ఆంధ్రప్రదేశ్ కేంద్రీయ విశ్వవిద్యాలయం - आंध्रप्रदेश केंद्रीय विश्वविद्यालय

CENTRAL UNIVERSITY OF ANDHRA PRADESH
Janthaluru, Ananthapuramu

Postgraduate Programme Structure
as per the UGC Credit Framework (NEP 2020)

Vidya Dadati Vinayam
(Education gives humility)

School of Interdisciplinary and Applied Sciences

Master of Science in Space Science and Technology

Programme Structure
(With effect from AY 2025 - 26)

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Master of Science in Space Science and Technology

Introduction to the Programme

The new generation course, M.Sc. in Space Science & Technology, forms the final formal training in physics with a specialization in space science. The program aims to provide students with in-depth knowledge of physics together with concepts of atmospheric and space science. After completing the program, a student should pursue research in theoretical/experimental physics, astronomy, space science, space instrumentation, and related areas. The student is expected to thoroughly understand the fundamentals of Physics and atmospheric and space science concepts to select an academic career at the secondary or tertiary level. The program also aims to enhance the employability of the student. Rigorous training requires phased teaching. With this intention, the credit and semester system is followed in this program. An M.Sc. student should be capable of researching at least in a preliminary way. To this aim, an oriented research project is made part of the curriculum.

Program Vision

Grooming students for India's Atmospheric Science Studies and Space Research.

Programme Objectives

- To develop a strong foundation in the fundamental principles of space science, including physics, astronomy, and astrophysics.
- Foster interdisciplinary thinking by integrating knowledge from various scientific and engineering disciplines.
- Cultivate a research-oriented mindset, encouraging students to explore cutting-edge technologies and contribute to the field

A Student completing this programme will be capable of taking a career path in Space Sciences.

Programme Outcomes

On successful completion of the programme, the student should be able to:

- Demonstrate a comprehensive understanding of the fundamental principles of space science, including astronomy, astrophysics, and planetary science.
- Collaborate effectively in interdisciplinary teams, demonstrating the ability to work with professionals from diverse backgrounds in the space industry.
- Be prepared to pursue further studies at the doctoral level or enter the workforce with the skills and knowledge required for various roles in academia, research institutions, space agencies, and private industries.

Pedagogy of the program

The Space Technology pathway is focused on the application of space technology in industrial settings. Its main objective is to provide a sound knowledge of the underlying principles that form a thorough basis for careers in space technology, satellite communications, and related fields. Students develop a comprehensive understanding of the fundamentals of:

- spacecraft, satellite communications, the space environment, spacecraft guidance and control, space operations and space project management;
- the electromagnetics of optical and microwave transmission and of communication systems modelling;
- a range of subjects relating to spacecraft technology and satellite communications.

Program Structure

- M.Sc. Space Science and Technology is a two-year program divided into four semesters with 97 credits.
- The program is designed with a combination of Core Courses, Discipline

Specific Electives, Multidisciplinary Courses, and MOOCS.

- The program consists of discipline-specific electives, comprising a wide range of courses from the disciplines catering to the present industry requirement.
- In Semester II and III, one multi-disciplinary elective offered by other departments will be selected by the students.
- Students need to complete one MOOCS Course in each of the I, II and III Semesters.
- Students will undergo for 2 months summer internship after II semester and submit internship report in III semester.
- In semester IV students will undergo 'Project Work' for a duration of 6 months.

Semester and Course wise Credits

Semester	Discipline Specific Core (DSC) (L+T+P)	Discipline Elective (DSE) / Elective (EL)	Seminar/ Project Work/ Dissertation/Thesis	Common Compulsory Course (CCC)	IDE/AECC/ SEC/VAC	Internship	Lab	Total Credits
I	DSC 1 (4) DSC 2 (4) DSC 3 (4) DSC 4 (4)	MOOC/Swayam Elective-I (4)	-		IDE 1 (3) online/offline		Computer Programming Lab1-1 (1) Space Instrumentation Lab-2(1)	**25**
II	DSC 5 (4) DSC 6 (4) DSC 7(4)	MOOC/Swayam /Elective-1I (4) Elective-III (4)	-	CCC -2 Introduction to AI & ML (4)	IDE 2 (3) online/offline	Internship (2)	Atmospheric Science Lab-3 (1) Remote Sensing Lab-4 (1)	**31**
III	DSC 9(4) DSC 10(4)	MOOC/Swayam/ Elective-IV (4) Elective-V (4)	Thesis Phase-1 (2) Seminar-1 (1)	CCC-1 Building Mathematical Ability Financial Literacy (4)	IDE 3 (3) online/offline VAC 1 (4)		Lab-5 (1) Computer Programming for Space Science Lab-6 (1)	**32**
IV	**-**	**-**	Dissertation (16)					**16**
Total	**36**	**20**	**19**	**8**	**13**	**2**	**6**	**104**
Percentage	**34.62**	**19.24**	**18.27**	**7.69**	**12.5**	**1.92**	**5.76**	**100**

IDE: Interdisciplinary Elective; **AECC**: Ability Enhancement Compulsory Course; **SEC:** Skill Enhancement Courses; **VAC:** Value-Added Courses; **MOOCs**: Massive Open Online Course

Programme Structure 2025-26

Semester – I

Sl. No.	Course Code	Title of the Course	Credits	Credit Distribution		
				L	T/L	P/S
1	MST101	Introduction to Space Sciences and Applications	4	3	1	0
2	MST102	Techniques of Space Instrumentation	4	3	1	0
3	MST103	Basics of Astrodynamics	4	3	1	0
4	MST104	Mathematical Methods & Computational Techniques	4	3	1	0
5	MST105	Elective I: Data Science and Data Analytics MOOCs/Online/Offline	4	3	1	0
6	MST106	Introduction to Artificial Intelligence & Machine Learning (Self-study course/Online/Offline/MOOCs)	4	3	1	0
7	MST113	Computer Programming Lab 1	1	0	0	1
8	MST114	Space Instrumentation Lab 2	1	0	0	1
Total			**26**	**18**	**6**	**2**

Semester – II

Sl. No	Course Code	Title of the Course	Credits	Credit Distribution		
				L	T/L	P/S
1	MST201	Introduction to Atmospheric Science	4	3	1	0
2	MST202	Remote Sensing and Applications	4	3	1	0
3	MST203	Spacecraft Guidance and Navigation	4	3	1	0
4	MST204	Elective II: MOOCs/Online/Offline (Anyone from 5A to 5E)	4	3	1	0
Elective III: Any one of the following electives						
5A		Special Theory of Relativity				
5B		Principles of Fluid Dynamics				
5C	MST211	Internet of Things	4	3	1	0
5D		Techniques of Astronomical Observations				
5E		Remotely Sensed Digital Image Processing and Analysis				
6	MST212	IDE 1 MOOCs/Online/Offline	3	3	0	0
7	MST213	IDE 2 MOOCs/Online/Offline	3	3	0	0
8	MST218	Atmospheric Science Lab 3	1	0	0	1
9	MST219	Remote Sensing Lab 4	1	0	0	1
10	MST220	Internship (Summer/Winter Vacation)	2	0	0	2
Total			**30**	**21**	**5**	**4**

Semester – III

Sl. No.	Course Code	Title of the Course	Credits	Credit Distribution		
				L	T/L	P/S
1	MST301	Climate Change	4	3	1	0
2	MST302	Concepts of Astronomy and Astrophysics	4	3	1	0
3	MST303	Elective IV: MOOCs/Online/Offline (Anyone from 4A to 4E)	4	3	1	0
		Elective V: Any one of the following electives				
4A	MST304	Theory and Observations of Stars	4	3	1	0
4B		General Circulation and Monsoon				
4C		Big Data Analytics				
4D		Spatial Statistics				
4E		Aerodynamics				
5	MST305	VAC: Research Skill Development	4	3	1	0
6	MST312	IDE 3 MOOCs/Online/Offline	3	3	0	0
7	MST313	Building Mathematical Ability and Financial Literacy	4	3	0	1
8	MST314	Lab 5: Elective (to choose one from the institute elective)	1	0	0	1
9	MST315	Computer Programming for Space Science Lab 6	1	0	0	1
10	MST320	Seminar-1	1	0	0	1
11	MST321	Thesis Phase-1	2	0	0	2
		Total	**32**	**21**	**5**	**6**

Semester – IV

Sl. No.	Course Code	Title of the Course	Credits	Credit Distribution		
				L	T/L	P/S
1	MST401	Dissertation	16	0	0	16
		Total	**16**	**0**	**0**	**16**

L – Lectures **T/L – Tutorials/Lab** **P/S – Practical/Seminar**

Note 1: Project Dissertation Phase-I shall be identified, and students have to make a presentation at the end of Semester – III compulsorily.

Note 2: Students can take one more MOOC course to score additional credits. Any course that is taken by the student can be approved by the competent authority of the University.

Note: 1. MOOCs are chosen by the student based on the availability of the courses offered on SWAYAM & other related platforms suggested or approved by the Department.
2.The Programme template and the title of the courses are tentative, any changes as required may be made.

Semester-Wise Credit Distribution

Semester	Total Credits	Cumulative credit at the end of the semester
1	26	26
II	30	56
III	32	88
IV	16	104

Important Information to Students

1. Eligibility: With at least 50% marks in the Bachelor's degree with Mathematics and Physics as compulsory subjects or B.E/B.Tech. in any Branch with 50% aggregate.
2. The minimum duration for completion of any PG Program is four semesters (two academic years), and the maximum duration is eight semesters (four academic years) or as per amendments made by the regulatory bodies from time to time.
3. A student should attend at least 75% of the classes, seminars, and practical's/labs in each course of study.
4. All theory courses in the programme carry a Continuous Internal Assessment (CIA) component of 40 marks and a Semester-end component of 60 marks. The minimum pass mark for each course is 40%. In the case of courses with lab components, the Continuous Internal Assessment (CIA) component shall be 60 marks and the Semester-end component 40 marks. The minimum pass mark for each course is 40%.
5. The student is given 3 Continuous Internal Assessment (CIA) tests per semester in each course from which the best 2 performances are considered for the purpose of calculating the marks in CIA. A record of the continuous assessment is maintained by the academic unit. The 3 internal tests are conducted for 15 Marks each; out of the best 2 tests, scores are considered for 30 marks. Out of the remaining 10 marks, 5 marks are awarded for assignments, class presentations, and class participation, and the remaining 5 marks are awarded for punctuality and student attendance.

Marks for the Attendance will be considered as follows:

Sl. No.	Attendance (%)	Marks
1	95% or more	5
2	90-94%	4
3	85-89%	3
4	80-84%	2
5	75-79%	1

6. A student should pass separately in both CIA and the ESE, i.e., a student should secure 16 (40% of 40) out of 40 marks for theory and 24 (40% of 60) out of 60 marks for lab components in the CIA. Therefore, a student should secure 24 (40% of 60) out of 60 marks for theory and 16 (40% of 40) out of 40 marks for lab components in the End-semester examination (ESE).
7. Semester-end examination shall consist of Objective type questions, descriptive type questions, short answer questions and case studies or any other recommended by the BOS.
8. A student failing to secure the minimum pass marks in the CIA is not allowed to take the end-semester examination of that course. She/he has to redo the course by attending special classes for that course and get a pass percentage in the internal tests to become eligible to take the end-semester examination.
9. Students failing a course due to lack of attendance should redo the course.
10. Re-evaluation applies only to theory papers and shall not be entertained for other components such as practical/ thesis/ dissertation/ internship etc. An on- campus elective course is offered only if a minimum of ten or 40% of the students registered, whichever is higher.

Semester-Wise Detailed Syllabus

SEMESTER-I

Introduction to Space Sciences and Applications

Course Code: **MST101** Core/Elective: **Core** No. of Credits: **4**	Course Title **Introduction to Space Sciences and Applications**

Course Objectives:

- This course introduces space science and its applications. From the space race through to the effects of inter-planetary space travel on future astronauts and the historical significance of the heavens to humankind in Aotearoa and globally.
- Introductory and accessible physics, astronomy, problem-solving, and discussion aid the student's learning experience in this course and into the rest of the Space Science programme.

Learning Outcomes:

- Understand the space life science and humans in space
- Understand the basic aspects of space physical science
- Understand the space management

Course Outline:

Unit-I **15 hrs**

Astronomy and astrophysics: Gravity, Radiation Physics-Intensity, flux density, luminosity, Solar System, Stars, Astronomical objects in stellar evolution, structures, interstellar medium, Milky Way, galaxies.

Unit-II **15 hrs**

Remote sensing and image analysis**:** reflectance spectrometry, spectral signatures, remote sensors, image formation and representation, platforms, resolutions, applications.

Unit-III **15 hrs**

Atmospheric science: structure and composition of the atmosphere, Scattering.

Unit-IV **15 hrs**

Growth of cloud droplets to rain, Hydrostatic equation, Fundamental forces, Monsoons, climate change.

Suggested Readings:

- An Introduction to Astronomy and Astrophysics, Pankaj Jain, Taylor &Francis, 2015.
- Fundamentals of Remote Sensing, George Joseph, and Jeganathan, Universities Press, 2018.

References:

- Atmospheric Science, An Introductory Survey, John M. Wallace, Peter V. Hobbs, Elsevier, 2006.

Techniques of Space Instrumentation

Course Code: **MST102** Core/Elective: **Core** No. of Credits: **4**	Course Title **Techniques of Space Instrumentation**

Course Objectives:

- Understand the fundamental concepts of space instrumentation.
- Learn about the unique challenges and requirements of designing instruments for space applications.

Learning Outcomes:

- Apply knowledge of space instrumentation to design and develop Instruments suitable for various space missions.
- Demonstrate an understanding of different sensor technologies

Course Outline:

Unit-I **15 hrs**

Space environment: Vacuum (very low pressure), Thermal environment and thermal design, Solar spectrum and effects on measurements/instruments, Other sources of radiation, Galactic rays, Radiation environment and its effect on measurements/instruments, Plasma and charged particle environment, Meteoroid environment.

Unit-II **15 hrs**

Review of relevant physical processes**:** secondary electron emission (SEE), ion-surface interactions, photoemission, ionization, particle and photon scattering.

Unit-III **15 hrs**

Materials for space instruments**:** CTE, outgassing, mass loss, radiation damage, various properties and limitations; Detectors: Photon detectors, Particle detectors; Electronics: Basics of front-end electronics.

Unit-IV **15 hrs**

Space Instruments: Dust detectors and analyzers, Magnetometers, UV spectrometers, IR instruments (thermal imaging, spectrometers), Imaging/cameras, Neutral/ion mass spectrometers, Plasma instruments (Faraday cups, solar wind analyzers, energetic particle detectors, Neutral particles (high and low energy)

Suggested Readings:

- Principles of Space Instrument Design, A. M. Cruise, J. A. Bowles, T. J. Patrick, C. V. Goodall, Cambridge University Press, 2009.
- Astrophysical Techniques, C.R. Kitchin, CRC Press, 2020

References:

- Physical Principles of Astronomical Instrumentation (Series in Astronomy and Astrophysics), Peter A. R. Ade, Carole E. Tucker, Matthew J. Griffin, 2022

Basics of Astrodynamics

Course Code: **MST103** Core/Elective: **Core** No. of Credits: **4**	Course Title **Basics of Astrodynamics**

Course Objectives:

- Understand the fundamental principles of celestial mechanics and their application to spacecraft motion
- Learn the laws governing the motion of celestial bodies and their implications for spacecraft dynamics

Learning Outcomes:

- Apply mathematical techniques and computational tools to solve astrodynamics problems, including trajectory optimization and mission planning

Course Outline:

Unit-I **15 hrs**

Equations of Motion, Kepler's equation, and Kepler's problem, Coordinate and Time Systems Observations, and Celestial Phenomena.

Unit-II **15 hrs**

Orbital Manoeuvring, Initial Orbit determination, Perturbation Theory, Special Perturbation Methods, Runge-Kutta Methods, Types of Perturbations, General Perturbation Techniques

Unit-III **15 hrs**

Orbit Determination and Estimation.

Unit-IV **15 hrs**

Mission Analysis, Interplanetary Mission Analysis

Suggested Readings:

- Fundamentals of Astrodynamics and Applications (Fifth Edition), David A. Vallado,2022,
- Modern Astrodynamics: Fundamentals and Perturbation Methods, Victor C. Bond and Mark C. Allman, Princeton University Press, 1996.

References:

- Fundamentals of Astrodynamics, Roger R. Bate, Donald D. Mueller, Jerry E. White Dover Publications, 2020.

Mathematical Methods and Computational Techniques

Course Code: **MST104** Core/Elective: **Core** No. of Credits: **4**	Course Title **Mathematical Methods and Computational Techniques**

Course Objectives:

- To enable the understanding of the mathematical and logical basis of many modern techniques in technology like Data Science, Artificial Intelligence, Machine Learning, Programming Language Design, etc.
- To understand important characteristics of Matrices, Eigen values, Eigen vectors, and vector spaces, etc.

Learning Outcomes:

- Understand the basic concepts of sets, vector space, subspace, basis, and dimension
- Check linear dependency of vectors and identify Eigen values and Eigen vectors derivative of matrix, which will form the basis for Principal Component Analysis.

Course Outline:

Unit-I **15 hrs**

Interpolation and approximation: Trigonometric interpolation and approximation, Fast Fourier transform; approximations by rational functions; polynomial and spline interpolations and approximation; least-squares approximation; Nonlinear equation solvers: Convergence of iterative methods (bisection, Newton's method, quasi- Newton's methods, and fixed-point methods) for both scalar equations and systems, finding roots of polynomials.

Unit-II **15 hrs**

Linear systems and eigenvalue problems: Classical and modern iterative methods for linear systems and eigenvalue problems, condition number and singular value decomposition, iterative methods for large sparse system of linear equations; Numerical solutions of ordinary differential equations: Single step methods and multi-step methods, stability, accuracy, and convergence; absolute stability, long time behavior; numerical methods for stiff ODE's

Unit-III **15 hrs**

Numerical solutions of partial differential equations: Finite difference method, finite element method, and spectral method: stability, accuracy and convergence, Lax equivalence theorem; Mathematical modelling, simulation, and applied analysis:

align behaviour and asymptotic analysis, stationary phase analysis, boundary layer analysis, qualitative and quantitative analysis of mathematical models, Monte-Carlo method

Unit-IV **15 hrs**

Linear and nonlinear programming: Simplex method, interior method, penalty method, Newton's method, homotopy method and fixed-point method, dynamic programming.

Suggested Readings:

- Advanced Mathematical Methods for Scientists and Engineers, C. M. Bender and S. A. Orszag, 1999
- Elementary Numerical Analysis, an algorithmic approach, C. de Boor and S.D. Conte, McGraw-Hill, 2000.

References:

- Numerical Methods for Engineers, Santosh K Gupta, New Age International, 2003
- Computational Science and Engineering, Strang, Gilbert, Wellesley, MA: Wellesley-Cambridge Press, 2007

Data Science and Data Analytics

Course Code: **MST105** Core/Elective: **Elective** No. of Credits: **4**	Course Title **Data Science and Data Analytics**

Course Objectives:

- Introduce R and Python as a programming language
- Introduce the mathematical foundations required for data science and data analuytics
- Introduce the first-level data science and analytics algorithms
- Introduce a data analytics problem-solving framework
- Introduce a practical capstone case study

Learning Outcomes:

- Describe a flow process for data science problems (Remembering)
- Classify data science problems into standard typology (Comprehension)
- Develop R and Python codes for data science and analytics solutions (Application)
- Correlate results to the solution approach followed (Analysis)
- Assess the solution approach (Evaluation)
- Construct use cases to validate the approach and identify modifications required (Creating)

Course Outline:

Unit-I **15 hrs**

Course Philosophy, introduction to R and Introduction to Python programming and its implementation in data science and data analytics.

Linear algebra for data science: Algebraic view (vectors, matrices, product of matrix & vector, rank, null space, solution of over-determined set of equations and pseudo-inverse), Geometric view (vectors, distance, projections, eigenvalue decomposition), Statistics (descriptive statistics, notion of probability, distributions, mean, variance, covariance, covariance matrix, understanding univariate and multivariate normal distributions, introduction to hypothesis testing, the confidence interval for estimates)

Unit-II **15 hrs**

Optimization, Typology of data science problems and a solution framework, Simple linear regression and verifying assumptions used in linear regression, Multivariate linear regression, model assessment, assessing the importance of different variables, subset selection, Classification using logistic regression, Classification using kNN, and k-means clustering

Unit-III **15 hrs**

Introduction to data analytics, Introduction to Probability, Sampling, and sampling distributions Hypothesis testing, Two-sample testing, and introduction to ANOVA, Two-way ANOVA, and linear regression

Unit-IV **15 hrs**

Linear regression and multiple regression, Concepts of MLE and Logistic regression, ROC and Regression Analysis Model Building, C2 Test, and introduction to cluster analysis, Clustering analysis, Classification and Regression Trees (CART).

Suggested Readings:

- Introduction to linear algebra - by gilbert strang
- Applied statistics and probability for engineers – by douglas montgomery
- Python for data analysis: Data wrangling with Pandas, NumPy, and IPython, McKinney, W. (2012), O'Reilly Media, Inc.
- Applied logistic regression (Wiley Series in probability and statistics), David W. Hosmer, Stanley Lemeshow (2000), Wiley-Interscience Publication.
- Data Mining: Concepts and Techniques, Jiawei Han and Micheline Kamber (2006).
- Probability and Statistics for Engineering and the Sciences. “Cengage Learning”, Jay L. Devore (2011).
- Finding Groups in Data: An Introduction to Cluster Analysis, Leonard Kaufman, Peter J. Rousseeuw (1990), John Wiley & Sons, Inc.

References:

- A Byte of Python. Python Tutorial, Swaroop, C. H. (2003).
- Ken Black, sixth Editing. Business Statistics for Contemporary Decision Making. “John Wiley & Sons, Inc”.
- Anderson Sweeney Williams (2011). Statistics for Business and Economics. “Cengage Learning”.
- Douglas C. Montgomery, George C. Runger (2002). Applied Statistics & Probability for Engineering. “John Wiley & Sons, Inc”

Introduction to Artificial Intelligence and Machine Learning

Course Code: **MST106** Core/ Compulsory: **Core** No. of Credits: **4**	Course Title **Introduction to Artificial Intelligence and Machine Learning**

Course Objectives:

- To familiarize students with the fundamental concepts, theories, and applications of artificial intelligence.
- Students will gain insight into the various subfields of AI, such as machine learning, natural language processing, computer vision, and robotics.
- To introduce students to the basics of Python programming, enabling them to write code, solve problems, and understand programming constructs. This objective emphasizes building a programming foundation as a prerequisite for implementing AI algorithms.

Learning Outcomes:

- Upon completing the course, students can expect to achieve the following outcomes:
- Students will have a clear understanding of the fundamental concepts and terminology of Artificial Intelligence, enabling them to discuss and comprehend AI-related topics

Course Outline:

Unit-I **15 hrs**

Introduction to artificial intelligence: Definition – future of artificial intelligence – Characteristics of intelligent agents – Typical intelligent agents – Problem-solving approach to typical AI problems. Problem solving by searching: uninformed and informed strategies and implementation; path planning; constraint satisfaction problems (CSP).

Unit-II **15 hrs**

Knowledge Representation: Logical Agents– Propositional and first-order predicate logic–inference– Knowledge representation and Automated Planning– Uncertain Knowledge and Reasoning: Quantifying uncertainty– probabilistic reasoning;

Unit-III **15 hrs**

Introduction to probability, Theory, distributions, and estimation. Neural Networks, Kernel and Sparse Kernel methods, and Sampling Methods.

Unit-IV **15 hrs**

Machine learning & AI Applications: Machine learning basics - Learning from examples - forms of learning (supervised, unsupervised, reinforcement learning) -

simple models (linear & logistic regression) - Deep Learning AI applications: Natural Language Processing - Language Models – Machine Translation; Speech Recognition; Computer Vision - Image classification.

Suggested Readings:

- S. Russell and P. Norvig, Artificial Intelligence: A Modern Approach, Prentice Hall, 4th Edition 2022.
- Christopher M. Bishop, Pattern recognition and machine learning , Springer
- M. Tim Jones, Artificial Intelligence: A Systems Approach (Computer Science)", Jones and Bartlett Publishers, Inc.; 1st Edition, 2008.
- Python GUI programming Cookbook -Burkahard A Meier, Packt Publication 2nd Edition.

References:

- Lavika Goel, Artificial Intelligence: Concept and Applications, Willy ,2021
- Nils J. Nilsson, The Quest for Artificial Intelligence", Cambridge University Press, 2009.
- Barry, P. (2016). Head First Python: A brain-friendly guide. " O'Reilly Media, Inc.". Lutz, M. (2013). Learning Python: Powerful object-oriented programming. "O'Reilly Media, Inc.".

SEMESTER-II

Introduction to Atmospheric Science

Course Code: **MST201** Core/Elective: **Core** No. of Credits: **4**	Course Title **Introduction to Atmospheric Science**

Course Objectives:

- To develop knowledge regarding the inter-relationships of Earth System Science components and their impacts on Earth's atmosphere and climate.
- To provide understanding the atmospheric composition, structure and the forces that drive three- dimensional atmospheric motions

Learning Outcomes:

- The student will acquire an understanding of the basic tenets governing the structure, constitution, physics and dynamics of the Earth's atmosphere.
- Understanding the functioning and inter-relationships of Earth System Science components and their impacts on climate.

Course Outline:

Unit-I **15 hrs**

Components of the earth system, structure and composition of the atmosphere the hydrologic cycle, radiation, and energy balance

Unit-II **15 hrs**

Atmospheric thermodynamics: the hydrostatic equation, adiabatic processes, Water vapor, scattering, absorption, clouds, and cloud interpretation

Unit-III **15 hrs**

Thunderstorms and severe weather, cyclones, and fronts.

Unit-IV **15 hrs**

Numerical weather prediction, general circulation, and climate.

Suggested Readings:

- Atmospheric Science, An Introductory Survey, John M. Wallace, Peter V. Hobbs, Elsevier, 2006.
- The Physics of Atmospheres, John Houghton, 3rd Edition, Cambridge University Press, Cambridge, 2002.

References:

- An Introduction to Atmospheric Thermodynamics, A.A.Tsonis, 2nd Edition, Cambridge University Press, Cambridge, 2007

Remote Sensing and Applications

Course Code: **MST202** Core/Elective: **Core** No. of Credits: **4**	Course Title **Remote Sensing and Applications**

Course Objectives:

- To understand the principles, applications, trends, and pertinent issues of geographical information systems and sciences, including remote sensing (RS).
- To provide learning and teaching experiences with real world problems.

Learning Outcomes:

- Fully equipped with concepts, methodologies and applications of Remote Sensing Technology.
- Prepare the candidates for National and Global Employability

Course Outline:

Unit-I **15 hrs**

Electromagnetic radiation and its interaction with matter, Spectral signatures, digital image formats, remote sensing satellite orbits and platforms

Unit-II **15 hrs**

Remote sensing sensor specifications, distortions, spectral indices, remote sensing image analysis techniques, thermal remote sensing

Unit-III **15 hrs**

Basics of microwave remote sensing, applications in environment,

Unit-IV **15 hrs**

Applications in Atmosphere. Agriculture, Forestry, Geoscience, Water Resources, Urban studies, etc.

Suggested Readings:

- Fundamentals of Remote Sensing by George Joseph and C Jegannathan, (3rd Ed.) Universities Press, 2018
- Quantitative Remote Sensing of Land Surfaces, Shunlin Liang, Wiley, 2003.

References:

- Digital Image analysis by John A. Richards and Xiuping Jia, Springer, 2006.
- Remote Sensing of the Environment: An Earth Resource Perspective by Jensen, (2nd Ed.) Pearson, 2013.

Spacecraft Guidance and Navigation

Course Code: **MST203** Core/Elective: **Core** No. of Credits: **4**	Course Title **Spacecraft Guidance and Navigation**

Course Objectives:

- The students will understand the concepts of Communication and Navigation and the necessary knowledge needed in modeling the communication and navigation process and methods.
- Understand the basic principles and workings of optical communication systems.

Learning Outcomes:

- Understand the various aspects related to the satellite navigation systems.
- The students will have exposure on various communication and navigation systems such as satellite systems

Course Outline:

Unit-I **15 hrs**

Continuous waves and frequency modulated radars, MTI and Doppler radars; types of navigation; LORAN, Decca, Omega, VOR, INS GPS; guided missiles.

Unit-II **15 hrs**

Guidance laws: pursuit, LOS, and PN laws. Control: Control systems, Classical Linear time-invariant control systems, Transfer function representations.

Unit-III **15 hrs**

Stability, time domain characteristics, frequency domain characteristics, root locus, Nyquist and Bode plots, Exposure to state space analysis

Unit-IV **15 hrs**

Sparse Modelling and Estimation, Modelling Sequence/Time-Series Data, Deep Learning and Feature Representation Learning

Suggested Readings:

- Control Systems Engineering, Nise, N., 2018, Wiley.
- Avionics Navigation Systems, Kayton, M., and Fried, W.R., Wiley.
- Advanced Control Systems Design, Lin, C-F, Prentice Hall, 1994.

References:

- Introduction to Radar Systems, Skolnik, M.I., McGraw-Hill, 2001.
- Modern Spacecraft Guidance, Navigation, and Control: From System Modeling to AI and Innovative Applications, Vincenzo Pesce et al (Eds), 2022, Elsevier.

Special Theory of Relativity

Course Code: **MST211** Core/Elective: **Elective** No. of Credits: **4**	Course Title **Special Theory of Relativity**

Course Objectives:

- Strive to grasp the fundamental concepts of special relativity thoroughly. Develop a solid foundation by studying the theory's principles, equations, and implications.
- To acquire knowledge on special relativity to practical scenarios, such as time dilation, length contraction, and relativistic energy. Solve problems and exercises to reinforce your understanding.

Learning Outcomes:

- Explore research opportunities related to special relativity. Investigate its applications, limitations, and open questions. Consider contributing to scientific papers or participating in research projects.
- Cultivate curiosity and a passion for discovery. Special relativity challenges our intuition about space, time, and motion. Embrace the wonder of unraveling the universe's secrets.

Course Outline:

Unit-I **15 hrs**

Introduction to special relativity: Galilean transformations, Michelson Morley experiment- Postulates of special relativity.

Unit-II **15 hrs**

Lorentz transformations, length contraction and time dilation, Minkowski space-time, twin paradox and time travel, addition of velocities, doppler effect and aberration, relativistic dynamics

Unit-III **15 hrs**

Equivalence of mass and energy, relativistic mass, charged particle in electric and magnetic fields, transformation of momentum, energy, and mass between frames, examples of relativistic dynamics

Unit-IV **15 hrs**

EM theory and relativity, Maxwell's equations, transformation of force, EM field, Transformation and field of a moving charge, photon and EM effects, equivalence principle of general relativity

Suggested Readings:

- Special Relativity by Anthony Philip French, W.W. Norton & Company
- Introduction to Special Relativity by, Robert Resnick.Wiley

References:

- Spacetime Physics Introduction to Special Relativity by Edwin Taylor and John

Principles of Fluid Dynamics

Course Code: **MST211** Core/Elective: **Elective** No. of Credits: **4**	Course Title **Principles of Fluid Dynamics**

Course Objectives:

- To learn about the fundamental concepts of fluid dynamics thoroughly. Develop a solid foundation by studying the principles of conservation of mass, momentum and energy.
- To enhance your ability to explain fluid dynamics concepts simply. Practice communicating complex ideas to both technical and non-technical audiences.

Learning Outcomes:

- Explore connections between fluid dynamics and other fields. Collaborate with experts in areas like mechanical engineering, environmental science, or oceanography. Combine knowledge to address complex challenges.
- Able to specialize in fluid dynamics for practical applications. Work on designing efficient pipelines, hydraulic systems, or aerodynamic structures. Optimize fluid flow to enhance performance and safety.

Course Outline:

Unit-I **15 hrs**

Basic Concept: Definition and properties of Fluids, Introduction to fluid statics and kinematics; Governing Equations of Fluid Motion: Langragian and Eulerian description, Reynolds transport theorem, Integral and differential forms of governing equations: mass, momentum and energy conservation equations, Navier-Stokes equations, Euler's equation, Bernoulli's Equation; Inviscid Incompressible Flows: Stream function and Velocity potential function, Circulation, Line vortex.

Unit-II **15 hrs**

Basic plane potential flows: Uniform stream; Source and Sink; Vortex flow, Doublet, Superposition of basic plane potential flows, Flow past a circular cylinder, Robins and Magnus effect; Kutta-Joukowski lift theorem; Concept of lift and drag; Compressible Flows: Speed of sound and Mach number, Basic equations for one dimensional flows, Isentropic relations, Normal-shock wave,

Oblique shock wave, Prandtl-Meyer expansion waves, Fundamentals of hypersonic flows, Mach number independence, Compressible viscous flows, Compressible boundary layers

Unit-III **15 hrs**

Viscous Incompressible Flows: Couette flows, Poiseuille flows, Creeping flows, Concepts of boundary layer and flow separation; Dimensional Analysis: Introduction to dimensional parameters, Buckingham pi theorem, Non-dimensional parameter in fluid mechanics, Modeling and similitude, Flow similarity, Models and prototype, Distorted model; Flow Measurement Techniques: Measurements Temperature, Pressure Measurements: Pressure transducers, pitot tube, pressure sensitive paints

Unit-IV **15 hrs**

Velocity/Discharge measurements: Orifice meter, Venturiemeter, Anemometer, Force Measurements: Strain gauges force balances, Flow Visualization: PIV, Schlieren technique; Aero Testing Facilities: Closed and open circuit wind tunnels, Supersonic wind tunnels, Shock tunnels, Miscellaneous Facilities.

Suggested Readings:

- Introduction to Fluid Mechanics by Fox W. Robert, McDonald T. Alan, Wiley
- Incompressible Flow by Panton, Ronald L., Wiley
- Fluid Mechanics. By Kundu, Pijush K., and Ira M. Cohen, Academic Press.
- Fluid Mechanics by Frank M. White, Tata McGraw-Hill
- Fundamentals of Aerodynamics by John D. Anderson, McGrawHill

References:

- Hypersonic and High Temperature Gas Dynamics by John D. Anderson, McGraw-Hill
- Low-Speed Wind Tunnel Testing by Rae W.H. and Pope A, John Wiley & Sons

Internet of Things

Course Code: **MST211** Core/Elective: **Elective** No. of Credits: **4**	Course Title **Internet of Things**

Course Objectives:

- To understand the fundamentals of Internet of Things
- To learn about the basics of IOT protocols
- To understand the application areas of IOT

Learning Outcomes:

- Students can apply the concept of Internet of Things in the real- world scenario.

Course Outline:

Unit-I **15 hrs**

Introduction to IoT: sensing, actuation; basics of networking, Communication Protocols; sensor networks; machine-to-machine communications; Interoperability in IoT

Unit-II **15 hrs**

Introduction to Arduino programming; integration of sensors and actuators with Arduino; introduction to Raspberry pi; implementation of IoT with Raspberry pi

Unit-III **15 hrs**

Introduction to SDN, SDN for IoT; data handling and analytics, cloud computing; sensor-cloud

Unit-IV **15 hrs**

Fog computing, smart cities, and smart homes; connected vehicles, smart grid, industrial IoT; case study: agriculture, healthcare, activity monitoring.

Suggested Readings:

- The Internet of Things: Enabling Technologies, Platforms, and Use Cases by Pethuru Raj and Anupama C. Raman, CRC Press

References:

- Internet of Things: A Hands-on Approach, by Arshdeep Bahga and Vijay Madisetti, Universities Press

Techniques of Astronomical Observations

Course Code: **MST211** Core/Elective: **Elective** No. of Credits: **4**	Course Title **Techniques of Astronomical Observations**

Course Objectives:

- Acquire knowledge of the Physical universe and its evolution.
- Define and use fundamental principles and techniques of astronomy and astrophysics.
- Understand and apply basic physics and computational techniques to solve problems in astrophysics, and interpret the results.

Learning Outcomes:

- Demonstrate the ability to link observation and theory.

Course Outline:

Unit-I **15 hrs**

Telescopes: Optics, configurations: Newtonian, Cassegrain, and variants, Detectors – UV: Microchannel plates, optical – Photomultiplier tube.

Unit-II **15 hrs**

CCD – operation and characterization, infrared – IR arrays and bolometers, radio – Heterodyne

Unit-III **15 hrs**

Imaging – focal plane imagers, PSF and deconvolution, photometry, spectroscopy, polarimetry, interferometry

Unit-IV **15 hrs**

Surveys, astronomical databases, and virtual observatory.

Suggested Readings:

- Electronic Imaging in Astronomy: Detectors and Instrumentation by Ian S. McLean, Springer
- Astrophysical Techniques by C.R. Kitchin, CRC press.

References:

- Handbook of CCD Astronomy by Steve B. Howell, Cambridge University Press
- Astronomy Methods: A Physical Approach to Astronomical Observations by Hale Bradt, Cambridge University Press

Remotely Sensed Digital Image Processing and Analysis

Course Code: **MST211** Core/Elective: **Elective** No. of Credits: **4**	Course Title **Remotely Sensed Digital Image Processing and Analysis**

Course Objectives:

- To learn the basics of how satellites and other tools capture images of the Earth from afar.
- Discover methods to improve image quality so that important details are easier to see.
- Understand how to categorize and organize different features in images, like forests, water bodies, or urban areas

Learning Outcomes:

- Apply image interpretation skills to extract actionable information from remotely sensed images for various geospatial applications, including agriculture, forestry, ecology, hydrology, disaster management, and urban planning.
- Understand how remotely sensed digital images can be used for monitoring and assessing environmental parameters such as vegetation health, soil moisture, water quality, air pollution, and climate change impacts

Course Outline:

Unit-I **15 hrs**

Review of image formation processes, representation of remote sensing imagery.

Unit-II **15 hrs**

Image analysis pre-processing: radiometric and geometric distortion.,

Unit-III **15 hrs**

Digital image analysis techniques: statistical and machine learning image analysis

Unit-IV **15 hrs**

Image transformations, transformations, point and neighbourhood operations, image segmentation, basics of morphological image processing.

Suggested Readings:

- Remote Sensing Digital Image analysis by John A. Richards and Xiuping Jia, Springer, 2006.
- Remote Sensing of the Environment: An Earth Resource Perspective by Jensen, (2nd Ed.) 2013, Pearson

- Digital Image Processing by R. C. Gonzalez and R. E. Woods, (3rd Ed.) Prentice Hall, 2011.

References:

- Remote Sensing: Models and Methods for Image Processing by Schowengerdt (3rd Ed.) Academic Press, 2009.

SEMESTER-III

Climate Change

Course Code: **MST301** Core/Elective: **Core** No. of Credits: **4**	Course Title **Climate Change**

Course Objectives:

- Climate science, arid land ecology, hydrology, and sustainable land management
- To build a strong foundation of understanding about the specific challenges and dynamics of climate change in arid environments.
- To acquire practical skills through fieldwork, laboratory work, and simulations that simulate real-world scenarios in arid environments.

Learning Outcomes:

- To contribute to cutting-edge research initiatives focused on understanding and addressing climate change impacts in arid lands. This includes exploring innovative technologies, methodologies, and approaches to enhance resilience and sustainability.
- To work with communities, governments, and non-governmental organizations to implement practical solutions that address the immediate and long-term impacts of climate change in arid lands

Course Outline:

Unit-I **15 hrs**

Overview of global warming, climate as a factor in human history, greenhouse effect and radiative forcing, climate projection, vulnerability and resilience.

Unit-II **15 hrs**

Global warming and climate change: global warming and greenhouse gases, global climate change impact with a focus on arid environments, impact of climate change on water resources, impact of climate change on crops production.

Unit-III **15 hrs**

Climate change adaptation strategies: climate change scenarios, climate change modelling tools, mitigation and adaptation strategies, crop production alternative strategies

Unit-IV **15 hrs**

Climate change monitoring systems: climate change early monitoring systems, community tools for climate change adaptation in crops production, case studies on successful monitoring and adaptation strategies.

Suggested Readings:

- Climate change and land: an IPCC special report on climate change and land, IPCC, 2019.
- Semi-arid climate change, Jianping Huang, Xiaodan Guan, Haipeng Yu, World Scientific, 2023.

References:

- Climate change: the science of global warming and our energy future, Edmond A. Mathez and Jason E. Smerdon, Columbia University Press
- Climate change: what the science tells us, Chip Fletcher, Wiley, 2018

Concepts of Astronomy and Astrophysics

Course Code: **MST302** Core/Elective: **Core** No. of Credits: **4**	Course Title **Concepts of Astronomy and Astrophysics**

Course Objectives:

- Understand the impact of astronomical bodies and formations on earth and climate.
- Communicate astronomical concepts and theories effectively.

Learning Outcomes:

- Acquire knowledge of the Physical universe and its evolution.
- Define and use fundamental principles and techniques of astronomy and astrophysics.

Course Outline:

Unit-I **15 hrs**

Sky coordinates and motions: earth rotation, sky coordinates, seasons, the moon's orbit and eclipses, timekeeping

Unit-II **15 hrs**

Light & energy, telescopes, detectors and configurations, Instruments.

Unit-III **15 hrs**

Sun and planets: formation of the solar system, extrasolar planets; stars: Distance, temperature, spectral types and luminosity classes, HR diagram, clusters, stellar structure: Equilibrium-Nuclear energy generation- timescales, stellar evolution

Unit-IV **15 hrs**

Galaxies: our Milky Way: structure and kinematics, Cosmology: Hubble's law, Expansion of the universe, redshifts – Standard candles - the Big Bang.

Suggested Readings:

- An Introduction to Modern Astrophysics, BW Carroll & DA Ostlie, Addison- Wesley.
- Astrophysical Concepts, Martin Harwit, Springer.

References:

- Invitation to Astrophysics, T. Padmanabhan, World Scientific Publishing Co.

Theory and Observations of Stars

Course Code: **MST304** Core/Elective: **Elective** No. of Credits: **4**	Course Title **Theory and Observations of Stars**

Course Objectives:

- Analyze binary star systems and their importance in determining stellar masses and other properties.
- Discuss the gravitational dynamics within stellar clusters and galaxies

Learning Outcomes:

- Students will be able to examine and critique the expansive and dynamic nature of our Universe, within a historical perspective
- Student will be able to explain the evolution of stars as well as of the large-scale structure of the Universe.

Course Outline:

Unit-I **15 hrs**

Structure of stars- Viral Theorem – Hydrostatic Equilibrium – Energy Equation – Physics of gas and radiation in stars: Structure equations – example solutions.

Unit-II **15 hrs**

Nuclear energy Generation –stages of nuclear burning, Equilibrium configurations of stars: White Dwarfs and Chandrasekhar limit – Perturbation from Equilibrium configuration–

Unit-III **15 hrs**

Schwarzschild convection criterion – Observational signatures on HR diagram – Star formation – Main sequence.

Unit-IV **15 hrs**

Horizontal branch – giant and asymptotic giant branches – planetary nebula, formation – supernovae –compact objects – post-main sequence evolution

Suggested Readings:

- The Physical Universe: An Introduction to Astronomy by Frank Shu, University Science Books
- Dina Prialnik, An introduction to the theory of stellar structure and evolution, Cambridge University Press.

References:

- R.Kippenhahn and A.Weigert, Steallar Structure and Evolution , Springer.
- A. Weiss et al, Cox and Giuli’s Principles of Stellar Evolution, Cambridge Scientific Publishers.

Concepts of Astronomy and Astrophysics

Course Code: **MST304** Core/Elective: **Elective** No. of Credits: **4**	Course Title **General Circulation and Monsoon**

Course Objectives:

- To gain a thorough understanding of the general circulation of the atmosphere and the mechanisms driving monsoon systems.
- To delve into advanced topics such as climate modelling, atmospheric dynamics, and the influence of oceans on monsoon variability.

Learning Outcomes:

- To engage in research projects that apply theoretical knowledge to real- world scenarios, investigating factors affecting monsoon behaviour and variability.
- To contribute to the scientific understanding of general circulation and monsoon systems through research and analysis.

Course Outline:

Unit-I **15 hrs**

Global Circulation: differential heating, heat transport through atmosphere and ocean, jet stream, vorticity, instability - Barotropic instability & Rossby waves, planetary waves; global winds -general circulation of the atmosphere, single- cell model, three-cell model, ITCZ;

Unit-II **15 hrs**

Westerly winds and the jet streams, brewer dobson circulation, quasi-biennial oscillations; air masses and fronts: air mass production, classification, sources of air masses in winter and summer, fronts and frontal surfaces frontogenesis and frontolysis; extra-tropical cyclones- formation, life cycle, structure and movement; monsoons (Indian, Australian, African, American): global perspective of monsoon, CTCZ, ITCZ over Indian ocean – structure and movement.

Unit-III **15 hrs**

Monsoon rain bearing systems: monsoon trough/ CTCZ, depressions, onset Vortex, mechanism of formation, structure and dynamics, monsoon Mesoscale process, seasonal prediction and predictability of monsoon, Coupled monsoon system; Monsoon variability: interannual variability and Decadal variability, teleconnections of India summer monsoon with southern Oscillation.

Unit-IV **15 hrs**

Tropical cyclones (genesis, intensification, evolution, dissipation, structure, Motion, and forecasts), thunder storms (cape and cine, favourable conditions for severe thunderstorms, influence of vertical wind shear, stability indices, life Cycle and structure of thunderstorm).

Suggested Readings:

- Monsoon Dynamics by T. N. Krishnamurti, Springer
- Tropical Circulation Systems and Monsoons by Kshudiram Saha, Springer

References:

- An Introduction to the Global Circulation of the Atmosphere by David Randall, Princeton University Press

Big Data Analytics

Course Code: **MST304** Core/Elective: **Elective** No. of Credits: **4**	Course Title **Big Data Analytics**

Course Objectives:

- Design classification models for various standard datasets and user datasets.
- Develop clustering techniques and association rules for large standard datasets and user datasets.

Learning Outcomes:

- Analyse large scale data using MAPREDUCE programming which includes JAVA and HADOOP frameworks.
- Analyse large scale data using PIG and HIVE.

Course Outline:

Unit-I **15 hrs**

Introduction to Big Data Processing: Introduction to Big Data Analytics, Introduction to Apache Hadoop and MapReduce, Apache Spark, Spark programming, Spark - Resilient Distributed Dataset (RDDs)

Unit-II **15 hrs**

Large-Scale Data Processing With PySpark: Spark - RDDs, DataFrames, Spark SQL, PySpark + NumPy + SciPy, Code Optimization, Cluster Configurations, Linear Algebra Computation in Large Scale, Distributed File Storage Systems; Data Modelling and Optimization Problems: Data Modelling and Optimization

Unit-III **15 hrs**

Problems: Introduction to modelling - numerical vs. probabilistic vs. Bayesian, Introduction to Optimization Problems, Batch and stochastic Gradient Descent, Newton's Method, Expectation-Maximization, Markov Chain Monte Carlo (MCMC); Large-Scale Supervised Learning: Introduction to Supervised learning, Generalized Linear Models and Logistic Regression, Regularization, Support Vector Machine (SVM) and the kernel trick, Outlier Detection, Spark ML library.

Unit-IV **15 hrs**

Classification and clustering and trends in data miningLarge-Scale Unsupervised Learning: Introduction to Unsupervised learning, K-means / K- medoids, Gaussian Mixture Models, Dimensionality Reduction, Spark MLlib for Unsupervised Learning; Large Scale Text Mining: Latent Semantic Indexing, Topic models, Latent Dirichlet Allocation, Spark ML library for NLP.

Suggested Readings:

- Machine learning: a probabilistic perspective by Murphy, K., The MIT Press
- Mining of massive datasets by Leskovec, J. Rajaraman, A., Ullman, Cambridge University Press
- Essential PySpark for scalable data analytics: A beginner's guide to harnessing the power and ease of PySpark 3 by Nudurupati, S.,Packt Publishing
- Data mining: Concepts and techniques by Han, J., Kamber, M., Pei, J. Morgan Kaufmann.

References:

- The elements of statistical learning: Data mining, inference, and prediction by Hastie, T. and Tibshirani, R. Springer
- Applied data science using PySpark: Learn the end-to-end predictive model-building cycle by Ramcharan, K., Sundar, K., Alla, S., Apress

Spatial Statistics

Course Code: **MST304** Core/Elective: **Elective** No. of Credits: **4**	Course Title **Spatial Statistics**

Course Objectives:

- To grasp the basic principles of spatial statistics, including methods for analysing spatial data and understanding spatial patterns
- To learn statistical techniques specifically designed for spatial data analysis, such as spatial autocorrelation, interpolation, and spatial regression.

Learning Outcomes:

- To use spatial statistics to solve complex problems related to geography, environment, and society, contributing to evidence-based decision-making and policy formulation.
- To publish my research findings in academic journals, sharing insights and contributing to the advancement of knowledge in spatial statistics.

Course Outline:

Unit-I **15 hrs**

Geo-statistics: stationary random fields, variogram/covariance function, kriging, misspecification of covariance function, fixed-domain asymptotics

Unit-II **15 hrs**

Kriging and splines, spatio-temporal modelling, correcting non-isotropy, Markov random fields.

Unit-III **15 hrs**

Conditionally specified Gaussian and binary fields, simulation, parameter estimation, spatial data segmentation

Unit-IV **15 hrs**

Point processes: Poisson processes, stationary point processes, tests for complete spatial randomness, other models of point processes, scan statistics.

Suggested Readings:

- Statistics for Spatial Data, Noel Cressie, Wiley.
- Anselin L. (2005) Exploring Spatial Data with GeoDa: A Workbook
- Applied Spatial Data Analysis with R, Roger S. Bivand, Edzer J. Pebesma and Virgilio Gómez-Rubio 2nd edition (2013), Springer.

References:

- Geospatial Analysis A Comprehensive Guide to Principles, Techniques and Software Tools, Michael J de Smith, Michael F Goodchild, Paul A Longley & Associates, 2018

Aerodynamics

Course Code: **MST304** Core/Elective: **Elective** No. of Credits: **4**	Course Title **Aerodynamics**

Course Objectives:

- To learn the fundamental principles of aerodynamics, including airflow behaviour, lift and drag forces, and boundary layer phenomena.
- To learn mathematical and computational methods for analysing aerodynamic problems and predicting airflow patterns.

Learning Outcomes:

- To use knowledge of aerodynamics to design vehicles with improved aerodynamic performance, reducing fuel consumption and emissions.
- To apply aerodynamic principles to solve engineering challenges in various industries, such as aerospace, automotive, and renewable energy.

Course Outline:

Unit-I **15 hrs**

Introduction to tensors, Kinematics, Governing equations, Kelvin's theorem – Potential flow, Uniqueness and Kutta condition. Prandtl lifting line theory, Induced drag, Elliptic lift distribution, 3D panel methods, Viscous Incompressible Flows:

Unit-II **15 hrs**

Foundations of panel methods, Air foils; Thin Air foil Theory: Forces and moments on air foil, flaps; Finite Wings:

Unit-III **15 hrs**

Prandtl boundary layer equation, Similarity solutions, Flow separation and stall,

Unit-IV **15 hrs**

Introduction to turbulence, Turbulent boundary layer, Viscous-inviscid coupling, High lift devices, Swept wing, Delta wing.

Suggested Readings:

- Fundamentals of Aerodynamics by Anderson, J. D. McGraw-Hill
- Fluid Mechanics by Kundu, P. K., Cohen, I. M., and Dowling, D. R., Academic Press
- Viscous Fluid Flow by White, F. M., McGraw-Hill

References:

- Low-Speed Aerodynamics by Katz, J. and Poltkin, A., Cambridge University Press
- Boundary Layer Theory by Schlichting, H. and Gersten, K., Springer 6.Principles of Ideal-Fluid Aerodynamics by Karamcheti, K., Krieger Pub. Co.

Research Skill Development

Course Code: **MST305** Core/Elective: **VAC** No. of Credits: **4**	Course Title **Research Skill Development**

Course Objectives:

- To understand research methodology, research design, data collection and analysis
- To develop report writing and communication, critical thinking and evaluation, team collaboration, and personal and professional development

Learning Outcomes:

- Identify and formulate research problems, select appropriate research designs, collect, analyse, and interpret data using various research methods.
- Write comprehensive research reports and present findings effectively, critically evaluate research findings and draw appropriate conclusions, design and execute research projects independently or collaboratively.
- Demonstrate an understanding of ethical considerations in research, apply research skills in their respective fields of study or professional practice, and collaborate effectively in research teams.
- Communicate research findings effectively to various audiences.

Course Outline:

- Efficient usage of WORD and PDF, Explorer for research purposes, Search Strategies
- Selecting relevant literature on a topic (Space Science and Applications)
- Assignment on Properly linking Literature reference in appropriate places & Using endnotes
- Assignment on "Making half-page and 1-page abstract from research papers"
- Open-source tools for research and citation
- Formulating research problems, Statistical inference, Scientific inferences, Argumentation, and finding relevant information
- Technical manuscript writing and publishing and Collaborative Environment development

Evaluation Criteria

Writing an article, a presentation and its submission to his/her supervisor.

Article Writing (plagiarism less than 20%)	Presentation Preparation	Final Presentation
40 Marks	20 Marks	40 Marks

Building Mathematical Ability and Financial Literacy

Course Code: **MST313** Core/Elective: **Elective** No. of Credits: 1	Course Title **Building Mathematical Ability and Financial Literacy**

Course Objectives:

- To familiarise with fundamental mathematical concepts including set theory, permutations and combinations.
- To understand the logical reasoning for efficient problem-solving, analysis of propositions and conditional statements

Learning Outcomes:

- Analyzing financial instruments like stocks, shares, loans, insurance and income tax liabilities.
- Ability to compute central tendency, dispersion, correlation and regression measures.

Course Outline:

Unit-I **15 hrs**

Mathematics: Basic set theory - Permutations and combinations - Mathematical Logic: Introduction - proposition and truth values - logical connectives, Tautology and contradiction - logical equivalences - converse, inverse and Contra positive of a conditional statement.

Unit-II **15 hrs**

Commercial Mathematics: Cost price - selling price - profit and loss - Simple Interest - compound interest (reducing balance and flat interest rate) - stocks and shares. Housing loan - insurance - simple equated monthly instalments (EMI) calculation - Income tax: simple calculation of individual tax liability.

Unit-III **15 hrs**

Statistics: Sources of data: primary and secondary - types of data, graphical Representation of data - Population, sample, variable - parameter. Statistic, Simple random sampling - use of random number tables - Measures of Central Tendency: arithmetic mean, median and mode; measures of dispersion: range - Variance - standard deviation and coefficient of variation - Bivariate data: Scatter plot, Pearson's correlation coefficient, simple line regression.

Unit-IV **15 hrs**

Financial Literacy: Money Market: Money and its functions –The Concepts and definitions of money-Measurements of money supply –Advantages of money. Indian Financial System and Institutions: Banking and non-banking financial institutions, Scheduled and Non-scheduled Banks- Commercial Banks, recent innovations in Banking, Merging of Indian Banks, CIBIL, role and functions of Reserve Bank of India.

Capital Markets: primary market, secondary market, role and functions of SEBI.

Suggested Readings:

- Medhi, J. (2006). Statistical Methods: An Introductory Text. Wiley Eastern Ltd.
- Building Mathematical Ability, Foundation Course, University of Delhi, S. Chand Publications.
- Lewis, M.K. and p. d. (2000) Monetary Economics. Oxford University Press, New York,

References:

- C Rangarajan: Indian Economy: Essays in Money and Finance, 1999
- Brahmaiah, B. and P. Subbarao, Financial Futures and Options, Himalaya Publishing House.

SEMESTER-IV

Dissertation

Course Code: **MST401** Core/Elective: **Core (Compulsory)** No. of Credits: **16**	Course Title **Dissertation**

Objective:

Implement some existing techniques, develop a new algorithm/ tool, and produce meaningful research outputs.

Each student will work on a dissertation to apply the knowledge of Space Science & Technology to solving various real-world problems. Problems may be decided based on a literature survey by standard research articles—the significance of the proposed issue and the state-of-the-art to be explored. Relevant tools may be used to demonstrate the results with physical meaning and create necessary research components.

Students must submit a detailed project report on the selected topic for their project as per the department's guidelines. The project work is to be evaluated through presentations and viva voce during the semester, and the final evaluation will be done at the end of the semester as per the guidelines decided by the department from time to time. The candidate shall present/ publish one paper in a national/international conference/seminar/journal of repute.

However, the candidate may visit research labs/institutions with the due permission of the chairperson on the recommendation of the supervisor concerned.