

Guidelines for

Training of Faculty on Indian Knowledge Systems

University Grants Commission
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FOREWORD

Indian society is a treasure trove of knowledge, gained over thousands of years and manifested in the form of arts, literature, traditions, customs, languages, architecture, etc. Ancient practices developed by Indians over the centuries were passed on from one generation to another. However, this process of inter-generational transfer of information ended abruptly in the last centuries. The National Education Policy 2020 lays special emphasis on the promotion of Indian Languages, Arts and Culture, and tries to remove this discontinuity in the flow of Indian Knowledge System by integrating IKS into curriculums at all levels of education. The success of NEP 2020 and its special component on Indian Knowledge System relies heavily on the shoulder of the faculty of Higher Education Institutions. Despite of being experts in their respective fields, majority of the faculty in UGC recognized institutions are not much familiar with IKS.

In order to facilitate a seamless integration of Indian traditional knowledge with modern subjects, UGC has come up with 'Guidelines for Training of Faculty on IKS'. These guidelines have been developed keeping in mind the need to make our youth aware of the vast repositories of ancient traditional knowledge in India and clearly map this knowledge with modern scientific advancements and technologies. Separate guidelines have been specified for induction programme and refresher courses, given the different needs and approaches required for training faculty at different stages of career development.

These guidelines will surely help inspire the faculty in higher education institutions of the country to generate a positive attitude, explore, and undertake quality research on IKS, and herald a new era in higher education ecosystem of the country in the light of NEP 2020.

I take this opportunity to sincerely acknowledge the significant contributions made by the team of experts, Prof. Rajnish Jain, Secretary, UGC, Dr. Archana Thakur, Joint Secretary and other UGC officials in developing this framework.

(Prof. M. Jagadesh Kumar)

Chairman
University Grants Commission

GUIDELINES FOR TRAINING/ORIENTATION OF FACULTY ON INDIAN KNOWLEDGE SYSTEMS

Preamble

The NEP 2020 recommends the incorporation of the Indian Knowledge Systems (IKS) into curriculums at all levels of education. The success of the policy relies heavily on the shoulders of inspired teachers. Most of the faculty in Higher Education Institutions (HEIs) across the country, although experts in their respective fields, may require additional familiarization efforts for the Indian Knowledge Systems. Teacher training/orientation in the HEIs is typically conducted by various agencies such as HRDCs and Pandit Madan Mohan Malviya National Mission on Teachers Training (PMMMNTT) named as **Malviya Mission**. The faculty are required to attend a mandatory induction program and periodic refresher courses for their continued professional advancement.

The IKS aims to contribute to the second and third aspects of “PanchPran” resolutions i.e. “Erase all traces of servitude” and “Be proud of India’s heritage and legacy” by the Hon’ble Prime Minister in his Independence Day speech.

The purpose of these guidelines for teacher training during the induction program and refresher courses is to provide a roadmap to familiarize and enthuse faculty about the IKS and identify strategies to incorporate it into their specific classroom teachings.

1. Guidelines

The needs of faculty coming into the induction program are slightly different from the ones coming for the refresher courses. Faculty coming into the induction program are experts in their topics but may be new to IKS. The freshly inducted faculty members attending this program have different needs than already experienced faculty attending the refresher courses. Therefore, the guidelines are specified separately for the induction/orientation program and the refresher courses. The major purpose of all such training programs shall be to generate a positive attitude towards IKS and promote interest in knowing and exploring more, rather than covering a lot of content related to IKS.

The IKS guidelines will be a part of the training modules under “Malviya Mission” and will be considered under CAS scheme as per the UGC regulations.

1.1. Induction program

- ❖ Because of the special nature of IKS, the induction program should not be limited to the faculty's discipline. The content should be broad-based and cover introductory material in all aspects. It would enable teachers to explore the most fundamental ideas that have shaped IKS over the centuries.
- ❖ The IKS Induction programme should ideally be of 30 hours in a 10-10-10 format.
- ❖ The IKS-related content should be allocated a minimum of 10% of the total time spent during the induction program. This will translate to about 17.5-20 hours for a typical induction program.
- ❖ The induction module should be divided broadly into three parts:
 - a. Overview of IKS:** philosophy, cross-disciplinarity, main approaches and methods, the place of Indian civilization among other classical civilizations and inter-civilizational exchanges, sources of authentic material, etc.
 - b. Case studies:** to illustrate a few remarkable accomplishments in diverse fields.
 - c. Pedagogy related to IKS:** innovative methods to teach IKS including innovative methods propounded by NEP 2020, avoidance of bookish teaching, the use of audiovisual material, possible field studies, some exposure to a few primary sources, possible activities and micro-research projects, innovative ways to evaluate learning in IKS, avoidance of common pitfalls such as exaggeration or glorification, etc.
- ❖ All faculty must be exposed to the common underlying philosophical foundation across disciplines in the IKS.
- ❖ At least one to two lectures on the fundamental vocabulary of IKS must be conducted to familiarize faculty with the common terms used in IKS.
- ❖ Faculty must be exposed to the primary texts (Sutra Text) which are required for understanding the sources and origin of IKS. It would help teachers to understand the primary purpose of the text along with the objective, layout, concise and precise way (*sutraic*) of presenting ideas, content, etc.
- ❖ Common pedagogical templates should be used for designing IKS subjects for every discipline to maintain consistency and quality in the instruction.

- ❖ For each module, ready access to a wide range of primary and secondary resources must be provided to enable teachers to understand the continuous and vibrant tradition of IKS. These materials may be developed by a team of subject experts so that there is consistency in the source material used for instruction. Extreme care must be taken to ensure the authenticity and scholarly nature of the content that may be developed for the orientation/induction and refresher courses. Unverified or unverifiable content must not be used in any case.
- ❖ A database of authentic books, papers, articles, and videos should be created. Faculty should be invited to contribute to the database, with a mechanism for peer review to assess the quality of the submitted material.
- ❖ A list of IKS content available in regional languages must be compiled and made available for the benefit of non-English medium teachers.
- ❖ A field visit to nearby IKS-related prominent places such as Temples, Gurukuls, Historical sites, Arts & Crafts communities, Ayurvedic Healing Centers, and Astronomical Observatories (Jantar Mantar) that enable teachers to appreciate the various manifestations of IKS should be organized.
- ❖ Sharing the life and work of contemporary original thinkers who have made seminal contributions in their field, using IKS framework, would motivate teachers to explore various dimensions of IKS.
- ❖ The faculty must be informed about the opportunities to conduct original research in the IKS domain.
- ❖ Courses must be developed in a range of subjects across natural sciences, social sciences, humanities, engineering, medicine, agriculture, community knowledge systems, fine and performing arts, vocational skills, etc, which have IKS content. The courses must have a clear mapping of the traditional subjects in IKS with the modern subjects such as chemistry, mathematics, physics, agriculture, etc.

1.2. Refresher courses

- ❖ All faculty must be exposed to a common underlying philosophical foundation across disciplines in the IKS.
- ❖ At least one to two lectures on the fundamental vocabulary of IKS must be conducted to familiarize faculty with the common terms used in IKS.
- ❖ A strong emphasis must be placed on providing exposure to the primary texts (Sutra Text) of IKS which is required for deeper understanding.
- ❖ The refresher courses must focus on the development of courses under the following categories:
 - a. **Multidisciplinary courses:** These courses should serve faculty from at least two disciplines that are closely related. The courses should provide a greater depth and allow the faculty to explore the interdisciplinary aspects of the IKS and to appreciate the cross-disciplinary connections. The primary aim of these courses is to sensitize teachers about the possible interdisciplinary education which is a key aspect of the NEP 2020. As an example, a course on mathematics and astronomy could be conducted and discuss the simultaneous development of mathematical tools and astronomy models in India. This course could serve the needs of faculty in mathematics and astronomy disciplines. A second example course could be a course on civil engineering, architectural engineering, and town planning serving the disciplines of civil engineering, architecture, and town planning.
 - b. **Discipline-specific courses:** The discipline-specific courses must be focused on a particular subject. These courses are designed to provide a comprehensive understanding of the discipline in the IKS. The course should be usually designed using multiple source texts as the reference material. For example, a course on chemistry could use Rasaratnakara, Rasaratnasamucchaya, Sarveshwararasayana etc. The ayurvedic concepts of Dravyagunashastra with the underlying philosophy from the Vaisheshika-darshana can be taught together with their correlations to biochemistry, biophysics, and process engineering. A course for chemistry students can focus on the aspects related to the herbo-metal and mineral substances from a Dravyaguna perspective, whereas a course for Physics students can focus more on the classification of materials as per the Vaisheshika-darshana. Design of the course

content needs to be carefully thought out by a team of experts in both traditional shastras and modern subjects as most of the IKS subjects are organized differently than the organization of modern disciplines. For example, a chemistry-related book such as Rasaratnakara will have a discussion on laboratory construction and furnace construction in addition to discussing purely the chemistry aspects.

- c. **Specialized courses:** Specialized courses are to be designed for providing in-depth and comprehensive knowledge of a particular text. These courses should be open to those faculty who would like to develop specific expertise in a subject on a particular text and must be taught preferably in person by the experts. The courses must be designed to convey the primary purpose of the text along with objective, layout, concise and precise way (*sutraic*) of presenting ideas, content, etc. It may be envisioned that these courses may only be taught at particular centers where experts are available, and these courses could become the ‘USP’ of a particular center.
- ❖ Courses must be developed in a range of subjects across natural sciences, social sciences, humanities, engineering, medicine, agriculture, community knowledge systems, fine and performing arts, vocational skills, etc, which have IKS content. The courses must have a clear mapping of the traditional subjects in IKS with the modern subjects such as chemistry, mathematics, physics, agriculture, etc.

2. Suggestions for effective implementation

- To connect with the oral tradition of IKS, one practical session on the ancient technique of memorization, with a few examples from primary texts, would be helpful.
- A few immersive sessions on Yoga, Meditation, Ayurveda, and Classical Music should be arranged to give teachers some grounding in the experiential aspects of IKS.
- One session on Ayurveda with reference to self-exploration (Ayurvedic Personality Test) will be very helpful at a personal level.
- A suggested roadmap for effective implementation is shown below.

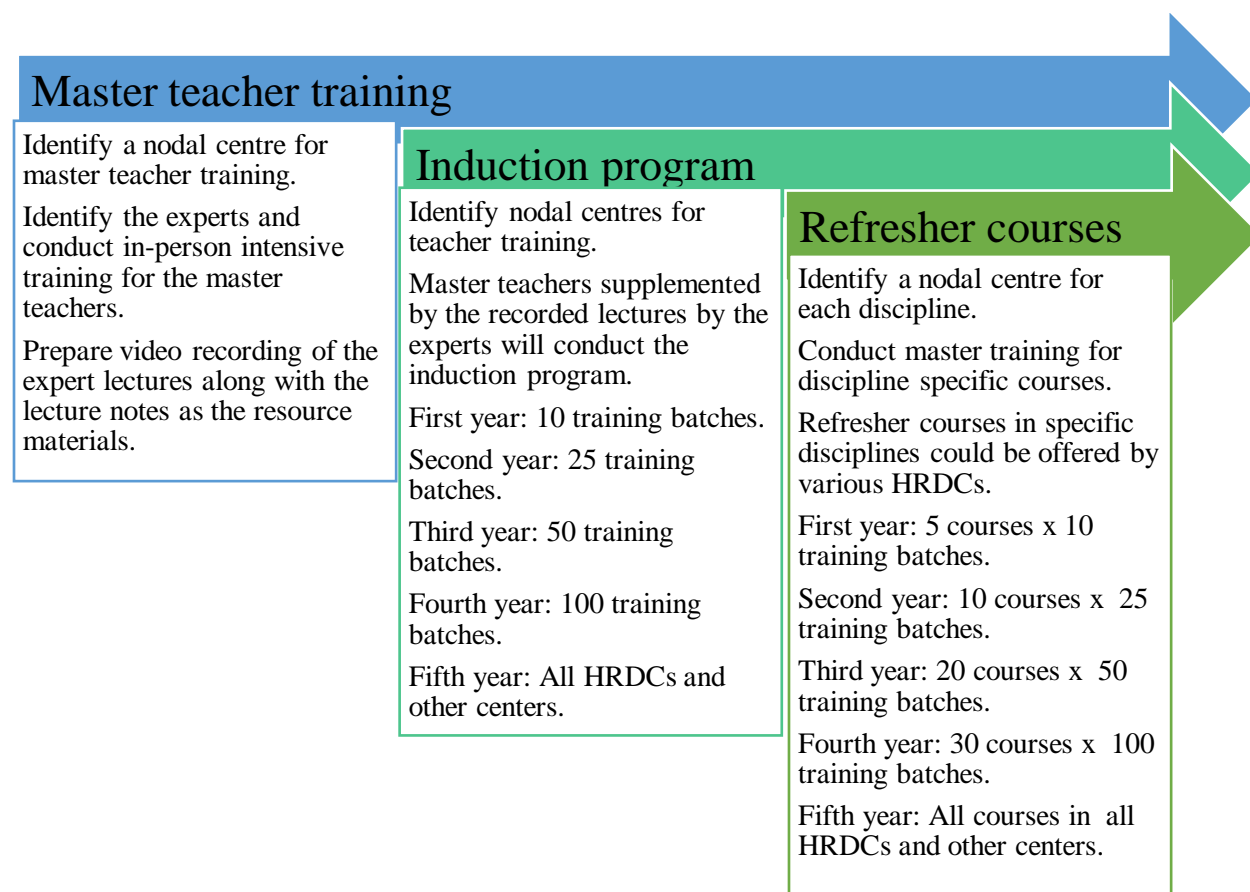


Figure 1. A roadmap for effective implementation of teacher training in IKS

Model Syllabi

Model Syllabi for the teacher training guidelines to help guide the creation of such courses for teacher training. These course outlines are not prescriptive and are intended to help the instructors in the preparation of course syllabi as per the needs of the learners.

1A: Model syllabi for IKS modules in the Induction Program

Course 1: IKS Induction Program in IKS

1. Overview of IKS

- Survey of IKS Domains: A broad overview of disciplines included in the IKS, and historical developments.
- Sources of IKS knowledge, classification of IKS texts, a survey of available primary texts, translated primary texts, and secondary resource materials. Differences between a sutra, bhashya, karika, and vartika texts. Fourteen/eighteen vidyasthanas, tantrayukti
- Vocabulary of IKS: Introduction to Panchamahabhutas, concept of a sutra, introduction to the concepts of non-translatables (Ex. dharma, punya, aatma, karma, yagna, shakti, varna, jaati, moksha, loka, daana, itihaasa, puraana etc.) and importance of using the proper terminology. Terms such as praja, janata, loktantra, prajatantra, ganatantra, swarjya, surajya, rashtra, desh,
- Philosophical foundations of IKS: Introduction to Samkhya, vaisheshika and Nyaya
- Methods in IKS: Introduction to the concept of building and testing hypothesis using the methods of tantrayukti. Introduction to pramanas and their validity, upapatti; Standards of argumentation in the vada traditions (introduction to concepts of vaada, samvaada, vivaada, jalpa, vitanda). Concept of poorvapaksha, uttarapaksha.

2. Case Studies (Few of these may be selected as appropriate)

- Mathematics of Madhava, Nilakantha Somayaji
- Astronomical models of Aryabhata
- Wootz steel, Aranumula Mirrors, and lost wax process for bronze castings
- Foundational aspects of Ayurveda
- Foundational aspects of Ashtanga yoga
- Foundational aspects of Sangeeta and Natya shastra

3. India and the World: Influence of IKS on the world, knowledge exchanges with other classical civilizations, and inter-civilizational exchanges.

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- Indian Knowledge Systems: Vol I and II, Kapil Kapoor and A K Singh; 2005 (D.K. Print World Ltd).
- The Beautiful Tree: Indigenous India Education in the Eighteenth Century, Dharampal, Biblia Impex, New Delhi, 1983. Reprinted by Keerthi Publishing House Pvt Ltd., Coimbatore, 1995.
- Indian Science and Technology in the Eighteenth Century, Dharampal. Delhi: Impex India, 1971. The British Journal for the History of Science.
- The Wonder That Was India, Arthur Llewellyn Basham, 1954, Sidgwick & Jackson.
- The India they saw series (foreigner visitors on India in history from 5CE to 17th century), Ed. Meenakshi Jain and Sandhya Jain, Prabhat Prakashan

Course 2: IKS Induction Program Module for Chemistry and Metallurgy

Introduction to IKS in general; introduction to a few Indic terms along with the IAST transliteration scheme with diacritic marks.

1. Outline of the contributions of ancient and medieval Indians in the area of chemistry and metallurgy as gleaned from archaeological artifacts, temple icons, and other such tangible objects like the Delhi Iron Pillar that have survived the test of time.
2. Specific use, processing, and finishing of 6 metals since the Vedic times and how the knowledge constantly evolved to incorporate other metals like mercury and zinc at later periods.
3. Chemistry of dyes, pigments, and other coloring materials used in paintings, fabrics, beads, and other day-to-day utilities since ancient times and their constant evolution through different periods of time.
4. Chemistry in Ayurvedic texts as well as in Ayurveda practice. A few case studies pertaining to the preparation, quality control, and delivery of herbo-mineral drug formulations.
5. Introduction to select original texts pertaining to chemistry and metallurgy like the *Rasārṇava* and *Rasaratnasamuccaya*; dwelling on the style of writing a technical subject as well as on the content that is in vogue in contemporary chemistry.

1B: Model Syllabi for Refresher Courses in IKS

Course 1: Course on Indian Science and Technology

1. Fundamentals

- An overview of Indian contributions to technology
- Technological Innovations

2. Metallurgy, Textile Chemistry & Pyro Technology

- Copper/Bronze/Zinc: Important Mines (*Zawar, Khetri* mines)
- Iron and Wootz Steel Technology
- Textile and Dyeing- Indian Specialities (*Kutchi Embroidery, Cotton Textile* etc.)
- Ceramic Technology, Stone (*Lapidary*), Shell, Ivory, Faience & Glass Technology

3. Water Management & Transportation

- Harappan and Traditional Water Management System of Gujarat
- Historical Sites- *Sringeverpur*, South Indian Water Management System, Western Ghats Cave- *Kanheri*, etc.
- Communities Involved in Water Management
- Modes of Transportations and Reforms
- Grand Trunk Road (*Uttarapath & Dakshinapath*)
- Development of Trading Techniques
- Boat & Ship Building

4. Mathematics & Astronomy

- Mathematics contained in the *Sulbasutra*
- Weaving Mathematics into Beautiful Poetry- *Bhaskaracarya*.
- The Evolution of Sine Function in India
- The Discovery of Calculus by Kerala Astronomers
- *Vedanga Jyotish* & Measuring Time & Calendar

5. Ecology and Environment

- *Nakshatrara Gyaan* and Agriculture
- Vernacular Architecture
- Forest Management and Urban Planning
- Agroforestry
- Tank, Lakes, and Stepwells

6. India's Contribution to the World

References:

- R.M. Pujari, Pradeep Kolhe, N. R. Kumar, 'Pride of India: A Glimpse into India's Scientific Heritage', Samskrita Bharati Publication.

- ‘Indian Contribution to science’, compiled by Vijnana Bharati.
- ‘Knowledge traditions and practices of India’, Kapil Kapoor, Michel Danino, CBSE, India.
- Dr. Subhash Kak , Computation in Ancient India, Mount, Meru Publishing (2016)
- Dharampal, *Indian Science and Technology in the Eighteenth Century*, Academy of Gandhian Studies, Hyderabad, 1971, republic. Other India Bookstore, Goa, 2000
- Robert Kanigel, *The Man Who Knew Infinity: A Life of the Genius Ramanujan*, Abacus, London, 1999
- Alok Kumar, *Sciences of the Ancient Hindus: Unlocking Nature in the Pursuit of Salvation*, CreateSpace Independent Publishing, 2014
- B.V. Subbarayappa, *Science in India: A Historical Perspective*, Rupa, New Delhi, 2013
- S. Balachandra Rao, *Indian Mathematics and Astronomy: Some Landmarks*, Jnana Deep Publications, Bangalore, 3rdedn, 2004
- S. Balachandra Rao, *Vedic Mathematics and Science in Vedas*, Navakarnataka Publications, Bengaluru, 2019
- Bibhuti bhushan Datta, *Ancient Hindu Geometry: The Science of the Śulba*, 1932, repr. Cosmo Publications, New Delhi, 1993
- Bibhuti bhushan Datta & Avadhesh Narayan Singh, *History of Hindu Mathematics*, 1935, repr. Bharatiya Kala Prakashan, Delhi, 2004
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- J. McKim Malville & Lalit M. Gujral, *Ancient Cities, Sacred Skies: Cosmic Geometries and City Planning in Ancient India*, IGNCA & Aryan Books International, New Delhi, (2000).
- Clemency Montelle, *Chasing Shadows: Mathematics, Astronomy and the Early History of Eclipse Reckoning*, Johns Hopkins University Press, 2011
- AnishaShekharMukherji, *Jantar Mantar: Maharaja Sawai Jai Singh's Observatory in Delhi*, AMBI Knowledge Resources, New Delhi, 2010
- Thanu Padmanabhan, (ed.), *Astronomy in India: A Historical Perspective*, Indian National Science Academy, New Delhi & Springer (India), 2010
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- R. Balasubramaniam, *Delhi Iron Pillar: New Insights*, Indian Institute of Advance Study, Shimla & Aryan Books International, New Delhi, 2002
- R. Balasubramaniam, *Marvels of Indian Iron through the Ages*, Rupa& Infinity Foundation, New Delhi, 2008
- Anil Agarwal & Sunita Narain, (eds), *Dying Wisdom: Rise, Fall and Potential of India's Traditional Water-Harvesting Systems*, Centre for Science and Environment, New Delhi, 1997
- Fredrick W. Bunce: *The Iconography of Water: Well and Tank Forms of the Indian Subcontinent*, DK Printworld, New Delhi, 2013

Course 2: Refresher Courses on IKS-based Chemistry and Metallurgy

1. Theoretical framework for the practice of science in ancient India:
 - *Sāṅkhya-Pātañjala* system, Evolution of different forms of matter (*Pañcīkaraṇa*) from the *Vedāntic* view, The atomic theory of the Buddhists and Jains, *Nyāya-Vaisesika* chemical theory
2. Chemistry in practice as gleaned from the medical schools of ancient India, Qualities of compounds; formation of molecular properties in chemical compounds, Chemistry of colors, measures of weight and capacity, size of the minimum visible, Ideas of chemistry as in *bṛhatsamhitā*
3. Metallurgical heritage:
 - *Arthaśāstra* as the earliest text describing gold, silver, and other metals;
 - Processing of gold, silver, copper, iron, tin, mercury, and lead as mentioned in the Indian texts in the ancient and Medieval Period
 - Zinc distillation as mentioned in *Rasārṇava* and *Rasaratnasamukāyā*
4. Concepts of acid and bases in Indian chemistry from organic fruit, vegetable-based. Acids, plant-ash-based bases to mineral acids of the medieval period

References:

- The Positive Sciences of the Ancient Hindus; Brijendra Nath Seal; 4th Edition; 2016
- Fine Arts & Technical Sciences in Ancient India with special reference to Someśvara's *Mānasollāsa*; Dr. Shiv Shekhar Mishra, Krishnadas Academy, Varanasi 1982
- Mints and Minting in India; Upendra Thakur; Chowkhanba Publication; 1972
- A Concise History of Science in India, ed. D M Bose, S N Sen and B V Subbarayappa; INSA; 2009
- Science and Technology in Medieval India - A Bibliography of Source Materials in Sanskrit, Arabic and Persian by A Rahman, M A Alvi, S A Khan Ghorī and K V Samba Murthy; 1982.
- Science and Technological Exchanges between India and Soviet Central Asia (Medieval Period), ed B V Subbarayappa; 1985
- Scientific and Technical Education in India, 1781-1900 by S N Sen; 1991
- History of Technology in India, Vol. I, ed. A K Bag (1997); Vol III, ed. K V Mital (2001); Vol-II by Harbans Mukhia (2012).

Course 3: Course on Indian Economics and Business Model

1. History of Indian Economy Thoughts, New Indian Economic Model & Sectorial Contribution Past vs Present

- History of Indian Economy Thoughts: Context from *Dharmashastras*, *Shukraniti*, *Mahabharata*, and *Arthashastra*.
- Kautilya's Economic thoughts in specific. India and Global GDP: Ancient India
- Beyond Capitalism and Communalism, Dharmic, Caste as Social Capital, Black Money, and Tax Heaven.
- Agriculture: Ancient India, Manufacturing: Ancient India, Education in India, Wealth in India, Governance, and Business in India, Where India Stands Globally.

2. Indian Business Model: Based on 10-point formula:

- Family Base, High Level of Savings, Self-Employment, Highly Entrepreneurial Nature, Non-corporate Sector as the Core of the Economy, Community Orientation and Higher Social Capital, Faith and Relationship in Economic Affairs, A Society-driven Economy, Driven by Norms and Values

3. Project Report: Indian Models of Economy, Business, and Management

References:

- Kanagasabapathi; "Indian Models of Economy, Business and Management", Third Edition, Prentice Hall India Ltd., Delhi.
- Lotus and Stones; Garuda Prakashan (31 October 2020); Garuda Prakashan Pvt. Ltd.
- Dwivedi D.N., Essentials of Business Economics, Vikas Publications, Latest Edition.
- India Uninc by Prof. R Vaidyanathan, Westland Ltd. Publication
- Economic Sutras by Prof. Satish Y. Deodhar, IIMA Books series
- Black Money Tax Heaven by R Vaidyanathan, Westland Ltd. Publication.

Web resources:

- Goswami Anandajit, Economic Modeling, Analysis, and Policy for Sustainability, IGI Global, Latest Edition.
- Ganguly Anirban, Redefining Governance, published by Prabhat Prakashan, Latest Edition.
- Vaidyanathan R., India Unincorporated, ICFAI Books, Latest Edition.

Course 4: Course on Ancient Indian Art and Architecture

1. Fundamentals of Art and Architecture, Traditional and Historical Town Planning & Ancient Indian Art & Architecture

- Geography of *Bharatvarsh* and Civilizational Journey, Origin of *Sthapatyaveda*, Concept of Space and Time, Vedic *Yajna*: Recreating the microcosmos, *Vastu Purusha*, Six Limbs of Indian Art and Architecture
- Harappan Town Planning, Early Historical Cities and Early Text (*Arthshastra*), Mud Forts of Chhattisgarh,
- Concept of Sacred and Profane, Techno-Typological Evolution & Regional Variations in Temple Architecture, Rock Cut Architecture, Structural Temple Architecture, *Tirthkshetra*- *Kashi*, *Dwaraka*, *Kanchi*, *Avantika*, *Ayodhya*, *Prabhas-kshetra* etc., Continuity of Traditional Town Planning: Jaipur, Madurai, Srirangam etc. Functional Aspects of Temples

2. Sacred Ecology

- Sacred Forest (*Naimisaranya*, *Panchvati*, *Dandkaranya* etc.), Sacred Groves (*Aaramika*, *Devkunj*, etc.), Rainwater Harvesting System: *Vav*, *Kund*, *Talav* etc, Sacred Hills and Mountains (*Kailash*, *Vindhya*, *Sahyadri*, *Satrunjay*, *Goverdhan*), *Kumbha*: assimilation of ritual, myth, symbology, and cosmology.

3. Modern Contribution to Indic Architecture

- Anand K. Coomaraswamy, Patrick Geddes, Alice Boner, Kapila Vatsayayan, Stella Kramrisch and Adam Hardy

References:

- Coomaraswamy, Ananda K. 2002. *Early Indian Architecture: Cities and City-Gates*, Munshiram Manoharlal Publishers.
- Vatsayayan, Kapila. 1997. *The Square and the Circle of the Indian Arts*, Abhinav Publication.
- Hardy, Adam. 2015. *Theory and Practices of Temple Architecture in Medieval India: Bhoja's Samrangansutradhar and The Bhojpur Line Drawings*, Dev Publishers & Distributors.
- Sathapati, V. Ganapati. 2001. *Indian Sculpture and Iconography-Forms and Measurements*, Auro Publications.

Course 5: Mathematics in India: from Vedic period to modern times

1. Mathematics in the Vedas and Śulva Sūtras

- Mathematical references in Vedas. The extant Śulbasūtra texts & their commentaries. The meaning of the word Śulbasūtra. Qualities of a Śulbakāra. Finding the cardinal directions. Methods for obtaining perpendicular bisector. Bodhāyana's method of constructing a square. The Bodhāyana Theorem (so-called Pythagoras Theorem)
- Applications of Bodhāyana Theorem. Constructing a square that is the difference of two squares. Transforming a rectangle into a square. To construct a square that is n times a given square. Transforming a square into a circle (approximately measure preserving). Rational approximation for $\sqrt{2}$. Construction of Cities. Details of fabrication of bricks, etc.

2. Pāṇini's *Aṣṭādhyāyī*, Piṅgala's *Chandaḥśāstra* & Mathematics in the Jaina Texts

- Development of Vyākaraṇa or Śabadaśāstra. Pāṇini and Euclid. Method of Pāṇini's *Aṣṭādhyāyī*. Śiva-sūtras and Pratyāhāras,
- Overview and development of Prosody or Chandaḥśāstra.
- Important Jaina mathematical works. Jaina geometry, The law of indices, Permutations, and Combinations.

3. *Āryabhaṭīya* of Āryabhaṭa

- Āryabhaṭa, his period and his work *Āryabhaṭīya*, Area of a circle, trapezium, and other planar figures. Approximate value of π . Computation of tabular Rsines (geometric and difference equation methods), Ekavarṇa-samikaraṇa and anekavarṇa-samikaraṇa.

4. *Brāhmasphuṭasiddhānta* of Brahmagupta

5. Bakṣālī Manuscript & *Gaṇitasārasaṅgraha* of Mahāvīra

6. Development of Combinatorics

7. *Līlāvātī* of Bhāskarācārya, *Bījagaṇita* of Bhāskarācārya & *Gaṇitakaumudī* of Nārāyaṇa Paṇḍita

8. Magic Squares, Trigonometry and Spherical Trigonometry

9. Proofs in Indian Mathematics, Mathematics in Modern India

- Srinivasa Ramanujan (1887-1920). A brief outline of the life and mathematical career of Ramanujan, Some highlights of the published work of Ramanujan and its impact

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Course 6: Basics of Indian Astronomy

- 1. The science of Astronomy and the different units of time discussed in the texts**
- 2. Systems employed for representing numbers**
- 3. Spherical trigonometry & Celestial Sphere**
- 4. *Pañcāṅga***
 - Division of the celestial sphere/ecliptic, significance by pointing out their basis, five elements that constitute *Pañcāṅga*– and their astronomical significance, computation of elements in a *Pañcāṅga*.
- 5. Key concepts pertaining to planetary computations and Computation of the true longitudes of planets**
- 6. Precession of equinoxes – *sāyana* and *nirayana* longitude**
- 7. Finding the cardinal directions and the latitude of a place**
- 8. Determination of the variation of the duration of the day at a given location**
- 9. *Lagna* and its computation**
- 10. Eclipses and their computation**

References:

- S. N. Sen and K. S. Shukla, *History of Astronomy in India*, 2nd Ed., INSA, Delhi, 2001.
- S. Balachandra Rao, *Indian Astronomy an Introduction*, Universities Press, Hyderabad, 2000
- *History of Astronomy: A Handbook*, Edited by K. Ramasubramanian, Aniket Sule and Mayank Vahia, S and HI, IIT Bombay, and T.I.F.R. Mumbai, 2016.
- B.V. Subbarayappa and K.V. Sarma, *Indian Astronomy: A Source Book*, Nehru Centre, Bombay, 1985.
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Course 7: Introduction to Indian Astronomy

1. Preliminaries

- Skyviewed as the inside of a hemisphere. Cardinal directions, zenith, horizon, pole star at any location. The daily motion of celestial objects (Sun, Moon, planets, stars) and diurnal circles. Motion in the stellar background. Ecliptic. Basic time units: Day, Month and Year.
- Celestial coordinates and elementary spherical trigonometry.

2. Developments from the Vedic period up to the *Siddhāntic* period

- *Vedic Astronomy*: Astronomical concepts in Vedic literature regarding Sun, Moon, Stars, and Earth. Planets, Comets, etc. Pole star in an earlier era. *Nakṣatra* division of the ecliptic and motion of the Sun along it in *Vedāṅga Jyotiṣa*
- *Siddhāntic astronomy*: Earlier *Siddhāntas* and *Pañcasiddhāntikā*. Introduction of trigonometry, Indian *jyā*-astronomy. *Āryabhaṭīya*. *Mahāyuga*, Revolution numbers of planets. *Ahargana* and Mean longitudes, Examples. Obtaining the true longitudes by applying corrections to mean longitudes.
- Epicycle models: *Manda* correction (Equation of center) in detail. Its significance. Latitude of Moon.
- *Śīghra* correction to planets and their significance: Essential features only with the aid of diagrams and final formulae. Latitudes of planets. Precession of equinoxes— *Nirayana* and *Sāyana* longitudes.
- Nature and Organisation of texts. *Sūtra* (algorithmic) format. *Siddhānta*, *Tantra*, *Karaṇa* and *Vākya* texts. *Sāraṇis* or Tables.

3. Indian Calendar

- *Pañcāṅga*. *Adhikamāsas*. Solar and Luni-Solar systems.

4. Solar and Lunar Eclipses

- Angular diameters of the Sun, Moon, and Earth's shadow. Possibility of eclipses. Finding the middle of an eclipse by iteration. Amount of obscuration at any time.

5. Tripraśna Topics (Diurnal problems)

- Description of the celestial spheres and various circles.
- Derivation of the expression for the declination in terms of the longitude.
- Finding the latitude. Mid-day shadow. Finding the declination. Relation between the time and the shadow at an arbitrary instant (no derivation).

6. Planetary longitudes and latitudes, Nīlakaṇṭha Somayājī's revised planetary model and Rates of Motion of Planets

- True longitudes of planets: *Manda* and *Śīghra* corrections in detail. Geometrical description. Comparison with Kepler's model. Latitudes of planets.
- Nīlakaṇṭha Somayājī's revision of the planetary model: Nīlakaṇṭha's analysis of the motion of the interior planets (Mercury and Venus). His geometrical model which is geometrically similar to the Tycho Brahe model (planets moving around the Sun which itself orbits the Earth), but computationally approximates the Kepler model.

- Idea of derivative in finding the *Mandagatiphala* (*manda*-correction to the mean rate of motion). The correct formula due to Nīlakaṇṭha.
- True rates of motion of planets: Correct expression due to Bhāskara. Application to calculate the retrograde motion of planets.

7. *Tripraśna* topics

- Latitudinal triangles (of Bhāskara) and applications. *Agrajyā* or the distance between the rising-setting line and the east-west line. Correction to the east-west line due to change in Sun's declination.
- Zenith distance in terms of the declination, hour angle, and latitude ($\cos z = \sin \phi \sin \delta + \cos \phi \cos \delta \cos H$). Derivation of this formula as in *Siddhānta śiromaṇi*. Relation among *Śaṅkutala* (*Śaṅkvagra*), *Bhujā*, *Agrajyā* and its applications.

8. Rising times of *Rāśis* and finding *Lagna*

- Relation between the right ascension and longitude and rising times of *rāśis* at the equator. Rising times at an arbitrary latitude.
- Finding the *Lagna* at any instant after Sunrise (approximate).

9. Eclipse calculations

5. The *Vākya* system

10. Astronomical Instruments

- Gnomon. *Cakra* and *Dhanur* yantras for measuring the zenith distance of the Sun. Approximate and exact times from a 'yaṣṭi'.
- *Phalakayantra* to measure the hour angle. Equatorial sundial to measure time.
- Clepsydra for measuring time. Celestial globe and Armillary sphere for explaining celestial coordinates and various circles.

11. Indian Astronomy in the 18th and 19th centuries

- Astronomical endeavors of Savai Jayasiṃha. *Samrat-yantra* and other instruments in the observatories of Jayasiṃha.
- European observers on the simplicity and accuracy of Indian eclipse computations.
- The work of Śaṅkaravarman and Candrasekhara Sāmanta. Efforts to update the Indian calendar.

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9. *Karaṇapaddhati of Putumana Somayājī*, Translation and Notes, R. Venkateswara Pai, K. Ramasubramanian, M.S. Sriram and M. D. Srinivas, Hindustan Book Agency, New Delhi and Springer, 2018.

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