M.D. UNIVERSITY, ROHTAK

SCHEME OF STUDIES AND EXAMINATION

Minor Degree in Space Technology

Scheme effective from 2026-27

COURSE CODE AND DEFINITIONS

Course Code	Definitions
L	Lecture
P	Practical
LC	Laboratory Courses
PCC	Program Compulsory Course.
PEC	Program Elective Course
OE	Open Elective

NOTE: The minor has to be a subject offered by a department other than the department that offers the major of the student, or it can be a different major offered by the same department. For example, a student with the declared Major in Electronics and Communication Engineering may opt to pursue a Minor in Space Technology. In such a case, the student shall receive the degree *B.Tech. (ECE) with a Minor in Space Technology*.

A student may pursue a major in the chosen discipline according to career goals, while the minor provides interdisciplinary knowledge, enhances technical competence, and broadens career opportunities in emerging technologies related to the space sector.

Advantages of Minor in Space Technology

- To apply interdisciplinary knowledge by integrating the student's Major discipline with emerging Space Technology.
- To develop a strong foundation in launch vehicles, spacecraft systems, satellite technologies, remote sensing, navigation systems, and space applications.
- To provide an academic mechanism for fulfilling multidisciplinary demands of the aerospace, defence, geospatial, and satellite industries.
- To provide students with opportunities to gain basic to intermediate competency in space technologies, satellite systems, and related engineering domains.
- To prepare students for careers in organizations working in space research, satellite communication, Earth observation, navigation systems, launch vehicle technologies, and private space enterprises.
- To encourage innovation, entrepreneurship, and start-up development in the rapidly growing space sector.
- To provide opportunities for pursuing higher studies and interdisciplinary research in Aerospace Engineering, Space Science, Remote Sensing, GIS, Satellite Communication, Robotics, Artificial Intelligence for Space Applications, and related domains.
- To enhance employability by equipping students with practical knowledge of modern space technologies, data products, and engineering applications.
- To increase the overall scope and value of the undergraduate engineering degree by integrating emerging technologies with the student's major discipline.

Minor Degree in Space Technology

Scheme effective from 2026-27

Sr. No	Semester	Course No.	Subject	Teaching Schedule			Examination Schedule (Marks)				Duration of Exam (Hours)	No of hours /week
				L	P	Total Credits	Marks of Class works	Theory	Practical	Total		
1	3	26SPTM-201-H	Introduction to Space Technology	3	-	3	25	50	-	75	3	3
2	3	26SPTM-203-H	Introduction to Space Technology lab	0	2	1	5	20	-	25	3	2
3	4	26SPTM-202-H	Launch Vehicle Systems and Technologies	3		3	25	50	-	75	3	3
4	4	26SPTM-204-H	Launch Vehicle Systems and Technologies Lab	0	2	1	5	20	-	25	3	2
5	5	27SPTM-301-H	Spaceflight Mechanics and Attitude Dynamics	3	0	3	25	50	-	75	3	3
6	5	27SPTM-303-H	Spaceflight Mechanics and Attitude Dynamics Lab	0	2	1	5	20	-	25	3	2
7	6	27SPTM-302-H	Spacecraft Systems Engineering	3	-	3	25	50	-	75	3	3
8	6	27SPTM-304-H	Spacecraft Systems Engineering Lab	0	2	1	5	20	-	25	3	2
9	7	28SPTM-401-H	Space Data Products and Services	3	-	3	25	50	-	75	3	3
10	7	28SPTM -403-H	Space Data Products and Services Lab	0	2	1	5	20	-	25	3	2
			TOTAL			20				500		

Note: *List ofLab/Practical can be framed at institutional level for the specified subjects as per above scheme. It is advised to implement at least one mini project as part of this course in the practical hours assigned for various subjects. It can be called as a Capstone project.*

Introduction to Space Technology

Course code	26SPTM-201-H				
Category	Minor Degree Course				
Course title	**Introduction to Space Technology**				
Scheme and Credits	L	T	P	Credits	
	3	0	0	3	
Internal Assessment	25 Marks				
Exam (Semester Exam)	50 Marks				
Total	75 Marks				
Duration of Exam	03 Hours				

Note: The examiner will set nine questions in total. Question one will be compulsory. Question one will have parts all units and remaining eight questions of 15 marks each to be set by taking two questions from each unit. The students have to attempt five questions in total, first being compulsory and selecting one from each unit.

CourseContents:

Unit – I:

Basics of Launch Vehicle Design and Missiles GNC and Satellite Systems Engineering design. Fundamentals of structure and mechanisms. Introduction to launch facilities, launch vehicle assembly, integration and launch readiness. Communication with the ground stations and ground tracking in collaboration with foreign space centers.

Unit – II:

Fundamentals of mission trajectory design Coordinate reference frames, space flight mechanics, satellite orbits, Kepler's laws; lunar and interplanetary missions. Attitude dynamics, Attitude parameterization: direction cosine matrix, Euler axis and angles, quaternions, Euler angles; attitude rates; attitude determination; Euler equations of motion and attitude dynamics

Unit – III:

Basics of Space data products and services including AI and ML Definition and Overview of Remote Sensing and Remote Sensing Systems: Electromagnetic Radiation, Laws of Radiation, EM Spectrum, Sources of EMR, Interaction between EM Radiation and matter, Reflection, Absorption and Transmission, Interactions between EM Radiation and Atmosphere, Atmospheric windows. Platforms: Types of platforms (Ground, Airborne and Space borne); Satellites for earth observation; Geostationary and UAV platforms

Unit – IV:

Space Technology Fundamentals of Digital Image Processing, Fundamentals of Photogrammetry, Cartography, space materials processing; Global Navigation Satellite System (GNSS)

Course outcomes

Space Law and Policy : Introduction to the need and overview of Space Laws and its interface with International Conventions and Treaties, Introduction and Basic Principles of International Laws, Indian Space Bill and Space policy 2022, Space-enabled Communication and Services Regulation, Space tourism

Course Objectives:

1. To develop a fundamental understanding of space technology, launch vehicle systems, satellite engineering, and their applications in modern space missions.
2. To familiarize students with mission trajectory design, orbital mechanics, spacecraft attitude dynamics, and satellite navigation principles.
3. To introduce remote sensing, space data products, digital image processing, and Earth observation technologies for scientific and societal applications.
4. To provide knowledge of space laws, policies, international treaties, and emerging trends in the global space sector.

Course Outcomes: At the end of the Course, the student will have the ability to:

CO1: Explain the fundamentals of space technology, launch vehicles, and satellite systems.
CO2: Analyze mission trajectories, orbital mechanics, spacecraft attitude dynamics, and navigation systems.
CO3: Apply remote sensing concepts and interpret space data products for Earth observation and geospatial applications.
CO4: Demonstrate an understanding of space policies, legal frameworks, and emerging technologies in the space sector.

Text Books:

1. Wie, B., Space Vehicle Dynamics and Control, 2nd ed., AIAA Education Series, 2008
2. Zarchan, P., Tactical and Strategic Missile Guidance, 6th ed., Progress in Astronautics and Aeronautics, 2007

Reference Books: 1. Joseph, G., Fundamentals of Remote Sensing, Universities Press, 2003
2. Fleeman, E. L., Missile Design and System Engineering, AIAA Education Series, 2012
3. Noton, M., Spacecraft Navigation and Guidance, Springer 1998
4. Farrell, J. A., Aided Navigation: GPS with High Rate Sensor, McGraw-Hill 2008

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2	2	2	–	–	–	–	2	2	2	3	2	2
CO2	3	3	2	3	2	–	–	–	–	2	2	2	3	2	3
CO3	3	3	3	3	3	–	–	–	–	2	3	2	3	3	3
CO4	2	2	–	–	–	2	2	3	2	3	2	3	2	2	2
WT. AVG	**2.75**	**2.50**	**2.33**	**2.67**	**2.33**	**2.00**	**2.00**	**3.00**	**2.00**	**2.25**	**2.25**	**2.25**	**2.75**	**2.25**	**2.50**

Launch Vehicle Systems and Technologies

Coursecode	26SPTM-202-H				
Category	Minor Degree Course				
Coursetitle	Launch Vehicle Systems and Technologies				
Scheme and Credits	L	T	P	Credits	
	3	0		3	
Classwork (Internal)	25 Marks				
Exam (Semester Exam)	50 Marks				
Total	75 Marks				
Duration of Exam	03 Hours				

Note: The examiner will set nine questions in total. Question one will be compulsory. Question one will have parts all units and remaining eight questions of 15 marks each to be set by taking two questions from each unit. The students have to attempt five questions in total, first being compulsory and selecting one from each unit.

Unit – I: Launch Vehicles and Missiles and their subsystems
Launch Vehicles and Missiles and their subsystems, Fundamentals and Types of Propulsion system: Solid / liquid / Cryogenic / Semi-Cryogenic /Monopropellant, Bi-propellant and Electric propulsion systems (including green propulsion) Fundamentals of Structures and Mechanisms: Structural Dynamics /Vibration modes for Dynamics modelling.

Unit – II: Launch Vehicle Dynamics
Gravity model, Point mass dynamics, Aerodynamics: Multi-strap-on Vehicles, its aerosurfaces, Fundamentals of Trajectories (Mission Design): Equations of Motion: short period / long period Model development, Slosh Dynamics analysis, Basic principles of inertial measurement units: Gyros, Fiber optic/ Laser Gyros and others, accelerometers, Actuators: Electrohydraulic, Electromechanical, Reaction Control Systems

Unit – III: Fundamentals of GNC loop, design problem and algorithms
Basics of Guidance: Open Loop / Closed Loop: Implicit / Explicit Guidance schemes, Basics of Navigation: Nav algorithm, compensation schemes, multiple sensor fusion, Basics of Control (Autopilot): Linear / nonlinear design Techniques

UNIT IV: Simple graphics and image processing:
On-board computer in the loop simulations (OILS), Hardware in the loop Simulations (HLS), Actuators in Loop Simulations (ALS), Flight Software in Loop Simulations (SILS), reliability analysis, Satellite interface and satellite deployment with separation dynamics
Descent and landing : Descent and landing of jettisoned stages, communication with ground stations, ground tracking in collaboration with foreign space center

Course Objectives:

1. To develop a comprehensive understanding of launch vehicle architecture, propulsion systems, structural design, and missile technologies.
2. To study launch vehicle dynamics, trajectory design, aerodynamics, inertial navigation, and onboard guidance systems.
3. To understand the principles of Guidance, Navigation, and Control (GNC) systems and their implementation in launch vehicles.

4. To introduce launch vehicle simulation, satellite deployment mechanisms, mission reliability, descent, and recovery technologies.

Course Outcomes: At the end of the Course, the student will have the ability to:

CO1: Explain the design, propulsion, and structural characteristics of launch vehicles and missile systems.

CO2: Analyze launch vehicle dynamics, aerodynamics, inertial navigation, and trajectory optimization.

CO3: Design and evaluate Guidance, Navigation, and Control algorithms for launch vehicle missions.

CO4: Analyze launch vehicle simulations, satellite deployment techniques, and mission reliability considerations.

Text Books

1. Edberg, D., and Costa, W., Design of Rockets and Space Launch Vehicles, AIAA Education Series, 2020
2. Kadam, N. V., Practical Design of Flight Control Systems for Launch Vehicles and Missiles, Allied Publishers, 2009

Reference Books

1. Wiesel, W. E., Spacecraft Dynamics,
2. 2nd ed, McGraw-Hill 1997 2. Noton, M., Spacecraft Navigation and Guidance, Springer 1998

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	2	2	–	–	–	–	2	2	2	3	2	3
CO2	3	3	3	3	3	–	–	–	–	2	2	2	3	2	3
CO3	3	3	3	3	3	–	–	–	–	2	3	2	3	3	3
CO4	3	3	2	3	2	1	–	–	–	2	3	2	3	2	3
WT. AVG	**3.00**	**3.00**	**2.50**	**2.75**	**2.50**	**1.00**	**–**	**–**	**–**	**2.00**	**2.50**	**2.00**	**3.00**	**2.25**	**3.00**

Launch Vehicle Systems and Technologies Lab

Coursecode	26SPTM-204-H				
Category	Minor Degree Course				
Coursetitle	**Launch Vehicle Systems and Technologies Lab**				
Scheme and Credits	L	T	P	Credits	
	0	0	2	1	
Internal Assessment	05 Marks				
Practical Exam	20 Marks				
Total	25 Marks				
Duration of Exam	03 Hours				

Students have to write at least 15 Experiments/programs based on the course 26SPTM-203-G

Spaceflight Mechanics and Attitude Dynamics

Course code	27 SPTM -301-H				
Category	Minor Degree Course				
Course title	**Spaceflight Mechanics and Attitude Dynamics**				
Scheme and Credits	L	T	P	Credits	
	3	0	0	3	
Classwork (Internal)	25 Marks				
Exam (Semester Exam)	50 Marks				
Total	75 Marks				
Duration of Exam	03 Hours				

Note: The examiner will set nine questions in total. Question one will be compulsory. Question one will have parts from all units and the remaining eight questions of 15 marks each to be set by taking two questions from each unit. The students have to attempt five questions in total, the first being compulsory and selecting one from each unit.

Unit – I: Spaceflight Mechanics

ECI frame, Two-body Orbital dynamics, Integrals of motion, Classical Orbital parameters, Satellite Orbit perturbations, sun-synchronous satellites, geosynchronous, orbital manoeuvres, orbit determination, orbit corrections and maintenance, relative motion in orbits, proximity operations

Unit – II: Spacecraft Attitude Dynamics

Attitude parameterization: direction cosine matrix, Euler axis and angles, Quaternions, attitude rates, Euler equations of rigid body attitude dynamics. Liquid propellant slosh effects. Aattitude stabilization, spin stabilization of a rigid spacecraft and an energy-dissipating Spacecraft, active nutation control, momentum bias satellites, passive and active nutation damping, control with Thrusters.

Unit – III: Spacecraft Attitude Control

Attitude control with three-axis reaction wheels, thrusters and magnets; ThreeAxis Stabilization, Disturbing torques, effect of structural flexibility, antenna beam pointing accuracy. Various types of attitude sensors, attitude determination.

Unit – IV: Remote Sensing and Propulsion Systems
Earth coverage by low-earth orbit and high-earth orbit remote sensing satellites; infrared and radar remote sensing from space, Propulsion Systems, Liquid Propellant Thrusters, Electric Propulsion

Flight Mechanics and Missile Guidance: Re-entry Flight Mechanics, guided re-entry, feedback guidance, Lunar and Minor Degree in Space Technology 10 interplanetary flights: Chandrayan and Mars missions. Missile guidance: Lambert, midcourse and endgame guidance; Tactical and strategic interceptors, zero-effort-miss guidance; Cruise missiles, Fundamentals of Space-based Navigation (GNSS)

Text Books

1. De Ruiter, A. H. J., Damaren, C. J., and Forbes, J. R., Spacecraft Dynamics and Control: An Introduction, Wiley 2013
2. Montenbruck, O., and Gill, E., Satellite Orbits: Models, Methods, Applications, Springer 2000
3. Sidi, M. J., Spacecraft Dynamics and Control, Cambridge University Press 1997
4. Wie, B., Space Vehicle Dynamics and Control, 2nd ed., AIAA Education Series, 2008

Reference Books

1. Chobotov, V. A., (Ed.), Orbital Mechanics, 3rd ed, AIAA Education Series 2002
2. Wiesel, W. E., Spacecraft Dynamics, 2nd ed, McGraw-Hill 1997
3. Noton, M., Spacecraft Navigation and Guidance, Springer 1998
4. Farrell, J. A., Aided Navigation: GPS with High Rate Sensor, McGraw-Hill 2008
5. Joseph, G., Fundamentals of Remote Sensing, Universities Press, 2003
6. Fleeman, E. L., Missile Design and System Engineering, AIAA Education Series, 2012
7. Zarchan, P., Tactical and Strategic Missile Guidance, 6th ed., Progress in Astronautics and Aeronautics, 2007

Course Objectives:

1. Develop a comprehensive understanding of orbital mechanics, spacecraft trajectories, and satellite motion for various space missions.
2. Understand the principles of spacecraft attitude dynamics, stabilization techniques, and attitude determination methods.
3. Analyze spacecraft attitude control systems, propulsion technologies, and their applications in space missions.
4. Study remote sensing satellites, flight mechanics, missile guidance, and satellite navigation systems for advanced aerospace applications.

Course Outcomes: At the end of the Course, the student will have the ability to:

CO1: Explain the principles of orbital mechanics, satellite motion, and spacecraft trajectory analysis.

CO2: Analyze spacecraft attitude dynamics, stabilization techniques, and attitude determination methods.

CO3: Apply spacecraft attitude control principles using reaction wheels, thrusters, magnetic actuators, and propulsion systems.

CO4: Evaluate remote sensing missions, flight mechanics, missile guidance, and satellite navigation techniques for space applications.

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	3	2	–	–	–	–	2	2	2	3	2	3
CO2	3	3	3	3	3	–	–	–	–	2	2	2	3	3	3
CO3	3	3	3	3	3	–	–	–	–	2	3	2	3	3	3
CO4	3	3	2	3	2	1	–	–	–	2	3	2	3	2	3
WT. AVG	**3.00**	**3.00**	**2.50**	**3.00**	**2.50**	**1.00**	**–**	**–**	**–**	**2.00**	**2.50**	**2.00**	**3.00**	**2.50**	**3.00**

Spaceflight Mechanics and Attitude Dynamics Lab

Coursecode	27 SPTM -303-H				
Category	Minor Degree Course				
Course title	**Spaceflight Mechanics and Attitude Dynamics Lab**				
Scheme and Credits	L	T	P	Credits	
	0	0	2	1	
Classwork (Internal)	5 Marks				
Exam (Semester Exam)	20 Marks				
Total	25 Marks				
Duration of Exam	03 Hours				

Students have to write at least 15 experiments/programs based on the course 26 SPTM -301-G

Spacecraft Systems Engineering

Coursecode	**27 SPTM -302-H**				
Category	Minor Degree Course				
Coursetitle	Introduction to OS and DBMS				
Scheme and Credits	L	T	P	Credits	
	3	0		3	
Classwork (Internal)	25 Marks				
Exam (Semester Exam)	50 Marks				
Total	75 Marks				
Duration of Exam	03 Hours				

Note: The examiner will set nine questions in total. Question one will be compulsory. Question one will have parts all units and remaining eight questions of 15 marks each to be set by taking two questions from each unit. The students have to attempt five questions in total, first being compulsory and selecting one from each unit.

Unit – I: Spacecraft Configurations and Satellite subsystems
Mission analysis and design, Space Environment and space weather,Disturbances acting on a satellite, Fundamentals of on-board computer andcontrol electronics, on-board software development for attitude and orbit control,propulsion, electrical power, solar arrays, batteries, power control electronics,telemetry and telecommand, mechanism, radiation tolerance, electromagnetic compatibility.

Unit – II: Spacecraft Structures and Thermal Control System
Introduction, Spacecraft Structural Configuration, Launch Loads, Stress-Strain Analysis, Matrix Methods of Structural Analysis, Finite Element Analysis,Instability of Structures, Dynamic Analysis, Multi-Degree-of-Freedom System,Random Excitation, Mode Synthesis, Materials, Structural Design Verification Tests, Introduction, Heat Transfer, Thermal Analysis, Thermal Control Techniques, Spacecraft Thermal Design, Thermal TestingDeadlocks: Definition, Necessary and sufficient conditions for Deadlock, Deadlock Prevention, and Deadlock Avoidance: Banker's algorithm, Deadlock detection and Recovery.

Unit – III: Satellite Communication
Basic Units and Definitions in Communications Engineering, Frequency Allocations and Some Aspects of the Radio Regulations, Electromagnetic Waves,Frequency, and Polarization Selection for Satellite Communications, LinkConsideration, Communications Subsystem of a Communications Satellite, SomeCommon Modulation and Access Techniques for Satellite Communications,Satellite Capacity and the Sizing of Satellites, Advanced communication systems in LEO, MEO and GEO, Small satellites: engineering and applications

Unit – IV: Remote Sensing Satellites
Payloads of communication satellites, remote sensing satellites, navigation satellites, science mission satellites and missile detection. Optical, Quantum Satellite communication

Ground Segment : Ground segment: assembly, integration, and verification, Quality control and product assurance

Course Objectives:

1. Develop a fundamental understanding of spacecraft configurations, mission analysis, and satellite subsystem engineering.
2. Study spacecraft structures, thermal control systems, onboard electronics, and environmental effects influencing spacecraft performance.
3. Understand satellite communication systems, payload integration, communication architectures, and space-based communication technologies.
4. Introduce remote sensing satellites, navigation systems, spacecraft assembly, integration, testing, and ground segment operations.

Course Outcomes: At the end of the Course, the student will have the ability to:

CO1: Explain spacecraft configurations, mission analysis, and the functions of various satellite subsystems.

CO2: Analyze spacecraft structures, thermal control techniques, and onboard engineering systems for reliable mission performance.

CO3: Evaluate satellite communication systems, payload integration, and communication architectures used in modern spacecraft.

CO4: Analyze remote sensing satellites, navigation systems, spacecraft ground segments, and mission support infrastructure.

Text Books
1. Larson, W. J., and Wertz, J. R., (Eds.), Space Mission Analysis and Design, Springer 2006
2. Fortescue, P., Swinerd, G., and Stark, J., (Eds.), Spacecraft Systems Engineering, 4th ed., Wiley 2011
3. Griffin, M. D., and French, J. R., Space Vehicle Design, 2nd ed, AIAA Education Series 2004

Reference Books
1. Maini, A. K., and Agrawal, V., Satellite Technology: Principles and Applications, Wiley 2007
2. Sandau, R., Roser, H.-P, and Valenzuela, (Eds.), Small Satellites for Earth Observation, Springer 2008

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	2	2	–	–	–	–	2	2	2	3	2	2
CO2	3	3	3	3	2	–	–	–	–	2	3	2	3	2	3
CO3	3	3	3	3	3	–	–	–	–	2	3	2	3	3	3
CO4	3	3	2	3	2	1	–	–	–	2	3	2	3	3	3
WT. AVG	**3.00**	**3.00**	**2.50**	**2.75**	**2.25**	**1.00**	**–**	**–**	**–**	**2.00**	**2.75**	**2.00**	**3.00**	**2.50**	**2.75**

Spacecraft Systems Engineering Lab

<table>
<tr><td>Coursecode</td><td colspan="5">27 SPTM-304-H</td></tr>
<tr><td>Category</td><td colspan="5">Minor Degree Course</td></tr>
<tr><td>Coursetitle</td><td colspan="5">Spacecraft Systems Engineering Lab</td></tr>
<tr><td rowspan="2">Scheme and Credits</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td rowspan="2"></td></tr>
<tr><td>0</td><td>0</td><td>2</td><td>1</td></tr>
<tr><td>Internal Assessment</td><td colspan="5">05 Marks</td></tr>
<tr><td>Practical Exam</td><td colspan="5">20 Marks</td></tr>
<tr><td>Total</td><td colspan="5">25 Marks</td></tr>
<tr><td>Duration of Exam</td><td colspan="5">03 Hours</td></tr>
</table>

Students have to write at least 15 experiments/programs based on the course **26 SPTM -303-G**

Space Data Products and Services

Coursecode	28SPTM-401-H				
Category	Minor Degree Course				
Coursetitle	**Space Data Products and Services**				
Scheme and Credits	L	T	P	Credits	
	3	0	0	3	
Classwork (Internal)	25 Marks				
Exam (Semester Exam)	50 Marks				
Total	75 Marks				
Duration of Exam	03 Hours				

Note:Examiner will set nine questions in total. Question one will be compulsory. Question one will have questions from all units and remaining eight questions of 15 marks each to be set by taking two questions from each unit. The students have toattemptfivequestionsintotal, first beingcompulsory andselectingonefromeachunit.

Course Objectives:

1. Develop a comprehensive understanding of remote sensing principles, satellite sensors, image interpretation, and Earth observation systems.
2. Understand digital image processing techniques, image enhancement, classification methods, and geospatial data analysis.
3. Study Geographic Information Systems (GIS), Global Navigation Satellite Systems (GNSS), photogrammetry, and spatial database management.
4. Analyze geospatial data processing, artificial intelligence, cloud-based geospatial platforms, and remote sensing applications for sustainable development.

Course Outcomes: At the end of the Course, the student will have the ability to:

CO1: Explain the principles of remote sensing, image interpretation, and satellite-based Earth observation systems.

CO2: Apply digital image processing techniques for satellite image enhancement, classification, and analysis.

CO3: Analyze GIS, GNSS, photogrammetry, and spatial data processing for geospatial applications.

CO4: Evaluate geospatial technologies, AI-based data analytics, cloud computing platforms, and remote sensing applications for real-world problem solving.

Course Content:

Unit – I: Remote Sensing & Image Interpretation

Definition and Overview of Remote Sensing and Remote Sensing Systems: Electromagnetic Radiation, Laws of Radiation, EM Spectrum, Sources of EMR,Interaction between EM Radiation and matter, Reflection, Absorption and Transmission, Interactions between EM Radiation and Atmosphere, Atmospheric windows. Platforms:Types of platforms (Ground, Airborne and Space borne); Orbit of satellites; Kepler's law; Satellite characteristics; Satellites for earth observation studies and planetary missions (Chandrayaan); Geostationary andUAV platforms. Sensors: Types and classification; Sensor resolutions. Microwaveand Thermal remote sensing: Principles and data characteristics Spectral-signatures and Image interpretation: Spectral signatures for common land use/land cover (LULC) classes; Principles of visual image interpretation.

Unit – II: Fundamentals of Digital Image Processing

Remote Sensing Images: Histogram, Image Statistics, Image Display, Colour cube, Look-up- Table, Colour Composites, FCC generation. Image Correction: Fundamentals of Image Rectification and Registration, Spatial Interpolation, Intensity Interpolation (Nearest neighbour, Bilinear interpolation, Cubic convolution), Radiometric Corrections. Image Enhancement: Contrast Enhancement (Linear and Non-linear); Spatial Enhancement: Noise and Spatial filters. Image Transformations: Principal Component Analysis; Image Fusion;Spectral Indices. Image Classification: Principle of Image Classification (Supervised and Un-supervised) and Accuracy Assessment. Advanced Classification Techniques: Image Segmentation, Object based Classification, Image Textures.

Unit – III: Fundamentals of Photographer and GNSS

Concepts of Photogrammetry: Overview of Aerial, Satellite & UAV Photogrammetry; Aerial cameras; Satellite stereo sensors; Types of Photographs; Geometry and scales of Aerial Photographs.Stereo Photogrammetry: Relief displacement, relation with different parameters and vertical exaggeration; Concept of Parallax; Ground height estimation from Parallax. Digital Elevation Model (DEM): Digital Terrain Model (DTM), DEM, Digital Surface Model (DSM),nDSM, bare earth DEM, Structures of DTM (Contours, Grid, and TIN), DEM interpolation techniques, derivatives and 3D visualisation, Ortho-photo. Basics of Geodesy: Concepts of land Surveying; Types of maps; Map projections; Concepts of vertical/ horizontal datum (MSL, Geoid, spheroid, WGS-84). Satellite Navigation and Augmentation systems: Principles and components of GNSS,collection methods, Differential Global Positioning System (DGPS), Errors in observations and corrections; Overview of GPS Aided GEO Augmented Navigation (GAGAN), Indian Regional Navigation Satellite System (IRNSS) (NavIC); GNSS reflectometry applications.

Unit – IV: Geographical Information System (GIS)

Introduction to GIS: GIS Components, Data formats and structures. Spatial and Non-spatial data models: Raster and Vector Data Models. Overview of DBMS: Database Design using RDBMS; Spatial and Non-spatial queries.
Spatial Data Analysis: Raster and Vector analysis, Buffer, Overlay, etc. Network Analysis and Spatial Interpolation Techniques. Geo-data visualization and analysis: Open-source tools and location-based services.

Data Processing and Dissemination techniques

Big Geo-data: Concepts (5 V's) Artificial Intelligence and Machine Learning: Supervised, Semi-Supervised, Un supervised and Reinforcement Learning. Deep Learning: CNN, RNN based models. Cloud Based Platforms: Earth Engine, Data Cube, Analysis Ready Data (ARD). Geo-Portals: Sources and Geocomputation. Data Analytics: Multidimensional data analytics and visualisation.

Terrestrial Applications of RS and GIS

Water Resources Assessment and Monitoring: Forestry and Ecology Studies, Climate Change Studies, Agriculture and Soils Studies, Geosciences. Oceanand Atmospheric Applications of RS and GIS: Marine Biology, Coastal Processes, Physical Oceanography, Satellite Meteorology. Space and Planetary Exploration:

Major processes affecting Planetary Systems; Overview of remote sensing-based observations of planetary surface from recent missions with emphasis on Indian Planetary Missions Lunar and Martian Geology.

Text Books

1. Avery, T. E. and G. L. Berlin, "Fundamentals of Remote Sensing and Airphoto Interpretation," Fifth Edition. New York, NY: Macmillan Publishing Company.
2. Robert A Schowengerdt, "Remote Sensing Models and methods for Image Processing, Elsevier
3. R C Olsen, "Remote Sensing from Air and Space," SPIE Press, Washington

Reference Books

1. Thomas M. Lillesand, Ralph W. Kiefer, J W Chipman, "Remote Sensing and Image Interpretation", 5th Edition, John Wiley
2. Campbell, J. B. "Introduction to Remote Sensing Third Edition," New York, NY: The Guilford Press

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	3	3	–	–	–	–	2	2	2	2	3	3
CO2	3	3	3	3	3	–	–	–	–	2	3	2	2	3	3
CO3	3	3	3	3	3	–	–	–	–	2	3	2	3	3	3
CO4	3	3	2	3	3	1	1	–	–	2	3	3	2	3	3
WT. AVG	**3.00**	**3.00**	**2.50**	**3.00**	**3.00**	**1.00**	**1.00**	**–**	**–**	**2.00**	**2.75**	**2.25**	**2.25**	**3.00**	**3.00**

Space Data Products and Services Lab

Coursecode	28 SPTM -403-H
Category	Minor Degree Course

Coursetitle	**Space Data Products and Services Lab**				
Scheme and Credits	L	T	P	Credits	
	0	0	2	1	
Internal Assessment	05 Marks				
Practical Exam	20 Marks				
Total	25 Marks				
Duration of Exam	03 Hours				

Students have to write at least 15 experiments/programs based on the course 26SPTM-401-G

Space Economics, Laws, Policy, and Benefits (Optional)

<table>
<tr><td>Coursecode</td><td colspan="5">28SPTM-403-H</td></tr>
<tr><td>Category</td><td colspan="5">Minor Degree Course</td></tr>
<tr><td>Coursetitle</td><td colspan="5">Space Economics, Laws, Policy, and Benefits (Optional)</td></tr>
<tr><td rowspan="2">Scheme and Credits</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td rowspan="2"></td></tr>
<tr><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td>Classwork (Internal)</td><td colspan="5">25 Marks</td></tr>
<tr><td>Exam (Semester Exam)</td><td colspan="5">50 Marks</td></tr>
<tr><td>Total</td><td colspan="5">75 Marks</td></tr>
<tr><td>Duration of Exam</td><td colspan="5">03 Hours</td></tr>
</table>

Note:Examiner will set nine questions in total. Question one will be compulsory. Question one will have questions from all units and remaining eight questions of 15 marks each to be set by taking two questions from each unit. The students have toattemptfivequestionsintotal, first beingcompulsory andselectingonefromeachunit.

Course Content:

Unit- 1

Introduction to the need and overview of all aspects of Space Law and its interface with:

1. International Conventions and Treaties
2. Intellectual Property
3. Trade Law
4. Risk and Liability Management
5. Financial Regulation

Unit- 2

Introduction and Basic Principles of International Law

1. Introduction to International Law - Sovereign Rights, International Cooperation, United Nations Bodies, Sustainable Development Goals.

2. United Nations Office of Outer Space Affairs - Conventions, Functions, Promotion, Indian Perspective.
3. International Telecommunications Union - Technology, Standardization and Regulatory Functions.

Unit- 3

International Space Law - Treaties & Conventions, Organizations, Technical Standardization

1. Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies.
2. Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space.

3. Convention on International Liability for Damage Caused by Space Objects
4. Agreement Governing the Activities of States on the Moon and Other Celestial Bodies.
5. Declarations and Principles of Legal, Nuclear Power, Broadcasting, Remote Sensing, and Benefits.
6. Technical Standards and Policy Initiatives - Perspectives on Debris Mitigation, CCSDS Compliance, Space Situational Awareness.
7. Other space treaties and General Assembly resolutions
8. Multilateral and bilateral agreements and intergovernmental organizations
9. International law relating to remote sensing

Unit- 4

Domestic Space Law Framework
1. Indian Space Bill and Space policy 2022
2. Principles of Remote Sensing and Space Communication.
3. Liability, Registration, Regulation - An interface between law, technology and governance.
4. Economic, Trade and Fiscal Policy - Analysis and Development.
5. Liability, Registration, Regulation - An interface between law, technology and governance.
6. Economic, Trade and Fiscal Policy - Analysis and Development.

Space-enabled Communication and Services Regulation
1. Telecommunications Law and Regulation - Licensing Frameworks for services and infrastructure.
2. Technical Standards - Regulations and Testing.
3. Policy on Remote Sensing and Space Communication.
4. Universal Service Obligations Fund - Basic principles and role in inclusion.
5. National Security, Defense Applications and Official Secrets Act - Understanding confidentiality, security and anti-espionage practices.
6. International trade in satellite communication services and global mobile personal communication services
7. Legal framework for GNSS services
8. International institutional context for GNSS operations

The Techno-Legal Practitioners Perspective - Essentials for Entrepreneurs and Leaders
1. Customs Act and Rules - For import and export of technology, products, services and SCOMET Rules.
2. Taxation - Benefits, Exemptions and Promotional Support.
3. Production Linked Incentives Schemes and Benefits.
4. Technology Transfer Initiatives.
5. SEBI, RBI and IRDAI - Financial Regulation Interface with Space Sector with specialized focus on Foreign Direct Investment Regime, External Commercial Borrowings, Bank Guarantees and Insurance.
6. Procurement of Goods and Procurement of Services Rules.
7. Defense Procurement Procedure.
8. Basic principles of General Finance Rules, Laws governing grants and financial support by Government.
9. Space tourism, space materials processing NB: This is an **optional course** and independent of the proposed space technology minor course structure.

Course Objectives:

CO1: Develop a fundamental understanding of national and international space laws, treaties, conventions, and regulatory frameworks governing space activities.

CO2: Understand the economic, financial, commercial, and policy aspects of the global space sector and emerging space industries.

CO3: Study intellectual property rights, international cooperation, risk management, technology transfer, and regulatory compliance in space missions.

CO4: Familiarize students with entrepreneurship, investment policies, commercial space applications, and sustainable development opportunities in the space economy.

Course Outcomes: At the end of the Course, the student will have the ability to:

CO1: Explain the principles of national and international space laws, treaties, and regulatory frameworks.

CO2: Analyze the economic, financial, and policy aspects influencing the global space industry.

CO3: Evaluate legal, commercial, and regulatory issues related to space missions, technology transfer, and international cooperation.

CO4: Demonstrate an understanding of entrepreneurship, investment, innovation, and emerging opportunities in the commercial space sector.

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2	–	–	–	3	3	3	2	3	2	3	2	2	2
CO2	2	2	–	–	–	3	2	3	3	3	3	3	2	2	2
CO3	2	2	1	1	–	3	3	3	3	3	3	3	2	2	3
CO4	2	2	1	1	1	2	3	3	3	3	3	3	2	2	3
WT. AVG	**2.00**	**2.00**	**1.00**	**1.00**	**1.00**	**2.75**	**2.75**	**3.00**	**2.75**	**3.00**	**2.75**	**3.00**	**2.00**	**2.00**	**2.50**

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