GEOSPATIAL DATA SCIENCE			
Course Code	*1MCGI201*	*Scheme*	*2026*
Type of course	**IPCC**	*Semester*	*II*
Teaching Hours/Week (L:T:P)	*70(3:0:2)*	*CIE Marks*	*50*
Total Hours of Pedagogy L:T:P:SL:TW	*120(42:0:28:50)*	*SEE Marks*	*50*
Credits	**4**	*Total Marks*	*100*
Type of Examination (IPCC):	*Theory- CIE +SEE, and Lab- CIE only.*	*Exam Hours*	*03*

Course outcome (Course Skill Set)

At the end of the course, the student will be able to:

1. *CO1 (L2- Understand): Understand the principles of data science and spatial data analytics for geospatial applications.*
2. *CO2 (L3-Apply): Apply statistical and machine learning techniques to analyze geospatial datasets 3. CO3 (L3-Apply): Develop programming skills for spatial data processing and visualization.*
4. *CO4 (L4-Analyse): Analyse and Perform spatial data mining and predictive modelling using geospatial datasets.*
5. *CO4 (L4-Analyse): Analyse and Build geospatial analytics workflows for environmental, urban, and resource management applications*
6. *CO5 (L5-Evaluate): Evaluate the effectiveness of geospatial data science techniques and models for solving realworld environmental, urban, and resource management problems using spatial data analytics*

Module-1

Foundations of Geospatial Data Science:

Introduction to Data Science: Concepts of data science and data analytics, Data science workflow, Data acquisition and pre-processing, Structured vs unstructured data.

Geospatial Data Characteristics: Spatial and spatio-temporal data, Vector and raster geospatial datasets, Geospatial metadata and standards, Spatial data quality and uncertainty

Spatial Statistics Basics: Descriptive spatial statistics, Spatial distribution and patterns, Spatial autocorrelation concepts, Exploratory spatial data analysis

CO linkage: CO1, Partial CO2 **Number of Hours:8 hrs**

Module-2

Data Processing and Visualization for Geospatial Data:

Data Processing Techniques: Data cleaning and pre-processing, Handling missing geospatial data, Data transformation and normalization.

Spatial Data Visualization: Visualization principles for spatial datasets, Geospatial data exploration, Map-based data visualization, Interactive geospatial dashboards

Tools and Libraries Geospatial data visualization using: Python libraries, GeoPandas, Matplotlib

CO linkage: CO2, Partial CO3 **Number of Hours:8 hrs**

Module-3

Spatial Data Mining and Machine Learning:

Introduction to Machine Learning: Supervised vs unsupervised learning, Classification and regression models, Model evaluation and validation

Spatial Data Mining: Spatial clustering techniques, Pattern detection in geospatial data, Spatial anomaly detection.

Machine Learning for Geospatial Data, Land use classification, Environmental monitoring, Predictive spatial modelling

CO linkage: CO3, Partial CO4 **Number of Hours:8 hrs**

Module-4

Geospatial Big Data and Cloud Analytics:
Big Geospatial Data Concepts, Characteristics of geospatial big data, Satellite time-series datasets, Geospatial data streams.
Distributed Data Processing, Big data frameworks overview, Parallel processing concepts, Cloud Geospatial Platforms, Large-scale geospatial analytics using Google Earth Engine
Applications: global environmental monitoring, climate change analysis, urban growth analysis
CO linkage: CO4, Partial CO5 **Number of Hours: 9 hrs**

Module-5

GeoAI and Spatial Predictive Modelling:
Introduction to GeoAI: Concept of geospatial artificial intelligence, Spatial feature engineering, Spatial deep learning concepts.
Predictive Spatial Modelling, spatial regression models, spatial prediction techniques geospatial decision support systems
Applications: disaster risk prediction, agriculture monitoring, smart city analytics.
CO linkage: CO5, CO6 **Number of Hours: 9 hrs**

PRACTICAL COMPONENTS OF IPCC

LIST OF EXPERIMENTS

1. *Geospatial data pre-processing and cleaning.*
2. *Spatial data visualization and exploratory analysis.*
3. *Spatial clustering and classification using machine learning models.*
4. *Geospatial time-series analysis of satellite datasets.*
5. *Development of a spatial predictive model for environmental or urban datasets.*
6. *Building a geospatial analytics workflow using satellite imagery.*
7. *Spatial Autocorrelation Analysis*
8. *Land Use/Land Cover (LULC) Classification using Machine Learning*

Textbooks:

1. *Paul A. Longley, Michael F. Goodchild, David J. Maguire, and David W. Rhind, Geographic Information Science and Systems, 5th Edition, Wiley, 2024.*
2. *Introduction to Geographic Information Systems Kang-tsung Chang McGraw-Hill Education, 2023.*
3. *Python Data Science Handbook Jake VanderPlas, O'Reilly Media, 2016*
4. *Deep Learning for the Earth Sciences: A Comprehensive Approach to Remote Sensing, Climate Science, and Geosciences Gustau Camps-Valls, Devis Tuia, Xiao Xiang Zhu, Markus Reichstein Wiley, 2021.*

Reference books / Manuals:

1. *Applied Spatial Data Analysis with R, 2nd Edition, Springer.*
2. *Python Geospatial Development Erik Westra Packt Publishing, 3rd Edition, 2023.*
3. *Geographic Data Science with Python Sergio J. Rey, Dani Arribas-Bel, Levi John Wolf CRC Press, 2023*
4. *Cloud-Based Remote Sensing with Google Earth Engine Tamás Szekeres Springer Nature, 2023.*

Web links and Video Lectures (e-Resources) and software tools:

- *QGIS Documentation- https://docs.qgis.org?utm_source=chatgpt.com*
- *GeoPandas Documentation- https://geopandas.org?utm_source=chatgpt.com*
- *Google Earth Engine Documentation* **-https://developers.google.com/earth-engine?utm_source=chatgpt.com**
- *Rasterio Documentation- https://rasterio.readthedocs.io?utm_source=chatgpt.com*
- *Scikit-Learn Documentation- https://scikit-learn.org?utm_source=chatgpt.com* **Software tools:**

QGIS and ArcGIS
Python
Jupyter Notebook
Google Earth Engine
PostgreSQL/PostGIS

Teaching-Learning Process

Interactive lectures supported by examples from satellite data analysis and GIS spatial datasets.
Demonstrations using real-world geospatial datasets.

Case studies using geospatial machine learning models.
Hands-on demonstrations with satellite datasets and cloud geospatial workflows.
Demonstration of GeoAI workflows using spatial datasets.

Assessment Structure (both CIE and SEE)

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for a pass in the course.
A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject /course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken together.

Continuous Internal Evaluation:

(i)Theory component

The CIE marks of 25 shall be earmarked for two tests.
The first test shall be conducted after completing two modules of the syllabus and the second one after completing the rest three modules.
Each test shall be conducted for 25 marks. The average of the two tests scaled down to 25 marks shall constitute the test marks for a maximum of 25 marks.

(ii) Laboratory component

Out of 25 marks, 15 marks shall be assigned for assessment of regular laboratory classwork as per the rubrics listed in Table - ICs/IPCCs1.
The remaining 10 marks shall be based on the practical test conducted by two Internal examiners appointed by the HoD. The allotment of marks shall be as per the rubrics defined for the practical test as indicated in the Table – ICs/IPCCs 1.
To qualify and become eligible to appear for the SEE of the IC/IPCC, a student shall secure at least 13 marks out of 25 in the CIE theory component, and at least 12 marks in the CIE Practical component.

Table – ICs/IPCCs 1 Distribution of marks corresponding to laboratory component

Component	Description	Marks
Allotment of marks for regular classwork		
Ability in Conducting Experiments	Initiative, skill, safety practices, teamwork, and independent handling of equipment during regular lab sessions.	5 marks

Laboratory Record / Journal	Regular and neat maintenance of lab record, accuracy of results, and timely submission.	10 marks
	Subtotal	**15**
Allotment of marks for CIE practical test		
Laboratory Test / Experiment Performance	Ability to set up apparatus, follow procedure, take observations, and obtain correct results in the test experiment.	5 marks
Viva-Voce	Understanding of theory, concepts, and experimental procedure; ability to explain results and answer related questions.	5 marks
	Subtotal	**10**
	Total	**25**

Term work and Self Learning:

Students' activities for TW/SL under NCrF: As per National credit framework (NCrF) students must spend 120 hours of study for 4 credit courses, which include Course instructions (CI-70 hour) and Teamwork/Self learning (TW/SL-50 hours).

Hence, students must complete minimum of two activities as part of NCrF. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below. The course coordinator can also design learning activities based on course outcomes.

Sl. No.	**Term Work (TW) Activity**	**Number of Hours / Semester**
1	*Laboratory Exercises, Completion of all prescribed practical experiments. Preparation and submission of laboratory records, Mini Project, Development of a geospatial data science application using GIS, Remote Sensing, Machine Learning, or GeoAI techniques. Project report and presentation.*	25
2	*Case Study Analysis: Study and presentation of real-world applications in environmental monitoring, urban planning, disaster management, agriculture, or climate change, Data Analysis Assignment, Processing and analysis of geospatial datasets using Python, GeoPandas, and Google Earth Engine.*	25
3	*Seminar on emerging topics such as GeoAI, Spatial Big Data Analytics, Digital Twins, Smart Cities, or Earth Observation Analytics, Comparative assessment of machine learning models for geospatial applications. Creation of thematic maps, dashboards, and geospatial visualizations.*	25
SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.		
Sl. No.	**Self-Learning (SL) Activity**	**Number of Hours / Semester**
1	*Foundations of Geospatial Data Science Self-study of geospatial data formats, metadata standards, and spatial data quality concepts. Explore open geospatial datasets from government and international portals. Online tutorials on spatial and spatio-temporal data concepts. Practice spatial clustering, classification, and predictive modeling techniques.*	25

2	*Hands-on learning of GeoPandas, Matplotlib, and interactive mapping tools. Development of thematic maps and spatial visualization dashboards. Spoken tutorials on Python programming and GIS applications. Self-learning of machine learning algorithms for spatial data analysis. Explore cloud-based geospatial platforms and satellite data archives. Perform geospatial analytics using Google Earth Engine.*	25
3	*Study GeoAI, spatial deep learning, and predictive analytics concepts. Explore applications in disaster management, agriculture, and smart cities. Review recent research papers and case studies in geospatial intelligence.*	12

Sample rubrics for TW activities:

Criterion	*Excellent*	*Good*	*Satisfactory*	*Needs Improvement*
Problem understanding	*Clearly identifies the problem, scope, and objectives; shows strong domain understanding.*	*Identifies the problem and objectives well, with minor gaps.*	*Basic understanding of the problem and objectives.*	*Problem statement is unclear or incomplete.*
Design / workflow planning	*Presents a complete, logical, and wellstructured workflow or database design.*	*Workflow/design is mostly complete and logical.*	*Workflow/design is partially complete.*	*Workflow/design is weak, incomplete, or incorrect.*
Technical implementation	*Implements the task accurately with correct database structure, queries, or scripts.*	*Implementation is mostly correct with minor errors.*	*Implementation works partially and needs support.*	*Implementation is incorrect or missing major parts.*
Output quality	*Outputs are accurate, relevant, and well presented.*	*Outputs are mostly correct and clear.*	*Outputs are acceptable but limited in detail.*	*Outputs are poor, inaccurate, or missing.*
Documentation and presentation	*Submission is neat, well organized, and clearly documented.*	*Good documentation with minor formatting issues.*	*Adequate documentation, but not well polished.*	*Poorly documented or difficult to follow.*

Sample rubrics for Self-Learning activities:

Criterion	Excellent	Good	Satisfactory	Needs Improvement
Concept understanding	Demonstrates strong understanding of the topic learned independently.	Shows good understanding with minor gaps.	Shows basic understanding of the topic.	Understanding is weak or unclear.
Learning effort	Shows thorough exploration beyond classroom content.	Shows good effort in exploring the topic.	Limited but acceptable learning effort.	Very little learning effort evident.

Application / example	Gives a relevant and correct example or mini application.	Gives a suitable example with minor issues.	Example is simple or partially relevant.	Example is missing or irrelevant.
Reflection and analysis	Provides thoughtful reflection and analysis of learning.	Provides reasonable reflection.	Reflection is brief and descriptive.	Reflection is minimal or absent.
Presentation and organization	Work is neat, well structured, and easy to follow.	Mostly organized with minor issues.	Acceptable organization.	Poorly organized or difficult to read.

Suggested rubrics for Practical continuous assessment:

Performance Indicators	Excellent	Very Good	Good	Satisfactory
Fundamental Knowledge (4) (PO1)	The student has well depth knowledge of construction planning, BIM-enabled 4D/5D workflows, project controls and site logistics. (4)	Student has good knowledge of some topics related to construction planning and BIM workflows. (3)	Student is capable of narrating the answer but not capable to show in depth knowledge. (2)	Student has not understood the concepts clearly. (1)
Design Of Experiment (5) (PO2 & PO3)	Student is capable of discussing more than one planning workflow/design for the problem statement and selecting the best suitable approach with proper reason. (5)	Student is capable of discussing a few workflows but not fully capable of selecting the best. (4)	Student is capable of discussing a single planning workflow with merits and demerits. (3)	Student can explain the planning/design approach only partly. (1-2)
Implementation (8) (PO3 & PO8)	Student is capable of implementing WBS, schedule logic, model linkage, resource mapping and issue tracking with an optimal and traceable workflow. (7-8)	Student is capable of implementing the workflow and explaining it with minor gaps. (5-6)	Student is capable of implementing the workflow with partial explanation. (3-4)	Student can implement only limited parts of the workflow. (1-2)
Result &Analysis (5) (PO4)	Student is able to run the workflow for various cases and compare 4D sequence, resource, progress and logistics results with proper analysis. (5)	Student will be able to run the workflow for all the cases. (4)	Student will be able to run the workflow for a few cases and analyze the output. (3)	Student will be able to run the workflow but not able to analyze the output. (1-2)
Demonstration (8) (PO9)	The lab record/portfolio is well organized, with clear sections such as brief, method, WBS, schedule, model QA, 4D output, resource sheet, issue log, results and conclusion. (7-8)	The lab record/portfolio is organized, with clear sections, but some sections are not welldefined. (5-6)	The lab record lacks clear organization or structure. Some sections are unclear or incomplete. (3-4)	The lab record is poorly organized, with missing or unclear sections. (1-2)

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UNMANNED AERIAL SYSTEMS (UAS) AND SPATIAL APPLICATIONS			
Course Code	*1MCG1202*	*Scheme*	*2026*
Type of Course	**PCC**	*Semester*	*II*
Teaching Hours/Week (L:T:P)	*42(3:0:0)*	*CIE Marks*	*50*
Total Hours of Pedagogy L /T/P/SL&TW:	*90(42:0:0:48)*	*SEE Marks*	*50*
Credits	**3**	*Total Marks*	*100*
Examination type (SEE)	*Theory*	*Exam Hours*	*03*

Course Objectives

At the end of the course, the student will be able to:

1. *CO1 (L1- Understand): Understand the fundamentals of Unmanned Aerial Systems (UAS), UAV architecture, flight dynamics, navigation systems, and emerging drone technologies.*
2. *CO2 (L2-Apply): Apply UAV sensor technologies, photogrammetric principles, georeferencing methods, and spatial data acquisition techniques for geospatial data collection.*
3. *CO3 (L3- Apply): Plan and execute UAV survey missions using flight planning software while adhering to operational safety requirements and regulatory frameworks.*
4. *CO4 (L4- Analyse): Analyze UAV-derived imagery and LiDAR data using photogrammetric workflows to generate orthophotos, surface models, point clouds, and 3D geospatial products.*
5. *CO5 (L5- Evaluate): Evaluate the suitability of UAS technologies and geospatial analytics for applications in agriculture, urban planning, infrastructure monitoring, environmental management, and disaster risk assessment.*

Module-1

Fundamentals of Unmanned Aerial Systems and Flight Dynamics

Introduction to UAS- Evolution of UAVs and drone technologies Components of Unmanned Aerial Systems (UAS), Air Vehicle, Ground Control Station and Communication Links

UAV classifications: Fixed-wing, Rotary-wing, Hybrid VTOL, Micro and Nano UAVs

UAV Architecture-Airframe structures, Flight control systems, Propulsion systems, Power systems and batteries, Payload integration.

Fundamentals of Aerodynamics-Principles of flight, Lift, drag, thrust and weight, Stability and control, Flight dynamics of multirotor and fixed-wing platforms

Navigation and Guidance Systems-GNSS/GPS integration, Inertial Measurement Unit (IMU), Autopilot systems, Waypoint navigation

Emerging Trends-Swarm drones, Autonomous UAVs, AI-enabled drones, Beyond Visual Line of Sight (BVLOS).

linkage: CO1 **Number of Hours:8 hrs**

Module-2

UAV Sensors, Photogrammetry and Spatial Data Acquisition

UAV Payload Systems- Optical Sensors, RGB cameras, High-resolution mapping cameras, Multispectral Sensors- Vegetation monitoring, Precision agriculture. Thermal Sensors- Heat mapping, Infrastructure inspection. LiDAR Sensors- Laser scanning principles Airborne LiDAR systems, UAV LiDAR integration.

Photogrammetry Fundamentals- Principles of aerial photogrammetry, Scale and resolution, Image geometry, Overlap and sidelap.

Georeferencing Concepts- Ground Control Points (GCPs), Check points, Direct georeferencing, RTK and PPK technologies.

Spatial Data Acquisition- Survey planning, Image acquisition strategies, Data quality considerations, Accuracy assessment.

linkage: CO2 **Number of Hours:9 hrs**

Module-3

Flight Planning, Regulations and UAV Survey Operations

UAV Mission Planning-Mission objectives, Area of Interest (AOI) definition, Flight path optimization, Coverage planning

Flight Planning Software- Q Ground Control, Mission Planner, DJI Pilot, Pix4D Capture

Survey Design-Ground Sampling Distance (GSD), Flight altitude calculations, Forward and side overlap, Terrain following missions.

UAV Regulations and Policies

Indian Context-DGCA Drone Rules, Digital Sky Platform, Drone Categories, NPNT (No Permission No Takeoff)

International Standards-ICAO regulations, FAA drone regulations, UTM (UAS Traffic Management)

Operational Safety-Risk assessment, Flight safety protocols, Emergency procedures, Data security considerations.

linkage: CO3 **Number of Hours: 8 hrs**

Module-4

UAV Data Processing, Photogrammetry and Geospatial Analytics

Structure from Motion (SfM)-Feature detection and matching, Bundle adjustment, Camera calibration

Photogrammetric Processing Workflow-Image alignment, Sparse point cloud generation Dense point cloud generation.

Surface Modelling-Digital Surface Model (DSM), Digital Terrain Model (DTM), Digital Elevation Model (DEM).

Orthophoto Generation- Orthorectification, Mosaicking, Quality assessment

UAV LiDAR Processing-Point cloud classification, Ground extraction, Feature extraction 3D

Mapping and Modelling-Mesh generation, Digital twins, 3D city models.

Geospatial Analytics-Change detection, Terrain analysis, Volumetric calculations, Spatial measurements

linkage: CO4 **Number of Hours: 9 hrs**

Module-5

Spatial Applications of UAS in Geoinformatics

Precision Agriculture-Crop health assessment, NDVI and vegetation indices, Precision irrigation, Crop yield estimation

Urban and Smart City Applications-Urban growth monitoring, Property mapping, Utility asset management, Smart city digital twins

Infrastructure Monitoring-Roads and highways, Railways, Bridges, Power transmission corridors. Environmental Applications-Forest monitoring, Wetland mapping, Biodiversity assessment, Coastal zone monitoring

Disaster Risk Management-Flood mapping, Landslide monitoring, Forest fire assessment Emergency response.

Emerging Geospatial Applications-GeoAI-enabled drone analytics, Cloud-based drone mapping, Real-time UAV monitoring, Drone-as-a-Service (DaaS)

linkage: CO5 **Number of Hours: 8 hrs**

Textbooks:

Suggested Learning Resources

1. *Introduction to UAV Systems Paul G. Fahlstrom, Thomas J. Gleason Wiley, 5th Edition, 2024.*
2. *Small Unmanned Aircraft: Theory and Practice Randal W. Beard, Timothy W. McLain Princeton University Press, Revised Edition.*
3. *Introduction to Modern Photogrammetry Edward M. Mikhail, James S. Bethel, J. Chris McGlone Wiley.*

Reference books / Manuals:

1. *Elements of Photogrammetry by Paul R Wolf Indian edition 2014.*
2. *Remote Sensing and Image Interpretation Thomas M. Lillesand, Ralph W. Kiefer, Jonathan W. Chipman Wiley.*
3. *Airborne and Terrestrial Laser Scanning George Vosselman, Hans-Gerd Maas CRC Press.*
4. *Deep Learning for the Earth Sciences: A Comprehensive Approach to Remote Sensing, Climate Science, and Geosciences Gustau Camps-Valls, Devis Tuia, Xiao Xiang Zhu, Markus Reichstein Wiley, 2021*

Web links and Video Lectures (e-Resources) & Software tools:

- *DJI Enterprise Academy*
- *Pix4D Training Academy*
- *OpenDroneMap Documentation*
- *ISRO-IIRS Outreach Program*
- *DGCA Digital Sky Portal* **Software Tools:** *QGroundControl*
- *Mission Planner*
- *Pix4D Mapper*
- *Agisoft Metashape*

- *DJI Terra*
- *OpenDroneMap*
- *QGIS*
- *ArcGIS Pro*
- *CloudCompare*

Teaching-Learning Process

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes.

Interactive lectures supported by UAV demonstrations, videos and case studies from mapping and infrastructure projects.

Demonstrations using UAV imagery, photogrammetric workflows and sensor integration examples.

Case studies and practical demonstrations on UAV survey planning and regulatory compliance.

Hands-on demonstrations using Pix4D, Agisoft Metashape, DJI Terra and open-source photogrammetry tools.

Case studies from ISRO, NRSC, Survey of India, Smart City Missions and international drone projects.

Assessment Structure (both CIE and SEE)

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be **50% each**. *A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of* **40%** *of the maximum marks prescribed for SEE to be eligible for passing.*

A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than **50% of the aggregate marks** *obtained in CIE and SEE taken together.*

Continuous Internal Evaluation:

Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal Evaluation CIE [25+25=50 marks]

A minimum of **two Internal Assessment Tests (IA)** *shall be conducted. Each test shall be conducted for a maximum of* **25 marks**. *The average of the two test marks shall be the marks secured by a student in IA.*

In addition, **Continuous Comprehensive Assessment (CCA)** *shall be conducted for a total of* **25 marks**.

Students' activities for TW/SL under NCrF: Samples only

As per National credit formwork (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions (CI-42 hour) and Teamwork/ Self learning (TW/Sl-48 hours). Hence, students must complete minimum of two actives as part of NCrF. These learning activities shall be considered as CCA components of CIE. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below. The sample activities are given below. The course coordinator can also give their own TW/SL activities as per the course outcomes.

Sl. No.	Term Work (TW) Activity	Number of Hours / Semester

	applications in urban mapping, agriculture, infrastructure monitoring, disaster assessment, or environmental studies. Seminar presentation and technical report submission on recent advancements in UAV mapping, digital photogrammetry, AI-enabled photogrammetry, or 3D geospatial modelling.	
SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.		
Sl. No.	**Self-Learning (SL) Activity**	**Number of Hours / Semester**
1	*MOOCs / Online Courses- NPTEL, SWAYAM, ISRO-IIRS Outreach Programme, Coursera, Geospatial and Remote Sensing Courses. Explore UAV regulations and drone operation guidelines in India. Download and process open UAV datasets for orthomosaic generation. Generate DEM/DSM products from sample imagery.*	24
2	*Compare outputs from different photogrammetry software platforms. Prepare case studies on smart cities, precision agriculture, mining, forestry, and disaster management applications. Review recent research papers on UAV photogrammetry and 3D geospatial modelling. Develop a portfolio of orthomosaics, point clouds, and 3D models generated during the course*	24
1	**Activity A –** *Students will work in teams to study the principles of photogrammetry, aerial image geometry, stereoscopy, and parallax measurement. The team will perform calculations related to photo scale, relief displacement, and coordinate transformations, and prepare a report on camera calibration, image orientation, and aerial triangulation techniques. Each team will conduct a UAV mission planning exercise using flight planning software, compare different UAV platforms and sensors (RGB, Multispectral, Thermal, and LiDAR), and demonstrate UAV image processing using Agisoft Metashape, Pix4Dmapper, or OpenDroneMap. The final outcome will include processed mapping products and a comprehensive technical report.*	24
2	**Activity B –** *Generation of orthomosaic maps from sample UAV datasets.Creation of DEM, DSM, and DTM from photogrammetric data. Point cloud visualization and analysis using CloudCompare. 3D terrain modelling and visualization using GIS software. Mini-project on UAV photogrammetry*	24

Sample rubrics for TW activities:

Criteria	4 – Excellent	3 – Good	2 – Fair	1 – Needs Improvement
Problem understanding and objective formulation	Clearly defines geospatial problem, objectives, and study area with strong justification.	Mostly clear with minor gaps in problem framing.	Basic attempt with limited clarity.	Problem and objectives poorly defined.
Data acquisition and processing	Appropriate selection of datasets, correct preprocessing and documentation.	Mostly appropriate data and processing with minor issues.	Limited data or partial preprocessing.	Inadequate data and incorrect processing.

Analysis and technical soundness	Robust methodology, correct analysis, and meaningful use of Photogrammetry and UAV tools.	Generally sound analysis with minor technical errors.	Partially correct analysis with noticeable technical gaps.	Weak or incorrect analysis, improper use of tools.
Interpretation, mapping, and reporting	Insightful interpretation, highquality maps (layout, legend, scale), and well-structured report.	Adequate interpretation and maps with minor formatting issues.	Acceptable but limited interpretation and basic maps.	Poor interpretation, incomplete maps, and/or weak report.

Sample rubrics for Self-Learning activities:

Criteria	4 - Excellent	3 - Good	2 - Satisfactory	1 - Needs Improvement
Concept understanding	Demonstrates clear and accurate understanding of the assigned concept.	Shows good understanding with minor gaps.	Basic understanding with limited detail.	Understanding is weak or incorrect.
Independent learning	Explores beyond the minimum requirement and shows initiative in learning.	Shows good initiative with some additional effort.	Completes the assigned task with limited exploration.	Relies heavily on guidance or shows little effort.
Task completion	Activity is completed fully, correctly, and on time.	Activity is mostly complete with minor omissions.	Activity is partially complete.	Activity is incomplete or missing.
Technical accuracy	Workflow, tool use, or analysis is correct and well justified.	Mostly correct with few technical errors.	Contains noticeable errors but shows partial correctness.	Major technical errors or no meaningful attempt.
Reflection and analysis	Provides strong reflection, interpretation, and learning outcomes.	Gives reasonable reflection with some analysis.	Reflection is brief and descriptive.	Reflection is minimal or absent.
Presentation and organization	Work is neat, well structured, and easy to follow.	Organized well with minor formatting issues.	Acceptable presentation with several issues.	Poorly organized or difficult to read.

REMOTE SENSING APPLICATIONS IN NATURAL RESOURCES			
COURSE CODE	*1MCG1203*	*Scheme*	*2026*
Type of Course	**PCC**	*Semester*	*II*
Teaching Hours/Week (L:T:P)	*42(3:0:0)*	*CIE Marks*	*50*
Total Hours of Pedagogy L /T/P/SL&TW:	*90(42:0:0:48)*	*SEE Marks*	*50*
Credits	**3**	*Total Marks*	*100*
Examination type (SEE)	*Theory*	*Exam Hours*	*03*

Course Objectives

At the end of the course, the student will be able to:

1. *CO1 (L2- Understand): Explain the principles of remote sensing, electromagnetic radiation interactions, satellite sensors, and data characteristics used in natural resource management.*
2. *CO2 (L3-Apply): Apply remote sensing techniques and vegetation indices for agricultural monitoring, crop assessment, and soil resource mapping.*
3. *CO4 (L3- Apply): Utilize remote sensing data for forest resource assessment, biodiversity mapping, and monitoring of forest changes and disturbances.*
4. *CO4 (L4- Analyze): Analyze satellite data for water resource evaluation, groundwater studies, watershed management, and environmental monitoring applications.*
5. *CO5 (L5- Evaluate): Evaluate multi-temporal remote sensing data integrated with GIS to support resourc management, change detection, climate impact assessment, and decision-making processes using geospatial tools.*

Module-1

Fundamentals of Remote Sensing for Natural Resources

Introduction- role of remote sensing in natural resource management, interaction of radiation with vegetation, soil, and water, geomorphology and mining

Satellite Data Sources- optical and microwave sensors, multispectral and hyperspectral data, spatial, spectral, temporal resolution for different applications.

Platforms and Missions- Earth observation satellites, data availability and access

linkage: CO1 **Number of Hours: 8 hrs**

Module-2

Agriculture and Soil Resource Applications

Agricultural Applications- crop identification and acreage estimation, crop health monitoring, yield prediction.

Vegetation Indices- NDVI and other indices, drought assessment, crop stress analysis.

Soil Resource Mapping- soil moisture estimation, soil salinity and degradation, land capability classification

linkage: CO2 **Number of Hours: 8 hrs**

Module-3

Forest and Biodiversity Applications

Forest Mapping- forest cover mapping, forest type classification, biomass estimation

Biodiversity Assessment- habitat mapping, ecosystem analysis, wildlife corridor mapping

Forest Monitoring- deforestation and degradation, forest fire detection, carbon stock estimation

linkage: CO3 **Number of Hours:8 hrs**

Module-4

Water Resources and Environmental Applications

Surface Water Mapping- lakes, rivers, reservoirs mapping, watershed delineation, flood mapping.

Ground water Studies- groundwater potential mapping, recharge zone identification.

Environmental Monitoring- land degradation, desertification, pollution monitoring

linkage: CO4 **Number of Hours: 9 hrs**

Module-5

Integrated Resource Management and Decision Support

Change Detection- multi-temporal data analysis, land use / land cover change detection, GIS Integration- integration of remote sensing with GIS, spatial modelling for resource management.

Decision Support Systems- resource planning and management, climate change impact assessment

e

Tools and Platforms Geospatial tools such as
QGIS, Google Earth Engine

linkage: CO5 **Number of Hours: 9 hrs**

Textbooks:

Suggested Learning Resources

1. *Introduction to Environmental Remote Sensing by Barrett E.C., Curtis, I.F., Chapman and Hall, New York, 1982*
2. *Remote Sensing principles and Interpretations- Sabins, F.F., (Ed) W.H. Freeman and Co., New York, 1986*
3. *Remote sensing and Image interpretation - Thomas M. Lillesand and Ralph W. Kiefer, John Wiley and Sons Inc., New York, 1994.*
4. **Franklin, S. E. (2020).** *Remote Sensing for Sustainable Forest Management (2nd Edition). CRC Press.*
5. **Wulder, M. A., & Coops, N. C. (Eds.). (2014).** *Earth Observation for Sustainable Development of Forests CRC Press.*

Reference books / Manuals:

1. *Introduction to Remote Sensing (5th Edition). Guilford Press.* **Campbell, J. B., & Wynne, R. H. (2011).**
2. *Remote Sensing Digital Image Analysis: An Introduction (7th Edition). Springer. Richards, J. A. (2022).*
3. *Introductory Digital Image Processing: A Remote Sensing Perspective by J R Jensen*
4. *Remote Sensing for Biodiversity and Wildlife Management: Synthesis and Applications Franklin, S. E. (2020).*
5. **Thenkabail, P. S. (Ed.). (2016).** *Remote Sensing Handbook, Volume II: Land Resources Monitoring, Modeling, and Mapping with Remote Sensing. CRC Press.*
6. *Remote Sensing Handbook - Three Volume Set Land Resources Monitoring, Modeling, and Mapping with Remote Sensing (Prasad S. Thenkabail)*
7. *Geographic Information Science and Systems (5th Edition). Wiley. Longley, P. A., Goodchild, M. F., Maguire, D. J., & Rhind, D. W. (2021).*
8. *Thinking About GIS: Geographic Information System Planning for Managers (5th Edition). Esri Press.* **Tomlinson, R. (2013).**

Web links and Video Lectures (e-Resources) & Software tools:

https://appliedsciences.nasa.gov/get-involved/training/english/arset-fundamentals-remote-sensing?utm_source=chatgpt.com

https://earthengine.google.com/?utm_source=chatgpt.com

https://docs.qgis.org/latest/en/docs/training_manual/index.html?utm_source=chatgpt.com

https://docs.qgis.org/3.44/en/docs/training_manual/index.html?utm_source=chatgpt.com

https://docs.qgis.org/3.44/en/docs/training_manual/index.html?utm_source=chatgpt.com

Software Tools:

QGIS
Google Earth Engine
ERDAS Imagine

Teaching-Learning Process

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes.

Conceptual lectures supported by examples of natural resource applications.
Case studies from agricultural monitoring using satellite data.
Examples from forest resource monitoring and biodiversity conservation.
Case studies on watershed management and environmental monitoring.
Demonstration-based learning with real-world datasets and applications.

Assessment Structure (both CIE and SEE)

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be **50% each**. *A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of* **40%** *of the maximum marks prescribed for SEE to be eligible for passing.*

A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than **50% of the aggregate marks** *obtained in CIE and SEE taken together.*

Continuous Internal Evaluation:

Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal Evaluation CIE [25+25=50 marks]

A minimum of **two Internal Assessment Tests (IA)** *shall be conducted. Each test shall be conducted for a maximum of* **25 marks**. *The average of the two test marks shall be the marks secured by a student in IA.*

In addition, **Continuous Comprehensive Assessment (CCA)** *shall be conducted for a total of* **25 marks**.

Students' activities for TW/SL under NCrF: Samples only

As per National credit formwork (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions (CI-42 hour) and Teamwork/ Self learning (TW/Sl-48 hours). Hence, students must complete minimum of two actives as part of NCrF. These learning activities shall be considered as CCA components of CIE. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below. The sample activities are given below. The course coordinator can also give their own TW/SL activities as per the course outcomes.

Sl. No.	Term Work (TW) Activity	Number of Hours / Semester
1	**Activity A –** *Students shall work in groups to analyze and interpret remote sensing data for natural resource applications. The team will undertake case studies related to agriculture, forest, water, and environmental resource management using satellite imagery.*	24
2	**Activity B –** *Group activities include preparing thematic maps, computing vegetation indices, conducting change detection analysis, integrating remote sensing data with GIS, and presenting findings using geospatial tools such as QGIS and Google Earth Engine.*	24
SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.		
Sl. No.	**Self-Learning (SL) Activity**	**Number of Hours / Semester**
1	*MOOCs / Online Courses- NPTEL, SWAYAM, ISRO-IIRS Outreach Programme, Coursera, Students are encouraged to independently explore satellite data portals, remote sensing software, and online geospatial platforms.*	24
2	*They should study recent applications of remote sensing in natural resource management, practice image interpretation and GIS analysis, and learn advanced techniques such as vegetation monitoring, change detection, and climate impact assessment using freely available datasets and tools. Self-learning activities may include completing online tutorials, reviewing research articles, and developing small geospatial projects related to resource management.*	24

Sample rubrics for TW activities:

Criteria	4 – Excellent	3 – Good	2 – Fair	1 – Needs Improvement

Team Participation	*Actively contributes and collaborates effectively*	*Participates regularly*	*Limited participation*	*Rarely contributes*
Technical Understanding	*Demonstrates strong understanding of concepts and tools.*	*Good understanding.*	*Basic understanding*	*Poor understanding.*
Analysis and Problem Solving	*Accurate analysis with meaningful interpretations*	*Good analysis*	*Basic analysis*	*Incomplete analysis*
Presentation and Reporting	*Well-organized report and presentation*	*Minor deficiencies*	*Adequate presentation*	*Poorly organized*

Sample rubrics for Self-Learning activities:

Criteria	4 - Excellent	3 - Good	2 - Satisfactory	1 - Needs Improvement
Concept understanding	Demonstrates clear and accurate understanding of the assigned concept.	Shows good understanding with minor gaps.	Basic understanding with limited detail.	Understanding is weak or incorrect.
Independent learning	Explores beyond the minimum requirement and shows initiative in learning.	Shows good initiative with some additional effort.	Completes the assigned task with limited exploration.	Relies heavily on guidance or shows little effort.
Task completion	Activity is completed fully, correctly, and on time.	Activity is mostly complete with minor omissions.	Activity is partially complete.	Activity is incomplete or missing.
Technical accuracy	Workflow, tool use, or analysis is correct and well justified.	Mostly correct with few technical errors.	Contains noticeable errors but shows partial correctness.	Major technical errors or no meaningful attempt.
Reflection and analysis	Provides strong reflection, interpretation, and learning outcomes.	Gives reasonable reflection with some analysis.	Reflection is brief and descriptive.	Reflection is minimal or absent.
Presentation and organization	Work is neat, well structured, and easy to follow.	Organized well with minor formatting issues.	Acceptable presentation with several issues.	Poorly organized or difficult to read.

GNSS, SURVEY AUTOMATION & DIGITAL CADASTRE			
Course Code	*1MCGI204*	*Scheme*	*2026*
Type of Course	**PCC**	*Semester*	*II*
Teaching Hours/Week (L:T:P)	*42(3:0:0)*	*CIE Marks*	*50*
Total Hours of Pedagogy L /T/P/SL&TW:	*90(42:0:0:48)*	*SEE Marks*	*50*
Credits	**3**	*Total Marks*	*100*
Examination type (SEE)	*Theory*	*Exam Hours*	*03*

Course Objectives

At the end of the course, the student will be able to:

1. *CO1 (L2- Understand): Explain the concepts, principles, components, and operation of Global Navigation Satellite Systems (GNSS), including GPS, GLONASS, Galileo, BeiDou, NavIC, and GAGAN.*
2. *CO2 (L3-Apply): Apply GNSS surveying techniques, positioning methods, differential GNSS concepts, and correction mechanisms for accurate geospatial data acquisition.*
3. *CO3 (L3-Apply): Utilize modern survey automation tools, GNSS-enabled instruments, total stations, and digital mapping systems for geospatial data collection and GIS integration.*
4. *CO4 (L4-Analyse): Analyze cadastral survey data and develop digital cadastral databases and land information systems for effective land administration.*
5. *CO5 (L5-Evaluate): Evaluate GNSS-based applications, smart land administration frameworks, and emerging geospatial technologies for infrastructure management, environmental monitoring, and decision support systems*.

Module-1

Fundamentals of GNSS and Satellite Positioning:

Introduction to GNSS-History and evolution of satellite navigation, Components of GNSS systems

Major satellite navigation systems including-Global Positioning System (Space segment, control segment, user segment), GLONASS, Galileo (satellite navigation), BeiDou Navigation Satellite System, India's NavIC, GAGAN

Principles of Satellite Positioning-trilateration concept, principle of ranging, satellite signals and pseudorange, satellite geometry and dilution of precision

linkage: CO1 **Number of Hours: 8 hrs**

Module-2

GNSS Surveying Techniques and Positioning Methods:

GNSS Survey Methods-static surveying, rapid static surveying, kinematic surveying, real-time kinematic (RTK) surveying, post-processed kinematic (PPK) surveying

Differential GNSS-differential GPS principles, base station and rover configuration correction signals and reference stations, GPS pseudolites, Receiver Independent Exchange Format (RINEX)

Positioning Accuracy-GNSS signal errors and corrections, Geofencing, Continuously Operating Reference Station (CORS) system

linkage: CO2 **Number of Hours:8 hrs**

Module-3

Survey Automation and Digital Mapping Systems:

Survey Automation-automated surveying systems, GNSS-enabled survey instruments, digital data collection methods

Modern Survey Instruments-total stations, robotic total stations, GNSS receivers, mobile mapping systems

Integration with GIS-conversion of survey data into GIS formats, georeferencing survey datasets spatial data management

linkage: CO3 **Number of Hours:8 hrs**

Module-4

Digital Cadastre and Land Information Systems:

Introduction to Cadastre-concept and evolution of cadastral systems, cadastral surveys and boundary mapping, parcel-based land records

Digital Cadastre-digitization of cadastral maps, cadastral database development, land parcel identification systems.

Land Information Systems-land ownership databases, cadastral GIS systems, spatial land administration frameworks

linkage: CO4 **Number of Hours: 9 hrs**

Module-5

GNSS Applications and Smart Land Administration:

GNSS Applications-infrastructure mapping, transportation and navigation systems, environmental monitoring, disaster management

Smart Land Administration, digital land records management, cadastral GIS integration

spatial decision support systems, SVAMITVA (Survey of villages and mapping with improvised technology in village area)

Emerging Technologies-mobile GIS-based land surveys, UAV-supported cadastral mapping, integration with spatial data infrastructures

linkage: CO5 **Number of Hours: 9 hrs**

Textbooks:

1. *Elementary Surveying: An Introduction to Geomatics – Charles D. Ghilani and Paul R. Wolf, Pearson, 2021.*
2. *Global Positioning System: Signals, Measurements, and Performance – Pratap Misra and Per Enge, GangaJamuna Press, 2006.*
3. *Understanding GPS/GNSS: Principles and Applications – Elliott D. Kaplan and Christopher J. Hegarty, Artech House, 2017.*
4. *Surveying for Engineers – John Uren and Bill Price, Palgrave Macmillan, 2010.*
5. *Fundamentals of Cartography by R P Misra, 2nd edition*

Reference books / Manuals:

1. *GNSS Applications and Methods – Scott Gleason and Demoz Gebre-Egziabher, Artech House, 2009.*
2. *Introduction to GPS: The Global Positioning System – Ahmed El-Rabbany, Artech House, 2006.*
3. *GPS Satellite Surveying – Alfred Leick, Lev Rapoport, and Dmitry Tatarnikov, John Wiley & Sons, 2015.*
4. *Essentials of GPS, N K Agrawal*
5. *Handbook of GNSS Teunissen Montenbruck Editors by Springer*

Web links and Video Lectures (e-Resources) & Software tools:

1. https://www.gps.gov?utm_source=chatgpt.com
2. https://www.gsc-europa.eu?utm_source=chatgpt.com
3. https://www.isro.gov.in/Navigation.html?utm_source=chatgpt.com
4. https://www.isro.gov.in/GAGAN.html?utm_source=chatgpt.com
5. https://bhuvan.nrsc.gov.in?utm_source=chatgpt.com
6. https://svamitva.nic.in?utm_source=chatgpt.com
7. https://www.ogc.org?utm_source=chatgpt.com
8. https://earthengine.google.com?utm_source=chatgpt.com

Software Tools

QGIS, ArcGIS Pro, Google Earth Engine, Trimble Business Center, Google Earth Pro, AutoCAD Map 3D, Micro Station

Teaching-Learning Process (Innovative Delivery Methods):

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes. Suggested Innovative Delivery Methods may include (but are not limited to):

- **Flipped Classroom**
- **Problem-Based Learning (PBL)**
- **Case-Based Teaching**
- **Simulation and Virtual Labs**
- **Partial Delivery of course by Industry expert/ industrial visits**
- **ICT-Enabled Teaching**
- **Role**

Suggested Strategy:

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes.

Conceptual lectures supported by examples of GNSS-based navigation and positioning systems. Case studies of GNSS-based surveying in engineering and environmental applications. Illustrations of automated surveying systems used in modern geospatial data acquisition. Examples of digital cadastral mapping systems and land administration frameworks.

Case studies from land management, infrastructure planning, and geospatial governance.

Assessment Structure (both CIE and SEE)

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be **50% each***. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of* **40%** *of the maximum marks prescribed for SEE to be eligible for passing.*

A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than **50% of the aggregate marks** *obtained in CIE and SEE taken together.*

Continuous Internal Evaluation:

Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal Evaluation CIE [25+25=50 marks]

A minimum of **two Internal Assessment Tests (IA)** *shall be conducted. Each test shall be conducted for a maximum of* **25 marks***. The average of the two test marks shall be the marks secured by a student in IA. In addition,* **Continuous Comprehensive Assessment (CCA)** *shall be conducted for a total of* **25 marks***.*

Students' activities for TW/SL under NCrF: Samples only

As per National credit formwork (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions (CI-42 hour) and Teamwork/ Self learning (TW/Sl-48 hours). Hence, students must complete minimum of two actives as part of NCrF. These learning activities shall be considered as CCA components of CIE. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below. The course coordinator can also give their own TW/SL activities as per the course outcomes.

Sl. No.	Term Work (TW) Activity	Number of Hours / Semester
1	**Activity A –** *Students shall work individually or in teams to perform GNSS-based surveying and digital mapping exercises. Activities may include planning and conducting GNSS surveys, collecting field coordinates using GNSS receivers, processing survey data, converting survey data into GIS formats, preparing cadastral maps, and analyzing land information systems.*	24

2	**Activity B –** *Students shall prepare a technical report and presentation on applications such as infrastructure mapping, land parcel management, smart land administration, or the SVAMITVA scheme using appropriate geospatial tools.*	24
SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.		
Sl. No.	**Self-Learning (SL) Activity**	**Number of Hours / Semester**
1	*MOOCs / Online Courses- NPTEL, SWAYAM, ISRO-IIRS Outreach Programme, Coursera, Students are encouraged to independently explore modern GNSS technologies, digital cadastre systems, and land administration frameworks through online resources, software tutorials, and case studies.*	24
2	*Self-learning activities may include studying GNSS data processing using RTKLIB or Emlid Studio, exploring cadastral mapping in QGIS, reviewing national initiatives such as NavIC, GAGAN, and SVAMITVA, and preparing short reports on emerging technologies such as UAV-*	24
	supported cadastral mapping, mobile GIS surveys, and spatial decision support systems.	

Sample rubrics for Term Work

Criteria	Excellent	Good	Satisfactory	Needs Improvement
Planning and Execution	*Well-planned and accurately executed survey/mapping activity*	*Minor deficiencies in planning*	*Basic execution completed*	*Incomplete execution*
Technical Accuracy	*Accurate data collection, processing and analysis*	*Minor technical errors*	*Acceptable accuracy*	*Significant errors*
Use of Software Tools	*Effective use of GNSS/GIS software tools*	*Good use of tools*	*Basic use of tools*	*Limited use of tools*
Report Documentation	*Comprehensive and wellorganized report*	*Good report with minor issues*	*Adequate report*	*Poor documentation*
Presentation & Interpretation	*Clear presentation and interpretation of results*	*Good presentation*	*Basic presentation*	*Poor presentation*

Sample rubrics for Self-Learning

Criteria	Excellent	Good	Satisfactory	Needs Improvement
Independent Learning Effort	*Extensive exploration of resources and technologies*	*Good exploration of resources*	*Basic exploration*	*Minimal effort*
Application of Concepts	*Effectively applies concepts to practical problems*	*Good application*	*Basic application*	*Poor application*
Report/Documentation Quality	*Well-structured and insightful report*	*Good documentation*	*Adequate documentation*	*Incomplete report*
Innovation and Additional Learning	*Demonstrates creativity and explores beyond syllabus*	*Some additional learning*	*Limited additional learning*	*No evidence of initiative*

ADVANCED EARTH OBSERVATION SYSTEMS: INDIAN AND INTERNATIONAL PERSPECTIVES			
Course Code	*1MCGI205A*	*Scheme*	*2026*
Type of Course	**PEC**	*Semester*	*II*
Teaching Hours/Week (L:T:P)	*42(3:0:0)*	*CIE Marks*	*50*
Total Hours of Pedagogy L /T/P/SL&TW:	*90(42:0:0:48)*	*SEE Marks*	*50*
Credits	**3**	*Total Marks*	*100*
Examination type (SEE)	*Theory*	*Exam Hours*	*03*

Course Objectives

At the end of the course, the student will be able to:

1. *CO1 (L2- Understand): Understand the principles, architecture, components, and operational framework of modern Earth Observation systems*
2. *CO2 (L2-Understand): Understand Earth Observation data infrastructures, satellite data dissemination mechanisms, and global observation initiatives.*
3. *CO4 (L4-Analyse): Analyze the evolution and capabilities of Indian and international Earth Observation missions and satellite programs.*
4. *CO5 (L5-Evaluate): Evaluate advanced Earth Observation technologies including optical, hyperspectral, thermal, microwave, SAR, and emerging sensor systems.*
5. *CO5 (L6-Create)- Examine emerging paradigms such as Digital Earth, Digital Twins, GeoAI, commercial satellite constellations, and future Earth Observation ecosystems.*

Module-1

Fundamentals of Earth Observation Systems

Earth Observation: Concepts and Evolution, History and evolution of Earth Observation.
Development of global remote sensing programs, Earth Observation ecosystem, Space segment, ground segment, and user segment.
Principles of Remote Sensing-Electromagnetic spectrum , Energy interactions with atmosphere and Earth surface, Spectral signatures, Active and passive remote sensing systems .
Earth Observation Platforms-Ground-based observation systems , Airborne remote sensing platforms, UAV-based observation systems, Satellite-based Earth Observation systems
Satellite Orbits and Coverage-Geostationary orbit, Polar orbit, Sun-synchronous orbit , Revisit cycles and coverage analysis.
Sensor Characteristics-Spatial resolution, Spectral resolution, Radiometric resolution, Temporal resolution

linkage: CO1 **Number of Hours: 8 hrs**

Module-2

Indian Earth Observation Systems and Space Missions

Evolution of India's Earth Observation Programme- Indian space programme and Earth Observation vision, National Remote Sensing Programme, Evolution of Indian Earth Observation missions
Indian Satellite Missions- IRS Programme IRS-1A and IRS-1B, IRS-1C and IRS-1D
Operational EO Missions- Resourcesat Series, Cartosat Series, Oceansat Series, RISAT Series.
Advanced Indian Missions- GISAT, EOS Series, HySIS, Scatsat, INSAT Meteorological Missions.
Indian EO Infrastructure- National Remote Sensing Centre (NRSC), Data reception and processing systems, Satellite data dissemination frameworks, Bhuvan Geoportal.
National Geospatial Initiatives- National Geospatial Policy 2022, Disaster Management Support Programme, National Information System for Climate and Environment Studies, Digital India and Geospatial India initiatives.

linkage: CO2 **Number of Hours:9 hrs**

Module-3

International Earth Observation Missions and Global Observation Programs

Major International Earth Observation Missions-NASA Missions, Landsat Programme , Terra and Aqua, MODIS, Suomi NPP, ECOSTRESS

European Space Agency Missions-Sentinel-1, Sentinel-2, Sentinel-3, Sentinel-5P

Other International Missions-SPOT (France), WorldView Series, PlanetScope Constellation, TerraSAR-X, COSMOSkyMed, ALOS (Japan), Gaofen (China)

Global Earth Observation Initiatives-Group on Earth Observations (GEO), Global Earth Observation System of Systems (GEOSS), Copernicus Programme, Committee on Earth Observation Satellites (CEOS)

Global Data Sharing and Collaboration-Open data policies, International satellite data sharing, Climate monitoring frameworks, International cooperation in Earth Observation

linkage: CO3 **Number of Hours:8 hrs**

Module-4

Advanced Earth Observation Technologies and Data Systems

Optical Earth Observation Systems-Panchromatic imaging, Multispectral imaging, High-resolution Earth Observation systems

Hyperspectral Remote Sensing-Principles of hyperspectral imaging, Spectral signatures and spectral libraries, HySIS mission, International hyperspectral missions

Thermal Remote Sensing Systems-Thermal infrared sensing principles, Land Surface Temperature retrieval, Thermal monitoring applications

Microwave and Radar Remote Sensing-Principles of microwave remote sensing, Synthetic Aperture Radar (SAR), Interferometric SAR (InSAR), RISAT and Sentinel-1 applications

Emerging Observation Technologies-CubeSats and nanosatellites, Small satellite constellations, High Altitude Platform Systems (HAPS), Commercial Earth Observation platforms

linkage: CO4 **Number of Hours: 9 hrs**

Module-5

Emerging Earth Observation Systems and Future Space Technologies

New Space Economy and Commercial Earth Observation-Evolution of NewSpace ecosystem, Commercial satellite operators, Earth Observation as a Service (EOaaS) Satellite data marketplace, Subscription-based geospatial intelligence services

Commercial EO Constellations-Planet Labs, Maxar WorldView, BlackSky, Satellogic

Digital Earth and Digital Twin Technologies-Concept of Digital Earth, Virtual Earth systems, Earth Observation Data Cubes, Earth Digital Twins, Geospatial simulation environments

International Initiatives-ESA Digital Twin Earth, Destination Earth (DestinE), Digital Earth Africa, Open Data Cube Programmes.

GeoAI and Intelligent Earth Observation-Artificial Intelligence in Earth Observation , Automated feature extraction, Deep learning-based image analytics, Foundation Models for Earth Observation, Earth Observation Large Language Models (EO-LLMs)

Space-Based Internet of Things (IoT)-Satellite-IoT integration, Earth Observation and sensor networks, Precision resource management, Environmental intelligence systems

Future Directions in Earth Observation- Autonomous satellite systems, Edge computing in space, Near real-time planetary monitoring, Cloud-native Earth Observation platforms AI-driven Earth system intelligence

linkage: CO5 **Number of Hours: 8 hrs**

Textbooks:

1. *Lillesand, Thomas M., Ralph W. Kiefer and Jonathan W. Chipman, Remote Sensing and Image Interpretation, 6th Edition, Wiley, 2008.*
2. *George Joseph and C.K. Jha, Fundamentals of Remote Sensing, 3rd Edition, Universities Press, 2018*
3. *Campbell, James B. and Randolph H. Wynne, Introduction to Remote Sensing, 5th Edition, The Guilford Press, 2011.*
4. *Sharma, Dinesh C., Space: The India Story, 1st Edition, Bloomsbury Publishing India Pvt. Limited, 2025*
5. *Observation of the System Earth from Space - CHAMP, GRACE, GOCE and future missions, edition/publisher not confirmed from the sources retrieved.*
6. *Thenkabail, Prasad S., Hyperspectral Remote Sensing of Vegetation, 2nd Edition, Taylor and Francis, 2019.search.*
7. *Earth Observation Handbook, CEOS/ESA coordinated handbook, 2023 edition.*

Reference Books / Manuals

1. *ISRO Earth Observation Mission Reports, ISRO, various reports, no single edition applicable.*
2. *CEOS Earth Observation Handbook, 2023 edition, coordinated by CEOS with ESA*
3. *Copernicus Programme Documentation, European Commission/Copernicus, various documents, no single edition applicable.*
4. *NASA Earth Observation and Earth Data Resources, NASA, online resources, no single edition applicable.*
5. *ESA Earth Observation Handbook, ESA/CEOS coordinated handbook, 2023 edition.*
6. *Digital Twin Earth Strategic Reports, various reports, no single edition applicable.*

Web links and Video Lectures (e-Resources) & Software tools: *1. ISRO, Bhuvan: Indian Geo-Platform of ISRO, online geoportal.*

2. *NASA, Earthdata / NASA Earthdata Search, online Earth observation data portal.*
3. *European Space Agency (ESA), Copernicus Data Space Ecosystem; formerly the Copernicus Open Access Hub, online Sentinel data access portal.*
4. *ESA, Earth Online, online Earth Observation information portal.*
5. *Group on Earth Observations (GEO), GEO Knowledge Hub, open-source knowledge repository.*
6. *Open Data Cube (ODC), Open Data Cube Documentation, online documentation, tutorials and guides.*
7. *European Space Agency (ESA), Destination Earth (DestinE) Knowledge Portal, online information portal.*

Software Tools

QGIS, ArcGIS Pro, Google Earth Engine, SNAP, ENVI , ERDAS IMAGINE , Cloud Compare, Agisoft Metashape

Teaching-Learning Process (Innovative Delivery Methods):

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes.

Interactive lectures supported by historical evolution of global Earth Observation missions and satellite imagery examples.

Case studies illustrating Indian Earth Observation applications in agriculture, resource management, environmental monitoring, and national development.

Comparative analysis of Indian and international satellite systems and their operational capabilities.

Demonstration and interpretation of advanced EO datasets including hyperspectral, SAR, thermal, and highresolution imagery.

Seminars, technology reviews, and case studies on Digital Twin Earth, commercial constellations, GeoAI, and nextgeneration Earth Observation systems.

	agriculture, or disaster management. Mini Project: Earth Observationbased monitoring of land use, climate change, disasters, water resources, or urban growth.	

SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.

Sl. No.	Self-Learning (SL) Activity	Number of Hours / Semester
1	*MOOCs / Online Courses- NPTEL, SWAYAM, ISRO-IIRS Outreach Programme, Coursera, Study different Earth Observation sensors and prepare a comparison chart based on resolution characteristics. Explore the Bhuvan Geoportal and prepare a report on available datasets and services.*	24
2	*Download and analyze Landsat or Sentinel data for a selected study area. Review research papers on SAR, InSAR, Hyperspectral, or Thermal Remote Sensing applications. Investigate recent developments in GeoAI, Digital Twin Earth, and EO Foundation Models.*	24

Assessment Structure (both CIE and SEE)

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In addition, **Continuous Comprehensive Assessment (CCA)** *shall be conducted for a total of* **25 marks**.

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Sl. No.	Term Work (TW) Activity	Number of Hours / Semester
1	**Activity A –** *Group presentation comparing airborne, UAV, and satellite Earth Observation platforms and their applications. Prepare a timeline and technical review of Indian Earth Observation missions (IRS, Cartosat, Resourcesat, Oceansat, RISAT, GISAT, EOS). Comparative study of Landsat, Sentinel, MODIS, WorldView, and PlanetScope missions with thematic applications.*	24
2	**Activity B –** *Develop a case study demonstrating applications of SAR, Hyperspectral, Thermal, and Optical Remote Sensing for environmental monitoring. Design a concept proposal for an AI-enabled Earth Observation system or Digital Twin application for smart cities,*	24

Sample rubrics for Term Work

Criteria	Excellent (4)	Good (3)	Satisfactory (2)	Needs Improvement (1)
Technical Understanding	*Demonstrates comprehensive knowledge of EO systems and technologies*	*Good understanding of concepts*	*Basic understanding*	*Limited understanding*
Team Participation	*All members contribute actively and effectively*	*Most members participate*	*Uneven participation*	*Minimal participation*
Analytical Ability	*Strong analysis and interpretation of EO data and missions*	*Good analysis*	*Basic analysis*	*Weak analysis*
Innovation & Problem Solving	*Innovative ideas and practical solutions*	*Good solutions*	*Limited innovation*	*Minimal effort*
Presentation Skills	*Clear, professional, and engaging presentation*	*Good presentation*	*Average presentation*	*Poor presentation*
Report Quality	*Excellent organization and technical documentation*	*Good report quality*	*Adequate documentation*	*Poor documentation*

Sample rubrics for Self-Learning

Criteria	Excellent (4)	Good (3)	Satisfactory (2)	Needs Improvement (1)
Independent Learning	*Extensive exploration beyond syllabus*	*Good exploration*	*Moderate effort*	*Minimal effort*
Conceptual Understanding	*Comprehensive understanding of EO concepts*	*Good understanding*	*Basic understanding*	*Limited understanding*
Technical Application	*Effective use of EO datasets, portals, and software*	*Good application*	*Basic application*	*Poor application*
Documentation Quality	*Professional, wellstructured report*	*Good report*	*Average report*	*Poor report*
Critical Thinking	*Insightful interpretation and evaluation*	*Good interpretation*	*Limited analysis*	*No critical evaluation*

LIDAR DATA PROCESSING & 3D INFRASTRUCTURE MODELLING			
Course Code	*1MCGI205B*	*Scheme*	*2026*
Type of Course	**PEC**	*Semester*	*II*
Teaching Hours/Week (L:T:P)	*42(3:0:0)*	*CIE Marks*	*50*
Total Hours of Pedagogy L /T/P/SL&TW:	*90(42:0:0:48)*	*SEE Marks*	*50*
Credits	**3**	*Total Marks*	*100*
Examination type (SEE)	*Theory*	*Exam Hours*	*03*

Course Objectives

At the end of the course, the student will be able to:

1. *CO1 (L2- Understand): Understand principles and working of LiDAR technology for geospatial data acquisition.*
2. *CO2 (L3-Apply): Apply LiDAR data for infrastructure planning and smart city applications 3. CO3 (L3- Analyse)): Process LiDAR point cloud data for terrain and infrastructure modelling.*
4. *CO4 (L4- Evaluate: Integrate LiDAR with GIS and BIM for advanced geospatial analytics.*
5. *CO5 (L5-Create): Generate Digital Elevation Models (DEM), Digital Surface Models (DSM), and 3D city models*.

Module-1

Fundamentals of LiDAR and 3D Data Acquisition

Introduction to LiDAR-principles of laser ranging, time-of-flight measurement, types of LiDAR systems (airborne, terrestrial, mobile). Components of LiDAR Systems-laser scanner, GNSS and IMU integration, data acquisition workflows. LiDAR Data Characteristics-point cloud structure, intensity values, accuracy and resolution

linkage: CO1,CO2 **Number of Hours: 8 hrs**

Module-2

LiDAR Data Processing and Point Cloud Analysis

Point Cloud Processing, data formats (LAS/LAZ), point cloud visualization, noise removal and filtering. Classification of Point Clouds-ground and non-ground classification, vegetation and building extraction, segmentation techniques Tools. LiDAR processing using: Cloud Compare, PDAL

linkage: CO2, CO3 **Number of Hours:8 hrs**

Module-3

Terrain Modelling and Surface Generation

Digital Terrain Modelling-Digital Elevation Model (DEM), Digital Surface Model (DSM). Triangulated Irregular Network (TIN). Surface Generation Techniques-interpolation from point clouds, contour generation, slope and aspect analysis. Applications-terrain analysis, watershed modelling, infrastructure planning.

linkage: CO4, CO5 **Number of Hours:8 hrs**

Module-4

3D Infrastructure and Urban Modelling

3D City Modelling-building extraction from LiDAR, Level of Detail (LoD) concepts, 3D GIS models Infrastructure Modelling-roads, bridges, and utilities mapping, corridor mapping using mobile LiDAR, digital twins for infrastructure. Integration with BIM-GIS–BIM integration, smart city applications

linkage: CO4 **Number of Hours: 9 hrs**

Module-5

Advanced Applications and Emerging Trends

Applications of LiDAR-disaster management (flood, landslide), forestry and biomass estimation, coastal zone mapping. Advanced Analytics-machine learning for point cloud classification, feature extraction and object detection. Emerging Trends-integration with UAV-based LiDAR, real-time 3D mapping, cloud-based LiDAR processing platforms. Tools and Platforms-Cloud Compare, PDAL, QGIS

linkage: CO5 **Number of Hours: 9 hrs**

Textbooks:

1. *Airborne and Terrestrial Laser Scanning George Vosselman & Hans-Gerd Maas CRC Press*
2. *LiDAR Remote Sensing and Applications Pinliang Dong & Qi Chen CRC Press*
3. *3D GIS and City Modelling*
4. *Introduction to Modern Photogrammetry and LiDAR Mapping Luhmann, Robson, Kyle & Boehm Wiley*
5. *Remote Sensing and GIS Technologies for Monitoring and Prediction of Disasters Prasad S. Thenkabail, CRC Press*

Reference books / Manuals:

1. *Digital Elevation Model Technologies and Applications David F. Maune ASPRS*
2. *Topographic Laser Ranging and Scanning: Principles and Processing Jie Shan & Charles K. Toth CRC Press*
3. **LiDAR Remote Sensing and Applications** – *Advanced concepts in airborne and terrestrial LiDAR systems.*
4. *Handbook of LiDAR Data Acquisition and Processing Robert J. Czerniak & Christopher A. Czerniak Wiley*

Web links and Video Lectures (e-Resources) & Software tools:

https://www.cloudcompare.org?utm_source=chatgpt.com

https://pdal.io?utm_source=chatgpt.com https://qgis.org?utm_source=chatgpt.com
https://opentopography.org?utm_source=chatgpt.com https://www.usgs.gov/3d-elevation-program?utm_source=chatgpt.com
https://docs.qgis.org/latest/en/docs/training_manual/?utm_source=chatgpt.com
https://www.sciencedirect.com/journal/isprs-journal-of-photogrammetry-and-remote-sensing?utm_source=chatgpt.com
https://www.tandfonline.com/journals/tgrs20?utm_source=chatgpt.com

Software Tools

QGIS, ArcGIS Pro, Google Earth Engine, SNAP, ENVI , ERDAS IMAGINE , Cloud Compare, Agisoft Metashape

Teaching-Learning Process (Innovative Delivery Methods):

- The following are sample strategies that educators may adopt to enhance the effectiveness of the teachinglearning process and facilitate the achievement of course outcomes.
- *Conceptual lectures supported by LiDAR data acquisition examples.*
- *Hands-on demonstrations of point cloud processing workflows.*
- *Case studies on terrain modelling using LiDAR data.*
- *Examples from urban modelling and infrastructure planning projects. Demonstration-based learning with real-world LiDAR datasets.*

Assessment Structure (both CIE and SEE)

~~*The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be*~~ *50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for passing.*

A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken together.

Continuous Internal Evaluation:

Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal Evaluation CIE [25+25=50 marks]

A minimum of two Internal Assessment Tests (IA) shall be conducted. Each test shall be conducted for a maximum of 25 marks. The average of the two test marks shall be the marks secured by a student in IA.

In addition, Continuous Comprehensive Assessment (CCA) shall be conducted for a total of 25 marks.

Students' activities for TW/SL under NCrF: Samples only

As per National credit formwork (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions (CI-42 hour) and Teamwork/ Self learning (TW/Sl-48 hours). Hence, students must complete

minimum of two actives as part of NCrF. These learning activities shall be considered as CCA components of CIE. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below. The sample activities are given below. The course coordinator can also give their own TW/SL activities as per the course outcomes.

Sl. No.	Term Work (TW) Activity	Number of Hours / Semester
1	**Activity A –** *Team presentation on evolution of LiDAR technologies and applications. Point cloud classification project using CloudCompare and PDAL, Group-based DEM, DSM and TIN generation from sample LiDAR datasets*	24
2	**Activity B –** *Design a 3D smart city model for a selected urban area, Comparative study of UAV-LiDAR and Airborne LiDAR applications, Mini Project: LiDAR-based urban infrastructure mapping*	24

SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.

Sl. No.	Self-Learning (SL) Activity	Number of Hours / Semester
1	*MOOCs / Online Courses- NPTEL, SWAYAM, ISRO-IIRS Outreach Programme, Coursera, Explore different LiDAR sensors and prepare a comparison chart, Download LAS/LAZ data and visualize point clouds using CloudCompare.*	24
2	*Generate contour maps from DEM data using QGIS, Study LoD standards (LoD0–LoD4) and prepare summary notes, Review recent research papers on AI-based point cloud classification, Develop a portfolio of LiDAR applications in chosen domain*	24

Sample rubrics for Term Work

Criteria	Excellent (4)	Good (3)	Satisfactory (2)	Needs Improvement (1)
Participation	*Active contribution throughout*	*Good participation*	*Limited participation*	*Minimal involvement*
Technical Knowledge	*Demonstrates strong understanding*	*Good understanding*	*Basic understanding*	*Poor understanding*
Problem Solving	*Innovative and effective solutions*	*Good solutions*	*Some solutions*	*Unable to solve problems*
Collaboration	*Excellent teamwork and leadership*	*Good teamwork*	*Average teamwork*	*Poor collaboration*
Presentation	*Clear, professional, wellorganized*	*Good presentation*	*Adequate presentation*	*Poor presentation*

Sample rubrics for Self-Learning

Criteria	Excellent (4)	Good (3)	Satisfactory (2)	Needs Improvement (1)
Content Understanding	*Comprehensive understanding*	*Good understanding*	*Basic understanding*	*Limited understanding*
Independent Learning	*Extensive exploration beyond syllabus*	*Moderate exploration*	*Limited exploration*	*No additional effort*
Technical Skills	*Accurate application of tools and methods*	*Good application*	*Basic application*	*Poor application*
Report Quality	*Well-structured and professional*	*Good quality*	*Average quality*	*Poor documentation*
Innovation & Critical Thinking	*Original insights and analysis*	*Some analysis*	*Limited analysis*	*No critical thinking*

GEOINFORMATICS IN WEATHER AND CLIMATE STUDIES			
Course Code	*1MCGI205C*	*Scheme*	*2026*
Type of Course	**PEC**	*Semester*	*II*
Teaching Hours/Week (L:T:P)	*42(3:0:0)*	*CIE Marks*	*50*
Total Hours of Pedagogy L /T/P/SL&TW:	*90(42:0:0:48)*	*SEE Marks*	*50*
Credits	**3**	*Total Marks*	*100*
Examination type (SEE)	*Theory*	*Exam Hours*	*03*

Course Objectives

At the end of the course, the student will be able to:

1. *CO1 (L2- Understand): Understand atmospheric processes, weather systems, and climate dynamics.*
2. *CO2 (L3-Apply): Apply remote sensing and GIS tools for weather monitoring and climate analysis.*
3. *CO3 (L4- Analyse)): Interpret meteorological and climate datasets using geospatial techniques.*
4. *CO4 (L5- Evaluate: Evaluate climate variability, extreme events, and climate change impacts.*
5. *CO5 (L6-Create): Design geospatial solutions for climate risk assessment and adaptation planning*.

Module-1

Fundamentals of Weather and Climate Systems

Atmosphere: structure, composition, and energy balance, Weather and climate concepts, Atmospheric circulation and pressure systems, Climate classification systems, Weather variables: temperature, rainfall, humidity, wind, Climate variability: ENSO, El Niño, La Niña, Southern Oscillation.

linkage: CO1 **Number of Hours: 8 hrs**

Module-2

Satellite Meteorology and Weather Monitoring

Principles of satellite meteorology, Meteorological satellites and sensors, Geostationary and Polar Orbiting Satellites, Cloud detection and cloud classification, Rainfall estimation using satellite data, Cyclone, thunderstorm, and drought monitoring, Weather forecasting using remote sensing.

linkage: CO2, CO3 **Number of Hours:8 hrs**

Module-3

GIS and Spatial Analysis in Climate Studies

Climate data models and databases, Spatial interpolation of climatic variables, Climate surface mapping, Geostatistical analysis of rainfall and temperature, Spatial pattern analysis and hotspot mapping, Climate zonation and agro-climatic mapping, Integration of GIS and climate datasets.

linkage: CO2, CO3 **Number of Hours:8 hrs**

Module-4

Climate Change Assessment and Environmental Impacts

Greenhouse effect and global warming, Climate forcing mechanisms, Carbon cycle and climate feedback, Land use/land cover change and climate interactions, Sea level rise and coastal vulnerability, Glacier retreat and snow cover changes, Impact assessment on agriculture, water resources, ecosystems, and urban environments.

linkage: CO4 **Number of Hours: 9 hrs**

Module-5

Advanced Geospatial Applications in Climate Science

Climate modelling and prediction systems, Machine Learning applications in climate studies, Climate vulnerability assessment, Flood, drought, and heat wave risk mapping, Carbon accounting and carbon sequestration mapping, Climate adaptation and resilience planning, Geospatial Decision Support Systems (GDSS). Emerging Trends- AI and Deep Learning in Climate Analytics, Google Earth Engine for Climate Applications, Cloud-based Climate Data Processing, Digital Twins for Climate Resilience

linkage: CO4,CO5 **Number of Hours: 9 hrs**

Textbooks:

1. *Barry, R. G. and Chorley, R. J., Atmosphere, Weather and Climate, 8th Edition, Routledge, 2004.*
2. *Kidder, S. Q. and Vonder Haar, T. H., Satellite Meteorology: An Introduction, 1st Edition, Academic Press, 1995.*
3. *Jensen, J. R., Remote Sensing of the Environment: An Earth Resource Perspective, 2nd Edition, Pearson Prentice Hall, 2007.*
4. *Lillesand, T., Kiefer, R. W. and Chipman, J., Remote Sensing and Image Interpretation, 6th Edition, Wiley, 2008.*
5. *Burrough, P. A. and McDonnell, R. A., Principles of Geographical Information Systems, International Third Edition, Oxford University Press, 2015.*

Reference books / Manuals

6. *IPCC, Assessment Reports / Sixth Assessment Report (AR6), IPCC, 2021–2023.*
7. *Wilks, D. S., Statistical Methods in the Atmospheric Sciences, 4th Edition, Elsevier, 2019.*
8. *Lunetta, R. S. and Elvidge, C. D., Remote Sensing Change Detection, publisher and edition not confirmed from the sources retrieved.*
9. *Trenberth, K. E., Climate System Modeling, Cambridge University Press, 1992.*

Web links and Video Lectures (e-Resources) & Software tools:

https://earthobservatory.nasa.gov?utm_source=chatgpt.com

https://mausam.imd.gov.in?utm_source=chatgpt.com

https://wmo.int?utm_source=chatgpt.com

https://www.ipcc.ch?utm_source=chatgpt.com

https://climate.copernicus.eu?utm_source=chatgpt.com

https://cds.climate.copernicus.eu?utm_source=chatgpt.com

Software Tools

QGIS, ArcGIS Pro, Google Earth Engine, Python Scientific Stack, SNAP ESA, Climate Data Operators (CDO)

Teaching-Learning Process (Innovative Delivery Methods):

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes.

- **Interactive Lectures:** *Fundamental concepts of weather systems, climate dynamics, and geospatial technologies will be taught through classroom lectures and discussions.*
- **Hands-on Laboratory Sessions:** *Students will perform practical exercises using GIS, Remote Sensing, Google Earth Engine, and climate data analysis tools.*
- **Case Study-Based Learning:** *Real-world case studies on cyclones, floods, droughts, heatwaves, and climate change impacts will be analyzed to understand practical applications.*
- **Problem-Based Learning:** *Students will solve weather and climate-related geospatial problems using analytical and computational techniques.*
- **Research-Oriented Learning:** *Students will be encouraged to explore current research challenges and emerging applications of Geoinformatics in weather and climate science*

Assessment Structure (both CIE and SEE)

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for passing.

A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken together.

Continuous Internal Evaluation:

Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal Evaluation CIE [25+25=50 marks]

A minimum of two Internal Assessment Tests (IA) shall be conducted. Each test shall be conducted for a maximum of 25 marks. The average of the two test marks shall be the marks secured by a student in IA.

In addition, Continuous Comprehensive Assessment (CCA) shall be conducted for a total of 25 marks.

Students' activities for TW/SL under NCrF: Samples only

As per National credit formwork (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions (CI-42 hour) and Teamwork/ Self learning (TW/Sl-48 hours). Hence, students must complete minimum of two actives as part of NCrF. These learning activities shall be considered as CCA components of CIE. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below. The sample activities are given below. The course coordinator can also give their own TW/SL activities as per the course outcomes.

Sl. No.	Term Work (TW) Activity	Number of Hours / Semester
1	**Activity A –** *Prepare a group presentation on global atmospheric circulation and climate classification systems. Analyze a recent cyclone, flood, or drought event using satellite imagery and present findings. Develop rainfall and temperature distribution maps for a selected region using GIS tools.*	24
2	**Activity B –** *Conduct a group study on climate change impacts in a selected sector (agriculture, water, forests, or urban areas). Prepare a climate vulnerability assessment map for a district using geospatial datasets. Mini Project: Geospatial Analysis of Extreme Weather Events and Climate Risks.*	24

SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.

Sl. No.	Self-Learning (SL) Activity	Number of Hours / Semester
1	*MOOCs / Online Courses- NPTEL, SWAYAM, ISRO-IIRS Outreach Programme, Coursera, Review IPCC reports and prepare notes on climate variability and climate change. Explore INSAT, MODIS, and NOAA weather products and compare their applications.*	24
2	*Download climate datasets and generate thematic maps using QGIS. Study a recent climate-related disaster and analyze its environmental impacts. Review research papers on AI and Machine Learning applications in climate studies. Develop a portfolio of weather and climate applications using geospatial technologies.*	24

Sample rubrics for Term Work

Criteria	Excellent (4)	Good (3)	Satisfactory (2)	Needs Improvement (1)

Technical Understanding	*Demonstrates comprehensive knowledge*	*Good understanding*	*Basic understanding*	*Limited understanding*
Team Participation	*Active contribution by all members*	*Most members contribute*	*Uneven participation*	*Poor participation*
Problem Solving & Analysis	*Innovative and critical analysis*	*Good analytical ability*	*Basic analysis*	*Limited analysis*
Data Interpretation	*Accurate interpretation and conclusions*	*Minor errors*	*Moderate errors*	*Incorrect interpretation*
Presentation & Communication	*Clear, professional, and engaging*	*Good presentation*	*Average presentation*	*Poor communication*
Report Quality	*Well-organized and technically sound*	*Good quality*	*Adequate quality*	*Poor quality*

Sample rubrics for Self-Learning

Criteria	**Excellent (4)**	**Good (3)**	**Satisfactory (2)**	**Needs Improvement (1)**
Independent Learning	*Extensive exploration beyond course content*	*Good exploration*	*Limited exploration*	*Minimal effort*
Content Understanding	*Comprehensive understanding of concepts*	*Good understanding*	*Basic understanding*	*Limited understanding*
Technical Application	*Effective use of software/tools*	*Good application*	*Basic application*	*Poor application*
Report/Documentation	*Well-structured and professional*	*Good quality*	*Adequate quality*	*Poor documentation*
Critical Thinking	*Insightful analysis and interpretation*	*Good analysis*	*Limited analysis*	*No analysis*

THERMAL, MICROWAVE AND HYPERSPECTRAL REMOTE SENSING			
Course Code	*1MCGI205D*	*Scheme*	*2026*
Type of Course	**PEC**	*Semester*	*II*
Teaching Hours/Week (L:T:P)	*42(3:0:0)*	*CIE Marks*	*50*
Total Hours of Pedagogy L /T/P/SL&TW:	*90(42:0:0:48)*	*SEE Marks*	*50*
Credits	**3**	*Total Marks*	*100*
Examination type (SEE)	*Theory*	*Exam Hours*	*03*

Course Objectives

At the end of the course, the student will be able to:

1. *CO1 (L2- Understand): Understand the physical principles of thermal, microwave, and hyperspectral remote sensing.*
2. *CO2 (L4- Analyze): Analyze the characteristics and applications of active and passive remote sensing systems.*
3. *CO3 (L2- Understand): Understand satellite sensors, data acquisition systems, calibration, and preprocessing techniques.*
4. *CO4 (L3- Apply): Apply advanced image processing and information extraction methods for environmental and infrastructure applications*
5. *CO5 (L5- Evaluate): Evaluate emerging Earth Observation technologies and future developments in thermal, microwave, and hyperspectral sensing.*

Module-1

Fundamentals of Thermal, Microwave and Hyperspectral Remote Sensing

Evolution of Advanced Remote Sensing: Development of non-visible remote sensing technologies, Thermal, microwave, and hyperspectral observations, Advantages over conventional optical remote sensing, Integrated Earth Observation systems. Electromagnetic Spectrum: Thermal infrared region, Microwave region, Hyperspectral wavelength regions, Atmospheric transmission windows.

Radiation Principles: Blackbody radiation, Planck's Law, Stefan-Boltzmann Law, Wien's Displacement Law, Emissivity and reflectance.

Microwave Fundamentals: Active and passive microwave sensing, Scattering mechanisms Dielectric properties, Surface roughness effects.

Hyperspectral Fundamentals: Spectral signatures, Spectral absorption features Endmembers and mixed pixels, Spectral libraries.

linkage: CO1 **Number of Hours: 8 hrs**

Module-2

Thermal Remote Sensing Systems, Processing and Applications

Thermal Infrared Remote Sensing: Principles, Thermal radiation processes, Surface temperature measurement, Energy balance concepts, Atmospheric effects.

Thermal Sensors and Satellite Systems: Indian Missions- INSAT-3D, INSAT-3DR, Oceansat thermal products.

International Missions- Landsat Thermal Sensors, ASTER, MODIS, ECOSTRESS, Sentinel-3 SLSTR

Thermal Data Processing: Radiometric correction, Atmospheric correction, Brightness temperature retrieval, Land Surface Temperature (LST) estimation.

Image Analysis: Surface temperature mapping, Thermal anomaly detection, Heat flux estimation, Change detection.

Applications: Urban Heat Island studies, Climate change monitoring, Drought assessment, Forest fire detection, Volcanic monitoring, Ocean monitoring and applications, Water resource monitoring and, Industrial thermal monitoring.

linkage: CO2 **Number of Hours:9 hrs**

Module-3

Microwave Remote Sensing and Radar Systems

Microwave Remote Sensing: Principles- Radar fundamentals, Backscatter mechanisms, Polarization concepts, Radar equation.

Radar Systems: Active Sensors- SAR, Scatterometers, Radar Altimeters. Passive Sensors- Microwave radiometers, Soil moisture sensors.

Microwave Satellite Missions: Indian Missions: RISAT Series, Oceansat Scatterometer, NISAR (ISRO-NASA) International Missions: Sentinel-1, TerraSAR-X, COSMO-SkyMed, ALOS-PALSAR, RADARSAT.

SAR Data Processing: Speckle filtering, Geometric correction, Radiometric calibration, Polarimetric processing.

Advanced Techniques: Differential InSAR (DInSAR), Persistent Scatterer InSAR, Polarimetric SAR, Interferometric DEM generation.

Applications: Flood mapping, Soil moisture estimation, Crop monitoring, Land subsidence studies, Glacier dynamics, Coastal monitoring, Disaster management.

linkage: CO3 **Number of Hours:9 hrs**

Module-4

Hyperspectral Remote Sensing and Spectral Analytics

Hyperspectral Imaging: Principles- Imaging spectroscopy, Spectral resolution concepts, Spectral signatures of natural materials, Spectral mixture analysis. Hyperspectral Sensors: Indian Missions- HySIS, Airborne Hyperspectral Sensors. International Missions- AVIRIS, Hyperion, EnMAP, PRISMA, EMIT.

Data Processing: Atmospheric correction, Noise removal, Dimensionality reduction, Spectral normalization. Spectral Analysis Techniques: Principal Component Analysis (PCA), Minimum Noise Fraction (MNF), Spectral Angle Mapper (SAM), Matched Filtering, Linear Spectral Unmixing.

Feature Extraction: Mineral mapping, Vegetation biochemical analysis, Water quality assessment.

Applications: Precision agriculture, Mineral exploration, Environmental monitoring, Forest health assessment, Coastal ecosystem studies, Defence and surveillance.

linkage: CO4 **Number of Hours: 8 hrs**

Module-5

Integrated Advanced Remote Sensing Applications and Future Systems

Multi-Sensor Data Integration: Sensor Fusion-Optical-Thermal integration Optical-SAR integration, Hyperspectral-LiDAR integration, Multi-platform observations Artificial Intelligence in Advanced Remote Sensing: Machine learning techniques, Deep learning for image classification, Feature extraction and object detection, GeoAI-based Earth Observation analytics.

Emerging Satellite Systems: Small satellite constellations, CubeSats, Commercial EO systems, High-revisit observation platforms.

Digital Earth Technologies: Digital Twins, Earth System Modelling, Near Real-Time Monitoring, Planetary-scale analytics.

Applications: Agriculture-Crop stress detection, Precision farming; Infrastructure-Smart city monitoring, Utility corridor assessment; Environment-Carbon monitoring, Biodiversity assessment; Disaster Management-Early warning systems, Rapid damage assessment.

Future Trends: AI-driven satellite analytics, Foundation Models for EO, Quantum Remote Sensing, Real-time Earth Observation systems, Future Satellite Systems.

linkage: CO5 **Number of Hours: 8 hrs**

Textbooks

1. *Jensen, J. R., Remote Sensing of the Environment: An Earth Resource Perspective, 2nd Edition, Pearson Prentice Hall, 2007.*
2. *Lillesand, T., Kiefer, R. W. and Chipman, J., Remote Sensing and Image Interpretation, 7th Edition, Wiley, 2015.*
3. *Huete, A., Lyon, J. G., Thenkabail, P. S. and others, Hyperspectral Remote Sensing of Vegetation, Volume IV: Advanced Applications in Remote Sensing of Agricultural Crops and Natural Vegetation, CRC Press, 2019.*
4. *Richards, J. A. and Jia, X., Remote Sensing Digital Image Analysis, 4th Edition, Springer, 2020.*
5. *Schowengerdt, R. A., Remote Sensing: Models and Methods for Image Processing, 3rd Edition, Academic Press, 2007.*

Reference books / Manuals

1. *Henderson, F. M. and Lewis, A. J. (Eds.), Principles and Applications of Imaging Radar, Manual of Remote Sensing, 3rd Edition, American Society for Photogrammetry and Remote Sensing (ASPRS), Wiley.*
2. *Ulaby, F. T., Moore, R. K. and Fung, A. K., Microwave Remote Sensing: Active and Passive, Artech House, 1981/1986.*
3. *Borengasser, M., Hungate, W. S. and Watkins, R., Hyperspectral Remote Sensing: Principles and Applications, CRC Press, 2007.*
4. *Chang, C.-I., Hyperspectral Imaging: Techniques for Spectral Detection and Classification, 1st Edition, Springer, 2003.*

Web links and Video Lectures (e-Resources) & Software tools:

https://earth.esa.int
https://www.nrsc.gov.in
https://developers.google.com/earth-engine
https://asf.alaska.edu
https://developers.google.com/earth-engine/tutorials
https://nptel.ac.in/courses/106105191
https://nptel.ac.in/
https://nptel.ac.in/

Software Tools

QGIS, ArcGIS Pro, ESA SNAP, ENVI, ERDAS IMAGINE, Google Earth Engine (GEE), PolSARpro

Teaching-Learning Process (Innovative Delivery Methods):

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes.

- *Interactive lectures with demonstrations of spectral behavior and sensor characteristics.*
- *Demonstration of thermal datasets and temperature retrieval workflows.*
- *Radar image interpretation and SAR processing demonstrations.*
- *Hands-on demonstrations using hyperspectral datasets and spectral libraries.*
- *Case studies, satellite mission reviews, and emerging technology discussions.*

Assessment Structure (both CIE and SEE)

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be **50% each**. *A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of* **40%** *of the maximum marks prescribed for SEE to be eligible for passing.*

A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than **50% of the aggregate marks** *obtained in CIE and SEE taken together.*

Continuous Internal Evaluation:

Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal Evaluation CIE [25+25=50 marks]

A minimum of **two Internal Assessment Tests (IA)** *shall be conducted. Each test shall be conducted for a maximum of* **25 marks**. *The average of the two test marks shall be the marks secured by a student in IA.*

In addition, **Continuous Comprehensive Assessment (CCA)** *shall be conducted for a total of* **25 marks**.

Students' activities for TW/SL under NCrF: Samples only

As per National credit formwork (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions (CI-42 hour) and Teamwork/ Self learning (TW/Sl-48 hours). Hence, students must complete minimum of two actives as part of NCrF. These learning activities shall be considered as CCA components of CIE. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below. The sample activities are given below. The course coordinator can also give their own TW/SL activities as per the course outcomes.

Sl. No.	Term Work (TW) Activity	Number of Hours / Semester
1	**Activity A –** *Form student teams to compare Thermal, Microwave, and Hyperspectral Remote Sensing technologies and prepare a comparative presentation. Analyze Land Surface Temperature (LST) datasets from different satellite missions and prepare thematic maps with interpretation. Develop a case study on SAR applications (flood mapping, agriculture, disaster management) using published datasets and present the findings.*	*24*
2	**Activity B –** *Perform hyperspectral image interpretation for vegetation, minerals, or water quality using available sample datasets and prepare a technical report. Design a concept proposal for an AI-enabled multi-sensor*	*24*
	Earth Observation application addressing agriculture, environment, or disaster management.	

SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.

Sl. No.	Self-Learning (SL) Activity	Number of Hours / Semester
1	*Study the electromagnetic spectrum, radiation laws, and sensor characteristics using ISRO, NASA, and ESA learning resources; prepare summary notes. Explore thermal datasets from Landsat, MODIS, or Sentinel-3 and study Land Surface Temperature estimation techniques through online tutorials.*	*24*
2	*Learn SAR image processing concepts (speckle filtering, calibration, InSAR) using ESA SNAP tutorials and prepare a short report. Study hyperspectral image processing methods (PCA, MNF, SAM, Spectral Unmixing) and review recent journal papers on hyperspectral applications. Review recent research on AI, GeoAI, Digital Twins, CubeSats, and Foundation Models for Earth Observation. Present a seminar on emerging technologies.*	*24*

	questions.			

Sample rubrics for Term Work

Assessment Criteria	*Excellent (4 Marks)*	*Good (3 Marks)*	*Satisfactory (2 Marks)*	*Needs Improvement (1 Mark)*
Technical Knowledge	*Demonstrates thorough understanding of concepts with accurate analysis and interpretation.*	*Demonstrates good understanding with minor inaccuracies.*	*Demonstrates basic understanding of concepts.*	*Demonstrates inadequate understanding of concepts.*
Practical/Analytical Skills	*Performs analysis independently with excellent interpretation of results.*	*Performs analysis correctly with limited guidance.*	*Performs basic analysis with frequent guidance.*	*Unable to perform analysis satisfactorily.*
Application of ɔls & To Techniques	*Effectively applies appropriate remote sensing software/tools and techniques.*	*Applies tools with minor errors.*	*Applies basic techniques with assistance.*	*Unable to apply appropriate tools effectively.*
Innovation & Problem Solving	*Demonstrates originality, critical thinking, and innovative solutions.*	*Shows good analytical thinking and problemsolving ability.*	*Demonstrates limited analytical skills.*	*Shows little evidence of analytical or innovative thinking.*
Documentation & Report Writing	*Well-organized, technically accurate, properly formatted, and referenced report.*	*Good report with minor formatting or technical issues.*	*Adequate report with limited technical details.*	*Incomplete or poorly organized report.*
Presentation & Communication	*Clear, confident, professional presentation with excellent responses to*	*Good presentation with satisfactory responses.*	*Average presentation with limited clarity.*	*Poor presentation and unable to answer questions.*

Sample rubrics for Self-Learning

Assessment Criteria	*Excellent (4 Marks)*	*Good (3 Marks)*	*Satisfactory (2 Marks)*	*Needs Improvement (1 Mark)*
Independent Learning	*Demonstrates extensive self-learning beyond the syllabus using multiple technical resources.*	*Demonstrates good self-learning with appropriate resources.*	*Demonstrates basic self-learning using limited resources.*	*Shows little evidence of independent learning.*

Literature Review	*Critically reviews journals, technical reports, and online resources with proper citations.*	*Reviews relevant literature with minor omissions.*	*Reviews limited literature.*	*Minimal or no literature review.*
Technical Understanding	*Demonstrates excellent understanding of advanced concepts and recent developments.*	*Demonstrates good conceptual understanding.*	*Demonstrates basic understanding.*	*Demonstrates poor understanding.*
Application of Knowledge	*Successfully applies acquired knowledge to case studies, datasets, or practical problems.*	*Applies knowledge with minor guidance.*	*Applies basic concepts with assistance.*	*Unable to apply learned concepts effectively.*
Technical Report/Seminar	*Excellent report/seminar with clear organization, technical depth, and proper references.*	*Good report/seminar with minor deficiencies.*	*Average quality report/seminar.*	*Poorly organized or incomplete report/seminar.*

LAND INFORMATION SYSTEMS & SDG MONITORING			
Course Code	*1MCGI206A*	*Scheme*	*2026*
Type of Course	**PEC**	*Semester*	*II*
Teaching Hours/Week (L:T:P)	*42(3:0:0)*	*CIE Marks*	*50*
Total Hours of Pedagogy L /T/P/SL&TW:	*90(42:0:0:48)*	*SEE Marks*	*50*
Credits	**3**	*Total Marks*	*100*
Examination type (SEE)	*Theory*	*Exam Hours*	*03*

Course Objectives

At the end of the course, the student will be able to:

1. *CO1 (L2- Understand): understand the concepts, architecture, and components of Land Information Systems (LIS), land administration, and cadastral systems.*
2. *CO2 (L3-Apply): Apply digital cadastral mapping, land records management, and geospatial data integration techniques for land administration.*
3. *CO3 (L4- Analyse): Analyze the role of geospatial technologies in monitoring Sustainable Development Goals (SDGs) and evaluating spatial indicators*
4. *CO4 (L5- Evaluate): Evaluate multi-source geospatial datasets and perform spatial analytics for sustainability assessment and SDG monitoring.*
5. *CO5 (L6-Create): Design GIS-based decision support systems and smart land governance solutions using emerging technologies such as AI, GeoAI, and Blockchain.*

Module-1

Fundamentals of Land Information Systems

Introduction to LIS-concept and evolution of land information systems, components of LIS, role of LIS in governance and planning.

Land Administration Concepts-land tenure systems, land ownership and rights, cadastral systems and land records.

LIS Architecture-spatial and non-spatial data integration, database design for land records, interoperability and data standards

linkage: CO1 **Number of Hours: 8 hrs**

Module-2

Digital Cadastre and Land Records Management

Cadastral Mapping-parcel-based mapping, boundary delineation methods, cadastral surveys

Digital Land Records-digitization of cadastral maps, land parcel identification systems, land registration workflows.

Land Information Systems Implementation-LIS databases and platforms, integration with GIS national land record modernization programs.

linkage: CO2 **Number of Hours:8 hrs**

Module-3

Geospatial Technologies for SDG Monitoring

Overview of SDGs-structure of SDGs, SDG indicators and targets, spatial dimension of SDGs.

Role of Geospatial Data-satellite remote sensing for SDG indicators, GIS-based monitoring frameworks, spatial data integration.

SDG Use Cases-land degradation (SDG 15), urban sustainability (SDG 11), agriculture and food security (SDG 2)

linkage: CO2,CO3 **Number of Hours:8 hrs**

Module-4

Spatial Data Integration and Analytics for SDGs

Data Integration-multi-source geospatial data integration, temporal and spatial data harmonization, data quality and uncertainty.

Spatial Analytics for SDGs-indicator computation using GIS, spatial modelling for sustainability assessment, hotspot and trend analysis.

Tools and Platforms-Geospatial analytics using: QGIS, Google Earth Engine.

linkage: CO4, CO5 **Number of Hours: 9 hrs**

Module-5

Smart Land Governance and Decision Support Systems

Land Governance-land policy frameworks, digital land governance systems, transparency and land reforms
Decision Support Systems-GIS-based planning tools, multi-criteria decision analysis, spatial dashboards for governance
Emerging Trends-integration with AI and GeoAI, blockchain in land records, participatory GIS and citizen data

linkage: CO5,CO6 **Number of Hours: 9 hrs**

Textbooks

1. *Williamson, I., Enemark, S., Wallace, J. and Rajabifard, A., Land Administration for Sustainable Development, Esri Press Academic, 2010.*
2. *Dale, P. F. and McLaughlin, J. D., Land Information Management: An Introduction with Special Reference to Cadastral Problems in Third World Countries, Oxford University Press, edition not confirmed from the sources retrieved.*
3. *Chang, K.-T., Introduction to Geographic Information Systems, 5th Edition, McGraw-Hill, 2010.*

Reference books / Manuals

1. *FIG (International Federation of Surveyors), Cadastre 2014 and Beyond, FIG Publication No. 61, 2014.*
2. *Dale, P. and McLaughlin, J., Land Administration, Oxford University Press, 2000.*
3. *Liang, Shunlin, Remote Sensing and GIS for Sustainable Development, publication details not confirmed from the sources retrieved.*
4. *Onsrud, Harlan, Spatial Data Infrastructures and GIS, publication details not confirmed from the sources retrieved.*

Web links and Video Lectures (e-Resources) & Software tools:

https://pysal.org?utm_source=chatgpt.com
https://geopandas.org?utm_source=chatgpt.com
https://scikit-learn.org/stable/documentation.html?utm_source=chatgpt.com https://scikit-learn.org/stable/documentation.html?utm_source=chatgpt.com
https://postgis.net/documentation?utm_source=chatgpt.com

Software Tools

QGIS, ArcGIS Pro, Google Earth Engine, PostgreSQL/PostGIS, GeoServer

Teaching-Learning Process (Innovative Delivery Methods):

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes.

- *Conceptual lectures supported by case studies of digital land systems.*
- *Case studies from national and state-level land information systems.*
- *Examples of SDG monitoring using geospatial datasets. Hands-on demonstrations using SDG-related datasets.*
- *Case studies from smart governance and sustainable land management*.

Assessment Structure (both CIE and SEE)

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be **50% each**. *A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of* **40%** *of the maximum marks prescribed for SEE to be eligible for passing.*

A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than **50% of the aggregate marks** *obtained in CIE and SEE taken together.*

Continuous Internal Evaluation:

Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal Evaluation CIE [25+25=50 marks]

A minimum of **two Internal Assessment Tests (IA)** *shall be conducted. Each test shall be conducted for a maximum of* **25 marks**. *The average of the two test marks shall be the marks secured by a student in IA.*

In addition, **Continuous Comprehensive Assessment (CCA)** *shall be conducted for a total of* **25 marks**.

Students' activities for TW/SL under NCrF: Samples only

As per National credit formwork (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions (CI-42 hour) and Teamwork/ Self learning (TW/Sl-48 hours). Hence, students must complete minimum of two actives as part of NCrF. These learning activities shall be considered as CCA components of CIE. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below. The sample activities are given below. The course coordinator can also give their own TW/SL activities as per the course outcomes.

Sl. No.	Term Work (TW) Activity	Number of Hours / Semester
1	**Activity A –** *Prepare a group presentation on land administration systems, land tenure, and cadastral frameworks in different countries. Develop a digital cadastral database for a sample village/town using GIS and land parcel information.*	24
2	**Activity B –** *Analyze selected SDG indicators (SDG 2, SDG 11, SDG 15) using satellite and GIS datasets and prepare thematic maps. Perform hotspot analysis and sustainability assessment for a selected region using multisource spatial datasets. Design a GIS-based decision support system for land management, urban planning, or environmental governance.*	24
SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.		
Sl. No.	**Self-Learning (SL) Activity**	**Number of Hours / Semester**
1	*MOOCs / Online Courses- NPTEL, SWAYAM, ISRO-IIRS Outreach Programme, Coursera, Study land administration models and land tenure systems adopted in India and other countries. Explore Digital India Land Records Modernization Programme (DILRMP) and prepare a review report.*	24
2	*Download and analyze SDG-related geospatial datasets from Bhuvan, Copernicus, or UN portals. Perform spatial analysis using QGIS and prepare maps showing sustainability indicators. Review recent research papers on GeoAI, blockchain in land records, and participatory GIS.*	24

Sample rubrics for Term Work

Criteria	Excellent (4)	Good (3)	Satisfactory (2)	Needs Improvement (1)
Technical Knowledge	*Demonstrates comprehensive understanding of LIS, GIS, and SDG concepts*	*Good understanding*	*Basic understanding*	*Limited understanding*
Team Participation	*All members actively contribute and collaborate*	*Most members contribute*	*Uneven participation*	*Minimal participation*
Data Analysis & Interpretation	*Accurate analysis and meaningful conclusions*	*Good analysis*	*Basic analysis*	*Weak analysis*
Problem Solving & Innovation	*Innovative solutions and critical thinking*	*Good solutions*	*Limited innovation*	*Minimal effort*
Presentation & Communication	*Clear, professional, and engaging presentation*	*Good presentation*	*Average presentation*	*Poor presentation*
Report Quality	*Well-organized, technically sound report*	*Good documentation*	*Adequate documentation*	*Poor documentation*

Sample rubrics for Self-Learning

Criteria	Excellent (4)	Good (3)	Satisfactory (2)	Needs Improvement (1)
Independent Learning	*Extensive exploration beyond syllabus content*	*Good exploration*	*Moderate exploration*	*Minimal effort*
Conceptual Understanding	*Comprehensive understanding of concepts*	*Good understanding*	*Basic understanding*	*Poor understanding*
Technical Application	*Effective use of GIS, remote sensing, and analytical tools*	*Good application*	*Basic application*	*Poor application*
Documentation & Reporting	*Professional, wellstructured report*	*Good report*	*Average report*	*Poor report*
Critical Thinking & Interpretation	*Insightful evaluation and interpretation*	*Good interpretation*	*Limited analysis*	*No critical evaluation*

GEOINFORMATICS IN MARINE AND COASTAL RESOURCES MANAGEMENT			
Course Code	*1MCGI206B*	*Scheme*	*2026*
Type of Course	**PEC**	*Semester*	*II*
Teaching Hours/Week (L:T:P)	*42(3:0:0)*	*CIE Marks*	*50*
Total Hours of Pedagogy L /T/P/SL&TW:	*90(42:0:0:48)*	*SEE Marks*	*50*
Credits	**3**	*Total Marks*	*100*
Examination type (SEE)	*Theory*	*Exam Hours*	*03*

Course Objectives

At the end of the course, the student will be able to:

1. *CO1 (L2- Understand): understand the principles of marine and coastal geoinformatics, ocean observation systems, and marine spatial data infrastructure.*
2. *CO2 (L3-Apply): Apply geospatial techniques for coastal zone management, habitat mapping, and marine resource assessment.*
3. *CO3 (L4- Analyse): Analyze marine and coastal resources using remote sensing, GIS, GNSS, and oceanographic datasets.*
4. *CO4 (L5- Evaluate): Evaluate coastal hazards, shoreline changes, marine pollution, and climate change impacts using geospatial tools.*
5. *CO5 (L6-Create): Develop geospatial decision-support solutions for sustainable marine and coastal resource management.*

Module-1

Fundamentals of Marine and Coastal Geoinformatics

Introduction to Marine Environment- Marine and coastal ecosystems, Oceanographic parameters, Coastal geomorphology, Marine resources and their significance.
Marine Geoinformatics Concepts- GIS in marine applications, Marine Spatial Data Infrastructure (MSDI), Marine cadastre concepts, Geospatial databases for coastal resources.
Ocean Observation Systems- Satellite oceanography, Buoys and ocean sensors, GNSS and navigation systems, Marine data acquisition techniques.

linkage: CO1 **Number of Hours: 8 hrs**

Module-2

Remote Sensing for Marine and Coastal Applications

Ocean Color Remote Sensing- Chlorophyll estimation, Primary productivity, Suspended sediment concentration, Water quality monitoring.
Coastal Remote Sensing- Shoreline extraction, Coastal land use/land cover mapping, Wetland and mangrove mapping, Coral reef monitoring.
Microwave and SAR Applications- Oil spill detection, Sea surface roughness, Coastal flooding, Ship detection

linkage: CO2 **Number of Hours:9 hrs**

Module-3

GIS and Marine Resource Assessment

Marine GIS- Spatial database development, Bathymetric data integration, Marine thematic mapping, Spatial analysis techniques.
Marine Resource Assessment- Fisheries resource mapping, Potential fishing zone (PFZ) mapping, Coastal biodiversity assessment, Habitat suitability analysis.
Marine Spatial Planning- Marine protected areas (MPAs), Coastal zone regulation, Marine resource allocation, Conflict analysis.

linkage: CO2,CO3 **Number of Hours:8 hrs**

Module-4

Coastal Hazard and Climate Change Assessment

Coastal Hazards- Shoreline erosion and accretion, Cyclones and storm surges, Coastal flooding, Tsunami vulnerability assessment.

Climate Change Applications- Sea-level rise assessment, Coastal vulnerability index (CVI), Blue carbon ecosystems, Climate adaptation planning.

Marine Pollution Monitoring- Oil spill tracking, Marine litter mapping, Water quality assessment, Coastal environmental monitoring.

linkage: CO4, CO5 **Number of Hours: 9 hrs**

Module-5

Advanced Geospatial Technologies and Decision Support Systems

Emerging Technologies- UAV applications in coastal zones, LiDAR bathymetry, Artificial Intelligence and Machine Learning, Digital Twin Oceans.

Decision Support Systems- Spatial multi-criteria analysis, Marine resource management models, Coastal governance frameworks, Sustainable development planning.

Case Studies- Integrated Coastal Zone Management (ICZM), Blue Economy Applications, Marine conservation planning.

linkage: CO5,CO6 **Number of Hours: 8 hrs**

Textbooks

1. *Wright, D. J. and Bartlett, D. J. (Eds.), Marine and Coastal Geographical Information Systems, Taylor & Francis, 1999.*
2. *Green, D. R. and King, S. D. (Eds.), Coastal and Marine Geo-Information Systems: Applying the Technology to the Environment, Kluwer Academic Publishers, 2003.*
3. *Valavanis, V. D., Geographic Information Systems in Oceanography and Fisheries, Taylor & Francis, 2002.*
4. *Fisher, W. L. and Rahel, F. J. (Eds.), Geographic Information Systems in Fisheries, American Fisheries Society, 2004.*
5. *Wright, D. J. (Ed.), Undersea with GIS, Esri Press, 2001.*
6. *Wright, D. J. and Scholz, A. J. (Eds.), Place Matters: Geospatial Tools for Marine Science, Conservation, and Management in the Pacific Northwest, AAAS Press, 2005.*
7. *Breman, J. (Ed.), Marine Geography: GIS for the Oceans and Seas, Esri Press, 2003.*

Reference books / Manuals

1. *Robinson, I. S., Measuring the Oceans from Space: The Principles and Methods of Satellite Oceanography, Springer, 2004.*
2. *Robinson, I. S., Discovering the Oceans from Space, Springer, 2010.*
3. *Trujillo, A. P. and Thurman, H. V., Essentials of Oceanography, 10th Edition, publisher/year not confirmed from the sources retrieved.*
4. *Kelkar, R. R., Satellite Meteorology, 2nd Edition, BS Publications, 2017.*
5. *Bartlett, D. J. and Smith, J. L., GIS for Coastal Zone Management, CRC Press, 2005.*

Web links and Video Lectures (e-Resources) & Software tools:

https://incois.gov.in?utm_source=chatgpt.com

https://www.nrsc.gov.in?utm_source=chatgpt.com

https://www.nrsc.gov.in?utm_source=chatgpt.com

https://marine.copernicus.eu?utm_source=chatgpt.com

https://ioc.unesco.org?utm_source=chatgpt.com

Software Tools

QGIS, ArcGIS Pro, Google Earth Engine, ERDAS IMAGINE, ENVI, Global Mapper

Teaching-Learning Process (Innovative Delivery Methods):

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes.

Structured lectures on the fundamentals prepared from standard books written by eminent authors through audiovisual technologies. Understand the types marine, coastal resources and other processing.

Encouraging students to give seminars, testing the outcome of teaching through conduct of internal tests, assignments, discussion in the class. Acquire knowledge about Oceanographic studies and applications.

Interactive/participative methods, through lectures, discussion, remedial instruction, study assignment (reading books, periodicals, research papers, and exercises for practicing at home). Acquire knowledge Coastal engineering application and modelling.

Tutorial methods for the laggards, seminar methods for the groups, demonstration method where the faculty member / instructor himself performs a set of operations. Design various RS and GIS applications Coastal zone and management.

Demonstration method where the faculty member / instructor himself performs a set of operations, Acquire knowledge about meteorological applications.

Assessment Structure (both CIE and SEE)

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be **50% each**. *A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of* **40%** *of the maximum marks prescribed for SEE to be eligible for passing.*

A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than **50% of the aggregate marks** *obtained in CIE and SEE taken together.*

Continuous Internal Evaluation:

Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal Evaluation CIE [25+25=50 marks]

A minimum of **two Internal Assessment Tests (IA)** *shall be conducted. Each test shall be conducted for a maximum of* **25 marks**. *The average of the two test marks shall be the marks secured by a student in IA.*

In addition, **Continuous Comprehensive Assessment (CCA)** *shall be conducted for a total of* **25 marks**.

Students' activities for TW/SL under NCrF: Samples only

As per National credit formwork (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions (CI-42 hour) and Teamwork/ Self learning (TW/Sl-48 hours). Hence, students must complete minimum of two actives as part of NCrF. These learning activities shall be considered as CCA components of CIE. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below. The sample activities are given below. The course coordinator can also give their own TW/SL activities as per the course outcomes.

Sl. No.	Term Work (TW) Activity	Number of Hours / Semester
1	**Activity A –** *Analyze multi-temporal satellite images to assess shoreline erosion and accretion patterns. Develop Coastal Vulnerability Index (CVI) using GIS-based multi-criteria analysis Map and assess health status of mangrove ecosystems using remote sensing data. Identify pollution-prone coastal areas using GIS and field observations.*	24
2	**Activity B –** *Analyze oceanographic and environmental data to identify potential fishing zones. Design a marine spatial planning framework considering ecological and economic factors. Prepare cyclone, tsunami, storm surge and flood hazard zonation maps. Develop a GIS-based web dashboard for coastal resource management.*	24
SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.		

Sl. No.	Self-Learning (SL) Activity	Number of Hours / Semester
1	*MOOCs / Online Courses- NPTEL, SWAYAM, ISRO-IIRS Outreach Programme, Coursera, Review recent journal articles on Marine GIS and Coastal Management. Explore INCOIS oceanographic products and services. Download and process Sentinel-1 SAR imagery for oil spill detection. Analyze shoreline changes using freely available Landsat imagery.*	24
2	*Learn marine spatial planning concepts through international case studies. Develop habitat suitability maps using QGIS. Study climate change impacts on coastal ecosystems. Prepare a report on Blue Carbon Ecosystems. Explore Copernicus Marine Service datasets. Complete online tutorials on UAV coastal mapping*	24

Sample rubrics for Term Work

Criteria	Excellent	Good	Satisfactory	Poor
Literature Survey	*Comprehensive review from reputed journals*	*Good review with adequate references*	*Limited references*	*Very few references*
Conceptual Understanding	*Excellent understanding and interpretation*	*Good understanding*	*Basic understanding*	*Poor understanding*
Critical Analysis	*Strong critical evaluation and insights*	*Good analysis*	*Basic analysis*	*Limited analysis*
Report Writing	*Well-structured, error-free report*	*Good organization*	*Acceptable structure*	*Poorly written*
Timely Submission & Originality	*Submitted on time with original work*	*Minor delay or minor similarity issues*	*Delayed submission*	*Significant delay/plagiarism concerns*

Criteria	Excellent (4 Marks)	Good (3 Marks)	Satisfactory (2 Marks)	Needs Improvement (1 Mark)
Technical Knowledge	*Demonstrates excellent understanding of concepts and tools*	*Good understanding with minor errors*	*Basic understanding*	*Limited understanding*
Data Collection & Analysis	*Accurate data collection and advanced analysis*	*Adequate analysis with minor issues*	*Basic analysis*	*Incomplete or incorrect analysis*
Team Collaboration	*Actively contributes and supports team members*	*Participates effectively*	*Limited participation*	*Minimal participation*
Innovation & Problem Solving	*Highly innovative approach and solutions*	*Some innovative ideas*	*Limited innovation*	*No innovation*
Presentation & Communication	*Clear, professional, and well-organized*	*Good presentation*	*Average presentation*	*Poor presentation*

Sample rubrics for Self-Learning

GIS-BIM INTEGRATION FOR DIGITAL INFRASTRUCTURE AND DIGITAL TWINS			
Course Code	*1MCGI206C*	*Scheme*	*2026*
Type of Course	**PEC**	*Semester*	*II*
Teaching Hours/Week (L:T:P)	*42(3:0:0)*	*CIE Marks*	*50*
Total Hours of Pedagogy L /T/P/SL&TW:	*90(42:0:0:48)*	*SEE Marks*	*50*
Credits	**3**	*Total Marks*	*100*
Examination type (SEE)	*Theory*	*Exam Hours*	*03*

Course Objectives

At the end of the course, the student will be able to:

1. *CO1 (L2- Understand): Understand BIM concepts, infrastructure information modelling frameworks, and international BIM standards.*
2. *CO2 (L3-Apply): Learn BIM-GIS interoperability methods and geospatial data integration standards.*
3. *CO3 (L3–Understand) Understand Digital Twin architectures and intelligent infrastructure information systems.*
4. *CO4 (L3- Apply): Apply GIS-BIM technologies for infrastructure planning, construction management, asset lifecycle management, and facility operations.*
5. *CO5 (L4 – Analyze) Analyze emerging technologies such as IoT (Internet of Things) , XR (Extended Reality), robotics, and sustainability frameworks for future digital infrastructure ecosystems.*

Module-1

Fundamentals of BIM and Infrastructure Information Modelling

Introduction to BIM- Evolution of Building Information Modelling, Need for BIM in infrastructure development, BIM versus CAD and BIM adoption across infrastructure sectors

BIM Dimensions and Lifecycle- 3D BIM – Geometric modelling, 4D BIM – Schedule integration, 5D BIM – Cost management, 6D BIM – Sustainability analysis and 7D BIM – Asset and facility management

Infrastructure Information Modelling- Concept of Infrastructure Information Modelling (IIM), Digital representation of infrastructure assets, Information flow across project lifecycle and BIM for transportation and utility networks

BIM Maturity and Collaboration: BIM maturity levels, Collaborative workflows, Common Data Environment (CDE) and Information management practices

BIM Standards and Frameworks - Open BIM concepts, ISO 19650 standards, BuildingSMART initiatives, Industry Foundation Classes (IFC), Construction Operations Building Information Exchange (COBie)

Linked COs: CO1, CO2 **Number of Hours: 8hrs**

Module-2

BIM-GIS Interoperability and Infrastructure Data Standards.

Need for GIS-BIM Integration- Spatial context in infrastructure projects, Integration challenges and opportunities and Geospatially enabled infrastructure management

BIM and GIS Data Models - BIM data structures, GIS data structures, Geometry and semantics and Object-oriented information models

Open Standards for Integration - BIM Standards - IFC schema, COBie standards and BIM Level of Development (LOD).

GIS Standards- CityGML (GML - Geography Markup Language), IndoorGML, LandInfra, InfraGML and OGC interoperability frameworks

BIM Georeferencing- Coordinate systems, Geospatial referencing of BIM models, Datum and projection systems and Transformation workflows

Data Harmonization and Semantic Integration - Semantic interoperability, Data mapping techniques, Information exchange mechanisms and BIM-GIS integration workflows

Practical Integration Concepts - BIM-to-GIS workflows, GIS-to-BIM workflows and Infrastructure data exchange pipelines.

Linked COs: CO1, CO2 **Number of Hours: 09 hrs**

Module-3

Digital Twins and Infrastructure Information Systems

Introduction to Digital Twins - Evolution of Digital Twin technology, Components of a Digital Twin, Physical and virtual system integration and Digital Twin lifecycle

Types of Digital Twins - Building Digital Twins, Infrastructure Digital Twins, City Digital Twins, Utility Digital Twins and Campus Digital Twins

BIM-IoT Integration - Internet of Things (IoT) fundamentals, Smart sensors and sensor networks, Sensor-enabled infrastructure, Real-time data acquisition

Infrastructure Monitoring Systems - Real-time infrastructure monitoring, Condition assessment systems, Structural health monitoring, Predictive infrastructure intelligence

Infrastructure Information Systems - Asset Information Models (AIM), Facility Management Information Systems, Enterprise Asset Management systems and Decision-support systems for infrastructure operations.

Linked COs: CO2, CO3 **Number of Hours: 8hrs**

Module-4

BIM-GIS Applications in Infrastructure Lifecycle Management

Planning Phase Applications: Site Selection - Spatial suitability analysis and Infrastructure location optimization.

Corridor Planning - Transportation corridor design and Utility corridor planning

Utility Planning - Water supply networks, Sewerage systems, Electrical distribution systems.

Design Phase Applications: Integrated Infrastructure Modelling - Multi-disciplinary design integration and Infrastructure coordination

Design Validation - Clash detection, Design conflict resolution and Engineering coordination

Construction Phase Applications, Construction Monitoring - Progress monitoring, Construction analytics and Site management

4D BIM Applications - Construction scheduling and Time-enabled project management

Operation and Maintenance Phase - Infrastructure Asset Management - Asset inventory systems and Lifecycle management

Maintenance Management - Preventive maintenance and Condition-based maintenance

Predictive Maintenance - Data-driven maintenance planning and Failure prediction frameworks

Sectoral Applications - Transportation infrastructure, Airports and aviation systems, Railways and metro systems, Smart utility networks, Industrial infrastructure and Energy infrastructure

Linked COs: CO3, CO4 **Number of Hours: 9 hrs**

Module-5

Future Infrastructure Ecosystems and Emerging Technologies

Digital Infrastructure Platforms: Enterprise BIM-GIS Platforms - ArcGIS GeoBIM, Bentley Infrastructure Cloud, Autodesk Tandem and Infrastructure Digital Twin platforms

BIM + IoT + GIS Ecosystems - Smart Asset Monitoring : Sensor integration, Connected infrastructure systems and Real-time operational intelligence

Intelligent Infrastructure Management- Integrated command and control systems and Infrastructure performance analytics

BIM and Robotics -Construction Automation: Autonomous inspections, Robotic infrastructure monitoring and Automated construction workflows

BIM and Extended Reality (XR) - Immersive Infrastructure Visualization: Augmented Reality (AR), Virtual Reality (VR) and Mixed Reality (MR)

Applications - Virtual site inspection, Infrastructure training environments and Design visualization

BIM and Sustainability- Sustainable Infrastructure Systems: Green buildings, Sustainable asset management and Net-zero infrastructure

ESG and Carbon Management- ESG reporting frameworks : Carbon accounting and Climate-resilient infrastructure

National and International Initiatives- India: National Infrastructure Pipeline (NIP), PM Gati Shakti National Master Plan, Smart Cities Mission and National Geospatial Policy 2022

Global Initiatives - Digital Twin initiatives worldwide, European Digital Twin programs, Smart infrastructure ecosystems and Future Digital Earth frameworks.

Linked COs: CO4, CO5 **Number of Hours: 8hrs**

Textbooks:

1. *Eastman, C., Teicholz, P., Sacks, R. and Liston, K., BIM Handbook: A Guide to Building Information Modeling for Owners, Designers, Engineers, Contractors, and Facility Managers, 4th Edition, John Wiley & Sons, 2025.play.*
2. *Borrmann, A., König, M., Koch, C. and Beetz, J., Building Information Modeling: Technology Foundations and Industry Practice, 1st Edition, Springer, 2018.link.*
3. *Smith, P., BIM & the 5D Project Cost Manager, Elsevier Science BV, 2014.*
4. *Zlatanova, S. and Lee, J. (Eds.), 3D Geo-Information Sciences, 1st Edition, Springer, 2009*
5. *Underwood, J. and Isikdag, U. (Eds.), Handbook of Research on Building Information Modeling and Construction Informatics: Concepts and Technologies, IGI Global, 2009.salford-repository.*

Reference books / Manuals

1. *Isikdag, U., Enhanced Building Information Models using GIS and Spatial Technologies, publication details not confirmed from the sources retrieved.*
2. *Kolbe, T. H., CityGML for Smart Cities and Digital Twins, best cited as an OGC/CityGML standards topic rather than a standalone book.*
3. *OGC, Standards Documentation for CityGML, IndoorGML, LandInfra and InfraGML, OGC standards documentation.*
4. *ISO, ISO 19650 Standards for BIM Information Management, international standards series; ISO 196501:2018 defines concepts and principles for BIM information management.*

Web links and Video Lectures (e-Resources) & Software tools:

1. *buildingSMART International, Standards Library / Standards Server, official standards and supporting documentation for IFC, BCF, IDS and related BIM standards.*
2. *Open Geospatial Consortium (OGC), OGC Geospatial Standards, official standards library for open geospatial specifications such as WMS, WFS, GeoPackage, CityGML and OGC APIs.*
3. *Esri, ArcGIS GeoBIM Documentation, tutorials, documentation, videos and resources for GIS–BIM integration.*
4. *Autodesk, Autodesk Tandem Learning Resources / Knowledge Center, tutorials, quick-start guides and digital twin learning materials.*
5. *Bentley Systems, Bentley Infrastructure Cloud Documentation, user guide and training resources for asset lifecycle and project collaboration.*

Software Tools

1. *QGIS or ArcGIS for spatial analysis and mapping.*
2. *Autodesk*
3. Bentley

Teaching-Learning Process (Innovative Delivery Methods):

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes.

- *Interactive lectures supported by demonstrations of BIM-enabled infrastructure projects and global BIM implementation case studies.*
- *Demonstration-based learning using BIM-GIS interoperability case studies and infrastructure data exchange examples.*
- *Case studies on airport digital twins, utility digital twins, smart campuses, and transportation digital infrastructure systems.*
- *Industry case studies involving transportation, airports, utility systems, metro rail projects, and industrial infrastructure.*
- *Seminars, industry presentations, and case studies on emerging digital infrastructure technologies and global best practices.*

Assessment Structure (both CIE and SEE)

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be **50% each**. *A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of* **40%** *of the maximum marks prescribed for SEE to be eligible for passing.*

A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than **50% of the aggregate marks** *obtained in CIE and SEE taken together.*

Continuous Internal Evaluation:

Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal Evaluation CIE [25+25=50 marks]

A minimum of **two Internal Assessment Tests (IA)** *shall be conducted. Each test shall be conducted for a maximum of* **25 marks**. *The average of the two test marks shall be the marks secured by a student in IA.*

In addition, **Continuous Comprehensive Assessment (CCA)** *shall be conducted for a total of* **25 marks**.

Students' activities for TW/SL under NCrF: Samples only

As per National credit formwork (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions (CI-42 hour) and Teamwork/ Self learning (TW/Sl-48 hours). Hence, students must complete minimum of two actives as part of NCrF. These learning activities shall be considered as CCA components of CIE. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below. The sample activities are given below. The course coordinator can also give their own TW/SL activities as per the course outcomes.

Sl. No.	Term Work (TW) Activity	Number of Hours / Semester
1	*Develop a BIM implementation framework for a road, bridge, or building project by identifying BIM dimensions (3D–7D), stakeholders, CDE, and BIM standards. Present the workflow.* *Prepare a conceptual BIM-GIS integration workflow for an infrastructure project (transportation, water supply, or campus). Explain IFC, CityGML, georeferencing, and data exchange process. Design a Digital Twin architecture for a smart campus, airport, or utility network integrating BIM, GIS, and IoT sensors*.	24
2	*Prepare a lifecycle management plan for an infrastructure project covering planning, design, construction, operation, maintenance, and predictive maintenance using BIM-GIS concepts. Develop a concept proposal for a Smart City or Digital Infrastructure platform integrating BIM, GIS, IoT, XR, sustainability, and Digital Twin technologies aligned with PM Gati Shakti or Smart Cities Mission.*	24

SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.

Sl. No.	Self-Learning (SL) Activity	Number of Hours / Semester
1	*Study ISO 19650, BuildingSMART, IFC, and COBie standards and prepare a summary report on BIM implementation practices.* *Explore ArcGIS GeoBIM, Autodesk Revit, QGIS, and CityGML documentation to understand BIM-GIS interoperability workflows.*	24

2	*Review Digital Twin implementations in airports, metro systems, smart campuses, or utility networks and prepare a case study.* *Study real-world BIM-GIS applications used in transportation, utilities, or smart cities and prepare a presentation highlighting lifecycle management.* *Review India's PM Gati Shakti, National Infrastructure Pipeline (NIP), Smart Cities Mission, and National Geospatial Policy 2022. Compare them with international Digital Twin initiatives.*	24

Sample rubrics for Term Work

Assessment Criteria	Excellent (4)	Good (3)	Average (2)	Needs Improvement (1)
Technical Understanding	*Demonstrates comprehensive understanding of BIM, GIS, Digital Twin, and infrastructure concepts.*	*Good understanding with minor inaccuracies.*	*Basic understanding of concepts.*	*Limited technical understanding.*
Problem Analysis & Solution Design	*Identifies project requirements and develops innovative, practical solutions.*	*Good analysis with feasible solutions.*	*Partial analysis with limited solutions.*	*Poor analysis and inadequate solutions.*
Team Collaboration	*Excellent coordination, leadership, and equal participation among members.*	*Good teamwork with active participation.*	*Moderate participation by team members.*	*Poor teamwork and limited contribution.*
Presentation & Communication	*Professional presentation with excellent technical explanation and visual aids.*	*Clear presentation with minor issues.*	*Average presentation with limited clarity.*	*Poor communication and presentation skills.*
Documentation & Report Quality	*Well-structured, technically accurate, properly referenced report.*	*Good documentation with minor improvements needed.*	*Basic documentation with some missing details.*	*Incomplete or poorly organized report.*

Sample rubrics for Self-Learning

Assessment Criteria	Excellent (4)	Good (3)	Average (2)	Needs Improvement (1)
Literature Review	*Comprehensive review using standards, research papers, and industry reports.*	*Good review using multiple sources.*	*Limited literature review.*	*Very limited or no review.*
Conceptual Understanding	*Demonstrates excellent understanding of concepts and technologies.*	*Good understanding with minor gaps.*	*Basic understanding.*	*Poor conceptual knowledge.*
Practical Application	*Effectively relates concepts to real-world infrastructure projects and case studies.*	*Good practical interpretation.*	*Limited practical application.*	*No practical relevance demonstrated.*
Critical Thinking & Innovation	*Provides insightful analysis and innovative ideas.*	*Good analytical ability.*	*Moderate analysis.*	*Minimal critical thinking.*

Report Quality	*Well-organized, professionally written, and properly referenced.*	*Good quality report.*	*Average report with some deficiencies.*	*Poorly prepared report.*

GEOINFORMATICS IN DEMOGRAPHY, BUSINESS, HEALTH AND INFRASTRUCTURE PLANNING			
Course Code	**1MCGI206D**	*Scheme*	*2026*
Type of Course	**Professional Elective Course**	*Semester*	*I*
Teaching Hours/Week (L:T:P)	*42(3:0:0)*	*CIE Marks*	*50*
Total Hours of Pedagogy per Semester CI (L /T): LI(P):TW&SL	*90 (42:0:0:48)*	*SEE Marks*	*50*
Credits	*3*	*Total Marks*	*100*
Type of Examination (SEE):	*Theory*	*Exam Hours*	*03*

Course outcome (Course Skill Set):

At the end of the course, the student will be able to:

1. **CO1:** *(L3-Apply) Apply GIS and spatial analytical techniques for geodemographic studies, population analysis, and spatial planning.*
2. **CO2:** *(L3-Apply) Utilize GIS, Remote Sensing, and GeoAI techniques for health mapping, disease surveillance, and public health planning.*
3. **CO3:** *(L3-Analyze) Analyze business and location-based problems using GIS for market analysis, site selection, customer profiling, and spatial decision support.*
4. *CO4: (L5- Evaluate) Evaluate and apply GIS and Remote Sensing techniques for tourism planning, cultural heritage management, and archaeological applications.*
5. **CO5***(L6- Create) Develop GIS-based solutions for infrastructure planning and management in power, telecommunication, and transportation sectors.*

Module-1

Geodemographics and Spatial Analytics:

Geodemographics: *Spatial distribution and analysis of population based on age, gender, socio-economic characteristics and migration patterns; census and demographic data integration; population density mapping; urbanization and settlement dynamics; socio-economic and health inequality analysis; crime mapping and hotspot analysis; labour market analysis; population-environment interactions; spatial and temporal demographic analysis; GIS-based demographic modelling; geodemographic segmentation; location intelligence; dashboard-based demographic visualization; applications of GeoAI and machine learning in demographic analysis.*

Linked COs: CO1. **Number of Hours: 08 hrs**

Module-2

Business GIS and Location Intelligence:

Business GIS: *Location intelligence and business analytics; competitive market analysis; trade area delineation; site suitability analysis for retail stores, warehouses and distribution centres; customer profiling and market segmentation; consumer behaviour analysis; sales territory optimization; facility location modelling; logistics and supply chain management; spatial decision support systems; mobile GIS for business operations; real-time business dashboards; cloud GIS applications; geospatial big data analytics; AI-enabled market forecasting and business intelligence.*

Linked COs: CO2 **Number of Hours: 08 hrs**

Module-3

Health GIS and Spatial Epidemiology

Health GIS: *Spatial epidemiology and disease surveillance; mapping and modelling of communicable and noncommunicable diseases (malaria, dengue, tuberculosis, COVID-19, cancer and emerging diseases); disease hotspot detection and cluster analysis; environmental health assessment; health accessibility and service area analysis; healthcare infrastructure planning; emergency medical response; GIS-based public health decision support; telemedicine and mobile health applications; GeoAI and machine learning in disease prediction; integration of IoT and real-time health monitoring; health dashboards and web-based disease surveillance systems.*

Linked COs: CO3 **Number of Hours: 09 hrs**

Module-4

GIS Applications in Power, Telecommunication, and Transportation Networks:

Power: *GIS for renewable energy planning; solar, wind, hydro and thermal power site suitability analysis; transmission and distribution network planning; smart grid applications; underground utility mapping; asset management; infrastructure monitoring using UAVs and remote sensing; digital twin concepts for utility management.*

Telecommunication: *GIS for telecom infrastructure planning; mobile network coverage analysis; 5G network planning; optical fibre network design; telecom asset management; internet GIS applications.*

Transportation: *Intelligent Transportation Systems (ITS); route optimization; fleet and logistics management; vehicle tracking using GNSS and IoT; traffic flow analysis; public transportation planning; smart mobility; electric vehicle charging infrastructure planning; GIS-enabled transportation decision support systems.*

Linked COs: CO4 **Number of Hours: 09 hrs**

Module-5

GIS for Tourism, Archaeology, and Cultural Heritage Management:

Tourism GIS: *Tourism resource inventory; tourism planning and destination management; ecotourism planning; tourism marketing; location-based tourism services; web GIS and mobile GIS for tourism; tourism impact assessment; smart tourism applications; 3D virtual tourism and digital tourism platforms.*

Archaeology and Cultural Heritage GIS: *Remote sensing and GIS for archaeological investigations; mapping and monitoring cultural heritage sites; heritage conservation planning; LiDAR and UAV applications in archaeology; historical GIS; palaeoriver identification; digital documentation of monuments; 3D heritage modelling; UNESCO heritage site management using GIS.*

Linked COs: CO5, CO6. **Number of Hours:08 hrs**

Suggested Learning Resources:

Text Books:

1. *Nyerges, T. L. and Jankowski, P., Regional and Urban GIS: A Decision Support Approach, Guilford Press, 2009.*
2. *Ballas, D., Clarke, G., Franklin, R. S. and Newing, A., GIS and the Social Sciences: Theory and Applications, Routledge, 2017.*
3. *Longley, P. A., Goodchild, M. F., Maguire, D. J. and Rhind, D. W., Geographical Information Systems: Principles, Techniques, Management and Applications, Wiley, abridged second edition, 2005.*
4. *GIS and Public Health, 2nd Edition, Guilford Publications, 2011.*
5. *Geoinformatics in Theory and Practice: An Integrated Approach to Geoinformation Systems, Remote Sensing and Digital Image Processing, publisher details not fully confirmed from the source retrieved.*
6. *Geographic Information Analysis for Sustainable Development and Economic Planning: New Technologies, publisher details not fully confirmed from the source retrieved.* **Reference Books:**

1. **John P. Wilson**, *The Handbook of Geographic Information Science,* **2nd Edition**, *Wiley-Blackwell, 2022.*
2. **Harvey J. Miller and Shih-Lung Shaw**, *Geographic Information Systems for Transportation: Principles and Applications, Oxford University Press.*
3. **Andrew J. Curtis**, *Spatial Epidemiology: Methods and Applications, CRC Press.*
4. **Yeqiao Wang**, *GIS for Environmental Applications: A Practical Approach, CRC Press, 2015.*

e-Resources

https://www.esri.com/en-us/arcgis/products/index
https://docs.qgis.org/ https://www.ogc.org/
https://docs.geoserver.org/
https://developers.google.com/earth-engine
https://www.worldpop.org/

Teaching-Learning Process (Innovative Delivery Methods):

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes.

- *Interactive lectures, GIS demonstrations, case studies, and hands-on spatial analysis exercises.*
- *Lectures, real-world case studies, GIS-based site selection exercises, and group discussions.*
- *Classroom lectures, disease mapping demonstrations, practical sessions using GIS and Remote Sensing, and case studies.*
- *Demonstrations, laboratory exercises on network analysis and utility mapping, and project-based learning*
- *Interactive lectures, GIS mapping exercises, case studies, and mini-projects on tourism and heritage applications.*

Assessment Structure (both CIE and SEE)

2 *The weightage assigned to Continuous Internal Evaluation (CIE)*

and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of

50 % of the maximum marks prescribed for CIE and a minimum of 40 % of the maximum marks prescrib

ed for SEE to be eligible for passing.

A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken together.

Continuous Internal Evaluation:

Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal Evaluation CIE [25+25=50 marks]

A minimum of two Internal Assessment Tests (IA) shall be conducted. Each test shall be conducted for a maximum of 25 marks. The average of the two test marks shall be the marks secured by a student in IA.

In addition, Continuous Comprehensive Assessment (CCA) shall be conducted for a total of 25 marks

Students' activities for TW/SL under NCrF: Samples only

As per National credit formwork (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions (CI-42 hour) and Teamwork/ Self learning (TW/Sl-48 hours). Hence, students must complete minimum of two actives as part of NCrF. These learning activities shall be considered as CCA components of CIE. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below. The sample activities are given below. The course coordinator can also give their own TW/SL activities as per the course outcomes.

Sl. No.	**Term Work (TW) Activity**	**Number of Hours / Semester**
1	*Develop a GIS-based demographic analysis project using census and spatial data. Perform site suitability analysis for a business or public facility using GIS.*	*2*

Prepare a Healt

			(2)	Improvement (1)
Technical Contribution	*Independently completes assigned tasks with high accuracy*	*Completes tasks with minor guidance*	*Completes basic tasks*	*Limited contribution*
Team Collaboration	*Actively participates and supports the team*	*Cooperates well with team members*	*Participates occasionally*	*Rarely participates*
Problem Solving	*Applies appropriate GIS techniques and provides innovative solutions*	*Solves most problems correctly*	*Solves simple problems*	*Unable to solve problems effectively*
Presentation & Communication	*Clear, well-organized presentation with confident explanation*	*Good presentation*	*Basic presentation*	*Poor presentation and communication*

h GIS map for disease distribution and healthcare accessibility. Design a GIS application for transportation, utility, or tourism planning and present the results as a team.

SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.

Sl. No.	Self-Learning (SL) Activity
1	*Explore open geospatial datasets (Census, WHO, OpenStreetMap) and prepare thematic maps. Study GeoAI, Location Intelligence, and Smart City GIS applications through online resources.*
2	*Learn and practice GIS tools for network analysis, site suitability, and spatial modeling. Prepare a technical report or seminar on recent GIS applications in health, business, infrastructure, or tourism.*

Sample rubrics for TW activities:

24

24

Number of Hours / Semester

24

24

Criteria	Excellent (4)	Good (3)	Satisfactory	Needs

3 **Sample rubrics for Self-Learning activities:**

Criteria	*Excellent (4)*	*Good (3)*	*Satisfactory (2)*	*Needs Improvement (1)*
Learning Initiative	*Explores additional GIS resources beyond the syllabus*	*Completes all assigned learning activities*	*Completes basic activities*	*Minimal effort*

Technical Understanding	*Demonstrates excellent understanding and application*	*Good understanding*	*Basic understanding*	*Poor understanding*
Documentation	*Well-organized, complete and technically accurate*	*Good documentation*	*Basic documentation*	*Incomplete documentation*
Timely Submission	*Always submits on time*	*Minor delay*	*Occasional delay*	*Late submission*

GIS & EARTH OBSERVATION LAB			
Course Code	*1MCGIL207*	*Scheme*	*2026*
Type of Course	*PCCL*	*Semester*	*II*
Teaching Hours/Week (L :T : P)	*(0: 0 : 28)*	*CIE Marks*	*50*
Total Hours of Pedagogy L :T:P:SL:TW	*(0: 0 : 28 :2)*	*SEE Marks*	*50*
Credits	*1*	*Total Marks*	*100*
Type of Examination	*Practical*	*Exam Hours*	*3*

Course outcome (Course Skill Set)

At the end of the course, the student will be able to:

1. *Develop practical skills in GIS and Earth Observation data processing.*
2. *Handle and analyze satellite imagery using GIS tools.*
3. *Perform spatial data creation, editing, and analysis.*
4. *Generate thematic maps and spatial outputs.*
5. *Apply geospatial workflows for environmental and urban applications.*

Note:

1. *The laboratory syllabus consists of PART-A and PART-B. While PART-A has 6-8 conventional experiments, PART-B has 6 typical open-ended experiments. The maximum marks for the laboratory course are 100.*
2. *Both PART-A and PART-B are considered for CIE and SEE.*
3. *Students have answer 1(one) question from PART-A and 1(one) question from PART-B.*
    a. *The questions set for SEE shall be from among the experiments under PART-A. It is evaluated for 80 marks out of the maximum 100 marks.*
    b. *The open-ended question set for SEE shall be any other open-ended question and not selected from the experiments under PART-A. It shall be evaluated for 20 marks.*

For Continuous Internal Evaluation (CIE) during the semester, classwork shall typically include open-ended questions from Part-B, along with other similar questions designed to enhance the students' skills

List of experiments

2. *Introduction to GIS Software- Interface and tools in QGIS, Loading raster and vector datasets, Advanced mapping, analytics, and data management in ArcGIS Pro.*
3. *Spatial Data Creation and Editing- Creation of point, line, and polygon layers, Attribute table management. Coordinate Reference Systems- Assigning and transforming CRS, Georeferencing spatial data.*
4. *Vector Data Analysis- Buffering, Overlay operations (intersection, union, clip), Spatial joins.*
5. *Earth Observation Data Processing- Satellite Data Handling- Downloading and visualizing satellite data, Band combinations and visualization.*
6. *Image Enhancement Techniques- Contrast stretching, Filtering techniques*
7. *Supervised Image Classification- Training sample selection, Classification and accuracy assessment.*
8. *Unsupervised Classification- Clustering techniques, Land use/land cover mapping*
9. *Spatial Analysis and Mapping- Digital Elevation Model (DEM) Analysis, Slope and aspect generation, Terrain visualization.*
10. *Raster Analysis- Raster calculator, Reclassification*
11. *Thematic Map Preparation- Layout design, Map elements (legend, scale, north arrow)*
12. *Cloud-Based Geospatial Analysis - Introduction to Cloud GIS- Basics of Google Earth Engine*
13. *Satellite Data Analysis using Cloud Platforms- Visualization and time-series analysis, NDVI and environmental indices*

Suggested Learning Resources: (Text Book/ Reference Book/ Manuals):

Text books:

1. *Sabins, F. F. and Ellis, J. M., Remote Sensing: Principles, Interpretation, and Applications, 4th Edition, Waveland Press, 2020. This is especially useful because the companion lab manual is designed for ArcGIS Pro/Desktop and satellite image processing exercises.*
2. *Chang, K.-T., Introduction to Geographic Information Systems, 5th Edition, McGraw-Hill, 2010. It is a strong introductory GIS text for lab workflows and basic spatial analysis*
3. *Jensen, J. R., Remote Sensing of the Environment: An Earth Resource Perspective, 2nd Edition, Pearson Prentice Hall, 2007. It is a standard remote sensing reference for interpretation and environmental applications*
4. *Longley, P. A., Goodchild, M. F., Maguire, D. J. and Rhind, D. W., Geographical Information Systems: Principles, Techniques, Management and Applications, Wiley, abridged second edition, 2005. It is useful as a broader GIS reference for advanced lab discussion.*
5. *Lillesand, T., Kiefer, R. W. and Chipman, J., Remote Sensing and Image Interpretation, 7th Edition, Wiley, 2015. It is a solid remote sensing text for image interpretation and analysis concepts.* **Recommended software tools**
   1. *ArcGIS Pro or ArcGIS Desktop, with Spatial Analyst for GIS and remote sensing labs.*
   2. *SNAP, the Sentinel Application Platform, for Earth observation processing and Sentinel data analysis; ESA provides it free of charge.*
   3. *QGIS, a free and open-source GIS platform suitable for mapping, spatial analysis, and general lab work.*
   4. *ENVI, a professional remote sensing image-processing package widely used for imagery analysis.*
   5. *ERDAS IMAGINE, another established remote sensing software for raster/image analysis.*
   6. *Google Earth Pro, useful for quick visualization, interpretation, and basic geo-exploration.*
   7. *GRASS GIS, for open-source geospatial analysis, modeling, and visualization.*
   8. *Orfeo Toolbox, for advanced open-source remote sensing and image processing workflows.*
   9. *PCI Geomatica or Catalyst, for EO and image processing where available.*

Web links and Video Lectures (e-Resources): **https://bhuvan.nrsc.gov.in?utm_source=chatgpt.com**
https://mosdac.gov.in?utm_source=chatgpt.com
https://developers.google.com/earth-engine?utm_source=chatgpt.com
https://developers.google.com/earth-engine/datasets?utm_source=chatgpt.com
https://search.earthdata.nasa.gov?utm_source=chatgpt.com

Teaching-Learning Process (Innovative Delivery Methods):

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes.

1. *Hands-on lab sessions with guided exercises*
2. *Demonstration of real-world geospatial workflows*
3. *Mini-project using satellite and GIS datasets*

Assessment Structure (both CIE and SEE)

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for a pass in the course.
A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject /course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken together.

Continuous Internal Evaluation (CIE):

For the Professional Core Course Laboratory, the maximum marks prescribed are 100. Out of these, 50 marks are allotted for Continuous Internal Evaluation (CIE) and 100 marks for the Semester End Examination (SEE). The SEE marks obtained out of 100 shall be proportionately scaled down to 50 marks. The final result shall be declared based on the aggregate of the CIE marks (50) and the scaled-down SEE marks (50), totalling 100 marks."

Out of 50 marks, 40 marks shall be assigned for assessment of regular laboratory PART -A classwork, and 10 marks for Part – B. (Table 1)

Out of 40 marks, 25 marks shall be based on the regular classwork and allotment of marks shall be as per rubrics listed in Table 1.

The remaining 15 marks shall be based on the practical test conducted by two Internal examiners appointed by the HoD. The allotment of marks shall be as per the rubrics defined for the practical test as indicated in the Table 1. The open-ended question set for CIE shall be any other open-ended question and not selected from the experiments under PART-A. It shall be evaluated for 10 marks. The allotment of marks shall be as per rubrics listed in Table 2.

Tabl – 1 Distribution of marks corresponding to laboratory component

Component	*Description*	*Marks*
Allotment of marks for regular classwork		
Ability in Conducting Experiments	*Initiative, skill, safety practices, teamwork, and independent handling of equipment during regular lab sessions.*	*10 marks*
Laboratory Record / Journal	*Regular and neat maintenance of lab record, accuracy of results, and timely submission.*	*15 marks*
Subtotal		*25*
Allotment of marks for CIE practical test		
Laboratory Test / Experiment Performance	*Ability to set up apparatus, follow procedure, take observations, and obtain correct results in the test experiment.*	*5 marks*
Viva-Voce	*Understanding of theory, concepts, and experimental procedure; ability to explain results and answer related questions.*	*10marks*
Subtotal		*15*
Total		*40*

Table 2 Distribution of marks corresponding to PART -B of the laboratory component

Evaluation Rubrics for continuous internal evaluation CIE). Maximum marks:10

Criteria and Guiding factors	*Students' Level and Rubrics*			
	Excellent: E, Good: G, Fair: F Needs Improvements: NI			
	E	*G*	*F*	*NI*
(1) Problem Understanding *Criteria: Is the problem understood correctly and framed appropriately?* *(i)Clarity in interpreting the given problem.* *(ii)Identification of relevant concepts and constraints.* *(iii) Ability to rephrase or model the problem logically.*	*2.0*	*1.5*	*1.0*	*0.5*

(2) Conceptual Knowledge *Criteria: Are the chosen methods or concepts valid for this type of problem?* *(i)Application of appropriate theories, principles, or laws.* *(ii)Integration of multiple concepts where necessary.* *(iii)Accuracy in stating relevant equations or models.*	*2.0*	*1.5*	*1.0*	*0.5*
(3) Approach and Strategy *Criteria: Is the approach well thought out and methodical?* *(i)Logical structure and progression.* *(ii)Use of diagrams, sketches, or flowcharts if applicable.* *(iii)Identification of assumptions and boundary conditions.*	*2.0*	*1.5*	*1.0*	*0.5*
(4) Execution and Accuracy *Criteria: Are the calculations correct? Is the final solution reasonable?* *(i) Correct application of formulas/methods.* *(ii)Accuracy of calculations or simulations (if any).* *(iii)Unit consistency and result verification.*	*2.0*	*1.5*	*1.0*	*0.5*
(5) Innovation or Depth *Criteria: Has the student shown original thinking or alternative methods?* *(i)Novel or efficient solutions.* *(ii)Consideration of alternate approaches.* *(iii)Interdisciplinary integration or practical extensions.*	*1*	*0.75*	*0.5*	*0.25*
(6) Presentation and Clarity *Criteria: Is the answer easy to follow and professionally written?* *(i)Organization and neatness.* *(ii)Clarity of explanation, labelling, and steps.* *(iii) Use of proper technical terminology.*	*1*	*0.75*	*0.5*	*0.25*
Total	*10*	*7.5*	*5.0*	*2.5*

Note:
(i)The marks shown for Excellent, Good, Fair, Needs Improvement are indicative. The evaluator may also assign intermediate scores depending on the quality of work.
(ii)If the total score results in a fraction, it should be rounded off to the next higher integer.
(iii)The listed criteria are guidelines; evaluators may also consider other authentic dimensions (e.g., depth of insight, critical thinking, and practical awareness, recognition of limitations, or justified compromises.
(iv)To award the full10 marks in the excellent category, the student must demonstrate reasonably good performance across all six criteria; otherwise, proportionally lower marks may be given.

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