

Module - 2

Traditional Knowledge in
Humanities and Sciences:
Linguistics, Number and
measurements-Mathematics,
Chemistry, Physics, Art, Astronomy,
Astrology, Crafts and Trade in India
and Engineering and Technology.

Unit 2 of the Indian Knowledge System

Unit 2 of the Indian Knowledge System (IKS), titled "**Traditional Knowledge in Humanities and Sciences**," focuses on the diverse and rich contributions of Indian traditions to various fields of study such as humanities, sciences, arts, and social practices. This unit aims to highlight how Indian scholars and thinkers have shaped and developed various knowledge systems that have been passed down through generations. It emphasizes the value of integrating traditional knowledge with modern perspectives to enrich understanding in both academic and practical domains.

Traditional Knowledge in Humanities and Sciences:

"Traditional knowledge" in the context of humanities and sciences refers to the collective body of knowledge, practices, and beliefs passed down through generations within a community, often deeply rooted in their cultural identity, encompassing areas like agriculture, medicine, environmental management, astronomy, and craft skills, which are typically transmitted orally and are highly adapted to the local environment and ecological conditions; this knowledge can be studied and integrated into academic disciplines across humanities and sciences, providing valuable insights into past practices and potential solutions to contemporary problems.

Key points about traditional knowledge:

Transmission:

Primarily passed down through oral traditions, stories, songs, rituals, and community practices.

Contextual relevance:

Deeply connected to the specific environment and cultural practices of a community.

Disciplinary applications:

Can be studied and integrated into fields like anthropology, ethnobiology, ecology, history, medicine, and even engineering.

Traditional Knowledge in Humanities:

- **Philosophy and Spirituality:** Indian philosophy, particularly through systems like Vedanta, Nyaya, and Buddhism, provides insights into human nature, ethics, and the universe.
- **Literature:** Ancient texts like the Vedas, Upanishads, Ramayana, Mahabharata, and various works in classical Sanskrit, Tamil, and other regional languages form a foundation for the humanities.
- **Art and Aesthetics:** The traditional arts in India—such as music, dance, theater, and painting—have deep philosophical and cultural meanings. Classical dance forms like Bharatanatyam and Kathak have both artistic and spiritual dimensions. Traditional designs and building techniques adapted to the environment.
- **Language and Linguistics:** Local dialects and linguistic practices that reveal cultural understanding. Ancient languages like Sanskrit, Prakrit, and Tamil have rich grammars and linguistic traditions, influencing modern linguistics and literature studies.
- **Folklore and mythology:** Stories and legends that hold cultural knowledge about the natural world, ancestors, and social norms.

Traditional Knowledge in Sciences:

- **Mathematics:** India contributed significantly to mathematics, including the development of zero, the decimal system, and early advancements in algebra and geometry. Ancient Indian mathematicians like Aryabhata, Brahmagupta, and Bhaskara are key figures.
- **Astronomy:** Indian astronomy has a long history, with ancient texts like the *Surya Siddhanta* providing insights into celestial movements. Contributions like the calculation of pi and the understanding of eclipses were early advancements.
- **Medicine (Ayurveda):** The traditional Indian system of medicine, Ayurveda, focuses on the balance of body, mind, and spirit. It has a profound understanding of herbal remedies, nutrition, and treatments that have influenced modern wellness practices.
- **Botany and Agriculture:** Traditional knowledge in agriculture, such as crop rotation, sustainable farming, and medicinal plants, has been passed down through generations. Indian traditional knowledge is also reflected in the ancient text *Sushruta Samhita* on surgery and anatomy.
- **Agriculture:** Indigenous farming practices like crop rotation, water management systems, and selection of resilient plant varieties.
- **Ecology:** Knowledge about plant and animal interactions, weather patterns, and ecosystem management.
- **Astronomy:** Traditional star charts and knowledge of celestial cycles used for navigation and timekeeping

Challenges and considerations when studying traditional knowledge:

Cultural sensitivity:

Respecting the intellectual property rights of communities and ensuring appropriate protocols when accessing and documenting traditional knowledge.

Validation and verification:

Integrating scientific methods to assess the efficacy and accuracy of traditional practices.

Power dynamics:

Recognizing potential imbalances in knowledge exchange between researchers and communities.

Loss of Traditional Knowledge: Modernization, globalization, and colonialism led to the gradual erosion of many traditional practices and knowledge systems. There is a growing need to document, preserve, and revitalize these practices.

Relevance Today: The challenge today is to incorporate traditional knowledge into contemporary systems of education, research, and practice, balancing modern scientific advancements with traditional wisdom.

Revival and Documentation: There is increasing interest in reviving and documenting ancient manuscripts, oral traditions, and systems of knowledge, making them accessible for future generations.

Interdisciplinary Approach:

- **Integration of Knowledge:** Indian traditional knowledge systems often integrated multiple disciplines, such as science, art, and philosophy, providing holistic approaches to understanding life and the universe.
- **Role of Gurus and Texts:** Much of the traditional knowledge was transmitted orally, with scholars and teachers (gurus) passing knowledge to students in gurukulas. Sacred texts, manuscripts, and later printed books became central to preserving this knowledge.

Traditional Knowledge Systems and their Influence:

- **Cultural Preservation:** Traditional knowledge systems helped maintain social order and cultural identity, ensuring that various knowledge streams were passed on and evolved through generations.
- **Sustainability:** Many traditional Indian practices, like water management (step wells, tanks), forest conservation (sacred groves), and organic farming, are examples of sustainability and environmental awareness that were embedded in culture.
- **Global Impact:** Indian traditional knowledge has not only shaped the local but also had a significant influence globally, especially in areas like medicine (Ayurveda), yoga, and spiritual practices.

Linguistics (भाषा विज्ञान)

- Linguistics is a branch of language research that provides a scientific study of a language.
- Language has been the most effective tool for our communication since time immemorial.
- The advancement of knowledge and collaborative working require a common method of communication.
- Language plays this role in a civilized society.

Components of a Language

- Language is a tool used by everyone in a community and it is very difficult to maintain it unchanged.
- Communication is a key to trade, science and technology and societal progress.
- The receptive part of a language deals with the ability of an individual to receive language inputs from multiple sources.
- The productive part of a language is to transmit back to others for their consumption.
- Receptive Skills
 - i. Listening (sound)
 - ii. Reading (script)
- Productive Skills
 - i. Speaking (sound)
 - ii. Writing (script)

Panini's Work on Sanskrit Grammar

- Panini composed 3983 rules to accommodate all the patterns and variations in Sanskrit language.
- The basic approach of Panini and its distinguishing features make Sanskrit a powerful language and eternal in its appeal.
- One of the Vedangas known as Vyakarana focuses on linguistics and phonetics (भाषाविज्ञान और धिन्यात्मकता) aspects of Sanskrit language.
- Astadhyayi is considered a fine creation of human intelligence and the best available descriptive model of a language.

Basic approach of Panini and its features

- The entire vocabulary of the Sanskrit language could be created using the 3983 rules.
- Language processing and word generation are strictly rule-based and derivative in nature.
- The entire scheme for word generation follows a highly modular approach.
- The derivation of words using the rules could be done using step by step process.
- The vocabulary is not fixed or static.

Phonetics (सिंर-क्षान्) in Sanskrit

- Phonetics is the study of sounds in a language, particularly the production of sound in a language and how it communicates the language corresponding to the scripts of the language.
- It also addresses the issue of how the sound is perceived in the language.
- Phonetics in the Sanskrit language has been addressed in some details since this is vital because the ancient Indian knowledge tradition is oral.

Phonetics (सिंर-विज्ञान) in Sanskrit

नासिका (nāsikā)- (Nasal effort): ङ् घ् ण् न् म्

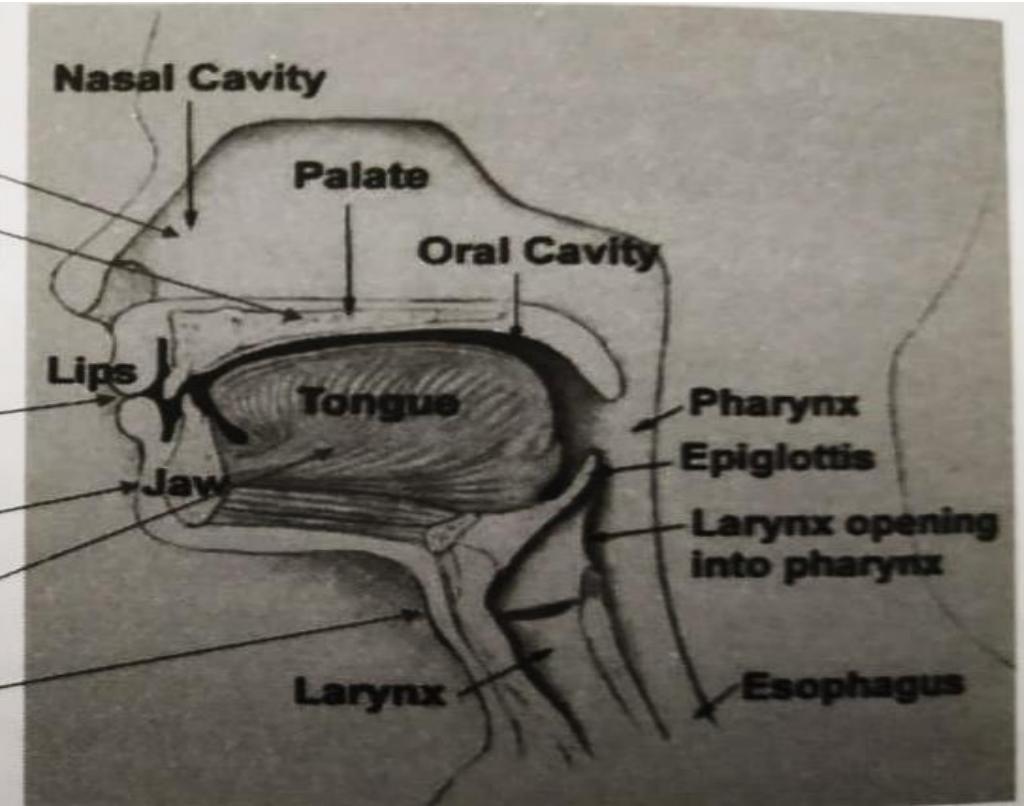
मूर्धा (mūrdhā) - Upper palate: क्ष् ट् ठ् ङ् र् ष्

ओष्ठौ (oṣṭhau) - Lips: उ प् फ् ब् भ् म्

दन्ताः (dantāḥ) - Teeth: लृ त् थ् द् ध् न् ल् स्

तालु (tālu) - Palate: इ च् छ् ज् झ् ज् य् श्

कण्ठः (kaṇṭha) - Throat: अ क् ख् ग् घ् ङ् ॐः ह्



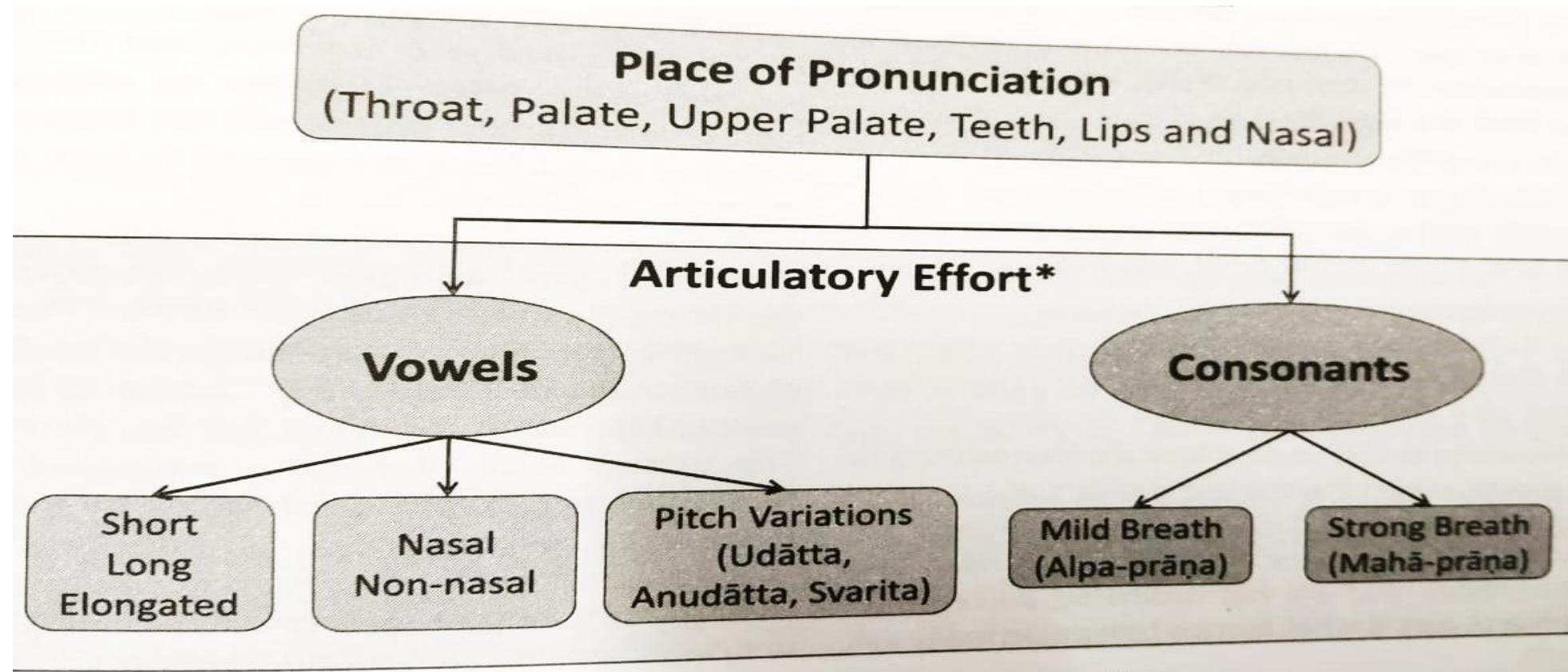
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FIGURE 5.2 Origin of Sound from the Oral Cavity – An Illustration

Phonetics (सिंर-क्षान्) in Sanskrit

- The entire transmission of the Vedas from time immemorial has been possible on account of a well-developed science of phonetics.
- Vowels have a temporal factor in the production of the sound.
- Three variations (short: hrasva, long: dirgha and prolate: pulta) have been specified for the pitch of the vowel sound.

Phonetics (सिंर-क्षान) in Sanskrit



This presents only a partial categorisation of the articulatory effort
FIGURE 5.3 Place of Pronunciation and Articulatory Effort in Sanskrit

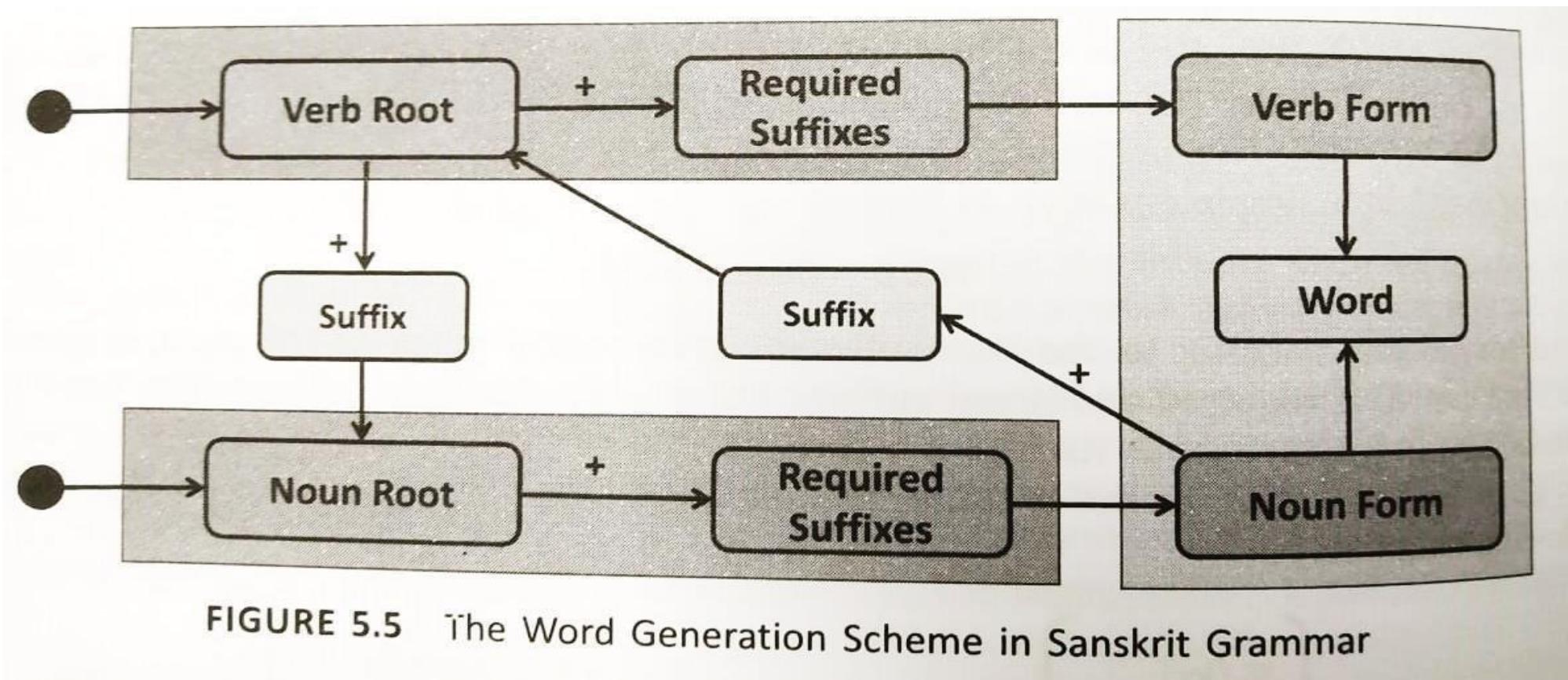
Patterns in Sanskrit Vocabulary

- The ultimate building block of any language is the word.
- The words are combined in several ways to communicate ideas and transact knowledge.
- The word in Sanskrit can be divided into two categories: Noun forms (Known as subanta) and verb forms (known as Tinanta).

Word= Base+ Suffix

- After adding a suffix to the base, relevant grammatical rules are invoked to generate the final word.

Patterns in Sanskrit Vocabulary



Computational concepts in Astadhyayi

- Sanskrit grammar has a robust mechanism to generate an infinite number of words.
- The following are some of the important common aspects seen in a computer language and Panini's rules:
 - i. Vocabulary exclusively meant for his work
 - ii. Abbreviated forms (mnemonics) for brevity and better retention of ideas
 - iii. Exclusive syntax for Astadhyayi
 - iv. An algorithmic approach to word generation
 - v. Recursive logic

Computational concepts in Astadhyayi

TABLE 5.1 The Word Generation Scheme in Sanskrit Grammar – Examples

<i>Base to Generate a Word</i>	<i>Role of the Suffix (pratyaya)</i>	<i>Examples</i>	<i>Remarks</i>
Nominal Root	For generating singular, dual and plural of seven cases of nouns the relevant suffixes are applied.	<p><i>For the nominal root 'राम' (Rāma), we can generate:</i></p> <p>रामः – रामौ – रामा: <i>(Rāmaḥ – Ramau – Rāmāḥ)</i></p> <p>रामेण – रामाभ्यां – रामैः <i>(Rāmena – Rāmābhyaṁ – Rāmaiḥ), etc.</i></p>	Additional suffixes for generating feminine forms can be added.
Verb Root	For generating singular, dual and plural of 1st person, 2nd person and 3rd person of verbs the relevant suffixes are applied.	<p><i>For verbal root 'पठ्' (path) the present tense forms can be generated:</i></p> <p>पठति – पठतः – पठन्ति <i>(paṭhati – paṭhataḥ – paṭhanti)</i></p> <p>पठसि – पठथः – पठथ <i>(paṭhasi – paṭhathah – paṭhatha)</i></p> <p>पठामि – पठावः – पठामः <i>(paṭhāmi – paṭhāvah – paṭhāmah)</i></p>	Relevant suffixes for generating 10 verb forms (6 tenses and 4 moods) can be added.

Mahesvara Sutra

- The entire Sanskrit grammar of Panini rests on a fundamental set of sutras known as Mahesvara Sutras.
- These sutras, 14 in number, present letters of Sanskrit uniquely.
- The first four sutras covers the alphabets in the normal order.
- Sutras 5 to 14 present the consonants in a somewhat obscure order than what are they normally used for.
- Each sutra ends with a termination which is a consonant.

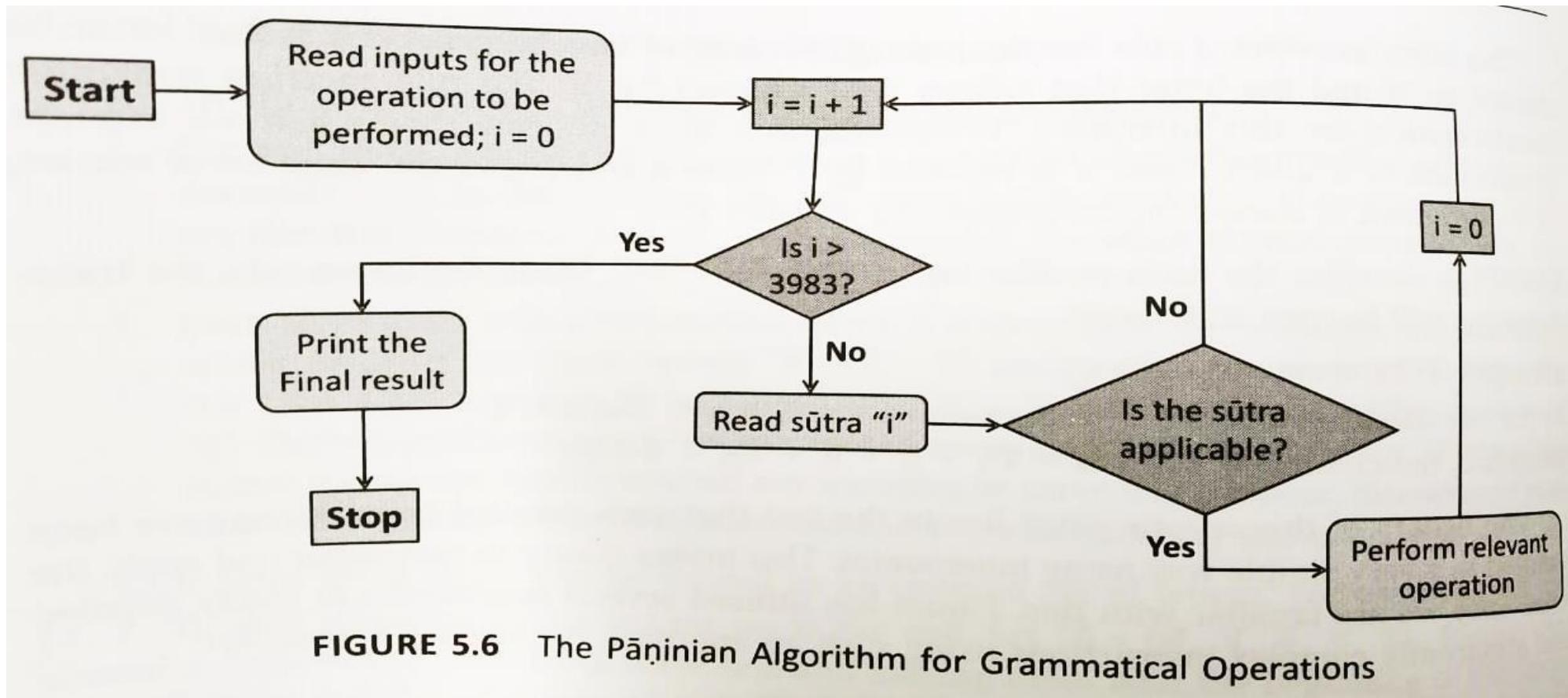
Use of Mnemonics

- In the previous discussion, we saw how the letters were jointly represented using mnemonics obtained out of combining set of letters specified through the Mahesvara sutra.
- Two set of suffixes for generating noun forms and verb forms; these two are concisely represented by two mnemonics sup and tin respectively.

Rule-based Grammatical Operations

- Panini's system of applying grammatical conditions to derive words exactly like a rule-based engine.
- Sutras from different locations of Astadhyayi under various heading come to operate where their conditions are satisfied.
- The final form remaining after all the operations are carried out is the word and it becomes eligible for use.

Rule-based Grammatical Operations



Logic for Sentence Construction

- Words are to be grammatically correct in terms of construction.
- Karaka is a concept that helps to link the words in a sentence to the Kriya (action).
- Kriya and Karaka are the essential elements of any sentence.
- All other elements that are found in a sentence are woven around these two.
- Therefore, for a sentence to be complete there must be a verb, implicit or explicit, denoting an action.

Logic for Sentence Construction

- On the other hand, a verb alone cannot make a meaningful sentence.
- The Sanskrit language uses a concept called karaka to provide in-built mechanisms for constructing unambiguous and grammatically correct sentence.
- A participant involved in the action in some manner is called Karaka.

Logic for Sentence Construction

TABLE 5.2 Issues in Sentence Formation – An Illustration

Sl. No.	Sentence in English	Sentence in Sanskrit
1	The fat boy eats the <i>tasty food</i> with the hand	स्थूलः बालकः स्वादु भोजनं हस्तेन खादति । sthūlah bālakah <i>svādu bhojanam</i> hastena khādati
2	The fat hand eats the <i>tasty food</i> with the boy	स्थूलः हस्तेन खादति स्वादु भोजनं बालकः । sthūlah hastena khādati <i>svādu bhojanam</i> bālakah
3	The fat food eats the <i>tasty hand</i> with the boy	स्थूलः भोजनं खादति स्वादु हस्तेन बालकः । sthūlah <i>bhojanam</i> khādati <i>svādu hastena</i> bālakah
4	The <i>food tasty</i> eats the fat hand with the boy	स्वादु भोजनं खादति स्थूलः हस्तेन बालकः । <i>svādu bhojanam</i> khādati sthūlah hastena bālakah
5	The <i>tasty boy</i> eats the fat food with the hand	स्वादु बालकः खादति स्थूलः भोजनं हस्तेन । <i>svādu bālakah</i> khādati sthūlah <i>bhojanam</i> hastena

Logic for Sentence Construction

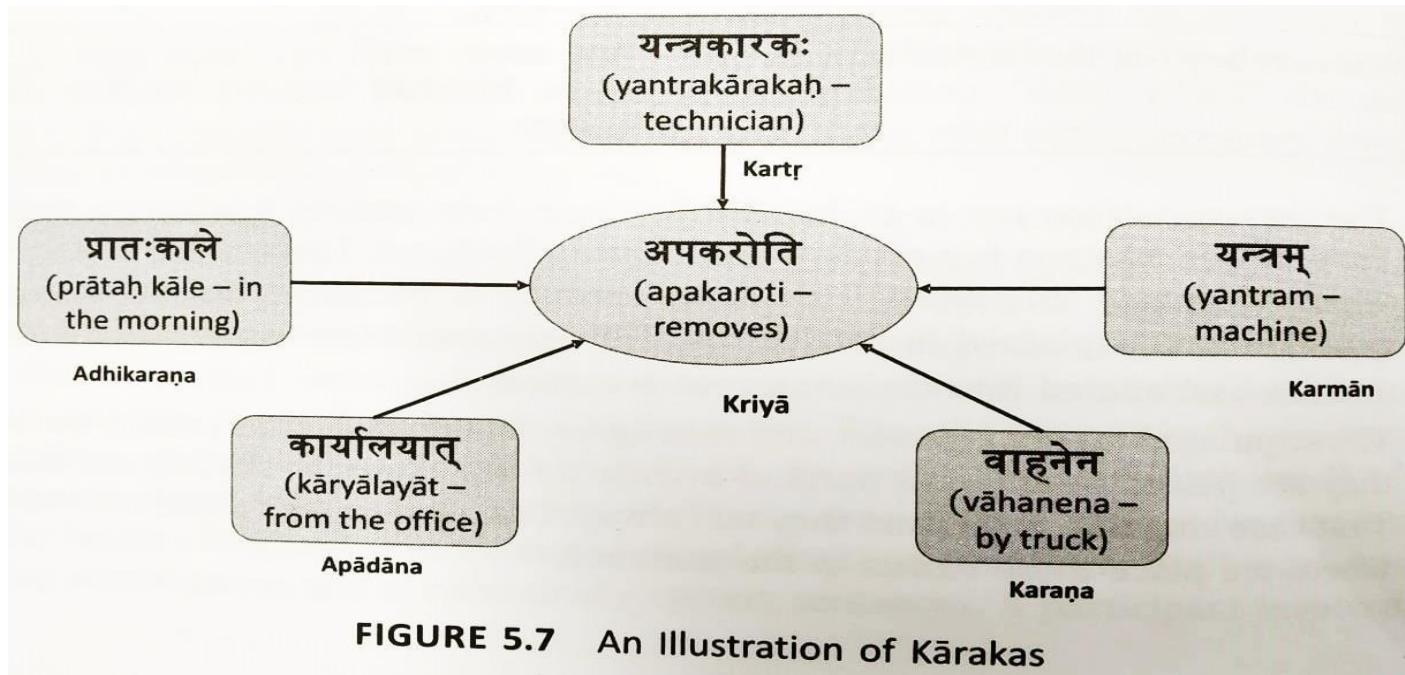
- In order to understand this, let us consider a sentence,
- “The technician removes the machine from the office in the morning with a truck.”
- This sentence can be written in Sanskrit as “yantrakarakah pratah kale yantram vahanena karyalayat apakaroti.”
- The kriya in this sentence is ‘removing’; therefore, every karaka will create a direct link to the kriya.

Logic for Sentence Construction

The six Karaka are related to vibhakits (cases) in Sanskrit. The six karaka (and the corresponding cases) are as follows:

- i. Karta- doer: one in whom the cause of action is resident. (first case)
- ii. Karma- the focus of the result of an action (second case)
- iii. Karana- instrument: That which aids in the attainment of the action. (third case)
- iv. Sampradaya- receiver: That with which the karma desires to get associated. (fourth case)
- v. Apadana- reference point in separation: That which has ability to create division. (fifth case)
- vi. Adhikarana- the locus of the action: That which provides the substratum, context or references to performed through kartr or karma. (sixth case)

Logic for Sentence Construction



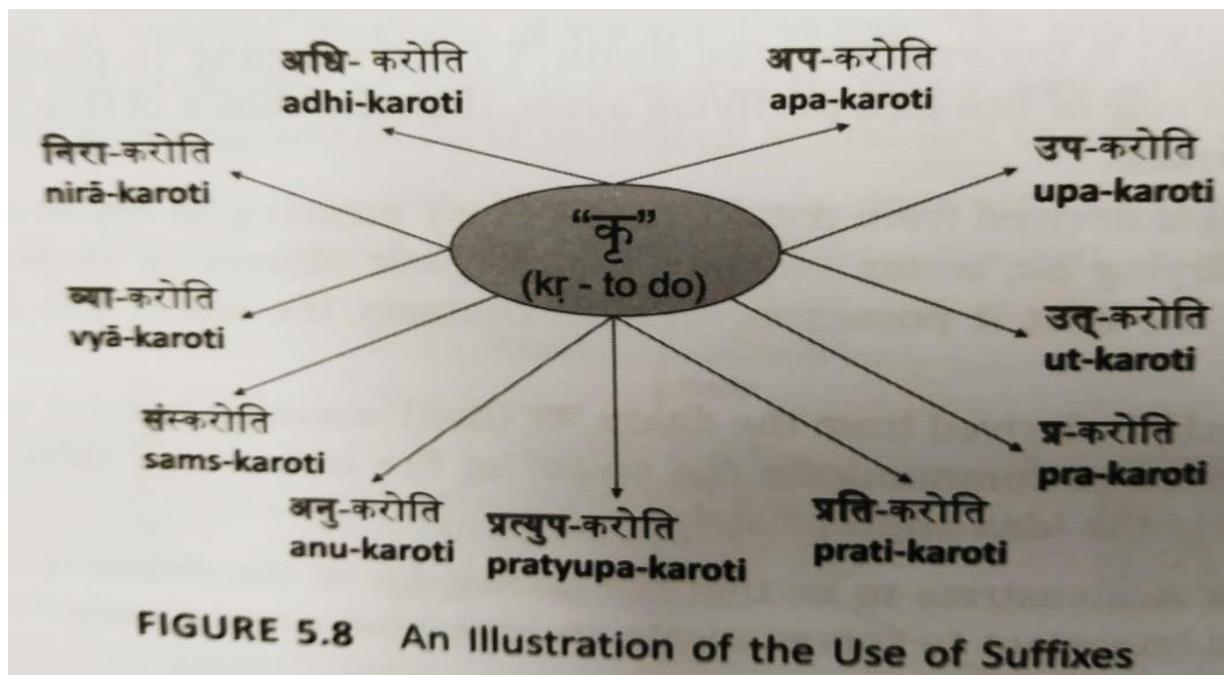
Importance of Verbs

- Language is required when we are in action. If no one is engaged in action, there is no need for language.
- The importance of verbs is further amplified by the fact that several of the noun roots are also derived from the verb roots only.
- Since most words (both verb forms and noun forms) originate from the verb roots (dhatu).
- In Sanskrit, we often find several synonyms for a word; each synonym for a word derived from dhatu.

Prefixes for Verb Forms

- Prefixes, known as upa-sargas, are appended to the verb forms in order to create additional words.
- There are 22 prefixes and one or more of these could be prefixed to a verb form.
- By adding the prefixes, it is possible to express the meaning in many ways.

Prefixes for Verb Forms



Role of Sanskrit in Natural Language

Processing

- Natural Language Processing (NLP) is a branch of linguistics mainly concerned with processing of natural language data using computers and programming techniques.
- The principles of karaka and vibhkti will enable us to distill the components and the encoded information in a sentence.
- Indian linguists have described fourteen determiners to fix the meaning of a word in case of multiple of a word in case of multiple meaning.

Sanskrit in Natural Language

Role of Processing

बाल	सुं	वृक्ष	स्य	फल	अम्	खाद्	ति
bāla	Sū	Vṛkṣa	Sya	phala	am	khād	Ti
boy	-	Tree	of	fruit	karma	To eat	Kartr
Noun base	1st case suffix	Noun base	6th case suffix	Noun base	2nd case suffix	Verb base	Present tense suffix

Number and measurements

Number System in India- Historical Evidence

- Several archaeological excavations provide evidence about maturity and supremacy of Indian mathematical foundations.
- The contribution of ancient Indians to the development of mathematical concepts is well known and acknowledged.
- An inscription on a temple wall in Gwalior dating back to the ninth century CE is considered the oldest recorded example of a zero.
- Still, surviving Sanskrit texts reveal a rich tradition of Indian mathematical discoveries lasting more than 2,500 years.
- In the Early Vedic period (1200–600 bc), a decimal system of numbers was already established in India, together with rules for arithmetical operations (ganita) and geometry (rekha-ganita).

Salient Features of the Indian Numeral System

- The Indian numeral system has a long history; the origin and the evolution of the numbers could be traced from the time of the Vedic period.
- Being an oral tradition, unique and unambiguous names were to be attributed to the numbers.
- The Sanskrit language has unique names for numbers starting from one and going up to very large numbers; the first nine digits have unique names (ekam, dve, trini, catvari, panca, sat, saptam, asta, nava).

Salient Features of the Indian Numeral System

Name	Indian notation	Power notation	Indian system	Short scale Western
एक (<i>ēka</i>)	1	10^0	One	One
दश (<i>daśa</i>)	10	10^1	Ten	Ten
शत (<i>śata</i>)	100	10^2	One hundred	One hundred
सहस्र (<i>sahasra</i>)	1,000	10^3	One thousand	One thousand
लक्ष (<i>lakṣa</i>)	1,00,000	10^5	One lakh	One hundred thousand
कोटि (<i>kōṭī</i>)	1,00,000 śata	10^7	One crore	Ten million
शङ्कु (<i>śariku</i>)	1,00,000 kōṭī	10^{12}	Ten kharab or One lakh crore	One trillion
महाशङ्कु (<i>mahāśariku</i>)	1,00,000 śariku	10^{17}	One shankh or One thousand crore crore	One hundred quadrillion
वृन्द (<i>vṛnda</i>)	1,00,000 <i>mahāśariku</i>	10^{22}		Ten sextillion (ten trilliard)
महावृन्द (<i>mahāvṛnda</i>)	1,00,000 <i>vṛnda</i>	10^{27}		One octillion
पद्म (<i>padma</i>)	1,00,000 <i>mahāvṛnda</i>	10^{32}		One hundred nonillion
महापद्म (<i>mahāpadma</i>)	1,00,000 <i>padma</i>	10^{37}		Ten undecillion
खर्व (<i>kharva</i>)	1,00,000 <i>mahāpadma</i>	10^{42}		One tredecillion
महाखर्व (<i>mahākharva</i>)	1,00,000 <i>kharva</i>	10^{47}		One hundred quattuordecillion
समुद्र (<i>samudra</i>)	1,00,000 <i>mahākharva</i>	10^{52}		Ten sexdecillion
ओघ (<i>ogha</i>)	1,00,000 <i>samudra</i>	10^{57}		One octodecillion
महौघ (<i>mahaugha</i>)	1,00,000 <i>ogha</i>	10^{62}		One hundred novemdecillion

The Concept of Zero and Its Importance

- The concept of zero was established during the period 500-300 BCE.
- Ancient Indians used a decimal System that allowed them to develop a method for handling large numbers.
- Brahmagupta developed a symbol for zero in 628 CE.
- With this invention zero could be used as an independent numeral for computational purposes.

Large Numbers and their representation

- Ancient Indians developed a systematic approach to the number- names that they used to describe large numbers. Three categories of naming conventions were employed to develop the number names in Sanskrit:

All numbers in the digits from 0 to 9 had unique names (sunya, ekam, dve, trini, catvari, panca, sat, sapta, asta, nava).

All numbers in the range of 11 to 99 had an additive principle for naming.

All numbers of higher powers of 10 starting form 10² were named using multiplicative principle using the unit digits as a factor for multiplication.

Unique approaches to Represent Numbers

- Ancient Indian mathematics seamlessly integrated mathematics with literature and poetry.
- We find well developed systems to address this requirement and discuss two of them here:
 - i. Bhuta-Samkhya system is a system of expressing numbers by means of words representing certain entities.
 - ii. Katapayadi system employs a technique to convert the numerals to alphabets using certain rules.

Bhūtasamkhyā (भूतसंख्या) system

- Bhūtasamkhyā (भूतसंख्या) system is a method of recording numbers in Sanskrit using common nouns having connotations of numerical values.
- The method was introduced already in astronomical texts in antiquity, but it was expanded and developed during the medieval period.
- A kind of rebus system, *bhūtasamkhyā* has also been called the “concrete number notation”.

Bhūtasamkhyā (भूतसंख्या) system

<i>Number</i>	<i>Represented by (partial list only)*</i>
0	śūnya, anata, pūrṇa, kha
1	ādi, candra, prithivī, eka
2	aśvin, pairs of limbs, ayana, dvandva, dvi
3	rāma, guṇa, loka, kāla, agni, trinetra
4	veda, śruti, yuga, aśrama, varṇa, samudra, kṛta
5	bhūta, śāstra, bāṇa, pāṇḍava, indriya
6	aṅga, ṛtu, darśana, ṣaṇmukha, ṣaṭ
7	rṣi, adri, svara, dhātu, chandas
8	vasu, bhujāṅga, siddhi, dik, kuñjara, nāga
9	gr̥ha, aṅka, nanda
10	dik, angulī, avatāra, rāvaṇaśiras
11	rudra
12	āditya, rāśi
13	viśva, kāma
14	manu
15	tithi, dina

* For all the items listed, any word from the synonyms may be used

Katapayadi System

- Another System to convert the numerals to words is to associate a number to one or more alphabets.
- Using the alphabets in place of numbers, one can construct words, which by deciphering one alphabet at a time will reveal the number expressed in the word.
- The advantage of such a system lies in representing large numbers using a word, which can be easily remembered.
- This provided a very efficient method of presenting results of complex calculations using number symbols.

Katapayadi System

The assignment of letters to the numerals are as per the following arrangement.

1	2	3	4	5	6	7	8	9	0
ka ක	kha හ	ga ග	gha ඝ	nga ණ	ca ඔ	cha ඡ	ja ජ	jha ඝ	nya අ
ඁ	ං	ඇ	ඉ	ආ	ඇ	ං	ඇ	ආ	ඇ
ta ත S	tha ත O	da ද	dha ද	na න	ta ත	tha ත	da ද	dha ද	na න
ඃ	ං	ඇ	ඉ	ආ	ඃ	ං	ඇ	ආ	ඇ
pa ප	pha එ	ba බ	bha ම	ma ම	-	-	-	-	-
ං	ං	ඇ	ඉ	ආ					
ya ය	ra ර O	la ල	va බ එ	sha එ	sha එ	sa ඒ	ha ඩ	-	-
ඇ	ං	ඇ	ඉ	ආ	ඇ	ඇ	ං	ං	

Measurement For Time, Distance and Weight

- In the ancient Indian literature three fundamental physical measures for quantifying length, time and weight are found.
- There are several sources in the literature specifying units of measurement for these three physical quantities.
- Three generic measures pertaining to length, weight and time could be used to measure physical entities.

Notion of Paramanu

- At the smallest level, there is a fundamental measure called paramanu.
- The measure of Paramanu are as follows:
 - Paramanu (length): 2.88×10^{-7} mm
 - Paramanu (weight): 5.79×10^{-5} g
 - Paramanu (time): 1.31×10^{-5} seconds

Measures for Length

TABLE 6.5 Ancient Indian Measures for Length

Unit	<i>Multiplier of Preceding Unit*</i>	<i>No. of Paramāṇus</i>	<i>Length (in mm)</i>
Paramāṇu-rajas	1	1	2.8778×10^{-7}
Rāmu	7	7	2.0145×10^{-6}
Truti	7	49	1.4101×10^{-5}
Vidhivama-rajas	7	343	9.8709×10^{-5}
Satka-rajas	7	2,401	6.9096×10^{-4}
Ekaśaka-rajas	7	16,807	4.8367×10^{-3}
Go-rajas	7	1,17,649	0.033857202
Likṣi-rajas	7	8,23,543	0.237000411
Sarsapra	7	57,64,801	1.65900288
Vana	7	4,03,53,607	11.61302016
Anguli-parva	7	28,24,75,249	81.29114114

Adapted from Brah, G. (2004). *The Universal History of Numbers II*. Penguin Books, pp. 138–139.

Unit	<i>Multiplier of Preceding Unit*</i>	<i>No. of Angulas</i>	<i>Length (in metre)</i>
Angula	1	1	0.016764
Dhanurṣaṇḍī	8	8	0.134112
Pṛakūpatya-hasta	3	24	0.402336
Dhanus	4	96	1.609344
Gartupatyā-dhanus	1.125	108	1.810512
Goruta	2000	216,000	3621.024
Nojana	4	864,000	14484.096

* The length of an Angula is 16.764 mm as per Indus inch.

Mathematics

Mathematics Vedic Hindus evinced special interest in two particular branches of mathematics, viz. geometry and astronomy. Sacrifice was their prime religious avocation. Each sacrifice had to be performed on an altar of prescribed size and shape. They were very strict regarding this and thought that even a slight irregularity in the form and size of the altar would nullify the object of the whole ritual and might even lead to an adverse effect. So the greatest care was taken to have the right shape and size of the sacrificial altar. Thus originated problems of geometry and consequently the science of geometry. The Chandogya Upanisad mentions among other sciences the science of numbers. In the Mundaka Upanisad knowledge is classified as superior and inferior. The term ganita, meaning the science of calculation, also occurs copiously in Vedic literature.

Post-Vedic Mathematics

In India, a substantial part of mathematics developed as a sequel to astronomical advancement; and it is no accident that the bulk of post-Vedic mathematics has been found only in association with the Siddhantas, a class of astronomical works. Jaina priests showed remarkable interest in the study and development of mathematics. They devoted one of the four branches of Anuyoga (religious literature) to the elucidation of ganitanuyoga (mathematical principles) and prescribed proficiency in samkhyana (science of calculation) and jyotisa (astronomy) as an important prerequisite of the Jaina priest. An idea as to the various mathematical topics discussed at this early age and recognized in later Jaina mathematical works such as the Ganitasarasangraha of Mahavira (A.D 850) and Ganitatilaka of Sripati (A.D. 999) may be obtained from an extant passage in the Sthananga-sutra (1 st Cent. B.C.). This passage enumerates: parikarma (fundamental operations), vyavahara (determination), raju (geometry), kalasavarna (fraction), yavat-tavat (linear equation), varga (quadratic equation), ghana (cubic equation), vargavarga (biquadratic equation), and vikalpa (permutations and combinations).

Arithmetic Decimal Place-value Numeration:

At first, from the Vedic times the basis of numeration in India has consistently been ten. Long lists of names for several decimal places are found in the sacred literatures of the Hindus, Jains, and Buddhists. The Vajasaneyi, Taittiriya, Maitradyani, and Kathaka Samhitas give denominations up to 13 places, e.g. eka (1), daja (10), sata (100), sahasra (1000),.. .samudra, madhya, anta, and pardrdha. Buddhist literature continued the same tradition and introduced a centesimal scale (Jatottara-ganana), obtaining the name talaksana for the 54th place. The Jains in the Anuyogadvara-sutra (c. 100 B.C.) called the decimal places ganana-sthana, gave a numerical vocabulary analogous to that of the Brahmanic literature, and mentioned fantastically large numbers up to 29 places and beyond.

Algebra

The differentiation of algebra as a distinct branch of mathematics took place from about the time of Brahmagupta, following the development of the techniques of indeterminate analysis (kuttaka). In fact, Brahmagupta used the terms kuttaka and kuttakaganita to signify algebra. The term bijaganita, meaning _the science of calculation with elements or unknown quantities' (bija), was suggested by Prthudakasvamin (A.D 860) and used with definition by Bhaskara II. Brahmagupta gave the following classifications: (1) ekavarna-samikarana-equations in one unknown, comprising linear and quadratic equations; (2) aneka-varnasamikarana-equations in many unknowns; and (3) bhavita-equations containing products of unknowns. Quadratic Equations: The Sulabhasutras contain problems involving quadratic equations.

Geometry, Trigonometry, Calculus

Problems receiving geometrical treatment were discussed under such topics as ksetra (plane figures), khata (excavations or cubic figures), citi (piles of bricks), krakaca (saw problems or cubic figures), and chaya (shadows dealing with problems of similarities and proportions). This mode of treatment continued up to the time of Bhaskara II or even later. But it was not until the beginning of the eighteenth century that Euclid's Elements was translated into Sanskrit by Jagannatha (A.D 1652) under the title of the Rekhaganita. **Trigonometry** was developed as an integral part of astronomy. Without its evolution many of the astronomical calculations would not have been possible. Three functions, namely, jyat kojya (also kotijya), and utkramajya, were used and defined in ancient times.

Calculus: Rudimentary ideas of integration and differentiation are found in the works of Brahmagupta and Bhaskara II. Bhaskara II, in particular, determined the area and volume of a sphere by a method of summation analogous to integration

Chemistry in IKS

eir alloys. In ancient India, chemistry had various names i.e., Rasāyana Śāstra, Rasatantra, Rasakriyā or Rasavidyā. It included metallurgy, medicine, manufacture of cosmetics, glass, dyes, inks, etc. Ancient Indians applied that knowledge of chemistry in various walks of life. The major chemical arts and crafts in early period were pottery, jewellery making, dying of cloths, tanning of leather, glass making, etc. Several evidences are available in favour of these in literature and many have been obtained from archaeological excavations.

Indus Valley people used a number of minerals for a variety of purposes. Archaeological findings show that baked bricks were used in the construction work. Gypsum cement has been used in the construction work in which lime, sand and traces of CaCO_3 have been found. Archaeological evidences show the mass production of pottery in Indus Valley Civilisation or the Harappan culture, which can be regarded as the earliest chemical process in which materials were mixed, moulded and subjected to fire to achieve desirable qualities.

Chemistry in IKS

There is a vast alchemical literature, authored by savants such as Nāgārjuna, Govinda Bhāgavat, Vāgbhata, Somadeva, Yaśodhara, among many others. The rasaśāstra texts discuss many chemical substances and their interactions. They were categorized as follows (with some variations):

- Mahārasas or eight major substances: mica, tourmaline, copper pyrite, iron pyrite, bitumen, copper sulphate, zinc carbonate, and mercury (sometimes lapis lazuli and magnetite or lodestone are included);
- Uparasas or eight minor substances: sulphur, red ochre, iron sulphate, alum, orpiment (arsenic trisulphide), realgar (arsenic sulphide), collyrium (compounds of antimony), and tinstone or cassiterite (tin dioxide).
- Navaratna's or nine gems, including pearl, topaz, emerald, ruby, sapphire and diamond;
- dhatus or seven metals: gold, silver, copper, iron, lead, tin, zinc; a few alloys (such as brass, bronze and combinations of five metals) were also included;
- poisons (visha or garala) and plants; among the latter, over 200 are named in the texts (their identification is not always certain); plants were required, in particular, to treat or 'digest' metals and minerals.

Physics in IKS

From the 19th century to the 21st century everyone knows John Dalton who is credited with the development of atomic theory. But today in this era a very few people know that the atomic theory was originated about 2,600 years ago by an Indian sage and philosopher.

It is believed that the sage lived between the 6th century to 2nd century BCE. It was Rishi Kanada, an Indian philosopher who drafted the ideas about the atom in a systematic manner. His real name was to be known as "Kashyap". Since his childhood, even small things tempted his attention. He is being called as the father of the atomism, who propounded the parmanu (atoms), an approach to physics and philosophy in the approach to physics and philosophy in the Sanskrit text "Vaisesika Sutra".

Kanada's statements about physics are central that is knowable which is based on motion. His imputation to physics is the understanding of the universe which follows from his invariance principles.

His primary area of study was Rasavadam, which is known to be a type of alchemy. He said that he presumed that all living beings are composed of 5 elements: water, fire, earth, air, and ether. He proposed that Gurutva (Hindi/Sanskrit for gravity) was responsible for the earth, rising of fire and heat upwards, the growth of grass, the natural rainfall, and thunderstorm. He then attempted to apply his observations with his theories on atoms, molecules, and their interaction. This atom between the 5th and 3rd centuries BC, the atom is mentioned in the Bhagavad Gita (chapter 8).

Physics in IKS

People in ancient times were well aware about electricity. Electricity has been cited in the 5 th Mandal of Rigveda.

Example: Oh people! The day and night can be spent in comfort, if electricity and fire, just like the Sun God are used tactically. सुपेशसं द्वाव सृजन्तत्यस्तं गवां सहस्रैरुशासो अग्ने । तीक्रा इन्तरङ्गन्त्वुः सुतासोऽक्तौव्यमुष्टौ परितक्मर्मयायादुः ॥ ऋग्वे – ष.४३०.१३

The three main sources of Light and Energy mentioned in the Rigveda are: 1. The Sun 2. Electricity 3. Fire inside the Earth त्री रोचना वरुण त्रीरुत द्युन्त्रीणण मित्र धारयथो रजांमि । वावधृ ानावयततां क्षत्रत्रयस्थानुव्रतिरक्षिणावजुयिय ०॥ ऋग्वेद ५.६९.१

Different kinds of electricity

- TADITA (तडित) – Generated by rubbing silk cloths
- SAUDĀMINĪ (सौदाडिनी) – Generated by rubbing two gems
- VIDYUT (डिद्युत) – Generated from thunder
- ŚATAKUMBHĪ (शतकुंभी) – Generated by hundred cells of pillars (Kumbha's)
- HRDANI (हृदनी) – Stored electricity with portable properties
- AŚANI (अशनी) – Generated from magnetic rods (P. P. Hole –Machines in Samskrit Literature)

The two technical terms 'Rayi' and 'Prāṇa' are used to mean 'Positive' and 'Negative' charges in ancient language. These are always in compound state together naturally. The compound state of these two are collectively called Electricity.

Physics in IKS

- Laws of Motion: Invention of laws of motion There are two great scientists behind the invention of law of motion: (1) Rishi Kanada and (2) Sir Isaac Newton (1643-1727). The Rishi Kanada's Vaisheshika Sutra [5, 6, 11] Mahrshi Kanada mentioned karma is related to motion, and there five types of motion: 1) Upward Motion 2) Downward Motion 3) Motion due to release of tensile stress 4) Shearing stress 5) General motion.

Matter States: On an interesting note, the above-mentioned value of Paramaanu corresponds to the organic molecular size as estimated by the modern western scientists. As mentioned in the Upanishads, the five elements of the nature are - • Earth • Water • Air • Fire and • Akasa

However, the concept of Akasa was missing amongst the ancient Greek or Roman philosophers. It was quite easy to deduce the role of the remaining four elements as –

- The Earth represents the solid state • The Water constitutes the liquid state • The Air forms the gaseous state and • The Fire constitutes of the plasma as the fourth state of matter.

Art in IKS

Indian art consists of a variety of art forms, including [painting](#), [sculpture](#), [pottery](#), and [textile arts](#) such as [woven silk](#). Geographically, it spans the entire [Indian subcontinent](#), including what is now [India](#), [Pakistan](#), [Bangladesh](#), [Sri Lanka](#), [Nepal](#), [Bhutan](#), and at times eastern [Afghanistan](#). A strong sense of design is characteristic of Indian art and can be observed in its modern and traditional forms.

The origin of Indian art can be traced to [prehistoric](#) settlements in the 3rd millennium BCE. On its way to modern times, Indian art has had cultural influences, as well as religious influences such as [Hinduism](#), [Buddhism](#), [Jainism](#), [Sikhism](#) and [Islam](#). In spite of this complex mixture of religious traditions, generally, the prevailing artistic style at any time and place has been shared by the major religious groups.

In historic art, sculpture in stone and metal, mainly religious, has survived the Indian climate better than other media and provides most of the best remains. Many of the most important ancient finds that are not in carved stone come from the surrounding, drier regions rather than India itself. [Indian funeral](#) and philosophic traditions exclude [grave goods](#), which is the main source of ancient art in other cultures.

Art in IKS

Indian Knowledge Systems (IKS) view art as a fundamental part of human expression and a way of understanding the world, encompassing various forms like classical dance, music, literature, and visual arts, all deeply rooted in Indian culture and spirituality. The spirit, motive and aim of Indian art is to render the sense of infinity, and the sense of Cosmo city through symbolic forms, forms that are subtle, forms which are symbolic and forms which are distinctive and which may correspond, in varying degrees, to the external forms which nature has fashioned in its own ...

Key Aspects of Art within IKS:

- **Aesthetic Expression:**

- Art is seen as a way to express human emotions and experiences, with Indian classical dance forms like Bharatanatyam, Kathak, and Odissi, and music with its intricate ragas and rhythms, serving as powerful mediums.

- **Spiritual and Philosophical Roots:**

- Indian art is deeply intertwined with spirituality and philosophy, drawing inspiration from ancient texts like the Vedas, Upanishads, and Puranas, as well as the epics Ramayana and Mahabharata.

- **Traditional Knowledge:**

- IKS emphasizes the importance of preserving and transmitting knowledge through various art forms, including traditional painting styles like Madhubani and Kalamkari, and performing arts like Bharatanatyam and Kathak.

Examples of Art Forms:

- **Classical Dance:** Bharatanatyam, Kathak, Odissi, Manipuri, Kathakali, Kuchipudi.
- **Classical Music:** Hindustani and Carnatic music.
- **Literature:** Epics like Ramayana and Mahabharata, ancient texts like the Upanishads and Puranas.
- **Visual Arts:** Painting, sculpture, and architecture.
- **Traditional Painting Styles:** Madhubani, Kalamkari, Warli, Pattachitra.
- **Shilpa shatra:** Rock carvings and Idol makings

What are the main features of Indian art?

Traditional Indian art usually had a religious character and Buddhism, Hinduism, and later Islam, have been a common theme throughout the centuries. The pieces often feature mythological, human, and animal forms and had elaborate ornaments.

Art in IKS

The tradition of Indian Classical dance & music is ancient like the flow of the river Ganga, from the Vedas (Upanisads) to contemporary time. In Indian tradition, dance and music have been used to express devotion. They form an integral part of the socio-religious rituals and festivities, to the extent that Bharatmuni's Natya Shastra (third century AD) has enjoyed the status of being the fifth Veda. Great Indian poet **Kalidas** mentions in Meghaduta that the Mahakal temple in Ujjain resounded with the sound of the ankle bells of the dancing girls. Several of the Puranas; Matsaya Purana, Kurma Purana, Bhagwat Purana and Shiva Purana – recommended that arrangement should be made to enlist the services of singing and dancing girls to provide vocal and instrumental music and dance at the time of divine services. The oldest archaeological evidence of dance exists in the form of pictures and sculptures dating from about 2500 B.C. As it can be closely linked with religion and ritual dances that are mentioned in the Vedas.

Sangeet Ratnakara written by Sarangdeva in the 13th century mentions 264 ragas. A variety of string and wind instruments were invented over the period of time. Many rulers patronised music & dance. The Gupta monarch Samudra Gupta was himself an accomplished musician. In some of his coins, he is shown playing on the Veena.

DANCES OF INDIA

Both dance and music, collectively known as Sangit, became connected with Drama. Like Indian music and dance has also developed a rich classical tradition. It has a great power of expression and emotions while telling a story. In India, the art of dancing may be traced back to the Harappan culture. The figure of Lord Shiva as Nataraja represents the creation and destruction of the cosmic cycle. The popular image of Shiva in the Form of Nataraja clearly shows the popularity of dance form on the Indian people. In fact classical dance forms like:

- Kathak, from Uttar Pradesh.
- Bharatanatyam, from Tamil Nadu
- Kuchipudi, from Andhra Pradesh
- Odissi, from Odisha.
- Sattriya, from Assam.
- Manipuri, from Manipur.
- Kathakali and Mohiniyattam, from Kerala are an important part of our cultural heritage

Gradually dances came to be divided as folk and classical. The classical form of dance was performed in temples as well as in royal courts. The dance in temples had a religious objective whereas in courts it was used purely for entertainment. In both the cases, the artists devoted to this art form, found it no less than praying to God.

Astronomy in IKS

Indian knowledge systems, particularly astronomy, have a rich history, with Vedic texts and later treatises demonstrating a deep understanding of celestial bodies and their movements, influencing calendrical systems, religious rituals, and even astrology. -Key aspects of Indian astronomy:

- **Ancient Roots:**

- The earliest evidence of astronomical knowledge in the Indian subcontinent can be traced back to the Vedic period (1500-600 BCE), with hymns and texts indicating knowledge of cosmological concepts, timekeeping, and the movements of celestial bodies.

- **Vedic Astronomy:**

- The Vedic texts, including the Rig Veda, mention the sun, moon, stars, solstices, seasons, equinoxes, and eclipses, demonstrating an understanding of the natural divisions of time.

- **Vedanga Jyotisa:** It is the earliest astronomical text attributed to **Maharishi Lagadha** dating back to the 6th century BCE.

- **Maharajah Sawai Jai Singh II** of Jaipur constructed five astronomical observatories in northern India (New Delhi, Jaipur, Ujjain, Mathura and Varanasi).

- The observatories, or "Jantar Mantars" incorporate multiple buildings of unique form, each with a specialized function for **astronomical measurement**.

Astronomy:

•Astronomy and astrology were closely linked in ancient India, with astronomical principles used for forecasting horoscopes and understanding the influence of celestial bodies on various aspects of life. Indian astronomy flowered in the 5th–6th century, with [Aryabhata](#), whose work, [Aryabhatiya](#), represented the pinnacle of astronomical knowledge at the time. The Aryabhatiya is composed of four sections, covering topics such as units of time, methods for determining the positions of planets, the cause of day and night, and several other cosmological concepts.^[10] Later, Indian astronomy significantly influenced [Muslim astronomy](#), [Chinese astronomy](#), European astronomy and others.^[11] Other astronomers of the classical era who further elaborated on Aryabhata's work include [Brahmagupta](#), [Varahamihira](#) and [Lalla](#).

Astrology

Hindu astrology, also called Indian astrology, *jyotiṣha* ([Sanskrit](#): ज्योतिष, [romanized](#): *jyotiṣa*; from *jyót* 'light, heavenly body') and, more recently, **Vedic astrology**, is the traditional [Hindu](#) system of [astrology](#). It is one of the [six auxiliary disciplines](#) in Hinduism that is connected with the study of the [Vedas](#).

The [Vedanga Jyotisha](#) is one of the earliest texts about astronomy within the [Vedas](#).^{[1][2][3][4]} Some scholars believe that the [horoscopic astrology](#) practiced in the [Indian subcontinent](#) came from [Hellenistic](#) influences.^{[5][6]} However, this is a point of intense debate, and other scholars believe that Jyotisha developed independently, although it may have interacted with [Greek astrology](#).^[7]

The [scientific consensus](#) is that [astrology](#) is a [pseudoscience](#) and has consistently failed experimental and theoretical verification.

In the Indian knowledge system, astrology, known as Jyotisha, is a traditional system of divination and astronomy, rooted in the Vedas and considered one of the six auxiliary disciplines of Hinduism. Astrology has holistic approaches and strongly rooted in Indian minds.

Crafts and Trade in India

Although a substantial number of non-producing people concentrated in the cities, the age of the Shamas, Kushans, Satavahanas (200 BC—AD250) and the first Tamil states was the most flourishing period in the history of crafts and commerce in ancient India.

Arts and crafts in particular witnessed remarkable growth.

The inscriptions of the period mention weavers, goldsmiths, dyers, workers in metal and ivory, jewellers, sculptors, fishermen, smiths and perfumers as constructors of caves and donors of pillars tablets, cisterns, etc. to the Buddhist monks. All these suggest that their crafts were in a flourishing condition.

Some of the popular Indian traditional products are Cane and Bamboo handicrafts, Pashmina shawla, Zardozi, Chikankiri, Bidriware metal handicrafts, block printing, mural art, etc. Throughout centuries crafts have been embedded as a culture and tradition within rural communities.

One of the oldest cultures in the world is the practice of handicrafts. The Indus Valley Civilization, one of the world's oldest civilizations, is the source of many handicrafts, including those made in India. The Indian handicrafts sector was thriving during the Middle Ages and kept expanding up until the arrival of the British. After the British and other colonial powers arrived in India, the handicrafts sector found it difficult to compete in the international market.

Types of Merchants:

The Garland of Madurai calls the streets broad rivers of people who buy and sell in the market place. The importance of shopkeepers is indicated by the repetition of the term apana in the description of the city of Sakala. Its shops appear as filled with various types of cloth made in Kashi, Kotumbara, and elsewhere. Many artisans and merchants were organized into guilds called sreni and ayatana, but how these organizations functioned is indicated neither in the Mahavastu nor in the Milinda-Panho. Both merchants and craftsmen were divided into high, low, and middle ranks.

The Buddhist texts mention the sresthi, who was the chief merchant of the nigama, and the sarthavaha, the caravan leader who was the head of the corporation of merchants (vanijgramo). It also speaks of nearly half a dozen petty merchants called vanija. They dealt in fruits, roots, cooked food, sugar, bark cloth, sheaves of corn or grass, and bamboo.

Money Economy:

How did the Indians use the silver and gold currency which came to India from Rome? The Roman gold coins were naturally valued for their intrinsic worth, but they may also have circulated in major transactions. In the north, the Indo-Greek rulers issued a few gold coins, but the Kushans issued gold coins in considerable numbers.

Engineering and Technology in ancient India

In Ancient India not only great accomplishments were achieved in the fields of art and architecture, literature, philosophy etc., but many natural and pure sciences also flourished and registered remarkable growth and development. In the realm of astronomy, mathematics, biological, and medical science ancient Indians made various breakthroughs.

The earliest-known **dockyard**, which could berth and service ships, was situated at **Lothal**. Indian metallurgy was very advanced. The **Mehrauli iron pillar** of Delhi is seven metres high and has never rusted, is a testimony to that technology.

India has been contributing to the fields of science and technology since ancient times. Even today, what we term as ‘traditional knowledge’ is actually based on scientific reasoning. Technology is today defined as applied science, but early humans **developed technologies such as** stone-working, agriculture, animal husbandry, pottery, metallurgy, textile manufacturing, woodcarving, boat-making, and sailing.

- The first stone tools in the Indian subcontinent go back more than two million years.
- The **Neolithic revolution** saw the development of agriculture in parts of the Indus and the Ganges valleys, which in turn triggered the need for pots, water management, metal tools, transport, etc.
- Metallurgy** brought about significant changes in human society as it gave rise to an entirely new range of weapons, tools, and implements.

Engineering and Technology in ancient India

Technology is today defined as applied science, but early humans developed technologies — such as stone-working, agriculture, animal husbandry, pottery, metallurgy, textile manufacture, bead-making, wood-carving, cart-making, sailing, etc. — with hardly any science to back them up. If we define technology as a human way of altering the surrounding material world, we find that the first stone tools in the Indian subcontinent go back more than two million years! (That was long before the advent of modern man in India, which is thought to have occurred some 70,000 years ago.) Jumping across ages, the “Neolithic revolution” of some 9,000 years ago saw the development in agriculture in parts of the Indus and the Ganges valleys, which in turn triggered the need for pots, water management, metal tools, transport, etc.

Metallurgy after the Harappans

As we have seen, the Indus civilization was essentially bronze-based, while the later Ganges civilization was iron -based. But it is now known that iron was produced in central parts of the Ganges valley right from 1800 BCE. Its use became widespread by about 1000 BCE, and we find in late Vedic texts mentions of a “dark metal” (*krishnāyas*), while the earliest texts, such as the Rig-Veda, only spoke of *ayas*, which, it is now accepted, referred to copper or bronze.