

Indian Knowledge System

Engineering and Technology in IKS

UNIT 4

By:

Mr. Hirdesh Sharma

JIMS, Greater Noida

Engineering and Technology

- Science, Engineering and Technology are the buzzwords of the last two centuries.
- Everything we learn in our educational system today on S & T has its origin in the west.
- There have been more activities in the Indian S & T sector, and we seem to be catching up with the cutting edge technology of the world with great difficulty.

The Indian S & T Heritage

- Indian civilization has a rich heritage spanning over the recorded history of the last two millennia.
- Engineering & Technology were part of ancient Indian society. The evidence could be from any of the following three:
 - a) The archaeological evidence shows how S & T ought to have been deployed in ancient times.
 - b) Living examples of physical entities that point to the use of good S & T practices
 - c) Literary resources pointing to the use of S & T in ancient times.

The Indian S & T Heritage

- India is known for its vibrant cultural diversity with a long history of developments in science and technology.
- Basics of mathematics, astronomy, medicine, metallurgy, ship building, town planning, harvesting of water power, textiles, technical craft were parts of cultural life of India thousands of years ago.
- Some of the basic discoveries of mathematics were made in India. Invention, assimilation and modification of techniques and processes in various fields of science and technology continue even today with greater vigour as the nation marches ahead to become a strong country in the world of science and technology.

The Indian S & T Heritage

- The story of ancient Indian science and technology development is presented here through sections on physical concepts, mathematics, astronomy, metals and metallurgy, town planning and architecture, technical crafts, coin minting, water technology, medicine, maritime activities, glass technology, perfumery, earth sciences, musical instruments and agriculture.
- The exhibition portrays 5000 years of Science and Technology Heritage of India through varied period setting dioramas, models, interactive exhibits and multimedia kiosks.

The Indian S & T Heritage

- Mining is the extraction of valuable minerals or other geological materials from the Earth, usually from an ore body, lode, vein, seam, reef, or placer deposit.
- The history of metallurgy in the Indian subcontinent began prior to the 3rd millennium BCE and continued well into the British Raj.
- Metals and related concepts were mentioned in various early Vedic age texts. The Rigveda already uses the Sanskrit term *Ayas*(आयस) (metal).
- The Indian cultural and commercial contacts with the Near East and the Greco-Roman world enabled an exchange of metallurgic sciences.

The Indian S & T Heritage

- In the Vedic texts, we find ample references to Gold, Silver, iron, copper and their alloys.
- The Indian metal smiths were adept in alloy technology as they could produce alloys of controlled composition.
- Ancient Indians developed skills to explore ore deposits and mine portions that are remunerative.

Metals and Metalworking Technology

- In many ways, the usage of metals in antiquity is tied to the history of civilization.
- Metals have been given names to several periods of early human civilization.
- The ability to extract metals yielded a large number of metals and ushered in a number of changes in human society.
- It provided weapons, tools, jewellery, utensils, and other items, as well as enriching cultural life.
- The Seven metals of antiquity are gold, copper, silver, lead, tin, iron and mercury.

Metals and Metalworking Technology

- The first form of crucible steel was wootz, developed in India some time around 300 BCE.
- In its production the iron was mixed with glass and then slowly heated and then cooled.
- As the mixture cooled the glass would bond to impurities in the steel and then float to the surface, leaving the steel considerably purer.

Metals: Brass

- Brass was used in Lothal and Atranjikhhera in the 3rd and 2nd millennium BCE.
- Brass and probably zinc was also found at Taxila in 4th to 3rd century BCE contexts.

Metals: Copper

- Copper technology may date back to the 4th millennium BCE in the Himalaya region.
- It is the first element to be discovered in metallurgy, Copper and its alloys were also used to create copper-bronze images such as Buddhas or Hindu/Mahayana Buddhist deities.
- Collections of archaeological texts from the copper-plates and rock-inscriptions have been compiled and published by the Archaeological Survey of India during the past century.
- The earliest known copper-plate known as the Sohgaura copper-plate is a Maurya record that mentions famine relief efforts. It is one of the very few pre-Ashoka Brahmi inscriptions in India.

Metals: Gold and silver

- The deepest gold mines of the Ancient world were found in the Maski region in Karnataka.
- There were ancient silver mines in northwest India. Dated to the middle of the 1st millennium BCE.
- Gold and silver were also used for making utensils for the royal family and nobilities.
- The royal family wore costly fabrics that were made from gold and silver thin fibres embroidered or woven into fabrics or dress.

Metals: Zinc

- Zinc was extracted in India as early as in the 4th to 3rd century BCE.
- Zinc production may have begun in India, and ancient northwestern India is the earliest known civilization that produced zinc on an industrial scale.
- The distillation technique was developed around 1200 CE at Zawar in Rajasthan.
- The Arthashastra describes the production of zinc.
- The Rasaratnakara by Nagarjuna describes the production of brass and zinc.

Metals: Iron

- Recent excavations in Middle Ganges Valley show iron working in India may have begun as early as 1800 BCE.
- In the 5th century BCE, the Greek historian Herodotus observed that "Indian and the Persian army used arrows tipped with iron."
- Ancient Romans used armour and cutlery made of Indian iron. Pliny the Elder also mentioned Indian iron.
- Muhammad al-Idrisi wrote the Hindus excelled in the manufacture of iron, and that it would be impossible to find anything to surpass the edge from Hindwani steel.

Wootz and steel

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- Several attempts were made to import the process, but failed because the exact technique remained a mystery.

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Manufacture of Steel

- Varahamihira (550 CE) in Brhat-Samhita discussed the processes for carburization and hardening of iron swords.
- The European method of cementation using charcoal used to take six or seven days, and even fourteen to twenty days, while the Indian process takes only four to six hours.
- Steel is made from iron ore, a compound of iron, oxygen and other minerals that occurs in nature.
- The raw materials for steelmaking are mined and then transformed into steel using two different processes: the blast furnace/basic oxygen furnace route, and the electric arc furnace route.

Lost wax casting of Idols and Artefacts

- Lost-wax casting (also called "investment casting", "precision casting", or cire perdue which has been adopted into English from the French, pronounced is the process by which a duplicate metal sculpture (often silver, gold, brass, or bronze) is cast from an original sculpture. Intricate works can be achieved by this method.
- The oldest known examples of this technique are approximately 6,500-year-old (4550–4450 BC) and attributed to gold artefacts found at Bulgaria's Varna Necropolis.
- A copper amulet from Mehrgarh, Indus Valley civilization, in Pakistan, is dated to circa 4,000 BC.

Lost wax casting of Idols and Artefacts

- Cast copper objects, found in the Nahal Mishmar hoard in southern Israel, which belong to the Chalcolithic period (4500–3500 BC), are estimated, from carbon-14 dating, to date to circa 3500 BC. Other examples from somewhat later periods are from Mesopotamia in the third millennium BC.
- Lost-wax casting was widespread in Europe until the 18th century, when a piece-moulding process came to predominate.
- The steps used in casting small bronze sculptures are fairly standardized, though the process today varies from foundry to foundry.

Apparatuses used for Extraction of Metallic Components

- We shall see in brief some of the apparatuses found in ancient Indian Laboratory.
 - Dola-yantra
 - Svedani-yantra
 - Patana-yantra
 - Dheki-yantra
 - Valuka-yantra
 - Dhupa-yantra

Literary sources for Science and Technology

- One of the oldest civilizations in the world, the Indian civilization has a strong tradition of science and technology.
- Ancient India was a land of sages and seers as well as a land of scholars and scientists.
- Research has shown that from making the best steel in the world to teaching the world to count, India was actively contributing to the field of science and technology centuries long before modern laboratories were set up.
- Many theories and techniques discovered by the ancient Indians have created and strengthened the fundamentals of modern science and technology.

Achievements in the science of ancient India

- Indian science has come a long way from the sculpture of the bronze dancer and the advanced urbanization found in the Indus Valley Civilization to the exploration of the surface of the moon.
- Today, India is famous all over the world due to ISRO, DRDO, IT sectors, but ancient India was also advanced from the point of view of science and technology.
- India has achieved significant achievements in the fields of Mathematics, Physics, and Medicine in ancient India.

Achievements in the Field of mathematics

- Indus Valley Civilization was a business-oriented civilization. Therefore, weighing systems were developed there. According to archaeologists, in the Indus Valley Civilization, a system of scale ratio of 16 was developed.
- The Yajurveda describes numbers up to 10 Kharab.
- The most prevalent number of the decimal system (0 to 9) in the present world was invented in India.
- The description of the innumerable (Infinity) is firstly found In the Jain text "Anuyogdwar".
- Geometry is described in Vedang literature.

Achievements in the Field of mathematics

- The knowledge of the description of trigonometry in Varahamihira's 'Surya Siddhanta' (sixth century),
- Brahmagupta also provided sufficient information on trigonometry and he also constructed a sine table.
- Famous mathematicians like Aryabhata, Brahmagupta, Bhaskaracharya, Sridharacharya, etc. also had great proficiency in algebra. The greatest achievement in the field of algebra was Brahmagupta's solution of the square equation.

Achievements in the Field of Astronomy

- Indian astronomy is thought to have originated from the Vedas. The use of astrology in Vedang literature was based on the principles of astronomy.
- Indian scientist Aryabhatta told the circular shape of the Earth and the principle of circling on its axis. After that, the famous German astronomer Copernicus gave this theory.
- Brahmagupta confirmed the Earth's gravitational theory even before Sir Isaac Newton.

Achievements in the Field of Geometry

- People of Harappan culture are familiar with geometry. The brick formation, construction of buildings, cutting off roads at right angles are proof that people of that period knew geometry.
- In the Vedic period the Aryans used the knowledge of geometry to make the altars of the yajna which is also mentioned in Vedang.
- Aryabhatta has established the value of the ratio "pie" to the circumference and diameter of the circle 3.1416.

Achievements in the Field of Medical Science

- First written knowledge about the Indian system of medicine is found in 'Atharvaveda'. The treatment of various diseases is given in Atharvaveda's 'Bhaisjya Sutra'. A detailed description is found on the topics of general medicine and mental medicine.
- 'Sushruta Samhita', 'Charaksamhita' are authentic and world-renowned texts of the medical science of ancient India. 'Sushruta Samhita' describes 8 types of surgery.
- Along with the treatment of humans, the science of veterinary medicine was also developed in India since ancient times. The texts of a Veterinarian named 'Shalihotra' are available in Ayurveda, 'Ashva Symptoms' and 'Ashva Praja'. These include the description of diseases of horses and medicines for their treatment.

Achievements in the Field of Engineering and Architecture

- From the Indus Valley Civilization, India was a pioneer in the field of architecture. The urban system of the Indus is an inspiration for the present cities.
- Buildings, pillars, cave construction, chaitya construction during the Mahajanapada period and Maurya period are examples of advanced architecture of India.
- Ancient India has advanced series of temples. The Kailashnath temple built on the hillside is a great specimen of engineering.

Achievements in the Field of Metallurgy

- Glazed potteries and bronze and copper artefacts discovered in the Indus Valley excavations indicate a highly developed metallurgy.
- The Vedic people were aware of the processes of fermenting grain and fruits, tanning leather, and dyeing.
- By the first century AD, mass production of metals such as iron, copper, silver, and gold, as well as alloys such as brass and bronze, was underway.
- The iron pillar in the Qutub Minar complex demonstrates the high quality of alloying that took place.
- Alkali and acids were created and used to make medicines. This technology was also used in other crafts such as dyeing and coloring.
- Dyeing textiles was popular. The quality of color is reflected in the Ajanta frescoes. These paintings have survived to the present day.

Technology in Ancient India

- Early humans developed technologies such as stone-working, agriculture, animal husbandry, pottery, metallurgy, textile manufacture, bead-making, wood-carving, cart-making, sailing, and so on with little science to back them up.
- If we define technology as a human way of modifying the material world around us, we can find that the first stone tools in the Indian subcontinent date 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 ahead in time, the Neolithic revolution of around 9,000 years ago saw the development of agriculture in parts of the Indus and Ganges valleys, resulting in the need for pots, water management, metal tools, transportation, and so on.

Technology in Ancient India

- The Indus or Harappan civilization (2600-1900 BCE for its urban or Mature phase), which flourished in the northwest of the subcontinent, saw the rapid growth of an efficient agriculture that adapted to very diverse climates and conditions, ranging from the water-rich Indus valley to semi-arid areas of today's Rajasthan.
- The Harappans grew wheat, barley, and millets and practiced plough-based agriculture as well as intercropping in some areas.
- Their wheel-turned pots came in a variety of shapes and sizes, and some were also glazed and painted.
- Metal smiths extracted copper from ore found in the Aravalli hills, Ambaji (Gujarat), or Oman and alloyed it with tin to create bronze.
- Mixing various impurities into it, such as nickel or arsenic, hardened it to the point where bronze tools could be used to dress stones.

Technology in Ancient India

- The true saw was invented by the Harappans, with teeth and the adjoining part of the blade set alternately from side to side, a type of saw unknown until Roman times. They left us a few bronze figurines cast using the lost-wax process.
- The Harappans also invented advanced grid-based town planning and sanitation, which collected used water from individual bathrooms into municipal drains that were inspected and cleaned on a regular basis. They realised that bricks with the dimensions 1: 2: 4 (width equals two heights; length equals two widths).
- Harappan craftsmen used a variety of minerals for ornamental, cosmetic, and medicinal purposes; they excelled at bead-making, and their long carnelian (a semiprecious stone) beads, in particular, were highly prized in Mesopotamian royal families.

Technology in Ancient India

- The Harappans produced a large number of gold, bronze, conchshell, glazed faience, and humble terracotta bangles, which contributed to India's love of bangles.
- Weavers used wheel-spun thread, and evidence of silk, in addition to cotton, has recently been discovered at two sites. Stone and ivory carving, carpetmaking, and inlaid woodwork were among the other crafts.

Significant Science and Technology Discovery in Ancient India

Idea of Zero

- Aryabhata, a mathematician, was the first to create a symbol for zero, and it was through his efforts that mathematical operations such as addition and subtraction began to use the digit zero.
- The concept of zero and its incorporation into the place-value system also allowed for the writing of numbers of any size using only ten symbols.

Significant Science and Technology Discovery in Ancient India

Decimal System

- India invented the decimal system, which uses ten symbols to represent all numbers. In this system, each symbol was assigned a positional value as well as an absolute value.
- This system made the use of arithmetic in practical inventions much faster and easier due to the simplicity of the decimal notation, which facilitated calculation.

Significant Science and Technology Discovery in Ancient India

Numerical Notations

- India developed a system of different symbols for each number from one to nine as early as 500 BCE.
- The Arabs, who called it the hind numerals, adopted this notation system. Centuries later, the western world adopted this notation system, dubbed Arabic numerals because it arrived via Arab traders.

Significant Science and Technology Discovery in Ancient India

Binary Numbers

- The basic language in which computer programs are written is binary numbers. Binary is essentially a set of two numbers, 1 and 0, the combinations of which are known as bits and bytes.
- Pingala, a Vedic scholar, first described the binary number system in his book Chandahsastra, the earliest known Sanskrit treatise on prosody (the study of poetic metres and verse).

Significant Science and Technology Discovery in Ancient India

Chakravala Method of Algorithms

- The chakravala method is a cyclic algorithm for solving indeterminate quadratic equations such as Pell's equation. Brahmagupta, a well-known mathematician of the 7th century CE, developed this method for obtaining integer solutions.
- Jayadeva, another mathematician, later generalised this method for a broader range of equations, which was refined further by Bhaskara II in his Bijaganita treatise.

Significant Science and Technology Discovery in Ancient India

Ruler Measurements

- Excavations at Harappan sites have yielded ivory and shell rulers or linear measures.
- The calibrations, which are marked out in minute subdivisions with amazing accuracy, correspond closely with the hasta increments of $1\frac{3}{8}$ inches, which were traditionally used in South Indian ancient architecture.
- The dimensions of ancient bricks discovered at excavation sites correspond to the units on these rulers.

Significant Science and Technology Discovery in Ancient India

Plastic Surgery

- Sushruta Samhita, written by Sushruta in the sixth century BC, is regarded as one of the most comprehensive textbooks on ancient surgery.
- The text discusses various illnesses, plants, preparations, and cures, as well as complex plastic surgery techniques.
- The most well-known contribution of the Sushruta Samhita to plastic surgery is nose reconstruction, also known as rhinoplasty.

Significant Science and Technology Discovery in Ancient India

Ayurveda

- Long before Hippocrates, Charaka wrote the Charakasamhita, a foundational text on the ancient science of Ayurveda.
- Charaka, known as the Father of Indian Medicine, was the first physician to introduce the concepts of digestion, metabolism, and immunity in his book.
- For two millennia, Charaka's ancient manual on preventive medicine remained a standard work on the subject, and it was translated into many foreign languages, including Arabic and Latin.

Irrigation and Water Management

- The earliest mentions of irrigation are found in Rigveda chapters. The Veda mentions well-style irrigation, where *Kupa* and *avata* wells once dug are stated to be always full of water, from which *varatra* (rope strap) and *cakra* (wheel) pull *kosa*(pails) of water. This water was, state the Vedas, led into *surmi susira*(broad channels) and from there into *khanitrima* (diverting channels) into fields.
- Later, the 4th-century BCE Indian scholar Pāṇini, mentions tapping several rivers for irrigation. The mentioned rivers include Sindhu, Suvastu, Varnu, Sarayu, Vipas and Chandrabhaga. Buddhist texts from the 3rd century BCE also mention irrigation of crops. Texts from the Maurya Empire era (3rd century BCE) mention that the state raised revenue from charging farmers for irrigation services from rivers.

Irrigation and Water Management

- Patanjali, in Yogasutra of about the 4th century CE, explains a technique of yoga by comparing it to “the way a farmer diverts a stream from an irrigation canal for irrigation”.
- In Tamil Nadu, the Grand Anicut (canal) across the Kaveri river was implemented in the 3rd century CE, and the basic design is still used today.

THANKS