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.

Traditional knowledge (TK)

Traditional Knowledge is a collection of knowledge, skills, and practices that are passed down through generations and are often embedded in the cultural traditions of local communities. TK can be found in many fields, including linguistics, science, technology, agriculture, medicine, and ecology.

Traditional Humanities

The humanities are a group of educational disciplines that explore the human mind and its expressions through the study of languages, literature, history, philosophy, ethics, and the arts. The humanities are distinct from the physical and biological sciences, and to a lesser extent, the social sciences.

Some examples of humanities courses include:

- History
- Philosophy
- Religion
- Modern and ancient languages and literature
- Fine and performing arts
- Media and cultural studies

Traditional Science.

The traditional sciences in India's knowledge system include a wide range of subjects, including:

1. Mathematics - Indians developed advanced math, including the concept of zero, the base-ten decimal system, and important trigonometry and algebra formulae.
2. Astronomy - Indians made several astronomical discoveries.
3. Linguistics - Panini is considered the founder of linguistics, and his Sanskrit grammar is still considered the most complete and sophisticated in the world.
4. Medicine - The Charaka Samhitha discusses 165 varieties of animals and the animal products used for medical purposes. It also mentions 64 main minerals used for drugs.
5. Cosmology - Ancient Indian texts, including the Vedas, Puranas, and Siddhanta texts, discuss a variety of cosmological models.
6. Other traditional sciences in India include - architecture, agriculture, engineering, philosophy, yoga, metallurgy, metal working, and textiles.

Linguistics

1. **An Ecosystem for Sanskrit Language Processing**.

IKS IN ACTION 5.1

An Ecosystem for Sanskrit Language Processing

Sanskrit is one of three ancient languages (Sanskrit, Greek, and Latin). While ancient Greek and Latin have attained a state of being classical, the Sanskrit language continues to be in use, albeit in specific domains by researchers. However, in recent years, there is a growing recognition of the importance of Sanskrit and several initiatives have been taken globally to integrate technology aids with the Sanskrit language. One of them is building an ecosystem of language processing tools for Sanskrit.

The efforts began in the late 1980s with several projects digitizing Sanskrit texts. Over a decade a central registry of digitized Indic texts was created in some Universities in Germany. Another progress in this direction was the creation of digital dictionaries of Sanskrit. The Cologne Digital Sanskrit Lexicon project digitized the Monier Williams' Sanskrit-English Dictionary. Furthermore, the Digital Dictionaries of South Asia project at the University of Chicago digitized Apte's and MacDonell's Sanskrit-English dictionaries. The next step in this direction was the processing of Sanskrit text using machine coding. Academy of Sanskrit Research, Melkote developed a verbal cognition generator for Bhandarkar's Sanskrit primer in the early 1990s.

By the turn of the century, the Ministry of Communication and Information Technology, Government of India set up the Technology Development for Indian Languages program (TDIL). Further to this, there has been a spurt in the efforts evident from multiple national and international collaborative efforts in this direction.

The Akshar Bharati group developed 'Anusāraka', a language accessor that employed techniques based on Pāṇini's Aṣṭādhyāyī. Beginning in 2002, a suite of Sanskrit computational tools was developed through several research projects. These activities were carried out in several Universities including the Jawaharlal Nehru University (JNU), Delhi, University of Hyderabad, IIT Kanpur, IIT Bombay, and Rashtriya Sanskrit Vidyapeeth, Tirupati. Globally other Sanskrit linguistic researchers were collaborating on these.

Some of the fallout of these are developing several tools and enabling infrastructure for Sanskrit, including the following:

- Web-based Sanskrit reader program at Brown University called Kramapātha
- A digital edition of Whitney's roots that served as the source of verbal stems for their inflectional generation software
- The International Digital Sanskrit Library Integration project in the Classics Department at Brown University
- Sanskrit Library Phonetic encoding that allows all sounds represented in Vedic texts to be represented digitally
- Sanskrit Heritage platform (SH), centred around an electronic version of the Sanskrit-French Sanskrit Heritage dictionary
- Sanskrit Reader, allowing segmentation (sandhi analysis), tagging, and parsing

In 2008, the Indian Government funded a major consortium project to develop various tools for analysis of Sanskrit text and a Sanskrit-Hindi machine translation system. Sanskrit scholars and computational linguists collaborated to develop several tools for enhancing the Sanskrit language processing ecosystem. This includes Sandhi and Samāsa analyser, morphological analyser, generator, sandhi joiner and splitter, and full-fledged parser.

These tools are now being deployed in some machine translation systems for testing and further refinements.

Source: Adopted from, **Goyal, P., Huet, G., Kulkarni, A., Scharf, P., and Bunker, R. (2012).** "A Distributed Platform for Sanskrit Processing", *Proceedings of COLING 2012: Technical Papers*, pp. 1011–1028, Mumbai, December 2012.

Language has been the most effective tool for our communication since time immemorial. Though some basic communications can be handled with gestures, language becomes inevitable for communicating elaborate and complex ideas. Scientific discovery, the advancement of

2. Components of a Language

knowledge, and collaborative working require a common method of communication. Language plays this role in a civilized society. As technology and computing prowess improves, we are able to develop better applications using Artificial Intelligence (AI) techniques. This requires us to develop efficient Natural Language Processing (NLP) capabilities. A systematic study of languages and their capabilities for the evolving requirements has become important for the science and technology community. In this chapter we shall see the developments in the field of language in ancient India.

5.1 COMPONENTS OF A LANGUAGE

How many of us can read and comprehend Shakespeare's works or native Indian literature such as Rāmāyaṇa? Even if we know the language in which these texts are written, it is difficult because the way the language is used undergoes changes. Language is a tool used by everyone in a community and it is very difficult to maintain it unchanged. We also notice that there are differences in the same language spoken by people from different regions. For these reasons, the literature in a language becomes incomprehensible for the people in the future though they may be speaking the same language. Studying the structure of the language helps us not lose the underlying principles that govern a language and ensures that the received wisdom from the ancestors is not lost. It also maintains continuity in language processing.

- One of the Vedāṅgas known as Vyākarana focuses on linguistics and phonetics aspects of Sanskrit language.
- Aṣṭādhyāyī is considered a fine creation of human intelligence and the best available descriptive model of a language.

Communication is key to trade, science and technology, and societal progress. It hinges on our ability to effectively process language as it is central to all human transactions and pursuits. Language processing has two dimensions: receptive and productive. The *receptive* part of a language deals with the ability of an individual to receive language inputs from multiple sources and process them to decipher the intended message and comprehend them. On the other hand, the *productive* part of the language is to transmit back to others for their consumption. The focus in the former is on listening and reading, whereas it is on speaking and writing in the latter. Viewed from another perspective, sound (listening and speaking) and script (reading and writing) are the essential elements of a language. Therefore, language processing can be represented in a 2×2 framework as shown in Figure 5.1. Linguistics addresses all these aspects of a language. Phonetics will cater to the receptive and productive aspects of the sound and a syntactic structure will cater to the scriptural aspects of a language.

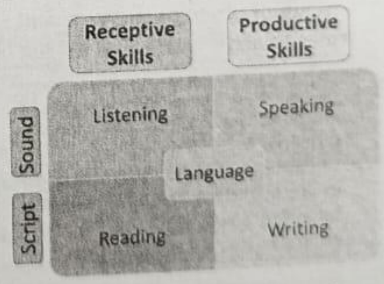

FIGURE 5.1 Components of a Language

Linguistics is a branch of language research that provides a scientific study of a language. It is a systematic study of language to understand speech sounds, grammatical structures, and meaning. It helps us analyse the language form and meaning and identify systematic methods integral to the language to derive the word forms and their meaning using structured rules and syntax. The earliest approach to a systematic treatment of linguistics is attributed to the Indian

3. Panini's work on Sanskrit Grammar

Panini's most important work on Sanskrit grammar is the Astadhyayi, which he wrote in the 6th to 5th century BCE:

What it is

The Astadhyayi is a Sanskrit treatise that defines the Sanskrit language and sets the standards for classical Sanskrit. It's considered the standard work on Sanskrit grammar.

What it contains

The Astadhyayi is made up of 3,959 sutras (rules) in eight chapters, each divided into four sections. It describes the algorithms for generating well-formed words from lexical lists.

What it does

The Astadhyayi defines the morphology and syntax of Sanskrit, and explains how to construct sentences and compound nouns. It's generative and descriptive, and uses complex metarules, transforms, and recursions.

How it was created

The Astadhyayi was the culmination of centuries of study and debate by Sanskrit linguists. It was created to preserve the language of the Vedic hymns from "corruption".

How it's been evaluated

The Astadhyayi is considered one of the greatest monuments of human intelligence. Its intricacy means that the correct application of its rules is still being worked out centuries later.

Related works

Patanjali's Mahabhashya explains the principles given in Panini's Astadhyayi.

Trimuni – Three Sages

Trimuni. —The grammar of Panini, called so, being the contribution of the reputed triad of Grammarians.

The famous three ancient grammarians

1. Panini (the author of the Sutras)
2. Katyayana (the author of the Varttikas)
3. Patanjali (the author of the Mahabhasya)

4. **Phonetics in Sanskrit**

Sanskrit is a phonetic language, meaning that written letters in Sanskrit always represent sounds on a one-to-one basis. Here are some aspects of Sanskrit phonetics:

Vowels

Sanskrit vowels can be long or short, with five vowels having both variants. The long version is usually pronounced the same as the short version, but twice as long. There is also a third category of length called prolation, which is used in specific contexts. Prolated vowels are written with the numeral "3" after them.

Consonants

Consonants in Sanskrit are also known as vyañjanāni or hal. They are pronounced by changing the flow of air through the mouth.

Sandhi

Sanskrit words and sentences undergo many different kinds of sound changes, such as vowels combining or becoming consonants, or consonants shifting class. These sound changes are called sandhi.

Silent letters

Sanskrit has no silent letters, and every letter has only one sound, except for the letter v.

Shiksha

The science of phonetics in Sanskrit is called Shiksha, and is one of the six vedangas, or limbs of Vedic studies. The text Panini Shiksha focuses on various aspects of Sanskrit phonetics, including letters, accent, quantity, stress, and melody.

5. **Patterns in Sanskrit Vocabulary**

Here are some patterns in Sanskrit vocabulary:

Compound words

Sanskrit compounds are formed by combining more than one word into a single word that conveys the same meaning. Some examples of compound word classes include Tatpuruṣa, Karmadhāraya, Dvigu, Nañ-tatpuruṣa, Prādi and gati, Upapada, Bahuvrīhi, and Dvandva.

Vowel gradation

Sanskrit has regular vowel variations within words, which is a feature inherited from Proto-Indo-European. This feature is fundamental to Sanskrit derivation and inflexion.

Word order

Sanskrit is a highly inflected language, so word order is not very important. In prose, the preferred word order is Subject-Object-Verb (SOV).

Consonant simplification

Sanskrit has two stems for consonant nouns: a regular stem used in front of vowels, and a second stem used in other circumstances. The second stem is a result of sandhi changes from the first stem.

Pluta vowels

Pluta vowels are a third vowel length that are found in ancient Vedic texts. They are marked with a Sanskrit number three (३) in Devanāgarī, or simply with a 3 in transliteration

Numbers & Measurements.

Origin of Mathematics.

The history of mathematics can be traced back to prehistoric times when hunter-gatherers used words to count objects and animals. The earliest evidence of written mathematics comes from the ancient Sumerians, who developed a complex system of metrology around 3000 BC. They wrote multiplication tables on clay tablets and solved geometrical exercises and division problems.

Here are some other milestones in the history of mathematics:

- **2500 BCE**: The Babylonians created the earliest known character for zero
- **1650 BCE**: The Rhind Papyrus was the first math textbook, showing how ancient Egyptians solved arithmetic and geometry problems
- **450 BC**: The Greeks began to independently develop mathematics
- **1200 BCE to 1800 CE**: India contributed to mathematics in the fields of arithmetic, algebra, and trigonometry, including the decimal number system, the concept of zero, and negative numbers
- **1827**: Mobius introduced homogeneous coordinate systems, which formalized how to project a 3-dimensional space onto a 2-dimensional space.

The Decimal system in Harappan Civilizations.

1. **Weights -** The higher denominations of weights used a decimal system, while the lower denominations used a binary system. The weights were usually cubical in shape and made of chert, a stone. The weights were used in ratios of 0.05, 0.1, 0.2, 0.5, 1, 2, 5, 10, 20, 50, 100, 200, and 500.
2. **Scales** - Several scales of measurement were found, including a decimal scale of 1.32 inches (3.35 cm) and a bronze rod marked in lengths of 0.367 inch (0.93 cm).

3. **Bricks**
   The bricks used for construction were of different sizes, but the dimensions of all the bricks were in the ratio 4:2:1.
   The Harappan civilization, also known as the Indus Valley civilization, had a highly developed trade and commerce system. The precise system of weights and lengths used in the Harappan civilization was in use in India until the international standardization of the SI system of unit.

Number Systems in Ancient India

The Indian numeral system is one of the most important contributions to world mathematics. Indian mathematicians developed a highly efficient and versatile system, which laid the foundation for modern arithmetic.

a. The Decimal System and Place Value System

- Decimal System (Base-10): India is credited with the development of the decimal system, which uses a base-10 system of numeration. This system forms the foundation for our current number system, where each digit has a place value based on powers of 10. This system was fully operational by the 6th century CE.
- Zero (0): The concept of zero as a number, not just a placeholder, was fully developed in India. This is considered one of the most important mathematical advancements, first documented in the Bakhshali Manuscript (circa 3rd–4th century CE), and later formalized by Brahmagupta in the 7th century CE. Brahmagupta described rules for arithmetic involving zero, including addition, subtraction, and division by zero.
- Hindu-Arabic Numerals: The Indian numeral system, which includes the digits 1-9 and 0, was passed on to the Arabs (through scholars like Al-Khwarizmi) and then to Europe. This system replaced the Roman numeral system in the West.

b. Advanced Arithmetic

- Addition, Subtraction, Multiplication, and Division: Indian mathematicians developed efficient algorithms for basic arithmetic operations. In addition to the basic operations, they also devised methods for long division and multiplication of large numbers.
- Negative Numbers: Indian mathematicians, particularly Brahmagupta, were the first to rigorously define and work with negative numbers, providing rules for operations involving both positive and negative quantities**.**

2. Measurement Systems in Ancient India

Ancient Indian scholars and practitioners developed detailed and sophisticated systems for measuring length, area, volume, time, and angles. These systems were used in various domains such as architecture, astronomy, trade, and rituals.

a. Units of Length and Distance

- **Yojana**: One of the key units of distance used in ancient India was the yojana, which is approximately equivalent to 12 kilometers. This unit was used in geographical texts and descriptions of vast distances in India and its neighbouring regions.
- **Krosha**: Another unit of distance, the kosha or krosha, was commonly used in ancient texts. It was roughly equal to 3 kilometers. In some sources, it is mentioned as 2.5 kilometers, depending on the region.
- **Angula (Finger):** The angula was a small unit of length, roughly equivalent to the width of a finger. It was part of the standard system used for smaller measurements in architecture and engineering.
- **Hasta**: The hasta was a unit of length equal to the length of an average human hand, about 18 inches or 45 centimeters.
- **Dhanusha**: The dhanusha was used to measure the length of a bow, roughly 1.5 meters.

b. Units of Area and Volume

- **Bigha and Katha**: These units were used for measuring land area. The size of a bigha varied by region but was typically around 1,500 square meters. A katha was a smaller unit of area, often around 150 square meters.
- **Pala**: The pala was used for measuring weight and was roughly equivalent to 80 grams.
- **Madhya**: This was a unit of volume, particularly used for liquids.

c. Geometrical Measurements and Architectural Application

The Sulba Sutras, which are part of the Vedic literature, contain many mathematical and geometrical principles related to measurements. They were primarily concerned with measurements for constructing ritual altars and temples, with an emphasis on accurate dimensions.

- **Pythagorean Theorem**: The Sulba Sutras describe the use of the Pythagorean theorem to construct right-angle triangles. It is evident that ancient Indian mathematicians understood the relationship between the sides of right-angled triangles (though it predates Pythagoras).
- **Pi (π):** Indian mathematicians, particularly Aryabhata, approximated the value of π (pi) to be 3.1416 in the 5th century CE, which was very close to its modern value. They used this approximation in the calculation of the areas of circles and other geometric shapes.

d. Time Measurement

- **Kalpa**: The ancient Indian measurement of time was highly developed. The Kalpa is the basic unit, a day of Brahma (comprising 4.32 billion years). Smaller units like kala

(14th part of a day) and muhurta (approximately 48 minutes) were used in ritual, astronomy, and daily activities.

- **Ghati**: One ghati is equivalent to 1/24th of a day, or 60 minutes. The concept of dividing the day into smaller units was also useful in the calculation of celestial motions.
- **Nakshatras**: In astronomy, time was also measured in terms of nakshatras (lunar mansions or segments of the celestial sphere) to track the positions of the moon and planets.

3. Mathematical Texts and Contributions

Ancient Indian texts contain detailed instructions on mathematical and measurement principles.

- **Sulba Sutras**: These texts from the Vedic period (circa 800–500 BCE) contain detailed geometrical and measurement rules. They were primarily concerned with the construction of altars but also dealt with the geometry of squares, rectangles, and circles.
- **Aryabhatiya**: The **Aryabhatiya** (5th century CE), written by **Aryabhata**, is one of the earliest texts that dealt with both mathematics and astronomy. Aryabhata's work on the approximation of π, trigonometric tables, and the concept of **sine** and **cosine** were foundational.
- **Brahmasphutasiddhanta**: Written by **Brahmagupta** in the 7th century CE, this text is one of the first to define zero, negative numbers, and solve quadratic equations. It also discussed the measurement of areas and volumes of geometric shapes.
- **Lilavati**: Written by **Bhaskara II** in the 12th century CE, the **Lilavati** contains problems related to arithmetic, geometry, algebra, and number theory. Bhaskara's approach to mathematics is noted for its application in everyday life.
- **Shulba Sutras**: These texts discuss geometric constructions, particularly in the context of sacrificial altars. They contain early instances of the Pythagorean theorem and formulas for calculating areas and volumes.

Mathematical Activity in the Vedic Period.

During the Vedic period, mathematical activities were centered around ritual activities and were recorded in Vedic texts. Here are some examples of mathematical activities from the Vedic period:

a. **Arithmetic**

   The Narad-Vishnu Purana lists arithmetic operations such as addition, subtraction, multiplication, fractions, squares, cubes, and roots.

b. **Geometry**

   The Sulva-Sutra of Baudhayana and Apasthamba describe techniques for constructing altars.

c. **Numeral terminology**
   The Vedic people developed a scientific numeral terminology based on the scale of 10.
d. **Fractional numbers and surds**
   The Vedic people were well versed in the use of fractional numbers and surds.
e. **Algebra**
   The Vedic people could solve some algebraic problems.
f. **Land measurement**
   The Vedic people needed to accurately measure cultivated areas for land grants and agricultural tax assessments.
g. **Vedic mathematics** is an ancient technique that uses 16 sutras (phrases) and 120 words to simplify mathematical problems. Vedic mathematics tricks can help with addition, subtraction, multiplication, division, squares, and square roots.

4. **Indian Contribution to Modern Mathematics**

Many concepts from the Indian Knowledge System on numbers and measurements were later transmitted to the Islamic world and to medieval Europe, significantly influencing modern mathematics. The **Hindu-Arabic numeral system** and concepts like **zero**, **algebra**, **trigonometry**, and **calculus** have had a lasting impact on global mathematical practice.

Chemistry, Physics & Arts.

In the Indian knowledge system, the domains of **Chemistry**, **Physics**, and **Art** are deeply interconnected with one another, blending empirical understanding with spiritual insight and holistic views of the cosmos. These disciplines have rich historical traditions that predate much of modern science and were approached through a unique framework combining practical applications, philosophical exploration, and metaphysical concepts. Here's a detailed overview of how each of these areas was perceived and developed in the Indian knowledge system:

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1. Chemistry in Indian Knowledge System (Rasa Shastra and Alchemy)

Rasa Shastra (the science of transformation) is the traditional Indian system of chemistry, closely linked to the fields of **alchemy** and **Ayurveda**. It focuses on the use of metals, minerals, and herbs to create medicinal and spiritual elixirs.

a. **Alchemy and Rasa Shastra**:
   - The term **Rasa** means "essence" or "liquid" and refers to the transformative process of substances. Alchemy in India aimed at achieving purification and transformation, both on a material and spiritual level. It includes the process of transmuting base metals into gold, preparing elixirs for longevity (*Rasayana*), and other formulations used in **Ayurvedic** medicine.
   - **Mercury (Rasa)**: Indian alchemists were known for their advanced use of mercury in medicine, particularly in the **preparation of medicinal compounds** such as **Swarna Bhasma** (gold ash) and **Rasa Sindura** (mercury-based formulations). These were believed to enhance vitality and longevity.
   - **Preparation of Herbal and Mineral Compounds**: Rasa Shastra includes the synthesis of medicinal compounds from both **herbs** and **minerals**. The practice of preparing medicinal **bhasmas** (calcined substances) and **rasaushadhis** (elixirs) required extensive knowledge of chemical reactions such as sublimation, calcination, and distillation.

b. **Alchemy for Spiritual and Healing Purposes**: Unlike Western alchemy, which was often concerned with material wealth, Indian alchemy was linked to spiritual liberation and health. The use of metals, minerals, and herbs was not just for physical healing but also for achieving spiritual purification.

2. Physics in Indian Knowledge System (Vijnana and Nyaya-Vaisheshika)

The Indian approach to **Physics** was integrated into broader philosophical systems that sought to understand the nature of matter, energy, and the cosmos. Central to Indian physics are the schools of **Nyaya** (logic), **Vaisheshika** (atomic theory), and **Sankhya**.

a. **Vaisheshika Philosophy**:
   - Founded by **Kanada** (6th century BCE), this school is particularly notable for its **atomic theory**, which closely mirrors modern concepts of matter. Kanada proposed that the universe is made of indivisible particles, called *Anu* (atoms), and that these particles combine to form various substances. He classified substances into categories such as **earth**, **water**, **fire**, **air**, and **ether**—the five classical elements.
   - **Atoms and Molecules**: Kanada's theory of atoms is remarkably similar to modern atomic theory, where he suggested that atoms combine to form molecules (which he called *druh*) and that all matter is essentially a combination of these eternal and indivisible atoms.

b. **Nyaya Philosophy**:
   - The **Nyaya** school, focused primarily on logic and epistemology, also contributed to understanding causality, material reality, and the concept of physical laws. The Nyaya thinkers emphasized the **logical analysis of reality**, suggesting that empirical evidence is critical in understanding the world.
   - They also formulated the concept of **parinama** (change) and **samyoga** (combination), both of which relate to how physical phenomena occur through interaction and transformation, similar to the concept of energy transformations in modern physics.

c. **Sankhya and the Gunas**:
   - The **Sankhya** school, one of the oldest philosophical systems, provides an early framework for understanding the material universe. It divides reality into **Purusha** (consciousness) and **Prakriti** (matter), which consists of three

fundamental qualities or "gunas": **Sattva** (balance), **Rajas** (activity), and **Tamas** (inertia). These three gunas govern the behavior and properties of all matter, akin to the forces of nature in physics.
   - Sankhya also discusses the evolution of the universe from a primordial state to the complex physical world, offering an early system of cosmology that is in some ways parallel to modern theories of evolution and the formation of matter.

d. **Quantum-like Concepts**:
   - The **Vaisheshika** theory, in particular, has been viewed by some modern scholars as a precursor to quantum physics, particularly with its focus on indivisible particles (atoms), the fundamental nature of the cosmos, and its detailed classification of substances.

3. Art in Indian Knowledge System (Shilpa Shastra and Aesthetics)

In Indian tradition, **Art** is seen not just as a creative activity, but as a deeply spiritual practice that connects the material world to higher realities. The study of art in India was governed by **Shilpa Shastra** (the science of architecture and sculpture), **Natyashastra** (the science of performance arts), and **Rasa Theory** (the science of emotions).

a. **Shilpa Shastra**:
   - **Shilpa Shastra** is the traditional manual for the creation of **sculptures**, **temples**, and **artifacts**. It covers not only techniques and materials but also the **spiritual significance** behind each object. This includes guidelines for the construction of temples, the design of **idols** and **murals**, and the crafting of sacred tools and instruments.
   - **Sacred Geometry**: Art, particularly architecture, was designed to mirror the **cosmic order**. This is evident in the design of Hindu temples, where geometry, proportions, and alignments follow principles that reflect cosmic and divine harmony. The central space in the temple (the sanctum sanctorum) was carefully constructed to house the deity and facilitate the flow of spiritual energy.
   - **Iconography**: The Shilpa Shastras also detail the **iconography** of deities and other symbolic representations in art. Each figure or gesture in Indian sculpture carries a deep symbolic meaning, often related to cosmic principles, philosophical ideas, and divine attributes.

b. **Natyashastra and Performing Arts**:
   - The **Natyashastra**, written by **Bharata Muni**, is the foundational text for **Indian dance, drama, and theatre**. It outlines the principles of **dramatic composition**, **stagecraft**, **acting**, **music**, and **dance**, and is closely tied to the concept of **Rasa** (emotional experience).
   - **Rasa Theory**: According to the Natyashastra, the purpose of art is to evoke a certain emotional response (Rasa) in the audience. There are **nine Rasas** (emotions)—such as love, anger, joy, and sorrow—that are expressed through various art forms, including theatre, dance, and music. The artist is seen as a conduit for **universal emotions**, and art is a means to connect with the divine.

c. **Aesthetics and the Philosophy of Beauty**:
   - In Indian aesthetics, **beauty** is not merely a visual attribute but a manifestation of **cosmic harmony**. The **Bhakti** and **Vedantic** traditions emphasize that art has the potential to guide one toward **spiritual liberation**. The creation of

beauty in art is seen as a reflection of the divine, and artistic expression is often intertwined with religious devotion.

Interconnections in Indian Knowledge System

- **Holistic View**: Indian knowledge systems tend to emphasize the interconnectedness of disciplines. For instance, the creation of art is governed not only by technical principles (Shilpa Shastra) but also by cosmic order (Vastu Shastra) and spiritual symbolism (iconography). Similarly, in Rasa Shastra, the transformation of materials is not merely a chemical process but also a spiritual journey aimed at self-realization.
- **Unity of Science and Art**: Indian thought has a deep integration of **science and art**. Art is not just for aesthetic enjoyment; it is an expression of **cosmic principles** and can influence the spiritual development of both the artist and the audience. Likewise, chemistry and physics are not viewed as isolated technical fields but as part of a larger, interconnected cosmic system that includes ethics, cosmology, and spirituality.

Astronomy & Astrology.

In the Indian knowledge system, **Astronomy** and **Astrology** are closely intertwined, often seen as two aspects of the same discipline, though they have distinct focuses. Astronomy in ancient India was concerned with the observation and study of celestial bodies and their movements, while Astrology (Jyotisha) dealt with interpreting these movements to predict human affairs, events, and spiritual destinies. The rich tradition of astronomical and astrological knowledge in India has ancient roots, with significant contributions to both fields that predate much of modern Western science.

1. Astronomy in the Indian Knowledge System

Indian astronomy has a long history, extending back over two millennia, and it is deeply connected to the cosmological, spiritual, and temporal concepts of the Vedic tradition. Indian astronomers were pioneers in observational techniques, mathematical calculations, and the conceptualization of the cosmos.

Key Concepts and Contributions:

a. **Vedic Astronomy**:
   - The earliest references to astronomy in India appear in the **Rigveda** (c. 1500 BCE), which mentions celestial bodies like the Sun (*Surya*), the Moon (*Chandra*), and the stars, and their roles in marking time and seasons. These texts refer to the **lunar calendar** and the observation of the **movements of planets**.
   - The **Vedanga Jyotisha** is one of the six Vedangas (auxiliary disciplines) and is the earliest known text on astronomy in India, written around the 5th century BCE. It provided the framework for the accurate calculation of **lunar months**, **solstices**, and **eclipses**, and was critical for determining the dates for important religious events and rituals.

b. **Surya Siddhanta**:
   - One of the most influential ancient texts on Indian astronomy is the **Surya Siddhanta**. This work, attributed to **Aryabhata** or a later compiler, presents a detailed description of the motions of the Sun, Moon, and planets, the length of the year, and the spherical shape of the Earth.

   - It includes precise calculations for the Earth's circumference, the duration of the year, and the position of celestial bodies. It also presents the idea of the **heliocentric model** (the Sun at the center of the solar system), a concept that Aryabhata articulated around 500 CE, centuries before it was proposed in the West by Copernicus.

c. **Aryabhata's Contributions**:
   - **Aryabhata I** (476–550 CE) was one of the most significant figures in Indian astronomy and mathematics. He calculated the Earth's **circumference** (which was remarkably accurate for his time), explained the **rotation of the Earth** on its axis, and correctly theorized that the **Moon** and **planets** shine by reflecting the light of the Sun.
   - Aryabhata's **Aryabhatiya** laid the foundation for subsequent Indian astronomical work and was studied extensively in later periods. His work also influenced scholars in the Arab world and Europe.

d. **Brahmagupta and Bhaskara**:
   - **Brahmagupta** (598–668 CE) made significant contributions to the understanding of **planetary motions**, **eclipses**, and **astronomical timekeeping**. He correctly described the behavior of the planets and the phenomenon of the **solar eclipse**, among other celestial events.
   - **Bhaskara I** (c. 600 CE) and **Bhaskara II** (1114–1185 CE) made further refinements to Aryabhata's theories. Bhaskara II, also known as **Bhaskara Acharya**, is known for his work in both astronomy and mathematics. His **Siddhanta Shiromani** provides detailed calculations of the motion of the planets and various astronomical phenomena.

e. **Indian Cosmology and Time**:
   - The Indian understanding of the cosmos is cyclic in nature, with the universe going through repeated cycles of creation, preservation, and dissolution (the **Kalachakra** or wheel of time). Indian cosmology is characterized by immense time scales, such as **Yugas** (epochs), **Mahayugas** (great epochs), and **Kalpas** (a day in the life of Brahma).
   - The measurement of time was based on the positions of celestial bodies, and Indian astronomers developed **lunar and solar calendars** that were used for agricultural, religious, and social purposes.

f. **Instruments and Observatories**:
   - The ancient Indian observatories (like those at **Jantar Mantar** in Jaipur and Delhi) were equipped with large, precision instruments such as **sundials**, **astrolabes**, **armillary spheres**, and **quadrants** for measuring the positions of celestial bodies.

2. Astrology in the Indian Knowledge System (Jyotisha Vidya)

Astrology, or **Jyotisha Vidya**, is an ancient system of knowledge that interprets the positions of the planets and stars to understand their influence on human affairs, behavior, and the course of events. Jyotisha is often considered a subset of **Vedic Science**, closely related to spirituality, ethics, and cosmology.

Key Concepts and Contributions:

a. **Vedic Roots of Astrology**:

- In the Vedic period, astrology was considered a sacred science that was tied to **rituals**, **prayers**, and **spiritual practices**. It was used to determine auspicious times for conducting rituals and sacrifices, and to understand the influence of celestial forces on the material and spiritual world.
- The **Rigveda** mentions the motion of the **Sun** and the **Moon**, as well as the importance of celestial bodies in marking the passage of time and the changing of seasons. These movements were seen as essential for maintaining the harmony of the cosmos.

b. The Four Pillars of Jyotisha:

- The classical system of Indian astrology is based on **four pillars**:
  1. **Grahas** (planets): The nine key planets (Navagraha) play a central role in the predictions.
  2. **Rashis** (zodiac signs): The twelve zodiac signs are linked to specific energies and qualities.
  3. **Nakshatras** (lunar constellations): The 27 or 28 lunar constellations that the Moon passes through, each representing specific energies and influences.
  4. **Bhavas** (houses): The twelve houses in the horoscope that represent different aspects of life (e.g., family, career, health).

c. The Nine Planets (Navagraha):

- Indian astrology emphasizes the **Navagraha**, the nine planets that influence human life. These are:
  - **Surya** (Sun)
  - **Chandra** (Moon)
  - **Mangala** (Mars)
  - **Budha** (Mercury)
  - **Guru** (Jupiter)
  - **Shukra** (Venus)
  - **Shani** (Saturn)
  - **Rahu** (the North Node of the Moon)
  - **Ketu** (the South Node of the Moon)

The positions of these planets in the sky at the time of one's birth are believed to influence everything from personality traits to destiny. The Sun and Moon are especially significant as they represent the **soul** and **mind**, respectively.

d. The Natal Chart (Kundali):

- In astrology, the most common tool used for prediction is the **Kundali**, or natal chart, which maps the positions of the planets at the time of an individual's birth. This chart is analyzed to determine various aspects of the person's life, including **career**, **relationships**, **health**, and **spiritual path**.
- The planets' positions in the twelve houses and their relationships (aspects) to each other give insight into an individual's life events and overall destiny.

e. Dasha System:

- One of the most unique features of Indian astrology is the **Dasha system**, a method of predicting the course of an individual's life based on planetary periods. The most widely used system is the **Vimshottari Dasha**, which divides life into planetary periods based on the Moon's position at birth. Each planet rules over a specific period (Dasha), influencing events during that time.

f. **Karma and Reincarnation**:
   - Astrology in India is also closely linked to the concepts of **karma** (the law of cause and effect) and **reincarnation**. Astrologers interpret an individual's birth chart not only to predict their life's events but also to help understand their **past karmas** and guide them in overcoming obstacles for spiritual progress.
   - The planets' positions are seen as reflections of an individual's karmic path, and remedies such as **mantras**, **gemstones**, or **rituals** are recommended to mitigate malefic influences and enhance favorable planetary conditions.

g. **Compatibility and Muhurta**:
   - Astrology plays a key role in **matching** horoscopes for marriage, which is an integral part of the Indian matrimonial system. **Muhurta** (auspicious timing) is also determined through astrology, and specific times are chosen for important events, such as weddings, starting new ventures, or building a house, based on planetary positions.

3. Interrelation Between Astronomy and Astrology

- In the Indian system, **astronomy** and **astrology** are **interconnected**. The movements of celestial bodies studied by astronomers are used by astrologers to interpret their influence on human affairs.
- While **astronomy** seeks to observe and understand the physical properties of celestial bodies, **astrology** is concerned with the symbolic meaning and the impact of these celestial bodies on life on Earth.
- The **Surya Siddhanta**, for instance, is an astronomical text that also has astrological implications, as it provides the calculations necessary for casting horoscopes and determining auspicious times.

Crafts & Trade in India

In the Indian knowledge system, **Crafts** and **Trade** have been central to the development of culture, economy, and society for millennia. These domains are deeply rooted in the philosophical, cultural, and technological practices of India, and they have contributed significantly to its historical legacy. Crafts and trade were not only economic activities but were also embedded in religious, social, and aesthetic dimensions of life.

The Indian approach to crafts and trade was holistic, emphasizing craftsmanship as an art, trade as a vehicle for cultural exchange, and both as integral parts of a thriving, interconnected world. Below is a detailed look at **Crafts** and **Trade** in the Indian knowledge system

1. Crafts in India: The Art of Creation

Indian craftsmanship is renowned for its diversity, intricacy, and centuries-old traditions, with artisans passing down their knowledge through **Gurukul** (master-apprentice) systems, guilds, and family traditions. Craftsmanship was not seen purely as a manual skill but as a **spiritual practice**, often intertwined with **religion** and **aesthetics**.

Key Aspects of Crafts in India:

a. **Shilpa Shastra (Science of Art and Craftsmanship)**:

- **Shilpa Shastra** is an ancient Indian text that outlines the principles of **sculpture**, **architecture**, and **crafts**. It provides guidelines on the proportions, materials, and techniques for creating sacred sculptures, temples, and other art forms.
- This text treats craftsmanship as a sacred duty, linking artistic expression with spiritual devotion. The precise measurements in temple architecture or the way **statues of gods** are sculpted are all seen as adhering to these cosmic principles.

b. Textiles and Weaving:

- India has a long tradition of textile craftsmanship, including **handloom weaving**, **block printing**, and **embroidery**. Each region in India developed its own distinct style, such as **Kanchipuram** silks, **Banarasi brocades**, **Patola saris**, and **Pashmina shawls**.
- The **cotton** and **silk** industry flourished in ancient India, and textiles became an important export commodity through trade. India was also the origin of **calico** (printed fabric) and **chintz** (hand-painted or block-printed cotton fabric), both of which were highly sought after in international trade.

c. Metalwork and Jewellery:

- Indian **metalwork** and **jewellery** craftsmanship were highly advanced, with techniques such as **lost-wax casting**, **filigree**, and **granulation** being practiced. The **goldsmith** tradition in India is particularly famous, and intricate jewellery pieces like **Kundan**, **Meenakari**, and **Jadau** are a significant part of Indian culture.
- The **Khajuraho temples** and the **Brahmanical images** created by skilled artisans show the intricate work in stone, bronze, and other metals. Metalwork, especially in **bronze**, was also important for religious statues used in temples.

d. Pottery and Ceramic Crafts:

- Pottery and ceramics have been an essential craft in India for thousands of years. From **Harappan pottery** to **Mughal-era ceramics**, pottery has had both functional and artistic significance.
- Techniques like **Terracotta sculpture**, **glazed pottery**, and **stoneware** were developed by skilled artisans. **Blue-and-white porcelain** during the Mughal period was especially prized.

e. Woodwork and Carpentry:

- **Woodwork** in India has a rich tradition, with finely carved wooden items such as **temple chariots**, **furniture**, and **decorative objects**. The art of **marquetry** and **inlay work** (as seen in the **Teakwood furniture** of Kerala) flourished in regions like **Mysore**, **Jaipur**, and **Punjab**.
- **Channa Patna toys**, known for their bright colours and traditional craftsmanship, are a world-famous example of Indian woodwork.

f. Traditional Crafts and Handicrafts:

- India has a rich diversity of **handicrafts** produced in rural areas, which include **carpets**, **madhubani paintings**, **stone carvings**, **embroidery**, and **handcrafted utensils**. Crafts like **Kalamkari**, **Pattachitra** painting, and **Sanjhi** paper cutting are distinct regional arts.
- Many of these crafts are tied to **local traditions**, **customs**, and **spirituality**, making them not just forms of aesthetic expression but also cultural symbols.

2. Trade in India: The Ancient Commercial Network

Trade has always been a vital aspect of India's economy and cultural exchange, both internally and with the rest of the world. From the **Indus Valley Civilization** to modern times, India has been at the crossroads of global trade routes, influencing and being influenced by diverse cultures.

Key Aspects of Trade in Ancient India:

a. **The Indus Valley Civilization**:
  - The **Indus Valley Civilization** (3300–1300 BCE) was one of the world's earliest urban cultures, and evidence of **trade** can be seen in the archeological remains of **Harappa** and **Mohenjo-Daro**. These cities had well-planned dockyards and traded extensively in goods such as **cotton**, **wool**, and **metal**.
  - The civilization had connections with Mesopotamia, and they traded commodities like **precious stones**, **cotton textiles**, and **beads**.

b. **Overland Trade Routes**:
  - **Silk Road**: India was a major link in the **Silk Road** trade route, facilitating the exchange of not only silk, **spices**, **gemstones**, and **textiles**, but also ideas, religion (especially **Buddhism**), and technology.
  - **Grand Trunk Road**: The ancient **Grand Trunk Road**, stretching from **Bangladesh** to **Afghanistan**, was one of the oldest and longest trade routes, linking India with **Central Asia** and **Southeast Asia**.

c. **Maritime Trade**:
  - India's coastal regions, including **Kerala**, **Gujarat**, and **Tamil Nadu**, were key centers for maritime trade. The **Chola dynasty**, particularly, developed robust maritime trade networks with Southeast Asia, China, and even as far as **Africa**.
  - Goods such as **spices** (like **pepper** and **cardamom**), **cotton textiles**, **ivory**, **precious gems**, and **metalware** were traded extensively.
  - The ports of **Barygaza** (modern-day Bharuch), **Muziris** (in Kerala), and **Tamralipta** were bustling commercial hubs.

d. **The Role of Guilds**:
  - In ancient and medieval India, the role of **guilds** was central to trade and craftsmanship. These were organized associations of merchants and craftsmen who controlled the production, sale, and pricing of goods in specific regions or markets.
  - Guilds were not just commercial entities but also had strong social and religious dimensions, helping manage labor, quality standards, and cultural practices.

e. **Instruments of Trade**:
  - The currency systems of ancient India were diverse. Early forms of money included **cowry shells**, **metal coins** (such as **punch-marked coins** in the Mauryan period), and later, **gold coins** minted by various dynasties like the **Guptas** and **Mughals**.
  - Trade also involved **barter systems**, especially in rural areas, where goods like **grains**, **cattle**, and **crafts** were exchanged.

3. Cultural and Spiritual Dimensions of Crafts and Trade

Both **crafts** and **trade** were deeply entwined with the cultural and **spiritual** life of India. They were not only means of livelihood but also acts of devotion, contributing to the broader **philosophical** and **religious** frameworks of society.

a. **Crafts as Spiritual Practices**: Many traditional crafts were considered a form of **devotion** and **offering** to the divine. For example, **temple carvings**, **sculptures**, and **ritual objects** created by artisans were meant to embody divine qualities. Crafts were often seen as an expression of cosmic principles, with artisans following specific rules and methods described in texts like the **Shilpa Shastra**.
b. **Trade and Cultural Exchange**: Through trade, India was exposed to different cultural, religious, and technological influences. **Buddhism**, **Islam**, and **Hinduism** all interacted through the trade routes, influencing art, architecture, and local customs. The exchange of knowledge, especially in fields like **medicine**, **mathematics**, and **astronomy**, was a result of extensive cultural interactions through trade.
c. **Art and Symbolism**: Many crafts were symbolic of specific cultural beliefs and rituals. For instance, **rangoli** (floor patterns) during festivals like **Diwali** had symbolic meanings, and the intricate **temple jewellery** often represented divine concepts. The **Batik** art from Gujarat and **Madhubani** paintings from Bihar are often infused with spiritual or symbolic elements that reflect the harmony between material and spiritual life.

Engineering and Technology.

In the Indian knowledge system, Engineering and Technology have been integral to the development of civilization for thousands of years. From the urban planning of the Indus Valley Civilization to the monumental architectural achievements of ancient India, and from early innovations in mathematics and mechanical engineering to cutting-edge advancements in space exploration in recent decades, India's contributions to engineering and technology are vast and profound.

Indian technological knowledge has always been deeply intertwined with science, philosophy, aesthetics, and spirituality, reflecting a holistic approach to understanding the material and immaterial worlds. Here's an overview of the significant milestones in Engineering and Technology in the Indian knowledge system.

1. Engineering in Ancient India

a. Indus Valley Civilization (3300–1300 BCE):

The **Indus Valley Civilization** is one of the earliest examples of sophisticated urban planning and engineering. Cities like **Mohenjo-Daro** and **Harappa** display a remarkable understanding of engineering principles:

- **Urban Planning**: The Indus cities were planned with a grid system, streets running at right angles to each other. Buildings were made using **uniform-sized bricks**, indicating a system of standardization.

- **Water Management**: The civilization had advanced **drainage systems**, with homes connected to a public drainage network. Large **public baths** like the **Great Bath of Mohenjo-Daro** suggest an understanding of plumbing and water purification.
- **Architecture**: The **granary** at Harappa is considered a feat of early engineering, designed for storage and protection of crops.

b. Maurya and Gupta Periods (c. 300 BCE–550 CE):

- **Ashoka's Engineering Projects**: The Maurya Emperor **Ashoka** (c. 3rd century BCE) is known for his **rock-cut edicts** and **stone pillars**, some of which were highly sophisticated in their design and construction. The **Ashokan Pillars** are famous for their **polished surfaces** and **aesthetic appeal**, showcasing advanced stone-working skills.
- **The Iron Pillar of Delhi**: The **Iron Pillar** at **Qutub Minar** (c. 4th century CE), a testament to India's advanced knowledge of metallurgy, stands at 7 meters tall and has not rusted despite being exposed to the elements for over 1,600 years. This reflects an early understanding of **corrosion resistance** in metals.
- **Gupta Advances in Medicine and Surgery**: The **Sushruta Samhita**, written by the ancient physician **Sushruta** around 600 BCE, outlines surgical techniques, including procedures for **plastic surgery**, **cataract surgery**, and **orthopedic treatments**. The text highlights India's early engineering applications in **medicine** and **surgical instruments**.

c. Medieval Period (c. 8th–16th century CE):

- **Water Management and Architecture**: Indian rulers continued to excel in the management of water resources. The **Stepwells** (like **Rani ki Vav** in Gujarat) are examples of advanced **hydraulic engineering**. These structures were designed not only for water storage but also as architectural marvels.
- **Fortifications and Siege Engines**: The construction of **forts**, **palaces**, and **siege engines** (such as **catapults** and **ballistae**) was an important engineering feat during this period. The **forts** of Rajasthan and the **Qutb Minar** showcase advanced **fortification techniques**, including the use of stone, brick, and iron.
- **Mechanical Engineering**: Ancient Indian texts such as the **Vastu Shastra** (the science of architecture) include detailed principles of construction that incorporate engineering and mechanical elements, such as **wind turbines** and **geothermal energy** for temperature control in homes.

2. Indian Contributions to Mathematical and Mechanical Engineering

India has made profound contributions to the development of **mathematics** and **mechanical engineering**, which laid the foundation for future technological advancements.

a. Mathematics and the Development of Algorithms:

- **Zero and Decimal System**: Ancient Indian mathematicians were the first to formalize the concept of **zero** and the **decimal system**. The **Brahmasphutasiddhanta**, written by **Brahmagupta** in the 7th century, described zero as a number and provided rules for its use in arithmetic and algebra.

- **Aryabhata's Contributions**: **Aryabhata** (476–550 CE) made significant contributions to **trigonometry**, **algebra**, and **number theory**. He calculated the **value of pi** with great accuracy and proposed the concept of the Earth's rotation on its axis, challenging earlier cosmological views.
- **Mathematical Algorithms**: The famous **Chakravala method**, an early algorithm for solving quadratic indeterminate equations, was developed in India and is one of the precursors to modern **algorithmic** techniques.

b. Mechanical Engineering and Automata:

- **Yazdani's Water Clock**: **Brahmagupta** and **Aryabhata** are believed to have invented various early versions of **water clocks** and other devices for measuring time, such as the **gatikalpa**.
- **Automata and Mechanical Devices**: Ancient texts describe mechanical inventions, such as **automata**, **robotic devices**, and **water-lifting mechanisms**. The **Yantra** (machine) systems were sophisticated devices powered by water, wind, and human labor, used for tasks like lifting water for irrigation.

3. Technological Advances in Medieval India

- **Textiles and Dyeing**: Indian craftsmanship in **textile engineering** was advanced during the medieval period. India was known for its **spinning** and **weaving** technologies, such as **spinning wheels** (like the **Charkha**), and complex techniques of **dyeing** and **embroidering** fabrics, particularly cotton and silk.
- **Shipbuilding**: Ancient Indian shipbuilding technology was advanced and used for both military and trade purposes. The **Chola dynasty** in southern India built **large ships** capable of long voyages to Southeast Asia, Indonesia, and even East Africa.

4. Modern Engineering and Technological Advances

In the modern era, especially after **Independence in 1947**, India has made significant strides in **engineering** and **technology**, marking its position as a global leader in several domains.

a. Space Technology:

- India's space program, particularly led by the **Indian Space Research Organisation (ISRO)**, has become a source of national pride. India is one of the few countries to have achieved major milestones in space exploration:
  - **Chandrayaan**: India's successful mission to the Moon with the **Chandrayaan-1** mission (2008), which discovered water on the Moon, and the subsequent **Chandrayaan-2** (2019).
  - **Mangalyaan**: India's successful mission to Mars, **Mangalyaan (Mars Orbiter Mission)** (2013), made India the first Asian nation to reach Mars orbit and the first in the world to do so on its maiden attempt.
  - **Gaganyaan Mission**: India's ambitious **human spaceflight program** is set to send Indian astronauts to space under the **Gaganyaan Mission**.

b. Nuclear Technology:

- India developed its **nuclear energy program** through the **Atomic Energy Commission**, making significant advances in nuclear research and energy generation. India has also developed nuclear weapons, establishing itself as a **nuclear power** in the global arena.

c. Information Technology and Software Engineering:

- India is one of the **global leaders** in the **IT and software engineering** sectors. Cities like **Bangalore**, **Hyderabad**, and **Pune** have become **tech hubs**, and India's contributions to global IT outsourcing and software development are unparalleled.
- The **Indian Institutes of Technology (IITs)** are internationally recognized as producing top engineers, and Indian software firms such as **Tata Consultancy Services (TCS)** and **Infosys** are major global players in the IT industry.

d. Biotechnology and Medical Engineering:

- **Biotechnology** has grown rapidly in India, particularly in fields such as **genetic engineering**, **pharmaceuticals**, and **medical devices**. Indian companies like **Biocon** and **Serum Institute** are global leaders in vaccine production and biopharmaceuticals.
- India has also become a hub for **medical engineering**, particularly in the development of **low-cost medical devices** and diagnostic tools, which are widely used across the developing world.

5. Sustainable Engineering and Green Technologies

- **Solar Power and Renewable Energy**: India is making significant strides in **solar power** and **renewable energy**. India has one of the largest **solar power** installations in the world and aims to be a global leader in renewable energy production.
- **Water Harvesting and Environmental Engineering**: The concept of **rainwater harvesting**, widely practiced in traditional Indian architecture, is gaining modern significance. Techniques such as **stepwells** and **check dams** are being revived to address water scarcity in rural areas.