MAHATMA GANDHI UNIVERSITY

Kottayam, Kerala

Undergraduate Programmes (HONOURS)
2024 Admission Onwards

SYLLABUS						
SIGNATURE COURSE						
Name of the College	St. Thomas College, Ranni					
Faculty/ Discipline	Physics					
Programme	BSc (Hons) Physics					
Course Coordinator	Marykutty James					
Contributors	Sreevalsa K					
Course Name	Positional Astronomy & Astro Physical Techniques					
Type of Course	DSE					
Specialization title	Observational Astronomy and Astrophysics					
Course Code	MG3DSEPHYA01					
Course Level	200					
Course Summary	This course provides a solid foundation in observational astronomy, combining theoretical knowledge with practical skills. It is divided into two main parts: Positional Astronomy, which covers celestial coordinate systems, star identification, and astronomical timekeeping; and Astrophysical Techniques, focusing on measuring stellar luminosity, magnitudes, distances, and motions using visual, photographic, and photoelectric methods. The course also introduces modern observational tools such as telescopes, detectors, and data analysis techniques across the electromagnetic spectrum. Hands-on practical sessions reinforce learning through real or simulated observations and data handling.						
Semester	3	**Credits**			4	**Total Hours**
Course Details	**Learning Approach**	Lecture	Tutorial	Practical	Others	
		3	0	1	0	75
Pre-requisites, if any	Nil					

Course Outcomes (CO)

Number of COs		**6**	
CO No.	**Expected Course Outcome**	**Learning Domains ***	**PO No**
1	Define and explain concepts of the celestial sphere and various celestial coordinate systems.	U	PO1, PO2
2	Explain and describe the concepts of right ascension, declination, equinoxes, and magnitude system.	A	PO1, PO2
3	Analyze the concepts of stellar luminosity	A	PO1, PO2
4	Understand and evaluate magnitudes using different observational techniques.	E	PO2, PO4
5	Understand different observational branches and techniques. Assess the effectiveness of different observational techniques.	E	PO1, PO2, PO4

Number of COs		6	
CO No.	**Expected Course Outcome**	**Learning Domains ***	**PO No**
6	To apply the astronomical concepts in experiments and cultivate curiosity and appreciation for astronomical observations and the scientific methods used to explore the universe.	S	PO2, PO6, PO10

**Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*

CO-PO Articulation Matrix

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10
CO 1	3	2	-	-	-	-	-	-	-	-
CO 2	3	2	-	-	-	-	-	-	-	-
CO 3	3	3	-	-	-	-	-	-	-	-
CO 4	-	3	-	2	-	-	-	-	-	-
CO 5	2	3	-	2	-	-	-	-	-	-
CO 6	-	3	-	-	-	2	-	-	-	3

'0' is No Correlation, '1' is Slight Correlation (Low level), '2' is Moderate Correlation (Medium level) and '3' is Substantial Correlation (High level).

Course Content

Content for Classroom transaction (Units)

Module	Units	Course Description	Hrs	CO No.
1	Positional Astronomy			
	1.1	Coordinate Systems :Coordinate Systems for heavenly bodies:- The Celestial Sphere, Identification of stars-Spherical Coordinates, The Altazimuth system,The Local Equatorial system, The Universal Equatorial system,	7	["1"]
	1.2	Celestial coordinates and Measurement of time : Identification of stars, Measurement of Right Ascension and Declination, Seasons- Timekeeping, Solar day versus Sidereal day, Equinox, Epoch and Julian Calendar.	8	["2"]
2	AstroPhysical Techniques			
	2.1	Measurement of Luminosity: Apparent luminosity, Measurement of Apparent luminosity: Visual method, Photographic method, Photo electric method	5	["3"]
	2.2	Magnitude systems & Measurements: Various magnitude systems: Visual systems, The photographic system, Photoelectric system, The photoelectric systems. Measurement of terrestrial distances, Measurement of distances within the solar system: moon, planets and sun, Aberration of star light, Radial velocities of stars, Trigonometric parallax method	10	["4"]
3	Observational Techniques in Astronomy			
	3.1	Space Astronomy: Sources of astronomical information Optical-IR-UV-Radio-X-Ray-Gamma Ray, Other new astronomy- Neutrino and Cosmic Rays, Gravitational Radiation, Imaging, Surveys, Astronomical Database, Virtual Observatory	8	["1"]
	3.2	Interferometry, Photometry & Polarimetry: Interferometry Basic ideas of Photometry, Spectroscopy & Polarimetry	7	["5"]

Module	Units	Course Description	Hrs	CO No.
4	Practicals (Any Six)			
	4.1	Construct a telescope and observe the craters of a Moon and also identify different astronomical objects in the night sky.	3	["6"]
	4.2	Observe the night sky and find Orion Constellations. Identify Rigel and Betelgeuse.	3	["6"]
	4.3	Identity any five different constellations in night sky with the help of Stellarium	3	["6"]
	4.4	Draw the solar Analemma curve with the help of stellarium	3	["6"]
	4.5	Measure astronomical distance using Cepheid variables.	3	["6"]
	4.6	Estimate the parallax of a star	3	["6"]
	4.7	Estimate the magnitude and luminosity of a star.	3	["6"]
	4.8	To measure the distances of any planet .	3	["6"]
	4.9	To identify the retrograde motion of Planets with respect to the Background star.	3	["6"]
	4.10	Using Stellarium track a planet and confirm Kepler's third law.	3	["6"]

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Classroom Procedure (Mode of transaction) Lectures, Tutorials, Seminar/Presentations, Activities, Demonstrations, Problem sheets, Practical sessions and Discussions

Assessment Types

MODE OF ASSESSMENT
Mode of Assessment: Both

A. Continuous Comprehensive Assessment (CCA)
• Theory – 25 Marks
1) Formative assessment : Quiz, Assignments, Seminar 2) Summative assessment : Written tests
• Practical – 15 Marks
Lab involvement, Viva

B. End Semester Evaluation (ESE)
• Theory – 50 Marks
Assessment Methods – Written Exam
Duration of Examination – 1.50 Hrs
Pattern of examination for Theory – Non-MCQ
Different parts of written examination – Part - A , B
Answer Type:
∘ PART - A
∘ Short answer - (10 out of 12) – 10 × 3 = 30
∘ PART - B
∘ Short Essays/Problems - (4 out of 7) – 4 × 5 = 20
• Practical – 35 Marks
Assessment Methods – Lab Exam: 30 Marks, Record: 5 Marks
Duration of Examination – 2.00 Hrs

References

- Abhyankar, K.D. Astrophysics: Stars and Galaxies. Universities Press, 2002.
- Carroll, Bradley W., and Dale A. Ostlie. An introduction to modern astrophysics. Pearson Addison-Wesley, 2007.
- Choudhuri, Arnab Rai. Astrophysics for Physicists. Cambridge University Press, 2010.

Suggested Readings

- Shu, Frank. The physical universe : an introduction to astronomy. University Science Books, 1982.
- Kitchin, Christopher R. Astrophysical Techniques, 2nd Edition. Taylor & Francis, 1991.
- Birney, D. Scott, et al. Observational Astronomy. Cambridge University Press, 2006.
- Appenzeller, Immo. Introduction to Astronomical Spectroscopy. Cambridge University Press, 2013.

Affidavit

- We, St. Thomas College, Ranni and Marykutty James, retain the copyright of this syllabus and expressly prohibit its distribution in complete form to any institution outside our own.
- We, St. Thomas College, Ranni, agree to appoint a new course coordinator for the proposed Observational Astronomy and Astrophysics in the event of the unavailability of the currently nominated coordinator. This appointment will ensure the continued coordination of course delivery, assessments, and all related academic responsibilities necessary for the successful implementation of the specialization, for as long as the college offers this programme.
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MAHATMA GANDHI UNIVERSITY

Kottayam, Kerala

Undergraduate Programmes (HONOURS)
2024 Admission Onwards

SYLLABUS						
SIGNATURE COURSE						
Name of the College	St. Thomas College, Ranni					
Faculty/ Discipline	Physics					
Programme	BSc (Hons) Physics					
Course Coordinator	Marykutty James					
Contributors	Sreevalsa K and Soumyamol K.S					
Course Name	Stellar Astrophysics- Radiative Process, Stellar Structure and Evolution					
Type of Course	DSE					
Specialization title	Observational Astronomy and Astrophysics					
Course Code	MG4DSEPHYA01					
Course Level	200					
Course Summary	This course covers the fundamental principles of radiative processes and stellar astrophysics. It begins with the interaction of radiation with matter, introducing key radiative quantities such as specific intensity, flux, and energy density, along with the inverse square law and emissivity. It then explores thermal processes like blackbody radiation and Kirchhoff's law, as well as non-thermal mechanisms including spontaneous and stimulated emission, synchrotron radiation, Bremsstrahlung, and scattering processes. Line broadening due to natural, collisional, and thermal effects is also discussed. The course then shifts to stellar structure, covering stellar parameters (mass, radius, luminosity, temperature), classification, the H-R diagram, hydrostatic equilibrium, and energy generation through nuclear fusion. Finally, it examines stellar evolution, from star formation in molecular clouds to end stages like white dwarfs, neutron stars, and black holes.						
Semester	4	**Credits**			4	**Total Hours**
Course Details	**Learning Approach**	Lecture	Tutorial	Practical	Others	
		3	0	1	0	75
Pre-requisites, if any	Nil					

Course Outcomes (CO)

Number of COs		**6**	
CO No.	**Expected Course Outcome**	**Learning Domains ***	**PO No**
1	Recognize the basic principles of how radiation interacts with matter.	U	PO1, PO2
2	Recall the key concepts of radiation process and analyze the roles of different radiative mechanisms in various astrophysical environments.	U	PO1, PO2
3	Understand the physical origins and characteristics of spectral line broadening, including natural broadening, collisional (pressure) broadening, and Doppler broadening.	A	PO1, PO2
4	Define the basic stages in stellar evolution.	E	PO1, PO2

Number of COs		6	
CO No.	**Expected Course Outcome**	**Learning Domains ***	**PO No**
5	Assess the role of initial mass and environmental conditions in determining a star's evolutionary pathway.	E	PO1, PO2, PO10
6	To achieve expertise in different tools and data and constructing sophisticated interpretations.	S	PO2, PO4, PO9, PO10

**Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*

CO-PO Articulation Matrix

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10
CO 1	3	3	-	-	-	-	-	-	-	-
CO 2	3	3	-	-	-	-	-	-	-	-
CO 3	3	3	-	-	-	-	-	-	-	-
CO 4	3	2	-	-	-	-	-	-	-	-
CO 5	3	3	-	-	-	-	-	-	-	2
CO 6	-	3	-	2	-	-	-	-	2	3

'0' is No Correlation, '1' is Slight Correlation (Low level), '2' is Moderate Correlation (Medium level) and '3' is Substantial Correlation (High level).

Course Content

Content for Classroom transaction (Units)

Module	Units	Course Description	Hrs	CO No.
1	Radiative Process			
	1.1	Interaction of Radiation with Matter : Radiative Basics, Radiative Transfer Specific Intensity-Flux- Energy Density-Inverse Square Law, Emissivity.	4	["1"]
	1.2	Thermal & Non thermal Radiative Process: Thermal Radiative Process-Black Body Radiation, Kirchoff's Law, Stefan's Law, R-J Limit Non Thermal Radiative Process- Spontaneous Emission, Stimulated Emission,Einstein Coefficients, Broadening Mechanisms, Inverse Compton Scattering, Synchrotron emission, Bremsstrahlung Radiation , Thomson Scattering.	9	["2"]
	1.3	Broadening Mechanism: Basic ideas of Line Broadening, Collision Broadening, Natural Broadening.	2	["3"]
2	Stellar Structure			
	2.1	Stars Basic Parameter : Stellar mass, Stellar Radius, Stellar Luminosity, Effective Temperature, Stellar spectrum.	4	["4"]
	2.2	Stellar Classification, H R Diagram.	3	["4"]
	2.3	Stellar structure- Basic idea, Hydrostatic equilibrium . Virial theorem, Stellar energy sources, Basics of thermo nuclear fusion.	8	["4"]

Module	Units	Course Description	Hrs	CO No.
3	Stellar Evolution			
	3.1	Star formation: Giant molecular clouds, Jeans Criteria, Protostar to Main Sequence Star.	7	["4"]
	3.2	Stellar Evolution: Late stages of stellar Evolution:- Red giant, Planetary Nebulae,White Dwarf, Supernova, Neutron Star, Pulsar, Black Hole.	8	["5"]
4	Practicals (Any Six)			
	4.1	Black body spectra of a star using Python	3	["6"]
	4.2	Color magnitude diagram of a star cluster	3	["6"]
	4.3	Stellar spectrum of a star using SDSS data	3	["6"]
	4.4	Age of a star cluster	3	["6"]
	4.5	Identify prominent spectral lines in the solar spectrum	3	["6"]
	4.6	Stellar Evolution Modelling using MESA	3	["6"]
	4.7	Optical Image fetching using TOPCAT	3	["6"]
	4.8	X-ray Image reduction of any object like star or galaxy	3	["6"]
	4.9	Plotting spectra using XSPEC	3	["6"]
	4.10	Plot the light curve of a pulsar / AGN with different bin size	3	["6"]

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Classroom Procedure (Mode of transaction) Lectures, Demonstrations, Problem sheets, Presentations and Discussions

Assessment Types

MODE OF ASSESSMENT
Mode of Assessment: Both

A. Continuous Comprehensive Assessment (CCA)
• Theory – 25 Marks
1) Formative assessment : Quiz, Assignments, Seminar 2) Summative assessment : Written tests
• Practical – 15 Marks
Lab involvement and Viva

B. End Semester Evaluation (ESE)
• Theory – 50 Marks
Assessment Methods – Written Exam
Duration of Examination – 1.50 Hrs
Pattern of examination for Theory – Non-MCQ
Different parts of written examination – Part - A , B
Answer Type:
◦ PART - A
◦ Short answer - (10 out of 12) – 10 × 3 = 30
◦ PART - B
◦ Short Essays/Problems - (4 out of 6) – 4 × 5 = 20
• Practical – 35 Marks
Assessment Methods – Lab Exam 30 Marks, Record 5 Marks
Duration of Examination – 2.00 Hrs

References

- Rybicki, George B., and Alan P. Lightman. Radiative Processes in Astrophysics. Edited by Alan P. Lightman, Wiley, 1979.
- Carroll, Bradley W., and Dale A. Ostlie. An introduction to modern astrophysics. Pearson Addison-Wesley, 2007.
- Choudhuri, Arnab Rai. Astrophysics for Physicists. Cambridge University Press, 2010.
- Abhyankar, K.D. Astrophysics: Stars and Galaxies. Universities Press, 2002.

Suggested Readings

- Longair, Malcolm S. High Energy Astrophysics. Cambridge University Press, 2011.
- Shu, Frank. Physics Of Astrophysics V1-Radiation. University Science Books, 1991.

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2024 Admission Onwards

SYLLABUS						
SIGNATURE COURSE						
Name of the College	St. Thomas College, Ranni					
Faculty/ Discipline	Physics					
Programme	BSc (Hons) Physics					
Course Coordinator	Marykutty James					
Contributors	Sreevalsa K					
Course Name	Astrophysical Dynamics: Hydrodynamics, Solar System, Galaxies, and the Interstellar Medium					
Type of Course	DSE					
Specialization title	Observational Astronomy and Astrophysics					
Course Code	MG5DSEPHYA01					
Course Level	300					
Course Summary	This course offers an integrated understanding of hydrodynamics and magnetohydrodynamics (MHD), emphasizing their role in astrophysical contexts. It also covers fundamental fluid dynamics concepts. It examines the structure and dynamics of the solar system, with emphasis on the Sun's interior, atmosphere, energy production, and solar activity, along with a comparative overview of planets and small bodies. The course also explores the structure, morphology, and classification of galaxies, their physical characteristics, and their role in the expanding universe. A detailed study of the interstellar medium (ISM) includes its discovery through multi wavelength observations and the physical nature of its components. Practical sessions includes the introduction of some astro tools.						
Semester	5	**Credits**			4	**Total Hours**
Course Details	**Learning Approach**	Lecture	Tutorial	Practical	Others	
		3	0	1	0	75
Pre-requisites, if any	Nil					

Course Outcomes (CO)

Number of COs		**6**	
CO No.	**Expected Course Outcome**	**Learning Domains ***	**PO No**
1	The fundamental equations of hydrodynamics and their relevance to astrophysical systems.	U	PO1, PO2
2	Understand the structure, energy generation, and activity of the sun, and analyze the physical properties and classification of planets in the solar system.	U	PO1, PO2
3	Understand the processes governing solar-terrestrial interactions, including solar wind and magnetic activity, and analyze their effects such as aurora and space weather on planetary environments.	AN	PO1, PO2, PO6
4	Describe the morphology, types, and dynamics of galaxies, and analyze their evolution in the context of the expanding universe.	A	PO1, PO2, PO10

Number of COs		6	
CO No.	**Expected Course Outcome**	**Learning Domains ***	**PO No**
5	Identify the major components of the interstellar medium (ISM) such as gas, dust, and plasma, and describe their basic physical properties.	U	PO1, PO2
6	Apply astronomical software tools such as SDSS, TOPCAT, and QFitsView to analyze observational data, perform galaxy classification, image reduction, and redshift calculation, and interpret the results in the context of astrophysical phenomena.	S	PO2, PO4, PO9, PO10

**Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*

CO-PO Articulation Matrix

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10
CO 1	3	2	-	-	-	-	-	-	-	-
CO 2	3	2	-	-	-	-	-	-	-	-
CO 3	3	2	-	-	-	3	-	-	-	-
CO 4	3	2	-	-	-	-	-	-	-	3
CO 5	3	2	-	-	-	-	-	-	-	-
CO 6	-	3	-	2	-	-	-	-	2	3

'0' is No Correlation, '1' is Slight Correlation (Low level), '2' is Moderate Correlation (Medium level) and '3' is Substantial Correlation (High level).

Course Content

Content for Classroom transaction (Units)

Module	Units	Course Description	Hrs	CO No.
1	Hydrodynamics			
	1.1	Introduction: Hydrodynamics, Basic concept of fluid, Basic Equation of Fluid Dynamics-Continuity Equation, Euler Equation, Jeans instability - Basic ideas Conservation of Energy, Steady Flow-Bernoulli's Equation.	6	["1"]
	1.2	Viscous fluids: Momentum flux and stress tensor; Viscous stress tensor, Turbulence: Reynolds number; Transition to turbulence in a Poiseuille flow.	6	["1"]
	1.3	Magnetohydrodynamics: Introduction, Basic equations of MHD.	2	["1"]
	1.4	Hydrodynamics in Astrophysics: Introduction on the astrophysical gas, Plasma-Basic ides, ISM in particular	4	["1"]
2	Solar System			
	2.1	Sun: Atmosphere of sun, Interior of sun, Radiative transfer, source of energy Sun spot, Coronal mass ejection, Solar activity, solar flares, solar wind, Aurora.	7	["2", "3"]
	2.2	Planets:- Terrestrial planets, Jovian Planets, Asteroids, Comets.	3	["2", "3"]

Module	Units	Course Description	Hrs	CO No.
3	Galaxy & Interstellar Medium			
	3.1	Galaxy: Introduction, Galaxy morphology, Distances and dimensions. Physical characteristics and kinematics Expansion of the Universe. Classification of Galaxies:- Normal Galaxy and Active Galaxy, Cluster Galaxies.	8	["4"]
	3.2	Basic of ISM Interstellar Medium- Introduction Discovery, Multi wavelength observations.	4	["5"]
	3.3	Constituents- Gas, Dust, Cosmic Rays, HII regions, Reflection Nebulae, Dark Nebulae/Molecular Clouds, Photo dissociation regions, Planetary Nebulae, Supernova remnants, etc.	5	["5"]
4	Practicals (Any Six)			
	4.1	Classification of Galaxies using SDSS data.	3	["6"]
	4.2	Image reduction of a Galaxy using TOPCAT software.	3	["6"]
	4.3	Plot and fit he Quasi Periodic Oscillations of a pulsar or neutron star.	3	["6"]
	4.4	Plot the power density spectrum of a pulsar using HEASoft.	3	["6"]
	4.5	Extraction of light curve and spectrum using ds9.	3	["6"]
	4.6	Image reduction of ULX data.	3	["6"]
	4.7	Plot the light curve of ULX using XMM- Newton data.	3	["6"]
	4.8	Using XSPEC model the given Source.	3	["6"]
	4.9	Determine the Spectral Properties, Flux and luminosity of the above source (model given).	3	["6"]
	4.10	Create and plot the light curve of Thermo nuclear burst from NICER data.	3	["6"]

Teaching and Learning Approach	Classroom Procedure (Mode of transaction) Lectures, Demonstrations, Problem sheets, Presentations and Discussions

Assessment Types

MODE OF ASSESSMENT
Mode of Assessment: Both

A. Continuous Comprehensive Assessment (CCA)
• Theory – 25 Marks
1) Formative assessment : Quiz, Assignments, Seminar 2) Summative assessment : Written tests
• Practical – 15 Marks
Lab involvement , Viva

B. End Semester Evaluation (ESE)
• Theory – 50 Marks
Assessment Methods – Written Exam
Duration of Examination – 1.50 Hrs
Pattern of examination for Theory – Non-MCQ
Different parts of written examination – Part - A , B
Answer Type:
∘ PART - A
∘ Short answer - (5 out of 7) – 5 × 4 = 20
∘ PART - B
∘ Short Essays/Problems - (5 out of 8) – 5 × 6 = 30
• Practical – 35 Marks
Assessment Methods – Lab Exam: 30 Marks, Record: 5 Marks
Duration of Examination – 2.00 Hrs

References

- Carroll, Bradley W., and Dale A. Ostlie, An introduction to modern astrophysics, Pearson Addison-Wesley, 2007.
- Choudhuri, Arnab Rai. The Physics of Fluids and Plasmas: An Introduction for Astrophysicists. 1 ed., Cambridge University Press, 1998.
- Sparke, Linda S., and John S. Gallagher, III. Galaxies in the Universe: An Introduction, Cambridge University Press, 2007.

Suggested Readings

- Binney, James, and Michael Merrifield. Galactic Astronomy. Edited by Michael Merrifield, Princeton University Press, 1998
- Shu, Frank. Physics Of Astrophysics V1-Radiation. University Science Books, 1991.

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2024 Admission Onwards

SYLLABUS						
SIGNATURE COURSE						
Name of the College	St. Thomas College, Ranni					
Faculty/ Discipline	Physics					
Programme	BSc (Hons) Physics					
Course Coordinator	Marykutty James					
Contributors	Sreevalsa K					
Course Name	Cosmology and X-ray Astronomy					
Type of Course	DSE					
Specialization title	Observational Astronomy and Astrophysics					
Course Code	MG6DSEPHYA01					
Course Level	300					
Course Summary	This course introduces essential mathematical tools and their applications in astrophysics, focusing on tensor analysis. It also covers the fourier transform and its foundational role in data analysis. In the cosmology section, students explore the principles of relativity, the expanding universe, redshift, Big Bang nucleosynthesis, the Cosmic Microwave Background, and an introduction to gravitational waves. The X-ray astronomy segment examines high-energy astrophysical systems such as X-ray binaries, accretion processes, pulsars, black hole binaries, and X-ray variability phenomena like quasi-periodic oscillations and thermonuclear bursts.					
Semester	6	**Credits**			4	**Total Hours**
Course Details	**Learning Approach**	Lecture	Tutorial	Practical	Others	
		4	0	0	0	60
Pre-requisites, if any	Nil					

Course Outcomes (CO)

Number of COs		**6**	
CO No.	**Expected Course Outcome**	**Learning Domains ***	**PO No**
1	Define and distinguish between covariant and contravariant tensors, including their transformation properties. Also explain the role of Jacobian matrices in coordinate transformations and tensor transformation laws.	U	PO1, PO2
2	Understand the mathematical foundations of fourier transforms including conditions of existence, periodicity, and convergence.	A	PO1, PO2
3	Understand the basic concepts of General Relativity to describe the geometry of spacetime. Knowledge of observational evidence for the expanding universe, particularly redshift data and Hubble's law.	U	PO1, PO2
4	Recall the classification and basic properties of X-ray binaries including low mass and high mass systems.	U	PO1, PO2

Number of COs		6	
CO No.	**Expected Course Outcome**	**Learning Domains ***	**PO No**
5	Understand the mechanism of mass transfer via Roche lobe overflow and its role in accretion processes. Differentiate between Low-Mass X-ray Binaries (LMXBs) and High-Mass X-ray Binaries (HMXBs) based on observational and physical characteristics. Analyse the origin and significance of X-ray variability such as Quasi Periodic Oscillations (QPOs) in neutron stars and black holes.	AN	PO1, PO3
6	Understand the design, instrumentation, and scientific objectives of major astronomy missions and Gain familiarity with real astronomical data and reduction workflows for research applications.	AN	PO1, PO2, PO10

**Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*

CO-PO Articulation Matrix

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10
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CO 3	3	2	-	-	-	-	-	-	-	-
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CO 5	3	-	2	-	-	-	-	-	-	-
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'0' is No Correlation, '1' is Slight Correlation (Low level), '2' is Moderate Correlation (Medium level) and '3' is Substantial Correlation (High level).

Course Content

Content for Classroom transaction (Units)

Module	Units	Course Description	Hrs	CO No.
1	Mathematical foundations of Astrophysics			
	1.1	Tensor:- Covariant tensor, Contravarient tensor, The Jacobian matrices, Scalar product, Raising and lowering of indices.	12	["1"]
	1.2	Introduction to Fourier Transform: The basic principles and mathematical foundations of Fourier transforms.	3	["2"]
2	Cosmology			
	2.1	Relativity: Basic Principle of Special theory of Relativity, Principle of Equivalence, General Theory of Relativity.	4	["3"]
	2.2	Expanding Universe, Interpretation of the Red-shift, Concept of Friedmann equations and solutions(Basic Idea) The hot Big bang: Nucleosynthesis, Cosmic Microwave Background, Introduction to Gravitational waves.	11	["3"]

Module	Units	Course Description	Hrs	CO No.
3	X-ray Astronomy			
	3.1	X-ray Binaries, Accretion, Roche lobe Overflow, Low Mass X-ray Binary, High Mass X-ray Binary, Neutron Stars, Accretion Powered Pulsars, Blackhole X-ray Binaries.	7	["4", "5"]
	3.2	Periodic and Aperiodic Variability, Be- X-ray Binaries- Type I and Type II bursts, Thermo nuclear X-ray bursts, Quasi Periodic Oscillations	8	["4", "5"]
4	Satellite-Based Observations and Computational Techniques in Astronomical Data Analysis			
	4.1	Overview of X-ray Astronomy missions: XMM-Newton, NICER, NUSTAR, SWIFT, Chandra X-ray Observatory, (Instruments, Wavelength coverage, Detectors and Payload instruments only)	3	["6"]
	4.2	Introduction to Indian Space-based Astronomy Missions:- Chandrayan, AstroSat, XPoSat	2	["5", "6"]
	4.3	Data formats in X-ray Astronomy: Fits files, Timing and Spectral Analysis in X-ray Astronomy, Spectral models (Basic idea only)	7	["6"]
	4.4	Multi-Messenger Astronomy- JWST, Fermi Gamma-ray Space Telescope, Aditya-L1, Gravitational Wave -LIGO Mission	3	["6"]

Teaching and Learning Approach	Classroom Procedure (Mode of transaction) Lectures, Demonstrations, Problem sheets, Presentations and Discussions

Assessment Types	**MODE OF ASSESSMENT** Mode of Assessment: Theory **A. Continuous Comprehensive Assessment (CCA)** **• Theory – 30 Marks** 1) Formative assessment : Quiz, Assignments, Seminar 2) Summative assessment : Written tests **B. End Semester Evaluation (ESE)** **• Theory – 70 Marks** Assessment Methods – Written Exam Duration of Examination – 2.00 Hrs Pattern of examination for Theory – Non-MCQ Different parts of written examination – Part - A , B , C Answer Type: ◦ PART - A ◦ Short answer - (10 out of 12) – 10 × 3 = 30 ◦ PART - B ◦ Short Essays - (5 out of 7) – 5 × 5 = 25 ◦ PART - C ◦ Essays - (1 out of 3) – 1 × 15 = 15

References

- Boas, Mary L. Mathematical Methods in the Physical Sciences. Wiley, 2006. Accessed 5 June 2025
- Theoretical Astrophysics Vol 2 South Asian Editon. Cambridge University Press.
- https://heasarc.gsfc.nasa.gov/
- https://www.isro.gov.in/
- https://astrosat-ssc.iucaa.in/
- https://jwst-docs.stsci.edu/#gsc.tab=0

- https://www.ligo.caltech.edu/
- https://heasarc.gsfc.nasa.gov/
- https://www.isro.gov.in/
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Suggested Readings

- Longair, Malcolm S. High Energy Astrophysics. Cambridge University Press, 2011.
- Abhyankar, K.D. Astrophysics: Stars and Galaxies. Universities Press, 2002.
- Carroll, Bradley W., and Dale A. Ostlie. An introduction to modern astrophysics. Pearson Addison-Wesley, 2007.
- Choudhuri, Arnab Rai. Astrophysics for Physicists. Cambridge University Press, 2010.

Affidavit

- We, St. Thomas College, Ranni and Marykutty James, retain the copyright of this syllabus and expressly prohibit its distribution in complete form to any institution outside our own.
- We, St. Thomas College, Ranni, agree to appoint a new course coordinator for the proposed Observational Astronomy and Astrophysics in the event of the unavailability of the currently nominated coordinator. This appointment will ensure the continued coordination of course delivery, assessments, and all related academic responsibilities necessary for the successful implementation of the specialization, for as long as the college offers this programme.
- We, St. Thomas College, Ranni and Marykutty James, declare that no part of this signature course submitted here for approval has been taken from the course content developed by, or from any of the course titles prepared by, the BoS/expert committee in the same discipline under our University.