

National Institute of Vedic Sciences
Certificate Course on
“Indian Mathematics”
 Suggested Draft Syllabus

Unit	Number of lessons	Lessons
3. 1	3. 1. 1 3. 1. 2	Numbers in Sanskrit Works; An Overview. Indian Decimal place-value system.
3. 2	3. 2. 1 3. 2. 2 3. 2. 3	Numerals in Sanskrit Works; a) Words as Numerals b) Alphabets as Numerals and c) Early Magic Squares.
3. 3	3. 3. 1 3. 3. 2	a) <i>Aryabhatiya Numerals</i> b) Number of Revolutions of Geo-centric Planets in a Yuga (43,20,000 years) in <i>Aryabhatiya Numerals</i>, comparison of sidereal periods of Geo-centric planets in <i>Aryabhatiya</i> with their present-day values and Reason for naming the week-days.
3. 4	3. 4. 1	Glimpses of Mathematics of <i>Sulvakaras</i> .
3. 5	3. 5. 1 3. 5. 2	Glimpses of Mathematics of <i>Aryabhata-I</i> 1) <i>Arithmetic and Mensuration</i> in <i>Aryabhatiya</i> . 2) <i>Circles</i> in <i>Aryabhatiya</i> .
3. 6	3. 6. 1 3. 6. 2	Glimpses of Mathematics of <i>Mahaveeracarya</i> .
3. 7	3. 7. 1 3. 7. 2	Glimpses of Mathematics of <i>Bhascara-II</i> .
3. 8	3. 8. 1 3. 8. 2	<i>Chandassutra</i> ; Zero and Binary number System. Transmission of Zero, Decimal place-value system and <i>Indian Trigonometry</i> outside India Ratio of <i>Circumference of a Circle to its Diameter</i> (π), in <i>Indian Mathematics</i>
3. 9	3. 9. 1 3. 9. 2	Biography of <i>Bharati Krishna Tirthaji</i> and Glimpses of His Contribution to <i>Indian Mathematics</i>
3. 10	3. 10. 1 3. 10. 2	Biography of <i>Srinivasa Ramanujan</i> and Glimpses of His Contribution to <i>Mathematics</i>
	20	Total number of lessons

Unit 3. 3 Mathematics

Structure: - The Unit 3. 3 contains two lessons.

The first lesson; 3. 3. 1 Rule for *Aryabhatiya Numerals* quotes has two parts.

3. 3. 1 a) states the rule from *Aryabhatiya*, explains the *rule* and gives a *chart for the rule* as a *ready-reckoner*.

3. 3. 1 b) quotes a sloka expressing diameter of the earth and other numerical data using *Aryabhatiya Numerals* and gives commentary of the sloka by Bhaskara-I in his *AryabhatiyaBhasya*.

The second lesson; 3. 3. 2 Number of Revolutions of Geo-centric Planets in a Yuga (43,20,000 years) in *Aryabhatiya Numerals*, comparison of sidereal periods of Geo-centric planets in *Aryabhatiya* with their present-day values and Reason for naming the week-days contains three parts.

3. 3. 2 a) explains the method of converting *Aryabhatiya Numerals* for the number of Revolutions of Geo-centric Planets in a Yuga into international numerals.

3. 3. 2 b) gives a table of *comparison of sidereal periods of Geo-centric planets in Aryabhatiya with their present-day values*.

Objective: - The Unit: *Aryabhatiya Numerals* is designed to facilitate the learner

- i) To appreciate the history of the Rule for *Aryabhatiya Numerals*.
- ii) To de-codify the *Aryabhatiya Numerals* by applying the Rule.
- iii) To appreciate the ingenuity of Aryabhata-I in expressing the number of revolutions of Geo-centric planets through *Aryabhatiya Numerals*.
- iv) To recognize the fact that *these values when converted into sidereal periods of each planet agreeing with their present-day values*.

Introduction: -

Aryabhata-I excelled in devising an innovative method for expressing huge numbers through Sanskrit alphabets, specifying the place-value of each digit in base ten. The rule for *Aryabhata Numeral* is very brief and reads thus; [Ref.: “Aryabhatiya of Aryabhata With the commentary of Bhaskara-I and Someswara” – K S shukla, INSA, (1976) P.7]

Siderial period of heavenly bodies are expressed in the form of slokas, where in Aryabhata has used compound alphabets as numerals, in a unique way to indicate them.

Lesson 3. 3. 1 : *Aryabhatiya Numerals* (A.D. 499)

3. 3. 1 a) Rule for *Aryabhatiya Numerals*.

[Note: - This article is prepared using ‘Baraha Unicode’ software.]

ABOUT THIS ARTICLE: - As a faculty of ‘*International Academy for Creative Teaching (under Jain Group of Institutions, Bengaluru)*’ conducting workshops for Teachers of a few schools in Coimbatore during 2003 – 2009, I faced difficulty in sharing the contributions of Indian mathematicians, specially of Aryabhata-I (5th c. AD) with those teachers (who are not familiar with *Devnagari* Script). Scripts of any language are *cryptic symbols* for the sounds needed in writing them to communicate with the public.

Certificate Course on
“*Indian Mathematics*”
Draft Syllabus

2

Compiled by Venkatesha Murthy, Dean-Math, *ī*ACT, Bangalore

My paper, an attempt to adapt modified Tamizh script to Devnagari script explaining Cryptic numeral of Arybhata-I (5th c. AD), expressing the number of revolutions in a *Mahayuga* (43,20,000 years) stated in his Arybhatiya, was blessed by Prof. P V Arunachalam, [vice-chancellor, Dravidian University, Kuppam (AP)] with his kind remark with a suggestion 'I am delighted to have gone through the 11-page scholarly article . It merits reading again and again. Congrats. I request you to do the same in Telugu script also. You have done a splendid job'.

Introduction: - Base ten place-value system having ten digits from 1 to 9 and 0 for number reckoning is the universally acclaimed invention by the visionaries of ancient India. Since then, numerals of numbers were written using the rule

“अङ्कानाम् वामतो गतिः”

Purport: - **The digits** (in the numeral of a number) **move** '(increase) **towards left** (in multiples of the base)'.
Cryptic numerals using words and alphabets were popular in Sanskrit texts to denote numbers in rhythmic *slokas* for easy memorization.

Aryabhata-I (5th c. AD) has named the names of nine place values, thus;

एकं च दशं च शतं च सहस्रमयुतानियुते तथा प्रयुतं ।
कोट्यर्बुदं च वृन्दम् स्थानात् स्थानं दशगुणं भवेत् ॥

Purport: - The ten names in the multiples of 10 are; एकं(10^0), दशं(10^1), शतं(10^2), सहस्रं(10^3) अयुतं(10^4), नियुतं(10^5), प्रयुतं(10^6), कोटि(10^7), अर्बुदं(10^8), वृन्दं(10^9).

And *Aryabhata-I* invented a unique *cryptic numerical system* adapting *Devnagari alphabets* to denote the astronomical numbers for the *number of revolutions of Geo-centric planets in a Mahayuga* (43,20,000 yrs).

I. Rule for *Aryabhatiya Devanagari Varnamala Cryptic Numerals* : -

वर्गाक्षराणि वर्गऽवर्गऽवर्गाक्षराणी कात् इमौ यः ।

खद्विनवके स्वरा नव वर्गऽवर्गं नवान्त्यवर्गं वा ॥

वर्गाक्षराणि वर्गऽवर्गऽवर्गाक्षराणी कात् इमौ यः ।

खद्विनवके स्वरा नव वर्गऽवर्गं नवान्त्यवर्गं वा ॥

Purport: - (1) Consonant, व्यञ्जन (a) मूल-वर्गाक्षर (मूल-वर्गाक्षर) from क् [(to म् (म्)] has numerical value from 1 (to 25) and (b) मूल-अवर्गाक्षर, (मूल-अवर्गाक्षर) from य् [(to ङ्)] has numerical value from 3 (to 10) to denote numbers.

(2) Vowels, स्वराक्षर (स्वराक्षर) (अ, इ, उ, ऋ, लृ, ए, ओ, ऐ, औ; अ, इ, उ, ए, ओ, ऐ, औ; अ, इ, उ, ए, ओ, ऐ, औ) specify two sets of nine zeros of powers of 10 (i) one set of nine even number of

powers of 10 zeros to follow ಮೂಲ-ವರ್ಗಾಕ್ಷರ (ಮೂಲ-ವರ್ಗಾಕ್ಷರ) and (ii) another set of nine odd number of powers of 10 zeros to follow ಮೂಲ-ಅವರ್ಗಾಕ್ಷರ (ಮೂಲ-ಅವರ್ಗಾಕ್ಷರ).

The above rules could be explained with Tables: -

(1)(a). ಮೂಲ-ವರ್ಗಾಕ್ಷರ (ಮೂಲ-ವರ್ಗಾಕ್ಷರ) from ಕ್ (ಕ್) to ಮ್ (ಮ್) denote numbers from 1 to 25 sequentially.

(i) ಮೂಲ-ವರ್ಗಾಕ್ಷರ (ಮೂಲ-ವರ್ಗಾಕ್ಷರ) from ಕ್ (ಕ್) to ಜ್ (ಜ್) denotes numbers from 1 to 10 sequentially.

Table I. 1(a)(i)

ಕ್ ನಿಂದ ಜ್ ವರೆಗೆ ಆರ್ಯಭಟೀಯ ಗುಪ್ತ ಸಂಖ್ಯೆ										
Time New Roman Numerals	1	2	3	4	5	6	7	8	9	10
Time New Roman Cryptic Numerals	k	K	g	G	~g	c	C	j	J	~j
ವರ್ಗಾಕ್ಷರ (Mangal)	ಕ್	ಖ್	ಗ್	ಘ್	ಙ್	ಚ್	ಛ್	ಜ್	ಝ್	ಞ್
ವರ್ಗಾಕ್ಷರ (Nirmala UI)	ಕ್	ಖ್	ಗ್	ಘ್	ಙ್	ಚ್	ಛ್	ಜ್	ಝ್	ಞ್

(ii). ಮೂಲ-ವರ್ಗಾಕ್ಷರ (ಮೂಲ-ವರ್ಗಾಕ್ಷರ) from ಟ್ (ಟ್) to ಮ್ (ಮ್) denote numbers from 11 to 25 sequentially.

Table I. 1(a)(ii)

ಟ್ = 11 ನಿಂದ ಮ್ = 25 ವರೆಗೆ ಆರ್ಯಭಟೀಯ ಗುಪ್ತ ಸಂಖ್ಯೆಗಳು															
Times New Roman Numbers	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Time New Roman Cryptic Numerals	T	Th	D	Dh	N	t	th	d	dh	n	p	P	b	B	m
ವರ್ಗಾಕ್ಷರ (Mangal)	ಠ್	ಠ್	ಙ್	ಠ್	ಠ್	ಠ್	ಠ್	ಠ್	ಠ್	ಠ್	ಠ್	ಠ್	ಠ್	ಠ್	ಠ್
ವರ್ಗಾಕ್ಷರ (Nirmala UI)	ಟ್	ಠ್	ಠ್	ಠ್	ಠ್	ಠ್	ಠ್	ಠ್	ಠ್	ಠ್	ಠ್	ಠ್	ಠ್	ಠ್	ಠ್

I (b). ಮೂಲ-ಅವರ್ಗಾಕ್ಷರ (ಮೂಲ-ಅವರ್ಗಾಕ್ಷರ) from ಯ್ (ಯ್) to ಹ್ (ಹ್) denote numbers from 3 to 10 sequentially.

Table I (b)

Aryabhatiya Cryptic Numerals in Devnagari & ಕನ್ನಡ from ಯ್ =3 to ಹ್ = 10									
Times New Roman Numbers	3	4	5	6	7	8	9	10	
Time New Roman Cryptic Numerals	y	r	l	v	S	Sh	s	h	
ವರ್ಗಾಕ್ಷರ (Mangal)	ಯ್	ರ್	ಲ್	ವ್	ಶ್	ಷ್	ಸ್	ಹ್	
ವರ್ಗಾಕ್ಷರ (Nirmala UI)	ಯ್	ರ್	ಲ್	ವ್	ಶ್	ಷ್	ಸ್	ಹ್	

I. (2) Vowels, स्वराक्षर(स्वराक्षर) (अ, इ, उ, ऋ, लृ, ए, ओ, ऐ, औ; अ, इ, ए, उ, ऋ, लृ, ए, ओ, ऐ, औ; अ, इ, उ, ऋ, लृ, ए, ओ, ऐ, औ) specify two sets of nine zeros (in multiples of 10),

I. (2) (i) Number of zeros to follow the numerals of मूलवर्गाक्षर from क् to म् (मूल-वर्गाक्षर क् निन्द म् वरगे) with vowels, स्वराक्षर (स्वराक्षर) (अ, इ, उ, ऋ, लृ, ए, ओ, ऐ, औ; अ, इ, ए, उ, ऋ, लृ, ए, ओ, ऐ, औ) are denoted with one group of nine sets of even number of multiples of ten zeros (from 2 to 16)..

(ii) Number of zeros to follow the numerals of मूलअवर्गाक्षर from य् to ह् (मूल-अवर्गाक्षर य् निन्द ह् वरगे) with vowels, स्वराक्षर (स्वराक्षर) (अ, इ, उ, ऋ, लृ, ए, ओ, ऐ, औ; अ, इ, ए, उ, ऋ, लृ, ए, ओ, ऐ, औ) is denoted with another group of nine sets of odd number multiples of ten zeros (from 1 to 17).

Modified Rule of Rule I. (2) (i) & (ii): -

(i) Place-values in powers of ten of the numerals of मूल-वर्गाक्षर from क् to म् (मूल-वर्गाक्षर क् निन्द म् वरगे) with vowels, स्वराक्षर (स्वराक्षर) अ is 0, and with svara (इ, उ, ऋ, लृ, ए, ओ, ऐ, औ; अ, इ, ए, उ, ऋ, लृ, ए, ओ, ऐ, औ) with vowels, स्वराक्षर (स्वराक्षर) (अ, इ, उ, ऋ, लृ, ए, ओ, ऐ, औ; अ, इ, ए, उ, ऋ, लृ, ए, ओ, ऐ, औ) are denoted with one group of nine sets of *even powers of ten* (starting from the index 2 to 16).

(ii) Place-values in powers of ten of the numerals of मूल-अवर्गाक्षर from य् to ह् (मूल-अवर्गाक्षर य् निन्द ह् वरगे) with vowels, स्वराक्षर (स्वराक्षर) (अ, इ, उ, ऋ, लृ, ए, ओ, ऐ, औ; अ, इ, ए, उ, ऋ, लृ, ए, ओ, ऐ, औ) are denoted with another nine sets of *odd powers of ten* (starting from the index 1 to 17).

I. 2(i) Place values in powers of 10 of the numerals of मूलवर्गाक्षर from क् to म् (मूल-वर्गाक्षर क् निन्द म् वरगे) is denoted with one group of eight sets of *even powers of ten* (starting from the index 0 to 16).

(ii) Place values in powers of 10 of the numerals of मूलअवर्गाक्षर from य् to ह् (मूल-अवर्गाक्षर य् निन्द ह् वरगे) is denoted with another nine sets of *odd powers of ten* (starting from the index 1 to 17).

Table I. 2

Place-values in powers of ten to each of ಮೂಲ-ವರ್ಗಾಕ್ಷರ ಅಥವಾ ಮೂಲ-ಅವರ್ಗಾಕ್ಷರ									
Vowels of Dev, Telugu. (Times New Roman)	a	i	u	Ru	lRu	E	O	ai	au
स्वराक्षर	अ	इ	उ	ऋ	ॠ	ए	ओ	ऐ	औ
ಸ್ವರಾಕ್ಷರ	ಅ	ಇ	ಉ	ಋ	ೠ	ಏ	ಓ	ಐ	ಔ
Place-values in powers of ten to each of ಮೂಲ-ವರ್ಗಾಕ್ಷರ	10^0	10^2	10^4	10^6	10^8	10^{10}	10^{12}	10^{14}	10^{16}
Place-values in powers of ten to each of ಮೂಲ-ಅವರ್ಗಾಕ್ಷರ	10^1	10^3	10^5	10^7	10^9	10^{11}	10^{13}	10^{15}	10^{17}

ಲೃ ಸ್ವತಂತ್ರ ಗುಣಿತಾಕ್ಷರ ಆದಾಗ; [ಲೃ = (ಲ್ . ಮು)] = $(5 \times 10^7) = 5, 00,00,000$.

ಉದಾಹರಣೆಗೆ, “ಶಶಿ ಚಯಗಿಯಿಜುಶುಛೃಲೃ” ವಿನಲ್ಲಿ ಲೃ ಗುಣಿತಾಕ್ಷರ.

ಸ್ವರಾಕ್ಷರ ಲೃ ವನ್ನು ಮೂಲ-ವರ್ಗಾಕ್ಷರಗಳು ಅಥವಾ ಮೂಲ-ಅವರ್ಗಾಕ್ಷರಗಳ ಜೊತೆಗೆ ಗುಣಿತಾಕ್ಷರದಲ್ಲಿ ಬಳಸಿರುವ ಉದಾಹರಣೆ ವಿರಳ.

(Ref. page 8 in this paper)

II. (i) ಮೇಲಿನ ವಿಷಯಗಳ ಸ್ಪಷ್ಟೀಕರಣ: -

‘ಜೃ ಯಃ’ ಎಂದರೆ ಜೃ = ಯ
 $ಜೃ = [(ಜ್ + ಮ್) . ಅ] = [(5 + 25) \times 1] = [30 \times 1] = [3 \times (10^1)]$
 $= ಯ = [(ಯ್) . ಅ] = [3 \times (10^1)]$

ಮೂಲ-ವರ್ಗಾಕ್ಷರ ಕ್ ನ ಗುಪ್ತಸಂಖ್ಯೆ = 1. ಆದ್ದರಿಂದ ಮೂಲ-ವರ್ಗಾಕ್ಷರ ಕ್ ನಿಂದ ಮ್ ವರೆಗಿನ ಗುಪ್ತಸಂಖ್ಯೆಗಳು ಕ್ರಮವಾಗಿ 1 ರಿಂದ 25.

ಗುಣಿತಾಕ್ಷರ ಕ ನಿಂದ ಮ್ ವರೆಗಿನ ಸ್ಥಾನಬೆಲೆ ಹತ್ತರ-ಘಾತದ ಸೊನ್ನೆಗಳ ಸಂಖ್ಯೆ, ಕ್ರಮವಾಗಿ 0 ಯಿಂದ ಸಮ-ಸಂಖ್ಯೆಯ ಸೊನ್ನೆಗಳು.

ಮೂಲ-ಅವರ್ಗಾಕ್ಷರ ಯ್ ನ ಗುಪ್ತಸಂಖ್ಯೆ = 3. ಆದ್ದರಿಂದ ಮೂಲ-ಅವರ್ಗಾಕ್ಷರ ಯ್ ನಿಂದ ಹ್ ವರೆಗಿನ ಗುಪ್ತಸಂಖ್ಯೆಗಳು ಕ್ರಮವಾಗಿ 3 ರಿಂದ 10.

ಗುಣಿತಾಕ್ಷರ ಯ ನಿಂದ ಹ್ ವರೆಗಿನ ಸ್ಥಾನಬೆಲೆ ಹತ್ತರ-ಘಾತದ ಸೊನ್ನೆಗಳ ಸಂಖ್ಯೆ, ಕ್ರಮವಾಗಿ 1 ರಿಂದ ಬೆಸ-ಸಂಖ್ಯೆಯ ಸೊನ್ನೆಗಳು.

(ii) ಮೇಲಿನ ವಿವರಣೆಗಳಿಂದ ನಿರೂಪಿತವಾದ ನಿಯಮಗಳು;

ನಿಯಮ ೧: ಯಾವುದೇ ವ್ಯಂಜನದೊಡನೆ ಸ್ವರವು ಸೇರಿದಾಗ, ಗುಣಿತಾಕ್ಷರವಾಗುತ್ತದೆ. ಆಗ ಅವುಗಳು ನಿರೂಪಿಸುವ ಸಂಖ್ಯೆಗಳನ್ನು ಗುಣಿಸಬೇಕು. [ಗುಣಿತ = ಗುಣಿಸುವಿಕೆ]

ಉದಾಹರಣೆ: ವಿ = (ವ್ x ಿ) = (ವಿ) = (ವ್ x ಇ) = $(6 \times 1000) = (6 \times 10^3) = 6000$.

ನಿಯಮ ೨: ಯಾವುದೇ ವ್ಯಂಜನದೊಡನೆ ವ್ಯಂಜನವು ಸೇರಿದಾಗ, ಸಂಯುಕ್ತಾಕ್ಷರ ವಾಗುತ್ತದೆ.

ಆಗ ಅವುಗಳು ನಿರೂಪಿಸುವ ಸಂಖ್ಯೆಗಳನ್ನು ಕೂಡಬೇಕು. [ಸಂಯುಕ್ತ = ಕೂಡುವಿಕೆ]

ಉದಾಹರಣೆ: ಜೃ = [(ಜ್ + ಮ್) . ಅ] = [(5 + 25) \times 1] = [30 \times 1] = (30).

Number of revolutions made by (Geo-centric) Planets in a Yuga (= 43,20,000 years) mentioned in Aryabhataiya through the Devnagari script are only Cryptic.

The same Cryptic words may be adapted to other language scripts, and describe the values of *number of revolutions of Geo-centric Planets in a mahayuga* stated in *Aryabhataiya* of Aryabhata-I (499 AD).

III. Sloka denoting the Number of revolutions of Geo-centric planets in *Aryabhataiya* Cryptic Devnagari Numerals in Devnagari & Kannada: -

युग रविभगणाः ख्युघृ, शशि चयगियिडुशुछृल, शनि दुड्विघ्व, गुरु ख्रिच्युभ,
कुज भद्लिङ्गनुखृ, बुध सुगुशितृन, भृगु जषबिखुछृ ॥ [(2) p.18]

ಯುಗ ರವಿಭಗಣಾಃ ಖ್ಯುಘೃ, ಶಶಿ ಚಯಗಿಯಿಡುಶುಞ್ಞಲ, ಶನಿ ಡುಡ್ವಿಘ್ವ, ಗುರು ಖ್ರಿಚ್ಯುಭ,
ಕುಜ ಭದ್ಲಿಂಗ್ಗನುಖೃ, ಬುಧ ಸುಗುಶಿತ್ರಿನ, ಭೃಗು ಜಷಬಿಖುಞ್ಞ ॥

III. (i) Explanation of Cryptic Devnagari Numerals in Devnagari & Kannada: -

Sun, रवि ; ख्युघृ, ಖ್ಯುಘೃ , 43,20,000,

Moon, सोम ; चयगियिडुशुछृल, ಚಯಗಿಯಿಡುಶುಞ್ಞಲ = 5,77,53,336,

Saturn, शनि ; दुड्विघ्व, ಡುಡ್ವಿಘ್ವ = 1, 46,564,

Jupiter, गुरु ; ख्रिच्युभ, ಖ್ರಿಚ್ಯುಭ = 3,64,224,

Mars, कुज (मङ्गळ) ; भद्लिङ्गनुखृ = 22, 96,824,

Mercury, बुध ; सुगुशितृन ; ಸುಗುಶಿತ್ರಿನ = 1,79,37,020,

Venus, भृगु ; जषबिखुछृ , ಜಷಬಿಖುಞ್ಞ = 70,22,388.

III (ii). Expansion of Cryptic Devnagari Numerals in Devnagari & Kannada:

These numerical values could be verified by the application of the above *Aryabhataiya* Cryptic numeral system adapted to Kannada Script.

Sun, रवि ; ख्युघृ, ಖ್ಯುಘೃ ; 43,20,000;

$$\begin{aligned} \text{ख्युघृ} &= (\text{ख} \times 3) + (\text{य} \times 3) + (\text{घ} \times ३) \\ \text{ಖ್ಯುಘೃ} &= (\text{ಖ} \cdot 3) + (\text{ಯ} \cdot 3) + (\text{ಘ} \cdot 3) \\ &= (2 \times 10^4) + (3 \times 10^5) + (4 \times 10^6) = 4320000 \end{aligned}$$

Moon, ಸೋಮ ; चयगियिडुशुछल, ಚಯಗಿಯಿಜುಶುಫ್ಯಲ್ಯ = 57753336;
चयगियिडुशुछल

$$= (च \times अ) + (य \times अ) + (ग \times इ) + (य \times इ) + (इ \times उ) + (श \times उ) + (छ \times ऋ) + (ल \times ऋ)$$

ಚಯಗಿಯಿಜುಶುಫ್ಯಲ್ಯ

$$= (ಚ್.ಅ) + (ಯ್.ಅ) + (ಗ್.ಇ) + (ಯ್.ಇ) + (ಜ್.ಉ) + (ಶ್.ಉ) + (ಛ್.ಋ) + (ಲ್.ಋ)$$

$$= (6 \times 10^0) + (3 \times 10^1) + (3 \times 10^2) + (3 \times 10^3) + (5 \times 10^4) + (7 \times 10^5) + (7 \times 10^6) + (5 \times 10^7)$$

$$= 57753336$$

Saturn, शनि ; ढुड्विघ्न, ಡುಜ್ವಿಘ್ನ = 1, 46,564,

$$\text{ढुड्विघ्न} = (ढ . उ) + (इ . इ) + (व . इ) + (घ . अ) + (व . अ)$$

$$\text{ढुज್ವಿಘ್ನ} = (ಢ್ . ಉ) + (ಙ್ . ಇ) + (ವ್ . ಇ) + (ಘ್ . ಅ) + (ವ್ . ಅ)$$

$$= (14 \times 10^4) + (5 \times 10^2) + (6 \times 10^3) + (4 \times 1) + (6 \times 10) = 1,46,564.$$

Jupiter ; गुरु ; खिच्युभ, ಖಿಚ್ಯುಭ = 3,64,224 ;

$$\text{खिच्युभ} = (ख . इ) + (र . इ) + (च . उ) + (य . उ) + (भ . अ)$$

$$\text{ಖಿಚ್ಯುಭ} = (ಖ್ . ಇ) + (ರ್ . ಇ) + (ಚ್ . ಉ) + (ಯ್ . ಉ) + (ಭ್ . ಅ)$$

$$= (2 \times 10^2) + (4 \times 10^3) + (6 \times 10^4) + (3 \times 10^5) + (24 \times 1) = 3,64,224.$$

Mars, कुज (मङ्गळ) ; ಭದ್ರಿಯುನುಖ್ಯ = 22, 96,824

$$\text{भद्लिङ्गनुख} = (भ . अ) + (द . इ) + (ल . इ) + (ङ . उ) + (न . उ) + (ख . ऋ)$$

$$\text{ಭದ್ರಿಯುನುಖ್ಯ} = (ಭ್ . ಅ) + (ದ್ . ಇ) + (ಲ್ . ಇ) + (ಙ್ . ಉ) + (ನ್ . ಉ) + (ಖ್ . ಋ)$$

$$= (24 \times 1) + (18 \times 10^2) + (5 \times 10^3) + (9 \times 10^4) + (20 \times 10^4) + (2 \times 10^6)$$

$$= 22,96,824.$$

Mercury, बुध ; सुगुशित्थन ; ಸುಗುಶಿಥ್ನನ = 1,79,37,020;

$$\text{सुगुशित्थन} = (स् . उ) + (ग् . उ) + (श . इ) + (थ् . ऋ) + (न् . अ)$$

$$\text{ಸುಗುಶಿಥ್ನನ} = (ಸ್ . ಉ) + (ಗ್ . ಉ) + (ಶ್ . ಇ) + (ಥ್ . ಋ) + (ನ್ . ಅ)$$

$$= (9 \times 10^5) + (3 \times 10^4) + (7 \times 10^3) + (17 \times 10^6) + (20 \times 1)$$

$$= 1,79,37,020$$

Venus, भृगु ; जषबिखुछ , ಜಷಬಿಖುಛ = 70,22,388;

$$\text{जषबिखुछ} = (ज् . अ) + (ष् . अ) + (भ् . इ) + (ख् . उ) + (छ . ऋ)$$

$$\text{ಜಷಬಿಖುಛ} = (ಜ್ . ಅ) + (ಷ್ . ಅ) + (ಭ್ . ಇ) + (ಖ್ . ಉ) + (ಛ್ . ಋ)$$

$$= (8 \times 1) + (8 \times 10) + (23 \times 10^2) + (2 \times 10^4) + (7 \times 10^6)$$

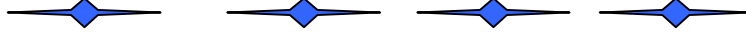
$$= 70,22,388$$

Formulae to convert *Aryabhata's cryptic numerals of the number of revolutions of Geo-centric planets to their sidereal periods are;*

$$\text{Sidereal period} = \frac{43,20,000}{\text{number of revolutions of the planet}} \text{ years}$$

$$\text{Sidereal period} = \frac{43,20,000}{\text{number of revolutions of the planet}} \times 365.26 \text{ days}$$

Comparison of Sidereal periods based on Aryabhata's values of number of revolutions of Geo-centric planets in a Mahayuga (43,20,000 yrs) (5th c AD), with the Present-day Recorded Sidereal periods is really, an astonishing eye-opener about our rich heritage.



Reference: -

1. "A Concise History of Science in India"; D. M. Bose, S. N. Sen, B. V. Subbarayappa, Editors] INSA, New Delhi
2. "Aryabhata, with the commentary of Bhaskara-I and Someswara" :Edited by K S Shukla, INSA, New Delhi, (1976),
3. "Aryabhata, with the commentary of Suryadeva Yajvan" : Edited by K V Sharma, INSA, New Delhi.
4. "From One to Zero - A Universal History of Numbers", Georges Ifra, Viking Penguin Inc. New York (1985).]
5. "भारतीय गणितम्- Indian Mathematics in Sanskrit: Concepts and Achievements" - Venkatesha Murthy, Rashtriya Sanskrit Vidyapeetha (Deemed University), Tirupati - 517 507 (2005).
6. "Bharatiya Ganita Darpana": Venkatesha Murthy, National Institute of Vedic Sciences, # 58, Raghavendra Colony, Chamarajapet, BANGALORE – 560 058.
7. CRYPTIC NUMERALS in SANSKRIT TEXTS : Venkatesha Murthy, National Institute of Vedic Sciences, #58, Raghavendra Colony, Chamarajapet, Bangalore, 560 058, Karnataka (2013)