ ८

॥ इति छायाव्यवहारः ॥

प्रतिकञ्चकरचनापटुपाशे पतनं न ते भवत्वस्मात्
श्रीधरकोविरचितं पद गणिताध्यायं रसिकरम्यम् । ॥२५ ॥

उत्तरतः सुरनिलयं दक्षिणतो मलयपर्वतं यावत् ।

[प्राग्], परोदधिमध्ये नो गणकः श्रीधरादन्यः । ॥२६ ॥

वेदाङ्गांदधिभू १४६४ भूपे शुभकृन्नामिन्नसंस्थिते ।

अयने चोत्तरे जातं चैत्रेपक्षे च बाहुले ॥

इति श्री पञ्चविंशतिका श्रीधराचार्यविरचिता समाप्ता ।

१ छायाज्ञाने सूत्रम् – (B)

शङ्कुप्रदीपतलशङ्कुतलान्तरध्ने

श्छाया भवेद्विनरदीप शिरवौच्चयभक्तः ।

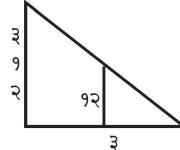
उदाहरणम् – शङ्कुप्रदीपान्तर भूस्त्रिहस्ता

दीपोच्छ्रितिः सार्वकरत्रया चेत् ।

शङ्कुप्रदीपतलशङ्कुतलान्तरध्ने

तस्य प्रभास्यात् कियती वदाशु ॥

न्यासः | लक्ष्यानि छायाङ्गुलानि १२ ।



॥ इति छाया ज्ञानम् ॥

दीपौच्चज्ञाने सूत्रम् –

छायोदधृते तु नरदीपतलान्तरध्ने

शङ्कुकौ भवेन्नरयुते खलु दीपकोच्चयम् ।

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