ANNEXURE-B

M.D. UNIVERSITY, ROHTAK
SCHEME OF STUDIES AND EXAMINATION
B.Tech. Minor in Space Technology

with effective from 2025-26

S. No.	Semester	Course Code	Course Title	Teaching Schedule			Sessional Marks	Examination Marks		Total	Credit	Duration of Exam
				L	T	P		Theory	Practical			
1	3rdSem	24-ST-M-01	Introduction to Space Technology	2	0	-	25	75	-	100	2	3
2	3rd Sem	24-ST-M-04	Space Economics, Laws, Policy, and Benefits	2	0	0	25	75		100	2	3
3	4thSem	24-ST-M-02	Launch Vehicle Systems and Technologies	3	0	0	25	75	-	100	3	3
4	4thSem	24-ST-M-03	Launch Vehicle Systems and Technologies Lab	0	0	2	25		25	50	1	3
5	5th Sem	25-ST-M-01	Spaceflight Mechanics and Attitude Dynamics	3	0	-	25	75	-	100	3	3
6	5thSem	25-ST-M-02	Spaceflight Mechanics and Attitude Dynamics Lab	0	0	2	25	-	25	50	1	3
7	6thSem	25-ST-M-03	Spacecraft Systems Engineering	3	0	0	25	75	-	100	3	3
8	6thSem	25-ST-M-04	Spacecraft Systems Engineering Lab	0	0	2	25	-	25	50	1	3
9	7thSem	26-ST-M-01 26-ST-M-04	Space Data Products and Services **or** Satellite Communication	3	0	0	25	75	-	100	3	3
10	7thSem	26-ST-M-02	Satellite Communication Lab	0	0	2	25	-	25	50	1	3
		Total		16		8	250	450	100	800	20	

24-ST-M-01 **Introduction to Space Technology**

L T P — Theory: 75 Marks
2 0 - — Sessional : 25 Marks
Total: 100 Marks — Duration of Exam: 3 Hours

Note: Examiner will set nine questions in total. Question one will be compulsory. Question one will have 6 parts of 2.5 marks each from 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.

Course Objectives: Familiarize students with

1. Concepts of launch vehicle design and missiles
2. Various parameters required for mission trajectory design and launch
3. Space data products and services
4. Space technology and laws

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

C201.1	Discuss concepts of launch vehicle design and missiles
C201.2	Determine various parameters required for mission trajectory design and launch.
C201.3	Use Space data products and services
C201.4	Explain Space technology concepts and laws

Mapping of Course Outcomes to Program Outcomes:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
C201.1	**3**	**3**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**3**	**3**	**2**	**3**	**3**
C201.2	**3**	**3**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**3**	**3**	**2**	**3**	**3**
C201.3	**3**	**3**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**3**	**3**	**2**	**3**	**3**
C201.4	**3**	**3**	**2**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**3**	**3**	**2**	**3**	**3**

Course Contents:

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)

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

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

24-ST-M-04 Space Economics, Laws, Policy, and Benefits

L T P
2 0 -
Total: 100 Marks

Theory: 75 Marks
Sessional: 25 Marks
Duration of Exam: 3 Hours

Note: Examiner will set nine questions in total. Question one will be compulsory. Question one will have 6 parts of 2.5 marks each from 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.

Course Objectives: Familiarize students with

1. Concept of space law and policy
2. Basic Principles of International Law
3. Space Finance, insurance etc,
4. Space technology and laws

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

C311.1	Understand the Benefits of space technology
C311.2	Space Economy Framework
C311.3	Learn International law i.e. Treaties & Conventions, accords, Technical Standardization
C311.4	Customs Act and Rules- SCOMET etc.

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

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- 2

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- 3

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

Unit- 4

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

24-ST-M-02 **Launch Vehicle Systems and Technologies**

L T P Theory: 75 Marks
3 0 - Sessional: 25 Marks
Total: 100 Marks Duration of Exam: 3 Hours

Note: Examiner will set nine questions in total. Question one will be compulsory. Question one will have 6 parts of 2.5 marks each from 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.

Course Objectives: Familiarize students with

1. Concepts of launch vehicle design and missiles
2. Launch Vehicle Dynamics
3. Fundamentals of GNC loop, design problem and algorithms

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

C201.1	Discuss concepts of launch vehicle design and missiles
C201.2	Explain Launch Vehicle Dynamics
C201.3	Apply Fundamentals of GNC loop, design problem and algorithms
C201.4	Describe Mechanism of Descent and landing

Mapping of Course Outcomes to Program Outcomes:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
C221.1	3	3	-	-	-	-	-	-	-	-	3	3	2	3	3
C221.2	3	3	-	-	-	-	-	-	-	-	3	3	2	3	3
C221.3	3	3	-	-	-	-	-	-	-	-	3	3	2	3	3
C221.4	3	3	2	-	-	3	2	3	3	-	3	3	2	3	3

Course Content:

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 /Mono propellent, Bi- propellent and Electric propulsion systems (including green propulsion) Fundamentals of Structures and Mechanisms: Structural Dynamics /Vibration modes for Dynamics modeling

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: Validation Test beds/ Simulation setups

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

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, 2nd ed, McGraw-Hill 1997
2. Noton, M., Spacecraft Navigation and Guidance, Springer 1998

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24-ST-M-03 **Launch Vehicle Systems and Technologies Lab**

L T P Practical: 25 Marks
0 0 2 Sessional: 25 Marks
Total: 50 Marks Duration of Exam: 3 Hours

Hands-on experiments related to the course contents 24-ST-M-02

25-ST-M-01 **Spaceflight Mechanics and Attitude Dynamics**

L T P — Theory: 75 Marks
3 0 - — Sessional: 25 Marks
Total: 100 Marks — Duration of Exam: 3 Hours

Course Objectives: Familiarize students with

1. Concepts of Spaceflight Mechanics
2. Spacecraft Attitude Dynamics and control system
3. Remote Sensing and Propulsion Systems
4. Flight Mechanics and Missile Guidance

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

C311.1	Discuss concepts of Spaceflight Mechanics
C311.2	Understand the need of Virtual Machines and Virtualization
C311.3	Determine various parameters required for Spacecraft Attitude Dynamics and control system.
C311.4	Explain remote sensing systems and various Propulsion Systems.
C311.5	Describe Flight Mechanics and Missile Guidance.

6. **Mapping of Course Outcomes to Program Outcomes:**

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
C311.1	3	3	2	2	3	-	-	-	-	-	-	3	-	-	1
C311.2	3	3	2	2	3	-	-	-	-	-	-	3	1	-	1
C311.3	3	3	2	2	3	-	-	-	-	-	-	3	3	-	3
C311.4	-	3	-	3	-	-	-	-	1	-	-	-	3	1	-
C311.5	3	3	2	2	3	-	-	-	-	-	-	3	-	-	1

Course Content:

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

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

Unit- IV: Flight Mechanics and Missile Guidance

Re-entry Flight Mechanics, guided re-entry, feedback guidance, Lunar and 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

25-ST-M-02 Spaceflight Mechanics and Attitude Dynamics Lab

L T P — Practical: 25 Marks
0 0 2 — Sessional: 25 Marks

Total: 50 Marks Duration of Exam: 3 Hours

Hands-on experiments related to the course contents 25-ST-M-01

25-ST-M-03 Spacecraft Systems Engineering

L T P
3 0 -
Total: 100 Marks

Theory: 75 Marks
Sessional : 25 Marks
Duration of Exam: 3 Hours

Note: Examiner will set nine questions in total. Question one will be compulsory. Question one will have 6 parts of 2.5 marks each from 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.

Course Objectives: Familiarize students with

1. Fundamentals of Spacecraft Configurations and Satellite subsystems
2. Spacecraft Structures and Thermal Control System
3. Satellite Communication principles
4. Basics of remote sensing satellites and ground segments

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

C401.1	Discuss fundamentals of Spacecraft Configurations and Satellite subsystems
C401.2	Elaborate Spacecraft Structures and Thermal Control System
C401.3	Apply Satellite Communication principles
C401.4	Explain remote sensing satellites and ground segments.

Mapping of Course Outcomes to Program Outcomes:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
C401.1	3	3	2	2	3	-	-	-	-	-	-	3	-	-	1
C401.2	3	3	2	2	3	-	-	-	-	-	-	3	1	-	1
C401.3	3	3	2	2	3	-	-	-	-	-	-	3	3	-	3
C401.4	-	3	-	3	-	-	-	-	1	-	-	-	3	1	-

Course Contents:

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 and control 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 Testing

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, Link Consideration, Communications Subsystem of a Communications Satellite, Some Common 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

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

25-ST-M-04 **Spacecraft Systems Engineering Lab**

L T P Practical: 25 Marks

0 0 2 Sessional: 25 Marks
Total: 50 Marks Duration of Exam: 3 Hours

Hands-on experiments related to the course contents 25-ST-M-03

26-ST-M-01 **Space Data Products and Services**

L T P
3 0 -
Total: 100 Marks

Theory: 75 Marks
Sessional: 25 Marks
Duration of Exam: 3 Hours

Note: Examiner will set nine questions in total. Question one will be compulsory. Question one will have 6 parts of 2.5 marks each from 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.

Course Objectives: Familiarize students with

1. Concepts of Remote Sensing & Image Interpretation
2. Fundamentals of Digital Image Processing
3. Geographical Information System and GNSS
4. Data Processing and Terrestrial Applications

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

C413.1	Discuss Concepts of Remote Sensing & Image Interpretation
C413.2	Apply Fundamentals of Digital Image Processing
C413.3	Explain Geographical Information System and GNSS
C413.4	Describe Data Processing and Terrestrial Applications

Mapping of Course Outcomes to Program Outcomes:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
C413.1	3	3	2		3	-	-	-	-	-	-	3	-	-	1
C413.2	3	3	2		3	-	-	-	-	-	-	3	1	-	1
C413.3	3	3	2		3	-	-	-	-	-	-	3	3	-	3
C413.4	-	3	-		-	-	-	-	1	-	-	-	3	1	-

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 and UAV platforms. Sensors: Types and classification; Sensor resolutions. Microwave and 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 Photogrammetry 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, Data 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.

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.

Unit- IV: 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. Ocean and 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

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26-ST-M-04 Satellite Communication

L T P
3 0 -
Total: 100 Marks

Theory: 75 Marks
Sessional: 25 Marks
Duration of Exam: 3 Hours

Note: Examiner will set nine questions in total. Question one will be compulsory. Question one will have 6 parts of 2.5 marks each from 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.

Course Objectives: Familiarize students with

1. Principles of satellite communication
2. Satellite orbits
3. Special purpose satellite
4. Laser communication

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

C415.1	To understand various aspects of satellite communication and satellite link design equations.
C415.2	To analyze digital satellite communication techniques.
C415.3	To understand various aspects such as orbital equation, subsystems in satellite, link budget and multiple access schemes.
C415.4	To analyze various special purpose communication satellites.
C415.5	To understand and analyze LASER communication in satellite-to-satellite communication.

5. **Mapping of Course Outcomes to Program Outcomes:**

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
C415.1	3	2	3	-	-	-	-		-	3	-	3	2		2
C415.2	3	2	3	1	-	-	-	-	-	3	-	3	2		2
C415.3	3	2	3	2		-	-	-	-	3	2	3	2		2
C415.4	2	1	1	-	-			-	-	1	1	2	2		2
C415.5	3	2	2	-	-	-	-	-	-	2	-	2	2		2

Course Content:

UNIT 1

PRINCIPLES OF SATELLITE COMMUNICATION: Evolution & growth of communication satellite, Synchronous satellite, Satellite frequency allocation & Band spectrum, Advantages of satellite communication, Active & Passive satellite, Applications of satellite communication, Block diagram of transponder and Earth Station, Satellite communication with respect to Fiber Optic Communication.

COMMUNICATION SATELLITE LINK DESIGN: Introduction, General link design equations, System noise temperature, C/N & G/T ratio, Atmospheric & Ionospheric effects on link design, Complete link design.

UNIT 2

DIGITAL SATELLITE COMMUNICATION: Advantages of digital communication, Elements of digital satellite communication systems, Digital baseband signals, Digital modulation techniques like MSK, QAM, QPSK.
MULTIPLE ACCESS TECHNIQUES: Introduction, TDMA, TDMA-Frame structure, TDMA-Burst structure, TDMA-Frame efficiency, TDMA- Superframe, TDMA Frame acquisition & Synchronization, TDMA Burst Time Plan. FDMA- FDM/FM/FDMA, Preassigned FDMA, Demand assigned FDMA, Spade System, Limitations of FDM/FM/FDMA, Comparison of TDMA and FDMA.

UNIT 3
SATELLITE ORBITS: Introduction, Kepler's laws, Synchronous orbit, Orbital parameters, Satellite location with respect to earth, Look angles, Earth coverage & slant range, Eclipse effect, Satellite stabilization, Geostationary and other orbits, Mechanism of launching a satellite.

UNIT 4
SPECIAL PURPOSE COMMUNICATION SATELLITES: BDS, INMARSAT, INTELSAT, VSAT(data broadband satellite), MSAT(Mobile Satellite Communication technique), Sarsat (Search & Rescue satellite) & LEOs (Lower earth orbit satellite), LANDSAT, Defense satellite.
LASER SATELLITE COMMUNICATION: Introduction, Link analysis, Optical satellite link transmitter, Optical satellite link receiver, Satellite Beam Acquisition, Tracking & Positioning.

Course Outcomes:

1. To und erstand various aspects of satellite communication and satellite link design equations.
2. To analyze analog and digital satellite communication techniques and signal to noise ratio.
3. To understand various aspects such as orbital equation, subsystems in satellite, link budget and multiple access schemes.
4. To analyze various special purpose communication satellites.
5. To understand and analyze LASER communication in satellite-to-satellite communication.

TEXT BOOK/ REFERENCE BOOK:

1. Satellite Communication: D.C. Aggarwal; Khanna.
2. Timothy Pratt Charles W. Bostian, Jeremy E. Allnutt: Satellite Communications: Wiley India. 2nd edition 2002
3. Tri T. Ha: Digital Satellite Communications: Tata McGraw Hill, 2009
4. Dennis Roddy: Satellite Communication: 4th Edition, McGraw Hill,2009

26-ST-M-02 **Satellite Communication lab**

L T P Practical: 25 Marks

0 0 2 Sessional: 25 Marks
Total: 50 Marks Duration of Exam: 3 Hours

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

C417.1	To Establish connection between earth stations and satellite with different uplink and downlink frequencies.
C417.2	To understand transfer of audio and video signal through satellite and transmission of telemetry data.
C417.3	To find out the delay of signal in satellite links.
C417.4	To analyze and understand the radiation pattern of Yagi Uda & Folded dipole, Circular & Triangular Patch antenna.
C417.5	

Mapping of Course Outcomes to Program Outcomes:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
C417.1	3	1	2	2	-	-	-	-	-	3	-	-	2	-	2
C417.2	3	1	2	2	-	-	-	-	-	3	-	-	2	-	2
C417.3	3	3	3	2	-	-	-	-	-	2	2	-	2	-	2
C417.4	3	1	2	2	2	-	-	-	-	3	-	-	2	-	2
C417.5	3	1		-	-	-	-	-	-	2	-	-	2	-	2

LIST OF EXPERIMENTS:

1. To set up a satellite communication link & study of change in uplink & downlink frequency.

2. To study Communication failure during satellite communication.

3. To Study Transmission of Audio Signals over satellite link.

4. To Study Transmission of Video Signals over satellite link

5. To Study Transmission of telemetry data like temperature & light intensity over satellite link

6. To measure the propagation delay of a signal in a Satellite communication Link.

7. To study different GPS data like longitude, latitude & different types of dilute of precision using a GPS receiver.

8. To study digital data transfer through satellite communication.

9. To study Minimum shift keying modulation & demodulation.

10. To study radiation pattern & calculate beam width for Yagi uda & Folded dipole antenna.

11. To study radiation pattern & calculate beam width for Circular & Triangular Patch Antenna.

NOTE:

At least Seven experiments are to be performed.