APPSC GROUP-I MAINS — STUDY NOTES

INDIA'S CONTRIBUTION IN S&T

Ancient to Modern | Mathematics • Medicine • Space • Nuclear • IT • Pharma

Paper V — Science & Technology | Day 4 (02 Apr 2026)

SECTION 1: SUMMARISED NOTES

1.1 Ancient India's Scientific Heritage

1.1.1 Mathematics

India's greatest contribution to world civilization is the decimal place-value number system and the concept of zero (Shunya). Aryabhata (476 CE): calculated the value of Pi (π) to 3.1416; proposed that the Earth rotates on its axis (heliocentric idea); developed sine tables; calculated the length of a solar year as 365.358 days (close to modern 365.256). Brahmagupta (598 CE): first to define zero as a number and formulated rules for zero arithmetic; solved quadratic equations; developed the formula for the area of cyclic quadrilaterals. Bhaskara II (1114 CE): wrote Lilavati and Bijaganita; developed concepts of differential calculus (centuries before Newton/Leibniz); calculated Pi to 10 decimal places. The Bakshali Manuscript (earliest evidence of zero, dated to 3rd-4th century CE) was found in present-day Pakistan.

1.1.2 Astronomy

Aryabhata proposed that the Earth is spherical and rotates on its axis — over 1,000 years before Copernicus. He calculated the circumference of the Earth as 39,968 km (modern: 40,075 km). Varahamihira (505 CE): wrote Brihat Samhita; classified stars; predicted eclipses. The Surya Siddhanta (ancient text) calculated the Earth's diameter and distance to the Sun with remarkable accuracy. Jantar Mantar observatories (Jai Singh II, 18th century) in Delhi, Jaipur, Ujjain, Varanasi, and Mathura were the world's largest stone astronomical instruments.

1.1.3 Medicine (Ayurveda & Surgery)

Sushruta (c. 600 BCE): the 'Father of Surgery.' Sushruta Samhita describes 300+ surgical procedures, 121 surgical instruments, and techniques for rhinoplasty (nose reconstruction), cataract surgery, lithotomy (removal of bladder stones), and Caesarean section. Rhinoplasty performed by Sushruta's methods was so advanced that British surgeons learned from Indian practitioners in the 18th century. Charaka (c. 300 BCE): wrote Charaka Samhita — foundation of Ayurvedic medicine. Described 600+ herbal drugs, diagnosis techniques, and the concept of Tridosha (Vata, Pitta, Kapha). Ayurveda is recognised by WHO as a traditional medicine system.

1.1.4 Metallurgy

The Iron Pillar of Delhi (Qutb complex, c. 402 CE): 7.21 metres tall, ~6 tonnes, made of 98% wrought iron — has not rusted in 1,600+ years. Demonstrates mastery of corrosion-resistant metallurgy. Wootz steel (crucible steel) produced in South India was exported to Damascus (for 'Damascus swords') and was the world's finest steel for centuries. Zinc extraction was pioneered at Zawar (Rajasthan, 6th century CE) — the world's earliest industrial-scale zinc smelting.

1.1.5 Other Contributions

- **Chemistry:** Nagarjuna (c. 2nd century CE) contributed to chemistry (Rasayana). The concept of distillation, extraction of metals, and preparation of alkalies was documented.
- **Linguistics:** Panini's Ashtadhyayi (c. 4th century BCE) — a grammar of Sanskrit in 3,959 rules — is considered the world's first formal system analysis, anticipating modern computational linguistics.
- **Textiles:** India pioneered cotton cultivation and weaving. Muslin from Dhaka, chintz from South India, and silk from various regions were prized globally.
- **Navigation:** The mariner's compass was known to Indian navigators. Lothal's dockyard (IVC) is the world's oldest known tidal dock.

1.2 Medieval Period

Despite political disruptions, scientific activity continued: Kerala School of Mathematics (14th-16th century) — Madhava of Sangamagrama developed infinite series for Pi and trigonometric functions (predating Newton and Leibniz by two centuries). Nilakantha Somayaji proposed a semi-heliocentric model where inner planets orbit the Sun, which orbits the Earth. Indian numerals were transmitted to the Arab world (Al-Khwarizmi, 9th century) and then to Europe ('Arabic numerals' are actually Indian). Gunpowder and paper technology were adapted from Chinese/Central Asian contacts.

1.3 Modern India's S&T Contributions

1.3.1 Pre-Independence Scientists

- **J.C. Bose (1858-1937):** Pioneered wireless communication (demonstrated radio waves before Marconi's patent). Proved that plants respond to stimuli (crescograph). Founded Bose Institute, Kolkata.
- **S. Ramanujan (1887-1920):** Mathematical genius. Contributed to number theory, infinite series, continued fractions. His notebooks contain 3,900+ results. Elected FRS at 30. The Ramanujan Prize honours mathematical talent from developing countries.
- **C.V. Raman (1888-1970):** Discovered the Raman Effect (inelastic scattering of light) in 1928. Won Nobel Prize in Physics (1930) — first Asian Nobel in science. February 28 = National Science Day.
- **M. Visvesvaraya (1861-1962):** Engineer. Designed the KRS dam (Mysore), block irrigation system, automatic floodgates. Engineer's Day (September 15).
- **Meghnad Saha (1893-1956):** Saha Ionization Equation — fundamental to astrophysics and stellar classification. Explained the thermal ionization of elements in stellar atmospheres.
- **S.N. Bose (1894-1974):** Bose-Einstein statistics (with Einstein). The 'boson' particle is named after him. Foundation of quantum statistics.

1.3.2 Post-Independence — Institutional S&T

- **Nuclear Programme:** Homi Bhabha founded TIFR (1945) and BARC. India's nuclear journey: Apsara reactor (1956, Asia's first), Pokhran-I (1974), Pokhran-II (1998). NPCIL operates 24 nuclear reactors (8.18 GW). Three-stage nuclear programme based on thorium utilisation.
- **Space Programme (ISRO):** Founded by Vikram Sarabhai (1969). Journey: Aryabhata satellite (1975), SLV-3 (1980, Kalam), PSLV (workhorse), Chandrayaan-1 (discovered water on Moon, 2008), Mangalyaan (Mars, 2014 — first attempt success, cheapest Mars mission),

Chandrayaan-3 (Moon landing, 2023 — 4th nation), SpaDeX (autonomous docking, 2025 — 4th nation), Gaganyaan (crewed mission, upcoming). NavIC (indigenous GPS). 100+ satellite launches for 30+ countries via Antrix/NSIL.

- **Defence Technology (DRDO):** 52 labs. Agni series (ICBM range), Prithvi, BrahMos (world's fastest cruise missile, Indo-Russian), Tejas (LCA), Arjun MBT, INS Arihant (nuclear submarine — completes nuclear triad), ASAT test (Mission Shakti 2019, 4th country).
- **IT Revolution:** India's IT services ($254 billion, FY24) transformed from Y2K bug-fixing to powering global digital infrastructure. TCS, Infosys, Wipro are among the world's largest IT companies. UPI, Aadhaar, CoWIN represent Digital Public Infrastructure innovations adopted/studied globally.
- **Pharma:** India = 'Pharmacy of the World' — 60% of global vaccines, 20% of generic medicines. Serum Institute = world's largest vaccine manufacturer. Covaxin (first indigenous COVID vaccine), iNCOVACC (first intranasal COVID vaccine). Drug exports = $27.9 billion (FY24).
- **Green Revolution:** M.S. Swaminathan and Norman Borlaug. HYV seeds transformed India from food-deficit to food-surplus. Foodgrain production rose from 51 MT (1950-51) to 3,577 LMT (2024-25).
- **White/Blue Revolution:** Verghese Kurien (Amul, Operation Flood) made India the world's largest milk producer (~230 MT). Blue Revolution expanded fish production by 140% (2014-2024).

1.3.3 Recent Achievements (Economic Survey 2025-26)

- **SpaDeX (2025):** India became 4th nation to achieve autonomous satellite docking. Critical for future space station and interplanetary missions.
- **Semiconductor Mission:** 10 projects, ₹1.60L Cr across 6 states. India building domestic chip capacity for electronics, defence, AI.
- **GII:** 38th rank (2025), up from 66th (2019). Innovation ecosystem (1.25L+ start-ups, 100+ unicorns) driving improvement.
- **RE Leadership:** 49.83% of 509.74 GW total power capacity from renewables. India 3rd globally in RE and solar. Target: 500 GW by 2030.
- **Digital Infrastructure:** UPI (13,000+ Cr txns), Aadhaar (142+ Cr), 5G (99.9% districts), CoWIN (220+ Cr doses). India's DPI model replicated globally.

SECTION 2: KEY DIMENSIONS TO COVER

Examiner angles.

1. **Ancient Contributions:** Zero and decimal system (Aryabhata, Brahmagupta). Surgery (Sushruta). Metallurgy (Iron Pillar, Wootz steel). Kerala School of Mathematics (Madhava). These are exam staples.
2. **Pre-Independence Scientists:** Bose (radio), Ramanujan (mathematics), Raman (Nobel 1930), Visvesvaraya (engineering), Saha (astrophysics), S.N. Bose (quantum statistics). Know contribution + significance.
3. **Nuclear:** Bhabha → BARC → Pokhran I (1974) → Pokhran II (1998). Three-stage programme (thorium). NPCIL 24 reactors.
4. **Space:** Sarabhai → ISRO. Aryabhata (1975) → SLV → PSLV → Chandrayaan 1/3 → Mangalyaan → SpaDeX → Gaganyaan. NavIC.
5. **Defence:** DRDO 52 labs. Agni, BrahMos, Tejas, Arjun, INS Arihant, ASAT (Mission Shakti 2019).
6. **IT & Digital:** IT $254B. UPI, Aadhaar, CoWIN = DPI. 5G (99.9% districts). This is India's globally unique contribution.
7. **Pharma:** 60% global vaccines. Covaxin, iNCOVACC. India = affordable healthcare provider to world.
8. **Green/White/Blue Revolutions:** Swaminathan, Kurien. Food security transformation.

SECTION 3: PRELIMS MUST-REMEMBER FACTS

Crisp factual points.

1. Aryabhata (476 CE): Pi = 3.1416; Earth rotates on axis; solar year = 365.358 days; sine tables.
2. Brahmagupta (598 CE): First to define zero as a number; rules for zero arithmetic; cyclic quadrilateral formula.
3. Bhaskara II (1114 CE): Lilavati, Bijaganita. Differential calculus concepts. Pi to 10 decimal places.
4. Sushruta (c. 600 BCE): Father of Surgery. 300+ procedures, 121 instruments. Rhinoplasty, cataract surgery.
5. Charaka (c. 300 BCE): Charaka Samhita. Ayurveda foundation. 600+ herbal drugs. Tridosha concept.
6. Iron Pillar, Delhi: c. 402 CE. 98% wrought iron. No rust for 1,600+ years. Corrosion-resistant metallurgy.
7. Wootz Steel: South India crucible steel. Exported as 'Damascus steel.' World's finest for centuries.
8. Panini: Ashtadhyayi. 3,959 rules of Sanskrit grammar. World's first formal system analysis.
9. Kerala School: Madhava (14th c.) developed infinite series for Pi and trigonometric functions before Newton/Leibniz.
10. J.C. Bose: Wireless radio demonstration (before Marconi patent). Crescograph. Plants respond to stimuli.
11. Ramanujan: 3,900+ mathematical results. Number theory, infinite series. FRS at 30. Died at 32.
12. C.V. Raman: Raman Effect (1928). Nobel Prize Physics (1930). Feb 28 = National Science Day.
13. S.N. Bose: Bose-Einstein statistics. 'Boson' named after him. Quantum statistics foundation.
14. Meghnad Saha: Saha Ionization Equation. Stellar classification. Astrophysics foundation.
15. Homi Bhabha: Founded TIFR (1945), BARC. Father of Indian nuclear programme. Apsara (1956) = Asia's 1st reactor.
16. Pokhran-I (1974): 'Smiling Buddha.' Pokhran-II (1998): 5 tests. India declared nuclear weapons state.
17. Vikram Sarabhai: Founded ISRO (1969). Father of Indian Space Programme.
18. ISRO milestones: Aryabhata (1975), Chandrayaan-1 (water on Moon, 2008), Mangalyaan (Mars, 2014), Chandrayaan-3 (Moon landing, 2023), SpaDeX (docking, 2025).
19. BrahMos: World's fastest cruise missile. Indo-Russian joint venture. Mach 2.8 speed.
20. INS Arihant: India's first nuclear submarine. Completes nuclear triad (land + air + sea).
21. Mission Shakti (2019): ASAT test. India = 4th country to destroy satellite in space (after US, Russia, China).
22. India = Pharmacy of World: 60% global vaccines; 20% generic medicines. Covaxin = 1st indigenous COVID vaccine.
23. UPI: 13,000+ Cr transactions. 85% of digital payments. ~50% of global real-time digital payments.

24. IT exports: $254 billion (FY24). TCS, Infosys, Wipro = global IT leaders.

SECTION 4: MAINS MUST-WRITE POINTS

Each can form a paragraph.

1. **Zero to Infinity — India's Mathematical Gift to the World:** India's invention of the decimal place-value system and zero is arguably the most impactful scientific contribution in human history. Without it, modern mathematics, computing, and science would be impossible. Aryabhata's sine tables, Brahmagupta's zero rules, Bhaskara II's proto-calculus, and the Kerala School's infinite series (two centuries before Newton) demonstrate a continuous mathematical tradition spanning over a millennium. When this system reached Europe via Arab mathematicians (hence 'Arabic numerals'), it triggered the Scientific Revolution. India's ancient mathematical heritage is directly relevant to its modern strengths in IT, software engineering, and data science.
2. **Sushruta — When India Led the World in Surgery:** The Sushruta Samhita describes 300+ surgical procedures and 121 instruments — including rhinoplasty techniques so advanced that British surgeons learned from Indian practitioners in the 18th century. Sushruta's classification of diseases, description of surgical tools, and post-operative care protocols make this text one of the most remarkable scientific documents of the ancient world. Today, India's medical tourism industry and pharmaceutical leadership are modern expressions of this ancient medical tradition.
3. **From Aryabhata to SpaDeX — India's Space Journey:** The journey from Aryabhata's calculations (476 CE) to ISRO's SpaDeX satellite docking (2025) represents one of the most inspiring national science narratives. ISRO, founded by Vikram Sarabhai with a vision of space technology for development, has achieved: the cheapest Mars mission (Mangalyaan, $74 million), Moon landing (Chandrayaan-3, 4th nation), commercial satellite launches for 30+ countries, NavIC navigation system, and now autonomous docking capability. India's space programme demonstrates that a developing country can achieve world-class science when institutional commitment is sustained across decades.
4. **Nuclear Sovereignty — The Bhabha Legacy:** Homi Bhabha's three-stage nuclear programme — designed around India's abundant thorium reserves — remains one of the most farsighted strategic technology decisions in any developing country. From Apsara (1956) to Pokhran-II (1998) to the current fleet of 24 reactors (8.18 GW), India has built a complete nuclear fuel cycle capability. The nuclear programme demonstrates India's ability to develop complex strategic technology despite international sanctions and technology denial regimes.
5. **Digital Public Infrastructure — India's 21st Century Contribution:** If zero was India's gift to ancient mathematics, UPI-Aadhaar-DigiLocker (India Stack) may be its gift to 21st century governance. No other country has built population-scale digital identity (142+ crore), real-time payments (13,000+ crore transactions), and digital document infrastructure simultaneously. UPI processes ~50% of global real-time payments. CoWIN managed the world's largest vaccination drive. This DPI model is being studied and replicated by countries worldwide. India has moved from being a technology adopter to a technology exporter in governance innovation.
6. **Pharmacy of the World:** India's pharmaceutical industry — producing 60% of global vaccines and 20% of generic medicines — makes affordable healthcare accessible to billions worldwide. During COVID, India supplied vaccines to 100+ countries. Covaxin was India's first indigenous vaccine; iNCOVACC the world's first intranasal COVID vaccine. The Serum

Institute of India is the world's largest vaccine manufacturer. This pharmaceutical capability builds on India's ancient Ayurvedic tradition while leveraging modern chemistry and biotechnology.

SECTION 5: VALUE ADDITION

4 topic-specific dimensions for India's Contribution in S&T.

Interlinkages — Ancient to Modern Continuum

- **Mathematics → IT:** Ancient Indian mathematical tradition (zero, decimal, algorithms) directly connects to modern India's strength in software engineering and IT services ($254B exports). The logical thinking developed over millennia found a modern expression.
- **Ayurveda → Pharma:** Sushruta/Charaka's medical tradition → India's modern pharmaceutical industry (60% global vaccines). AYUSH Ministry integrates traditional medicine with modern healthcare. Ayush drug exports growing.
- **Metallurgy → Materials Science:** Iron Pillar's corrosion resistance, Wootz steel → India's modern steel production (3rd largest globally at ~140 MT). Specialty steel under PLI.
- **Ancient Astronomy → ISRO:** Aryabhata calculated Earth's rotation 1,000 years before Copernicus. Today, India's first satellite (1975) was named Aryabhata. Chandrayaan means 'Moon vehicle' in Sanskrit. The civilisational continuum is deliberate and symbolic.
- **Navigation → NavIC:** Indian mariners navigated the Indian Ocean for millennia. NavIC (7-satellite indigenous GPS) continues this navigation tradition with modern technology.

Current Affairs

- **SpaDeX (2025):** 4th nation for autonomous satellite docking. Critical for future space station (Bharatiya Antariksh Station announced) and interplanetary missions. Two satellites (SDX01 Chaser and SDX02 Target) successfully docked.
- **Gaganyaan Progress:** India's first crewed space mission. Crew escape system tested (TV-D1). Four astronaut candidates trained at Russia's Gagarin Centre. Crew training facility in Bengaluru. Scheduled for 2025-26.
- **Deep Ocean Mission:** Samudrayaan (manned submersible to 6,000m depth). India will be 3rd nation with deep ocean exploration capability. Targets: polymetallic nodules, marine biodiversity, climate research.
- **Aditya-L1 (2023):** India's first solar observation mission. Placed at Lagrange Point 1 (L1). Studies solar corona, solar wind, and space weather. Operational and sending data.
- **Quantum Computing:** National Quantum Mission (₹6,000 Cr). Target: quantum computers with 50-1000 qubits. Applications in cryptography, drug discovery, materials science. Part of PM-STIAC's 9 missions.

International Recognition

- **Nobel Laureates:** C.V. Raman (Physics, 1930), Har Gobind Khorana (Medicine, 1968 — US citizen), Subrahmanyan Chandrasekhar (Physics, 1983 — US citizen), Venki Ramakrishnan (Chemistry, 2009 — UK citizen). Raman is the only Nobel won entirely in India.

- **UPI Global Adoption:** Accepted in Singapore, UAE, France, Sri Lanka, Bhutan, Nepal, Mauritius. India's DPI model studied by 25+ countries. G20 (India presidency, 2023) showcased DPI to the world.
- **Mars Mission Record:** Mangalyaan (2014) = first nation to reach Mars orbit on first attempt. Cost: $74 million (less than the movie Gravity). Demonstrated frugal engineering.
- **Vaccine Diplomacy:** During COVID, India supplied vaccines to 100+ countries. Covaxin (Bharat Biotech), Covishield (Serum Institute). 'Pharmacy of the World' reputation cemented.

Way Forward

- **R&D to 2% GDP:** India must close the R&D gap (0.64% vs 2% target). NRF (₹50,000 Cr) and private sector R&D incentives are critical. Without R&D, India remains a 'user' not 'creator' of technology.
- **Brain Gain:** Reverse brain drain through world-class research facilities, competitive salaries, and global-standard university infrastructure. NRF's industry-academia bridge is key.
- **Science Communication:** Art. 51A(h) mandates scientific temper. But pseudoscience persists. Science communication (IISF, Vigyan Prasar) and school-level STEM (AIM's Tinkering Labs) must scale.
- **Deep Tech:** India must invest in emerging technologies: quantum computing, AI, fusion energy, synthetic biology, and space manufacturing. PM-STIAC's 9 missions provide the framework but need accelerated funding.

SECTION 6: QUICK REVISION BOX

Last-minute glance.

▶ Aryabhata: Pi, Earth rotation, solar year (476 CE)	▶ Brahmagupta: Zero defined, zero arithmetic (598 CE)
▶ Sushruta: Father of Surgery; 300+ procedures	▶ Iron Pillar: 1,600+ years, no rust; 98% wrought iron
▶ Kerala School: Madhava's infinite series before Newton	▶ Panini: 3,959 rules; world's 1st formal system
▶ Raman: Nobel 1930; Feb 28 = Science Day	▶ Ramanujan: 3,900+ results; FRS at 30; died at 32
▶ ISRO: Sarabhai founded 1969; Chandrayaan-3 (Moon 2023)	▶ Mangalyaan: Mars 1st attempt 2014; cost $74M
▶ SpaDeX: 4th nation satellite docking (2025)	▶ Pokhran-I (1974); Pokhran-II (1998); 24 reactors
▶ BrahMos: Fastest cruise missile; Mach 2.8	▶ Mission Shakti (2019): ASAT; 4th country
▶ India = 60% global vaccines; 20% generics	▶ IT = $254B; UPI = 50% of global real-time payments
▶ Covaxin: 1st indigenous COVID vaccine	▶ NavIC: Indigenous GPS; 7 satellites; India +1500km
▶ GII 38th; R&D 0.64% GDP; NRF ₹50K Cr	▶ Wootz steel = South India → Damascus swords

SECTION 7: RECOMMENDED SOURCES

Refer to these.

Source	What to Read	Why
NCERT Class VI — Our Pasts I	Chapters on Vedic science, ancient achievements	*Foundation-level ancient S&T*
Ravi Agrahari — S&T for Civil Services	Ch. on India's Contribution; Space; Nuclear; IT	*Exam-oriented with scientist profiles*
Economic Survey 2025-26	Innovation, semiconductor, space, DPI sections	*Latest data on ISRO, GII, PLI, IT*
ISRO website	Mission history; Gaganyaan; SpaDeX	*Official mission details and timelines*
Science Reporter (Monthly)	Current S&T achievements	*Recent discoveries and programme updates*

Source	What to Read	Why
India Year Book	Science & Technology chapter	*Updated institutional data and achievements*