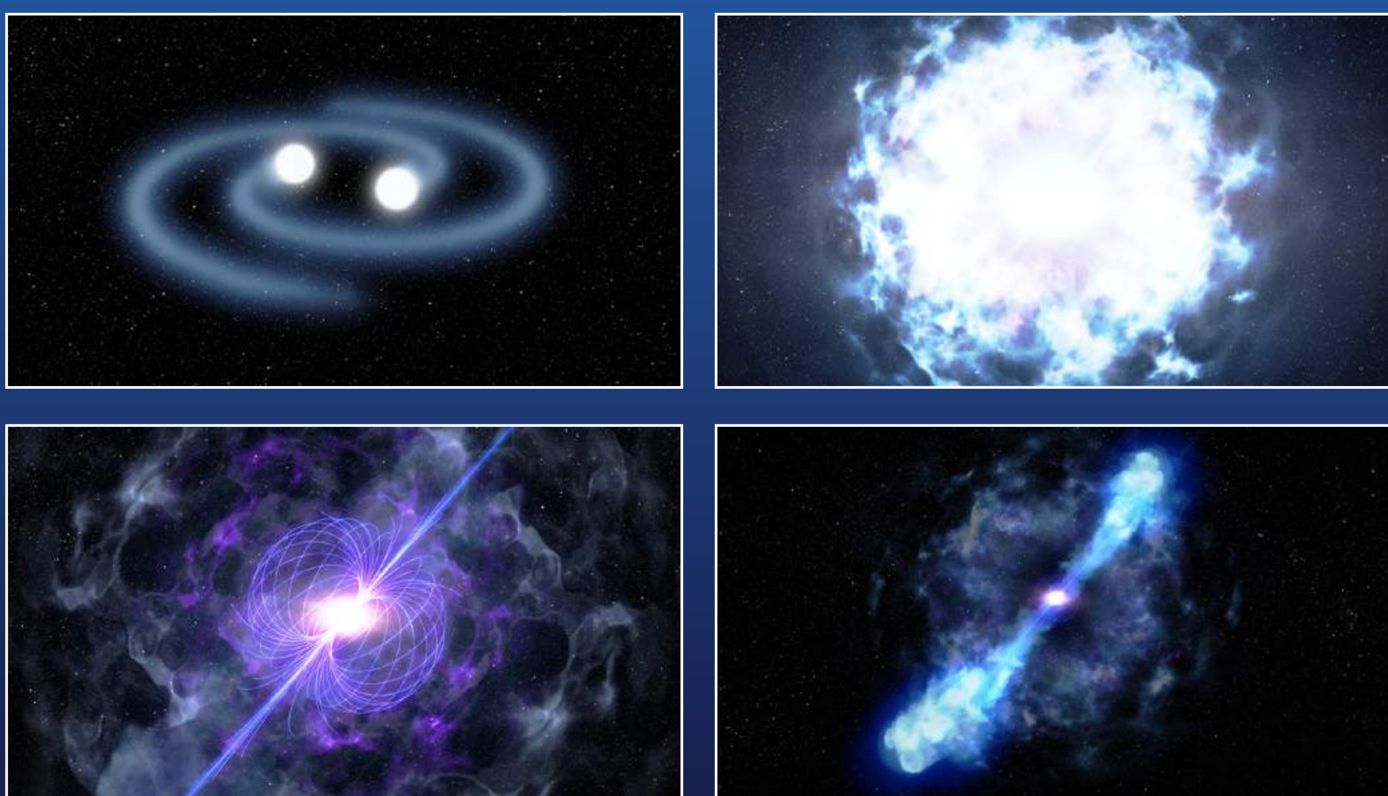
CENTRE FOR
STEM & SPACE SCIENCE

Nurturing Technocrats of Future

DIPLOMA IN SPACE SCIENCE



COURSE DESCRIPTOR

Preamble

Space has long been described as the final frontier for humanity. Modern space research began less than 80 years ago during the aftermath of a global war. As of today, Astronomy and Space Science are at the forefront of global collaborative research and are one of the most challenging fields to work in.
Research in space science has benefitted the human race in several aspects. Technological advancements that are made to solve a problem in spaceflight have proven to be of great importance. The Infrared Thermometer was originally developed through NASA collaboration for studying the temperature of planets and stars. Today, it is used extensively for checking a person's body temperature especially since the Covid-19 pandemic. Similarly, the wireless headphones that everyone uses today were developed for astronauts and were even used by Neil Armstrong when he delivered his monologue from the Moon. There are several such examples of 'technology transfer' that have enriched our daily lives.

Astronomy and space science research is not limited to scientists however. Every space research mission requires a diverse group of experts with an optimal technical skillset. Astronomers, physicists, chemists, computer scientists, mathematicians, aerospace, chemical, and electronic engineers are just a few of the extensive group of individuals that can work in space science.
Students who wish to take this path must possess the right skills and tools for enhancing their education and career. The Diploma course offers an insight into the technical tools and skills required for studying astronomy along with providing a comprehensive overview of core topics in astronomy making it a unique blend of scientific and technical.

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Course Objectives

- To explain 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 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 expose students for academic collaborations at reputed institutions like IUCAA, NCRA-TIFR, and GMRT.
- To understand the need of space technologies and their role in improving quality of life

Course Benefits

- Conceptual and practical understanding of astronomy and astrophysics
- Introduction to the recent discoveries in the field
- Closes the gap between basic understanding of the field and higher education
- Expert Guidance
- Exposure to experimental data analysis
- Introduction to current technology in space science
- Exposure to different/multiple career opportunities in the field.
- Stronger foundations for further education

Course Duration:	1 year/2 semesters/5 days a week/2 hours a day
Eligibility:	Undergraduate students currently enrolled in B.E/B.Sc. programmes and wish to go for further education and career in Astronomy and Space Science. Students who wish to appear for competitive examinations in Astronomy and go for M.Sc./Ph.D. in the future. Amateur astronomers and aspiring teachers are also welcome to apply.
Awarding Institution:	Centre for STEM and Space Science (affiliated to Tilak Maharashtra Vidyapeeth, Pune)
Mode of conduction:	Classroom

Course Structure:

Semester 1:

Paper Name	Number of Units	Theory sessions (hours)	Experiments	Assignments
I-Foundations of Science and Astronomy	**3**	**70**	**6**	**2**
II-Technical Tools and Skills for Astronomy	**4**	**70**	**8**	**2**
III-Stars and Galaxies	**2**	**60**	**4**	**2**

Semester 2:

Paper Name	Number of Units	Theory sessions (hours)	Experiments	Assignments
I-Observational Techniques	**3**	**70**	**5**	**2**
II-Physical Space Exploration	**3**	**70**	**2**	**2**
III-Earth and Space Science	**3**	**60**	**3**	**2**

Course Syllabus
Semester 1

Paper I – Foundations of Science and Astronomy

Unit 1 – Methods and Tools of Science
Why do we study science, Knowledge and its types, Empirical knowledge, Scientific method, Hypothesis, Theory, Experiment, Deductive and inductive models, Verification, Falsifiability, Modelling and simulation, Peer review
Unit 2 – Basics of Astronomy
History of astronomy, astrophysics, and space science
Sky, Stars, Planets, Solar system, Physical properties, Mass, Size, Orbit, Rotation, Luminosity, Distance measurements
Naked eye astronomy, Celestial sphere, Coordinate systems, Positions of stars and constellations, Astrometry
Telescopes, Mounts, Spectrometers, Photometers, Non-optical telescopes, UV, IR, X-ray and gamma-ray astronomy
Unit 3 – Introduction to Astrophysics
Newton's law of gravitation, Kepler's laws, Orbits of planets, dwarf planets, comets and asteroids, Tidal forces, Celestial mechanics, Orbital resonances of planets and moons
Gravitational potential, Gravitational and tidal interactions, gravitationally bound systems, Virial theorem, Gravitational collisions and relaxation
Practicals:
- Understanding celestial sphere and celestial coordinate systems
- Measurement of parallax angle
- Measurement of solar constant
- Solar limb darkening
- Study of telescope
- Study of photometer

References:

1 Robert M. Martin – Scientific Thinking – Broadview Press
2 Paul Hewitt, Suzanne Lyos, John Suchocki, Jennifer Yeh – Conceptual Integrated Science – Addison-Wesley
3 Karl Popper - The Logic of Scientific Discovery - Routledge
4 Daniel Fleisch, Julia Kregenow - A Students Guide to the Mathematics of Astronomy – Cambridge University Press
5 K.D. Abhyankar – Astrophysics of the Solar System - Universities Press
6 Dinah Moche – Astronomy: A Self-Teaching Guide –John Wiley and Sons
7 Royal Observatory Greenwich - Stargazing – Collins
8 Alessandra Celletti - Celestial Mechanics - Springer

Paper II – Technical Tools and Skills for Astronomy

Unit 1 – Electronics
Amplifiers, Rectifiers, Filters, Modulation and Demodulation, Timers
Combinational Logic, Gates, Encoders, Multiplexers, Sequential Logic, Registers, Counters
Unit 2 – Digital Signal Processing
Fourier transforms Signal classification, Continuous and Discrete time signals, Beamformer, Lag Correlator, Polyphase decomposition, Filterbanks
Unit 3 – Image Processing
Image formation, grayscale, RGB, CMYK, image formats, CCD, Types of colour images, FITS, Stellarium, Maxim DL, SAOImage DS9, and AstroImageJ
Unit 4 – Data Analysis
Astronomical data, Digital sky surveys, Data grids, Statistics, Correlation and regression, Statistics and analysis in astronomy

Practicals:

- Characteristics of operational amplifiers
- Making and analysis of filter circuits
- Study of the components of signal processing system
- Analysis of digital signals
- Obtaining image data from databases
- Image analysis using programs and software
- Acquiring data from digital sky surveys
- Study of linear regression using computational techniques

References:

1 Jacob Millman, Christos Halkias – Integrated Electronics – McGraw Hill
2 Robert Boylestad, Louis Nashelsky – Electronic Devices and Circuit Theory, 11th Edition – Pearson
3 John Proakis, Dimitris Manolakis – Digital Signal Processing – Pearson
4 Rafael Gonzalez, Richard Woods – Digital Image Processing – Pearson
5 Jean-Luc Starck, Fionn Murtagh – Astronomical Image and Data Analysis – Springer

Paper III – Stars and Galaxies

Unit 1 – Stellar Astronomy

Stars, Luminosity, Flux, Electromagnetic spectrum, Blackbody radiation, Spectral classification, H-R Diagram, Composition of stars
Star systems, Binary stars, Types, Variable stars
Nebula, Star formation, Stellar evolution process, Supernova, Compact objects

Unit 2 – Galactic Astronomy

Interstellar medium, Diffuse matter, HI and HII regions, Molecular gas and dust
The Milky Way, Types of galaxies, Structure of galaxies, Galactic halo, Rotation curves, Active Galactic Nuclei, Dark Matter
Galaxy clusters, Intergalactic medium, Cosmic web

Practicals:

- Reading and understanding H-R Diagram
- Study of binary star systems
- Study of H1 hydrogen line
- Wien's displacement law

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

Semester 2:

Paper I - Observational Techniques

Unit 1 – Radio Astronomy
Radio signals, Generating radio waves, Physical parameters, Fundamentals of radio astronomy, Radio sources, Solar radio astronomy, Galactic and extra-galactic radio astronomy

Unit 2 – Spectroscopy
Types of Spectrum, Spectral analysis, Atomic transitions, Spectroscopic data, Stellar spectra, Doppler shifts, Spectroscopic techniques, Applications

Unit 3 – Interferometry
Principle of interference, interferometers, detection techniques, Types of interferometers, Applications in astronomy, LIGO and gravitational wave detection, other applications

Practicals:
- Study of radio telescope data
- Analysis of solar radio signals
- Observation and analysis of hydrogen spectrum
- Lloyd's mirror
- Michelson interferometer

References:

1 Bernard Burke – An Introduction to Radio Astronomy – Cambridge
2 John Kraus – Antennas & Wave Propagation – McGraw Hill
3 Kristen Rohlfs, Thomas Wilson – Tools of Radio Astronomy - Springer
4 Ajoy Ghatak – Optics – McGraw Hill
5 Eugene Hecht – Optics, 5th Edition – Pearson
6 Daniel Schroeder – Astronomical Optics – Academic Press
7 C.N. Banwell – Fundamentals of Molecular Spectroscopy – McGraw-Hill

Paper II – Physical Space Exploration

Unit 1 – Rockets
Rocket components, Construction, Capacities, Working principle, Rocket equation, Rocket stages, Rocket engines, Propulsion systems, Fuels, Space launchers

Unit 2 – Spacecrafts
Spacecrafts, History, Space probes, Rovers, Sample gathering and retrieval, Space missions, Need for space exploration

Unit 3 – Satellites
History, Satellite communication, Transmission technology, Satellites in orbit, Lagrangian points, Earth orbiters, Effects of atmosphere, Space telescopes, other uses

Practicals:
- Demonstration of satellite communication
- Study of satellite components

References:

1 Ramamurthy – Rocket Propulsion –Trinity
2 Y. Cengel, M. Boles, M. Kanoglu – Thermodynamics: An Engineering Approach, 9th Edition – McGraw-Hill
3 Martin Turner – Rocket and Spacecraft Propulsion – Springer
4 H.S. Mukunda – Understanding Aerospace Chemical Propulsion – Wiley
5 Timothy Pratt, Jeremy Allnutt – Satellite Communications – Wiley
6 Dennis Roddy – Satellite Communications, 4th edition – McGraw Hill
7 Howard Curtis – Orbital Mechanics for Engineering Students, 4th Edition - Elsevier

Paper III – Earth and Space Science

Unit 1 – Earth and Moon

Earth as a planet, Formation of Earth and Moon, Internal structure, Magnetosphere, Tidal interactions, Hydrosphere

Unit 2 – Atmospheric science

Earth's atmosphere, Layers, Temperature and pressure changes, Clouds, fog, Weather systems, Climate, Climate Change, Aerosols, Environmental issues, Resolutions

Unit 3 – Space Physics

The Sun and solar atmosphere, Solar wind, Solar cycle, Sunspots, Solar flares

Space Weather, Cosmic rays, Aurora, Sky glow, Geocorona, Ionosonde

Practicals:

- Observation and analysis of local weather parameters
- Reading and understanding ionosonde data
- Observation of sunspots

References:

1. John Oliver, John Hindore – Climatology: An Atmospheric Science – Pearson
2. Frederick Lutgens, Edward Tarbuck – Foundations of Earth Science – Pearson
3. J.M. Wallace, P.V. Hobbs – Atmospheric Science – Elsevier
4. David Stevenson – Evolution of Earth, Volume 9 – Elsevier
5. James Holton – An Introduction to Dynamic Meteorology, 5th Edition – Academic Press
6. Space Studies Board – Solar and Space Physics – National Academies Press

Exam Pattern

Semester 1:

Theory Exam:

Paper Name	Maximum Marks	Question Type & Distribution
I-Foundations of Science & Astronomy	100	MCQ-20 Numerical-20 Subjective-60
II-Technical Tools & Skills for Astronomy	100	MCQ-20 Numerical-20 Subjective-60
III-Stars and Galaxies	100	MCQ-20 Numerical-20 Subjective-60

Practical Exam (50 marks):
Students have to perform an experiment from the given list for the first semester. 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.

Assignments (100 Marks):
Two assignments for each paper will be provided to students each semester. These will be short assignments based on certain topics 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 (50 marks):
Throughout the course, students will be undergoing multiple stargazing sessions under experts. Students are strongly advised to share this knowledge and improve on their science communication skills by conducting a stargazing session under the guidance of experts. Students will conduct a session for newcomers into the field of astronomy and will be graded based on their performance. All students will get a separate certificate besides the one that they will get after completing the normal coursework.

Semester 2:

Theory Exam:

Paper Name	Maximum Marks	Question Type & Distribution
I-Observational Techniques	100	MCQ-20 Numerical-20 Subjective-60
II-Physical Space Exploration	100	MCQ-20 Numerical-20 Subjective-60
III-Earth and Space Science	100	MCQ-20 Numerical-20 Subjective-60

Practical Exam (50 marks):
Students have to perform an experiment from the given list for the second semester. 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.

Assignments (100 Marks):
Two assignments for each paper will be provided to students each semester. These will be short assignments based on certain topics 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.

Project (50 marks):
This is an individual project that is an essential part of the course. 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:

- Scientific Models in Astronomy and Space Science
- Problem solving in Astronomy using Simulation and Coding
- 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.

For Admission Contact +91 9850 49 9850

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