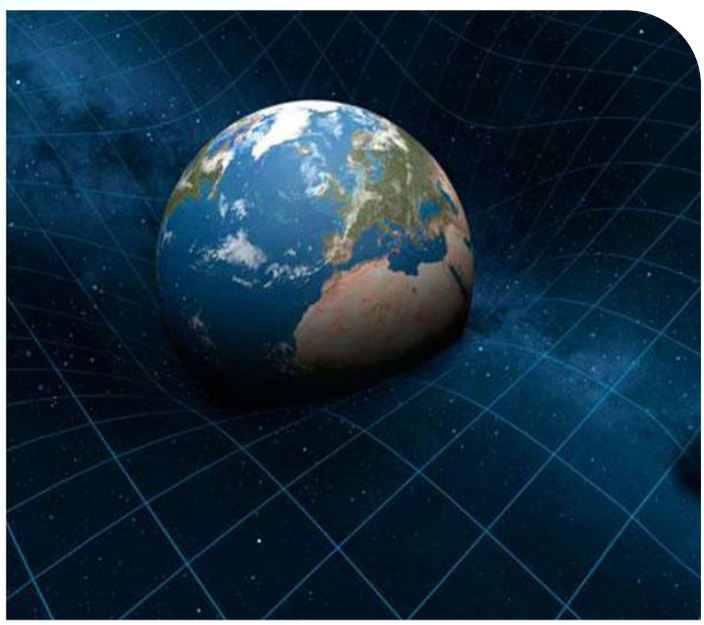
CENTRE FOR STEM & SPACE SCIENCE

Nurturing Technocrats of Future

CERTIFICATE COURSE IN ASTRONOMY



COURSE DESCRIPTOR

Preamble

Everyone wants to know about the universe in which we live. There is curiosity about questions such as 'How does the universe work?', 'How many stars, planets and galaxies are there?', and 'What are black holes?' And the one that inspires the most
'Is there life beyond Earth?'

Astronomy is a science that seeks to answer such questions through observation and scientific methods. Space science is an interdisciplinary subject that is naturally linked with technology and instrumentation which puts the field in a position to contribute significantly in building a strong technical work force.
With the current advancement in this field, there will be a continuous demand of professionals and educators.
In India, astronomy and space science courses are taught at the post graduate level. These courses are generally specialized. There is a need of a curriculum that fills the gap between the current school and college curriculum, and these specialized courses.

The Certificate Course is designed for these purposes. It is a first stage course that intends to provide a comprehensive and in-depth insight into Astronomy and Space science. The onus is on introducing students to extensive topics which can lead to a realistic approach towards higher education and career in Astronomy, Space science and allied fields. It will help you on your journey to become a professional or amateur astronomer. It will also add value in building your profile as a science teacher.

Course Objectives

- To explore the in-depth concepts of Astronomy and Astrophysics.
- To provide hands-on experience for students on the astronomy instruments.
- To develop scientific temper and critical thinking.
- To nurture the ideas and curiosity of students.
- To create awareness about various opportunities in space related fields.
- To provide a bridge that connects current formal education and the avenues in astronomy and space science.
- To aid in building a profile as a science teacher or educator.
- To expose the vast extent of Astronomy and Space Science to learners.

Course Benefits

After completion of the course you will be able to

- Gain conceptual and practical understanding of astronomy and astrophysics
- Understand the recent discoveries in the field
- Bridge the gap between basic understanding of the field and higher education
- Excel with the aid of expert Guidance
- Learn experimental data analysis
- Understand current technology in space science
- Learn about different/multiple career opportunities in the field.
- Teach Astronomy and Space Science to various public forums
- Achieve a stronger foundation for further education

Course Duration:	6 months, 5 days/week, 2 hours/day
Eligibility:	12^{th} and above ● Science and Geography Teachers ● Aspiring amateur astronomers
Awarding Institution:	Centre for STEM & Space Science (affiliated to Tilak Maharashtra Vidyapeeth, Pune)
Mode of Course:	Offline ● Online

Course Structure:

Unit Name	Theory sessions (hours)	Experiments	Assignments
Fundamentals of Astronomy	40	6	1
Stars and Galaxies	60	4	1
Tools of Astronomy and Space Exploration	60	4	1
Related Fields and Applications	40	-	1

Course Syllabus

- **Unit 1: Fundamentals of Astronomy**
  Topic 1: Introduction to Astronomy
  What is Astronomy, Foundations of Astronomy, Astronomy as an ancient science, History of Astronomy, Famous Astronomers, Foundations of Astrophysics and Space Science, Value of Astronomy

- **Topic 2: Celestial Sphere**
  The sky, Celestial sphere, Celestial coordinate systems, Star Charts, Measurements in Astronomy, Stellar Parallax, Astrometry, Distance Measurements, Brightness, Brightness Magnitudes, Size

- **Topic 3: The Sun**
  The Sun, Physical parameters of the Sun, Photosphere, Sunspots, Solar Atmosphere, Solar Activities, Prominences, Coronal Mass Ejections, Solar Flares, Solar Wind, Space Weather
  Solar Interior, Thermonuclear fusion in the Sun, Hydrodynamics, Solar Neutrinos, Energy Transport

- **Topic 4: Earth and Moon**
  Earth, Interior of Earth, Earth's Atmosphere, Magnetic Field of Earth, van Allen Radiation Belts, Timeline of Earth, Formation of Moon, Tidal effects, Axial tilt and Seasons, Eclipses
  Time zones, Latitude, Longitude, Time calculations, Sidereal Time, Mean Solar Time, Ephemeris Time

- **Topic 5: Solar system**
  History of the solar system, Formation of Sun and planets, Models of solar system, Terrestrial planets, Jovian planets, Moons, Rings, Dwarf planets, Asteroids and Comets
  Kepler's laws, Newton's law of gravitation, The Two Body Problem, Restricted Three Body Problem

Practical for Unit 1

1 Measurement of Parallax
2 Measurement of Angular size of celestial bodies
3 Study of Celestial Sphere
4 Study of Celestial coordinate systems
5 Solar limb darkening
6 Measurement of Temperature of Sun

References

1 Daniel Fleisch, Julia Kregenow - A Students Guide to the Mathematics of Astronomy – Cambridge University Press
2 K.D. Abhyankar – Astrophysics of the Solar System - Universities Press
3 Dinah Moche – Astronomy: A Self-Teaching Guide –John Wiley and Sons
4 Alessandra Celletti – Celestial Mechanics – Springer
5 Space Studies Board – Solar and Space Physics – National Academies Press
6 Eric Chaisson, Steve McMillan – Astronomy: A Beginner's Guide to the Universe – Pearson

Unit 2: Stars and Galaxies

- **Topic 1: Stars**
  Stars, Luminosity, Flux, Absolute magnitude, Observing stars, Electromagnetic Spectrum, Doppler Effect, Binary Stars, Variable stars, Classification of Stars, HR Diagram, Star Clusters, Globular clusters

- **Topic 2: Evolution of Stars**
  Stellar Nurseries, Gravitational collapse, Jeans instability, Protostars, Hydrostatic equilibrium, Blackbody spectrum, Stefan-Boltzmann Law, Life on the main sequence, Stellar nucleosynthesis, Nuclear processes

- **Topic 3: Compact Objects**
  Life of stars after the main sequence, Giants and Supergiants, Collapse of equilibrium, Planetary nebula, White Dwarf, Supernova, Types of supernova, Neutron Stars, Pulsars, Black holes

- **Topic 4: Galactic Astronomy**
  Galaxies, Components, Structure, Classification of galaxies, The Milky Way, Interstellar Medium, Galactic centre, Galactic Disk, Halo, Beyond the Milky Way, Local Group
  Observing galaxies, Understanding components of a galaxy using imaging data, Galactic Rotation Curves, Dark Matter, Clusters and Super clusters

- **Topic 5: Active galaxies**
  Difference between normal and active galaxies, Active Galactic Nuclei, Radio Galaxies, Seyferts, Quasars, Supermassive Black holes, Galaxy collisions, Galaxy Mergers, Starbursts

Practical for Unit 2

1 Obtaining spectrum from a lab source
2 Study of Fraunhofer lines
3 Analysis of Variable Stars
4 Classification and Analysis of Galaxies using SkyView Data

References

1 Ian Morison – Introduction to Astronomy and Cosmology – Wiley
2 T. Padmanabhan – Theoretical Astrophysics Volume II: Stars and Stellar Systems – Cambridge University Press
3 T. Padmanabhan – Theoretical Astrophysics Volume III: Galaxies and Cosmology – Cambridge University Press
4 Peter Schneider – Extragalactic Astronomy and Cosmology - Springer
5 Steven Stahler, Francesco Palla – Formation of Stars – Wiley
6 Dina Prialnik – An Introduction to the Theory of Stellar Structure and Evolution – Cambridge University Press

Unit 3: Tools of Astronomy and Space Exploration

- **Topic 1: Optical Astronomy**
  Light, Fermat's Principle, Reflection, Refraction, Parabolic Mirrors, Lenses, Optical defects, Telescopes, Refractors, Reflectors, Newtonian, Cassegrain. Dobsonian, Telescope Collaborations, Very Large Telescope, Limitations of Ground based optical telescopes, Hubble Space telescope

- **Topic 2: Photometry**
  Photons, Photo detectors, Optical and IR detectors, CCD, Photometers, Photomultipliers, Scintillation detectors, X-Ray Telescopes, Photometry systems in astronomy

- **Topic 3: Spectroscopy & Interferometry**
  Atomic structure, Photon interactions, Spectrum, Continuous Spectra, Absorption and Emission Spectra, Optical and UV Spectrum, IR spectrum, Astronomical spectroscopy, Hydrogen Spectrum, Spectra of other elements
  Superposition of waves, Interference of waves, Interference of light, Michelson interferometer, Interferometry, Gravitational Waves, LIGO, Laser Interferometer Space Antenna (LISA)

- **Topic 4: Foundations of Space Exploration**
  History of space exploration, Ground based space exploration, Radio Telescopes, Physical Space Exploration, Space Probes, Rovers, Active Missions, Space Exploration of the Future

- **Topic 5: Space Propulsion**
  Rockets, Design & Construction, Laws of Thermodynamics, Rocket Equation, Types of Rockets, Capacities, Fuels, Propulsion Systems, Stages, Payloads, Uses
  Satellites, Design & Launching, Orbital Dynamics, Lagrangian Points, Applications, Technological advancement and Future scope

Practical for Unit 3

1 Working of telescope
2 Study of emission and absorption spectra
3 Study of 21 cm Hydrogen line
4 Demonstration of Satellite Communication

References

1 Ajoy Ghatak – Optics – McGraw Hill
2 Eugene Hecht – Optics, 5th Edition – Pearson
3 Daniel Schroeder – Astronomical Optics – Academic Press
4 C.N. Banwell – Fundamentals of Molecular Spectroscopy – McGraw-Hill
5 Ramamurthy – Rocket Propulsion –Trinity
6 S.K. Das – All About Satellites – Rupa Publications India
7 Y. Cengel, M. Boles, M. Kanoglu – Thermodynamics: An Engineering Approach, 9th Edition – McGraw-Hill

Unit 4: Related Fields and Applications

- **Topic 1: Relativity**
  Special Theory of Relativity, Postulates, Transformation Equations, Lorentz Transformation, Time Dilation, Length Contraction, Relativistic velocity addition, Conservation of momentum, Mass Energy Equivalence, Relativistic Doppler Shift
  Minkowksi Space-time, Space-time Diagrams, Equivalence Principle, Introduction to General Relativity and Implications

- **Topic 2: Cosmology**
  Introduction to Cosmology, Cosmological parameters, Cosmological Scales, Cosmic Microwave Background, Redshift, Hubble Parameter, Expanding Universe, Dark Energy, Cosmological Models, Big Bang, Steady State, Evolution of the Universe, Large scale structures

- **Topic 3: Astrochemistry**
  Chemistry of solar system, Chemical composition of Sun, planets, moons, asteroids, comets, Kuiper belt objects
  Earth's atmosphere, Chemistry of clouds, Seasons, Volcanic activity, Rock formation, outgassing, Geochemistry on other solar system bodies
  The Interstellar Medium, Interstellar clouds, Astration, Interstellar environments, star forming regions

- **Topic 4: Astrobiology**
  Conditions for Life, Chemistry of Life, Evolution of Life on Earth, Biochemistry, Biomolecules, Role of Atmosphere, Evolution of intelligence
  Possibility of life on other Solar system bodies, Exoplanets, Search for habitable exoplanets, Detection of exoplanets, Studying planetary atmospheres, Chemical compositions
  Search for Life in the universe, Ground and Space Based Surveys, Search for Extra Terrestrial Intelligence (SETI), Origin of life on earth-Panspermia, Comets, Abiogenesis

- **Topic 5: Applications**
  Applications of Astronomy and Space Science, Technology Transfer, Weather and Communication Satellites, RADAR, Space pharmacies, Space based architecture and design, Discoveries in Physics, Chemistry and Engineering

References

1 J. V. Narlikar – Introduction to Cosmology – Cambridge University Press
2 J.V. Narlikar – An Introduction to Relativity – Cambridge University Press
3 Robert Resnick – Introduction to Special Relativity – Wiley
4 Andrew Shaw – Astrochemistry – Wiley
5 David Catling – Astrobiology: A Very Short Introduction – Oxford
6 Chris Impey, J. Lunine, Jose Funes – Frontiers of Astrobiology – Cambridge University Press

Exam Pattern
Theory Exam (4 x 100 marks):

Unit wise theory exam, each of 100 marks will be held at scheduled dates during the course period. The theory exam will be held at the end of the course. The paper will consist of the following type of questions:

Type of Question	Maximum Marks
MCQ	20
Numerical Answer Type	30
Subjective Questions	50

Practical Exam (50 marks)

Students have to perform an experiment from the given list of practicals. The performance in the exam will be graded out of 25 marks. A viva voce of 25 marks will also be conducted based on the same list of experiments.

Project (50 marks)

The project is an important part of the course. It will have to be done individually. Students have the freedom to choose a topic of their choice, provided that the topic is from Astronomy or Space Science. They must get the topic verified from the faculty before starting on the project work. Along with this, students must submit a one page write-up about the topic of their choice.

Students can opt for one of the following methods:

- Effective Teaching Methods in Astronomy Education
- Scientific Models in Astronomy and Space Science
- Online seminar about Active and Open Problems in Space Science

Students can also choose from other methods if they are willing to, but they will have to check in with the faculty and explain their method of choice.

Assignments (4 x 25 marks):

Unit wise assignments will be provided to students while the unit is being taught in class. These will be short assignments based on topics from that unit and are designed to help students study for the theory exam. Solutions can be submitted anytime within 10 days after the handing out of assignments. Any solutions submitted after day 10 will be considered for evaluation but will not be awarded maximum marks.

Conducting Stargazing Session:

Throughout the course, students will be undergoing multiple stargazing sessions under experts. Students may opt to share this knowledge and improve on their science communication skills by conducting a stargazing session under the guidance of experts. Any student who chooses this will conduct a session for newcomers into the field of astronomy and will be graded based on their performance. All students who opt for this will get a separate certificate besides the one that they will get after completing the normal coursework.

For Admission Contact +91 9850 49 9850

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