GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Bachelor of Engineering
Level: UG
Branch: ALL (Except Civil Engineering and Allied Branches)
Subject Code: BE05000441
Subject Name: Application of RS and GIS in Engineering

w. e. f. Academic Year:	2024-25
Semester/Year	5
Category of the Course:	MOPEC

Prerequisite:	Nil
Rationale:	The subject of RS–GIS includes interdisciplinary, practical, and aligned with current industry trends topics. It incorporates modern tools, open-source software, and freely available geospatial data to ensure accessibility and hands-on learning. The content is broadened to cater diverse branches such as Environmental, IT, and AI/ML. Emphasis is given to real-world applications like climate change, smart cities, and disaster management. The syllabus also promotes higher-order thinking and problem-solving skills, enhancing student employability and relevance to global sustainability goals.

Course Outcome:
After Completion of the Course, Student will be able to:

No	Course Outcomes	RBT Level
CO-1	Identify and analyze real-world engineering problems where RS & GIS can be applied using modern datasets.	U, N
CO-2	Apply image interpretation and processing using open tools.	A
CO-3	Integrate spatial and non-spatial datasets from multiple free sources to develop GIS-based solutions.	R, U, N
CO-4	Design and implement spatial analysis workflows for solving engineering problems using GIS tools.	A, N, C
CO-5	Evaluate and communicate geospatial solutions effectively using maps, reports, and digital platforms.	E

Teaching and Examination Scheme:

Teaching Scheme (in Hours)					Total Credits =TH/30	Assessment Pattern and Marks					Total Marks
						Theory		Tutorial / Practical			
L	T	P	PBL	TH		ESE (E)	PA (M)	PA/ (I)	TW/ SL(I)	ESE (V)	
45	0	0	15	60	2	70	30	20	00	00	120

where L = Lecture, T= Tutorial, P= Practical, PBL=project base learning, TH = Total Hours, ESE = end- Semester Examination, PA = Progressive Assessment/

Course Content:

Sr. No.	Course Content	No. of Hours	% of Weightage
1	FUNDAMENTALS OF REMOTE SENSING: • Introduction to Remote Sensing: Definition, components, and role in multidisciplinary applications. • Types of Remote Sensing: Active and Passive systems with real-world examples (weather radar, satellite imaging). • Electromagnetic Spectrum: Basic concepts and relevance in environmental monitoring, imaging systems, and sensor design. • Interaction of EMR with Atmosphere: Scattering, absorption, atmospheric windows and implications for weather, climate, and communication systems. • Interaction of EMR with Earth's Surface: Spectral signatures of natural and built features (vegetation, water, soil, urban areas). • Introduction to freely available satellite data and platforms (Bhuvan, USGS, Copernicus). • Basic visual interpretation using tools like Google Earth.	7	12
2	REMOTE SENSING DATA PRODUCTS: • Types and classification of remote sensing data products (optical, thermal, microwave). • Spatial, spectral, radiometric, and temporal resolutions. • Freely available RS datasets: Bhuvan, USGS Earth Explorer, Copernicus Open Access Hub. • Overview of modern satellite missions (e.g., NISAR, Sentinel, Landsat). • Introduction to UAV/Drone-based remote sensing and its applications. • Data formats, metadata, and data preprocessing basics.	6	12
3	INTRODUCTION TO GEOGRAPHIC INFORMATION SYSTEM: • Definition and scope of GIS in multidisciplinary applications (engineering, environment, IT, business analytics). • Components of GIS (hardware, software, data, methods, people). • Spatial vs Non-spatial data and their integration. • Data input/output methods (manual, GPS, remote sensing, APIs). • Data standards and formats (Shapefile, GeoJSON, KML). • Coordinate systems and map projections; georeferencing concepts. • Introduction to spatial data infrastructure and open data ecosystems.	6	12

4	RS-GIS SOFTWARE AND OPEN PLATFORMS: • Overview of GIS and image processing software (QGIS, SNAP, Google Earth Engine). • Capabilities and limitations of open-source vs commercial tools. • Data management and visualization in GIS platforms. • Spatial data models: Raster and Vector. • Attribute data management and database basics. • Open GIS data sources: OpenStreetMap, Natural Earth, Bhuvan. • Mobile GIS tools (QField, SW Maps) and field data collection. • Introduction to Web GIS and cloud-based geospatial platforms.	6	12
5	IMAGE INTERPRETATION AND DIGITAL IMAGE PROCESSING: • Digital image fundamentals: sensors, image formats, and visualization. • Visual interpretation techniques: tone, texture, pattern, shape, association using tools like Google Earth. • Image processing techniques: NDVI, NDWI, NDBI, change detection. • Image enhancement: contrast stretching, filtering, band combinations. • Image rectification and restoration. • Introduction to AI/ML-based classification concepts (non-mathematical overview).	7	18
6	GIS SPATIAL DATA ANALYSIS: • Spatial and non-spatial data operations in GIS. • Raster vs Vector analysis in QGIS. • Terrain analysis using DEM: slope, aspect, hillshade, drainage network. • Introduction to Python in GIS (conceptual exposure for IT/AI students). • Use of GIS plugins and processing tools. • Basics of spatial modeling and decision support systems.	7	18
7	APPLICATION OF REMOTE SENSING & GIS: • Smart cities, urban analytics, and infrastructure planning. • Climate change monitoring and sustainability assessment. • Disaster management: floods, fires, earthquakes (real-time monitoring). • Agriculture and environmental applications (crop monitoring, deforestation). • Introduction to Web-GIS and geospatial dashboards. • Case studies using free datasets (Bhuvan flood maps, Sentinel LULC mapping).	6	16

	• Emerging trends: AI/ML in geospatial analysis, IoT integration, big geospatial data.		

Distribution of Theory Marks (in %)					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
5	25	30	15	10	15

Where R: Remember; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create (as per Revised Bloom's Taxonomy)

Reference Book:

1. Lilliesand T.M. and Kiefer R.W., Remote Sensing and image Interpretation , John Wiley and Sons, New York, 2004.
2. Burrrough P.A and McDonnel R.A., Principles of Geographic Information Systems, Oxford university press, 1998.
3. A.M. Chandra and S.K. Ghosh,Remote Sensing and Geographical information System, Narosa Publishing House, New Delhi, 2006.
4. Bhatta B., Remote Sensing and GIS, Oxford University Press, New Delhi, 2008
5. Stan Aronoff, "Geographical Information Systems", WDL Publications, Ottawa, Canada, 1989.
6. Agrawal N. K., Essentials of GPS, Spatial Network Pvt. Ltd., Hydrabad, 2004.
7. Lo C.P. and Yeung Albert K.W., Concepts and Techniques of Geographical Information Systems, Prentice-Hall of India Pvt. Ltd. New Delhi, 2006.

Sustainable Development Goals Addressed:

SDG 4 – Quality Education
- Promotes modern, interdisciplinary, and skill-based geospatial education.

SDG 6 – Clean Water and Sanitation
- Supports water resource mapping, watershed analysis, and hydrological monitoring.

SDG 9 – Industry, Innovation and Infrastructure
- Introduces advanced technologies like UAVs, AI/ML, and geospatial innovation.

SDG 11 – Sustainable Cities and Communities
- Enables urban planning, smart city development, and infrastructure analysis.

SDG 13 – Climate Action
- Supports climate monitoring, disaster management, and environmental sustainability.

SDG 15 – Life on Land
- Helps in vegetation mapping, biodiversity monitoring, and land management.

Open-source software and website:

1. http://nptel.ac.in/
2. Indian Data Sources: Bhuvan Geoportal URL: https://bhuvan.nrsc.gov.in, Data: IRS imagery, thematic maps, flood maps, LULC
3. Global Data Sources:
    a. USGS Earth Explorer URL: https://earthexplorer.usgs.gov, Data: Landsat, SRTM DEM, MODIS.
    b. Copernicus Open Access Hub URL: https://scihub.copernicus.eu, Data: Sentinel-1 (SAR), Sentinel-2 (optical), Sentinel-3.
4. High-resolution and free source: NASA Earthdata URL: https://earthdata.nasa.gov, Data: MODIS, TRMM, GPM, climate data
5. Free GIS Data Sources:
    a. OpenStreetMap URL: https://www.openstreetmap.org, Data: Roads, buildings, infrastructure.
    b. Editable and crowd-sourced: Natural Earth URL: https://www.naturalearthdata.com, Data: Administrative boundaries, physical features.
    c. DIVA-GIS URL: https://www.diva-gis.org, Data: Country-level GIS datasets.
    d. FAO GeoNetwork: URL: https://www.fao.org/geonetwork, Data: Soil, agriculture, water resources.
6. Hydrology & Climate Data:
    a. CHIRPS URL: https://www.chc.ucsb.edu/data/chirps, Data: Rainfall time-series.
    b. GPM (Global Precipitation Measurement) URL: https://gpm.nasa.gov, Data: Satellite rainfall
    c. WorldClim URL: https://www.worldclim.org, Data: Temperature, precipitation.
7. Free GIS & Remote Sensing Software
    a. Desktop GIS Software: QGIS URL: https://qgis.org.
    b. GRASS GIS URL: https://grass.osgeo.org, Advanced spatial analysis
    c. SAGA GIS URL: https://www.saga-gis.org, Strong in DEM analysis
8. Remote Sensing Software:
    a. SNAP URL: https://step.esa.int, Ideal for Sentinel data.
    b. Orfeo Toolbox URL: https://www.orfeo-toolbox.org, Image classification & ML
9. Cloud-Based Platforms: Google Earth Engine URL: https://earthengine.google.com,
10. Mobile GIS Apps (Field Data Collection): QField, Android app for field surveys. SW Maps Easy field data collection. Google Earth Visualization & interpretation

Suggested Course Practical/Assignment List: Students should follow the DTE laboratory manual for assignments and practical.

Suggested list of Experiment:

1. Downloading data from USGS Earth Explorer / BHUVAN
2. Digitization using QGIS + OpenStreetMap
3. Field data collection using QField

4. NDVI calculation using Sentinel data
5. Simple Web Map creation/ Country map

Suggested Micro/Mini Projects under Project Based Learning (PBL)			
A. Beginner Level Micro Projects:			
Sr. No.	Project Title	Tools/Data Sources	Approximate Hours
1	Land Use/Land Cover Mapping of Local Area	QGIS + Sentinel Data	5
2	Mapping Water Bodies using NDWI	QGIS/SNAP + Sentinel	5
3	Urban Growth Analysis using Google Earth Images	Google Earth + QGIS	5
4	Road Network Mapping using OpenStreetMap	OSM + QGIS	5
5	Tree Cover Mapping in Campus Area	Google Earth + QGIS	7.5
6	Flood-Prone Area Identification using DEM	SRTM DEM + QGIS	5
7	Campus Utility Mapping	QField + QGIS	7.5
8	Change Detection of Nearby Area using Satellite Images	Landsat/Sentinel	5
9	Mapping Solid Waste Dumping Locations	Mobile GIS + QGIS	5
10	Village/City Base Map Preparation	OSM + QGIS	5
B. Environmental & Sustainability Projects:			
Sr. No.	Project Title	Tools/Data Sources	
11	Monitoring Vegetation Health using NDVI	Sentinel-2 Data, QGIS, SNAP	10
12	Rainfall Trend Visualization using CHIRPS Data	CHIRPS Rainfall Data, QGIS, Google Earth Engine	10
13	Air Pollution Mapping using Open Data	CPCB/OpenAQ Data, QGIS	5
14	Wetland Inventory Mapping	Landsat/Sentinel Data, QGIS	7.5
15	Watershed Delineation and Analysis	SRTM DEM, QGIS, GRASS GIS	7.5
16	Climate Vulnerability Mapping of Local Area	WorldClim Data, QGIS	7.5
17	Heat Island Mapping using Thermal Data	Landsat Thermal Bands, QGIS	5
18	Deforestation/Green Cover Change Study	Landsat Time-Series Data, Google Earth Engine	5

C. Smart City & Urban Analytics Projects:			
Sr. No.	Project Title	Tools	
19	Smart Parking Location Suitability Analysis	QGIS	5
20	Public Transport Accessibility Mapping	OSM + QGIS	5
21	Hospital/School Service Area Analysis	Buffer Analysis	5
22	Traffic Congestion Mapping using GPS Data	Mobile GIS	5
23	Urban Sprawl Analysis using Satellite Images	Landsat/Sentinel	5
24	Site Suitability Analysis for EV Charging Stations	GIS Overlay Analysis	5
D. Water Resources Engineering Projects:			
Sr. No.	Project Title	Tools/Data	
25	Reservoir Area Monitoring using Satellite Data	Sentinel	7.5
26	River Course Change Detection	Landsat Time Series	7.5
27	Flood Inundation Mapping using Bhuvan Data	Bhuvan + QGIS	5
28	Groundwater Recharge Zone Mapping	DEM + GIS Layers	10
29	Rainwater Harvesting Site Selection	GIS Overlay	5
30	Stream Network Extraction using DEM	SRTM + QGIS	5
E. IT / Computer / AI-ML Oriented Projects			
Sr. No.	Project Title	Focus Area	
31	Web GIS Dashboard for Local Area	Web GIS	5
32	Satellite Image Classification using ML (Basic)	AI/ML	10
33	Python-based GIS Automation Workflow	Python + QGIS	5
34	GeoJSON-based Interactive Map Development	Web Mapping	5
35	GPS-based Mobile Data Collection App Study	Mobile GIS	10
36	AI-based Land Cover Classification (Conceptual)	AI in GIS	5
37	Spatial Database Creation using PostgreSQL/PostGIS	Spatial DBMS	5
F. Disaster Management Projects			
Sr. No.	Project Title	Application	
38	Flood Hazard Zonation Mapping	Disaster Management	7.5
39	Earthquake Vulnerability Mapping	Risk Analysis	5
40	Forest Fire Risk Mapping	Environmental Monitoring	5
41	Cyclone Tracking Visualization using Open Data	Climate Studies	5

42	Emergency Route Planning using Network Analysis	GIS Routing	5
G. Advanced/Open Innovation Projects			
Sr. No.	Project Title	Platform	
43	Google Earth Engine-based Time Series Analysis	GEE	5
44	UAV/Drone Image Mapping Workflow	Drone Data	5
45	Smart Agriculture Monitoring System	GIS + IoT	5
46	Multi-Criteria Decision Analysis for Site Selection	MCDA	5
47	Interactive SDG Monitoring Map using GIS	Sustainability	10
48	Digital Twin Concept using GIS Data	Emerging Tech	10

Recommended Structure for PBL

Each project may include:

1. Problem Statement
2. Objectives
3. Data Collection
4. Methodology
5. GIS/RS Analysis
6. Results & Maps
7. Conclusion

Expected Learning Outcomes from PBL

Students will learn:

- Geospatial problem solving
- Open-source GIS workflows
- Spatial data analysis
- Teamwork & reporting

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