CURRICULUM
FOR
POSTGRADUATE DEGREE COURSE

M.Tech.
in
REMOTE SENSING
[W.E.F. 2023-2024]

DEPARTMENT OF GEO ENGINEERING & RDT
A.U. COLLEGE OF ENGINEERING (AUTONOMOUS)
ANDHRA UNIVERSITY VISAKHAPATNAM-530 003
## M.Tech. (REMOTE SENSING)
### Scheme of Instruction and Examination
(with effective from 2023-24 admitted batch)

### SEMESTER – I

<table>
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<tr>
<th>Code</th>
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**RS 1.4:**
- a) Environmental Planning & Impact Assessment
- b) Natural Hazards & Disaster Risk Management
- c) Earth Systems and Processes
- d) Geodesy and GNSS

**RS 1.5:**
- a) Agriculture & Soil Resources Management
- b) Forest Resource & and Ecosystem Analysis
- c) Coastal Zone Management
- d) Planetary Remote Sensing
## SEMESTER – II

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**RS 2.3:**
- a) Water Resources Development
- b) Water Resources Management
- c) Water Resources Assessment
- d) Hydrology and Water Resources Engineering

**RS 2.4:**
- a) Urban & Regional Studies
- b) Geological Remote Sensing
- c) GIS for Utilities
- d) GIS for Transportation Engineering
### SEMESTER – III

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**RS 3.1:**
- a) Drone & UAV Remote Sensing
- b) Climate Change Studies
- c) Health GIS
- d) Airborne and Terrestrial LIDAR

**RS 3.2:**
- a) WebGIS Development
- b) Spatial Data Warehousing and Data Mining
- c) Spatial Relational Database Management Systems
- d) Digital Cartography

### SEMESTER – IV

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SEMESTER I

RS 1.1 REMOTE SENSING & PHOTOGRAMMETRY

Unit-I

**Interaction of EMR:** With atmosphere, Atmospheric Windows, imaging spectrometry, Interaction with Earth. Spectral signature of various land cover features.

Unit-II
**Platforms:** Types of platforms. Orbits of satellites, Kepler’s Law, satellite characteristics, satellites for Earth observations studies, and planetary missions.

**Sensors:** Types and classification of sensors, imaging modes, Characteristics of optical sensors, sensor resolution-spectral, radiometric and temporal, Characteristics of detectors.

Unit-III
**Data Reception, Processing and Image Interpretation.**

**Visual Image Interpretation:** Basic principles of Visual Interpretation Elements of Visual Interpretation, Techniques of Visual Interpretation, Interpretation Keys

Unit-IV

**Analytical and Digital Photogrammetry:** Concepts of orientation-interior, relative and absolute orientation of aerial photographs, Strip triangulation, Block Adjustment of Independent Models (BAIM), Special cases (resection, intersection, and stereo-pair generation), Aerial triangulation, Block adjustment, Orthophotos, mosaics.

Unit-V


Text Books:
RS 1.2 GEOGRAPHIC INFORMATION SYSTEMS

Unit-I

Unit-II

Unit-III

Unit-IV
Network Analysis and Surface Analysis: Network – Creating Network Data - Origin, Destination, Stops, Barriers – Closest Facility Analysis, Service Area Analysis, OD Cost matrix analysis, Shortest Path Analysis – Address Geocoding – Surface Analysis – DEM, DTM - Point data to Surface interpolation – DEM Representation – Applications

Unit-V

Text Books:
RS 1.3 RESEARCH METHODOLOGY & IPR

Unit-I

Unit-II

Unit-III

Unit IV

Unit V
New Developments in IPR: Administration of Patent System - New developments in IPR; IPR of Biological Systems, Computer Software etc. - Traditional knowledge Case Studies, IPR and IITs.

Text Books & References:

RS 1.4 Program Elective-I

a. ENVIRONMENTAL PLANNING & IMPACT ASSESSMENT

Unit-I
Introduction to Environmental Planning & Policy: Principles of environmental planning and policy; The historical evolution of environmental policies; International environmental agreements and treaties; Sustainable development goals and their relevance; The role of government agencies and NGOs in environmental policy-making. Environmental Policy Development: Environmental policy formulation and implementation process: Stakeholder engagement and public participation; Regulatory frameworks and compliance;

Unit-II

Unit-III
Environmental Data and GIS Analysis: Geospatial analysis techniques for informed planning decisions; Integration of remote sensing and GIS for environmental planning: Data fusion approaches for enhancing planning data, Ensuring interoperability between remote sensing and GIS technologies. Spatial analysis methods: Geostatistics and spatial interpolation, Multi-criteria decision analysis (MCDA) for environmental assessment.

Unit-IV
Environmental Planning & Resource Management: Using GIS for land-use planning, Zoning and land suitability analysis; Urban and regional planning applications; Applications of remote sensing in ecosystem monitoring and conservation: Forest cover analysis, Wetland mapping and monitoring; Sustainable resource management: Water resource management with GIS, Agriculture and natural resource management

Unit-V
Environmental Impact Assessment (EIA): Need of EIA; Scope and objectives; Types of environmental impacts; Steps involved in conducting the EIA Studies; Environmental Impact Assessment techniques- Ad-hoc method, checklist method, overlay mapping method, network method, simulation and modeling technique, matrix method, and system diagram technique; Merits and Demerits of EIA studies.

Textbooks:
1. "Environmental Policy: New Directions for the Twenty-First Century" by Norman J. Vig and Michael E. Kraft.
b. NATURAL HAZARDS AND DISASTER RISK MANAGEMENT

Unit-I
Concepts and overview of Disaster Management: Fundamentals and concepts of Vulnerability, Susceptibility, Risk Assessment and DRR. An overview of Natural Hazards (Geological, Hydrological and Environmental), Urban and industrial Hazards. Global Disaster Management Frameworks and International charter. Impact of Climate Change & Global Warming on frequency, intensity and recurrence of Natural Hazards.

Unit-II

Unit-III

Unit-IV

Unit-V
Coastal and Extreme weather events Hazards: Mapping and monitoring of coastal hazard – cyclones, erosion, salt water intrusion. Overview of space technology for tsunami hazard and early warning system (GL). Satellite remote sensing for extreme rainfall events. Fog, Haze, Smog & dust storm analysis & prediction with emphasis on DRR & mitigation. Overview of space technology for air quality related hazards – Aerosol, PM 2.5, PM 10.

Textbooks:
c. EARTH SYSTEMS AND PROCESSES

Unit-I

Unit-II

Unit-III

Unit-IV

Unit-V
Soil forming processes, Soil profile, Soil components. Pedogenic regimes. Classification of soils. Soils of India

Text Books:
1. Structural Geology by Billings, M. 1984
2. Earth History & Plate Tectonics by Carl K. Seyfert, Leslie A. Sirkin
4. General Climatology by H.J. Critchfield
5. Physical Geology by Arthur Holmes
6. Physical Geography by Stahler
7. The Atmosphere by Frederick K. Lutgens and Edward J. Tarbuck
d. GEODESY AND GNSS

**Basic principles of Geodesy:** History of Geodesy; Spherical Earth; Ellipsoidal Earth; Geoidal Earth; Geodetic Survey Systems; Horizontal Positioning – Determination of Astronomic position, Triangulation, Trilateration; Vertical Positioning.

**Fundamentals of Reference Systems and Frames:** Geodetic and Cartesian coordinate system; principles of coordinate transformation; Datums: Horizontal and vertical datums – national, regional and local datums; Major datums and Indian datum; World Geodetic System(WGS) WGS84; tidal datums. **Satellite Geodesy:** definition; observational systems: Historical systems; Doppler; laser; radar altimetry.

**Global Positioning System (GPS):** Definition; GPS elements – space segment, user segment and control segment; Observation principles; phase measurement techniques; determining orthometric heights; GPS Error Sources and Error Handling Procedures: Atmospheric effects, clock and orbital errors, multipath, anti-spoofing and selective availability, etc; interference and jamming. Accuracy issues, GPS satellite navigation message; GPS time, fundamental and derived frequencies. Multi-Channel, sequential and multiplexing receivers

**Surveying with GNSS:** Planning a GNSS Survey, Positioning methods – point positioning, relative positioning, Static, Differential, RTK, and Field data collection. **Data Processing:** Ambiguity resolution, Post-processing, real-time processing, Accuracy measures, software modules, GIS and GNSS data integration, Applications of GNSS

Applications: Defense, civilian, Navigational and Geodetic applications; GPS-GIS integration; GPS applications in surveying, mapping, GIS and land navigation and precision farming; integration with other sensors: GPS in intelligent transportation and fleet management.

**Textbooks:**

1. Physical Geodesy by Weikko A. Heiskanen and Helmet Moritz, Freeman and Company.
5. GNSS Insights into GPS, GLONASS, Galileo, Compass and Others, B. Bhatta., CRC Press, 2011
RS 1.5 Program Elective-II

a. AGRICULTURAL & SOIL RESOURCES MANAGEMENT

Unit-I
LULC & Crop Inventory: Land Use / Land Cover classification system (Global). Multi-temporal RS data for LULC mapping. Optical Spectral characteristics of crops, Spectral Vegetation Indices and Crop Inventory & mapping. Microwave sensors parameters and signatures of vegetation in reference to Polarization, incidence angle, frequency. Crop discrimination, crop growth monitoring retrieval from microwave RS.

Unit-II

Unit-III

Unit-IV

Unit-V
Textbooks:
1. Remote sensing applications (2009), Published by NRSC, ISRO, Hyderabad, Chapters – 1, 4 &13
5. 67–74. IAHS Publ. 186. IAHS Press, Wallingford, UK.
b. FOREST RESOURCE & ECOSYSTEM ANALYSIS

Unit-I

Unit-II
Forest Inventory: Forest inventory concept and scope. Sampling design survey. Sampling concept and methods, statistical treatment of inventory data. Growing stock, biomass estimation using optical RS data. LiDAR applications in forest inventory (Forest height, structure, and biomass estimation). SAR applications in forest inventory (Forest height, structure, and biomass estimation).

Unit-III
Forest informatics: Multi-criteria decision making for ecological applications. Ecological niche concept and Species distribution modelling. Wildlife habitat suitability analysis and protected areas. Satellite telemetry for wildlife dispersal studies.

Unit-IV

Unit-V
Climate change and impact assessment: Broad concept on forest ecosystem and climate linkages, climate change impacts on forest ecosystems. Fire ecology, Global and Asia-Pacific region issues, EO-based active fire detection and monitoring, Burnt area mapping and recovery assessment. Forest fire risk zonation and danger rating, Forest fire alert systems. Environmental impact assessment.

Textbooks & References
1. India State of Forest Report (2017) Forest Survey of India, Dehra Dun, India
c. COASTAL ZONE MANAGEMENT

Unit-I
**Introduction:** Coastal and littoral zones – definitions and scope of study Shore zone processes – waves, tides and currents Coastal landforms; River deltas: types and their morphological variations. Anthropogenic impact of deltas. Coastal wetlands – Mangrove swamps, marshes, lagoons, tidal channels/creeks and their significance in coastal stability and economic importance. Continental margins – forms and processes; territorial waters and Exclusive Economic Zone.

Unit-II
**Overview of geospatial technologies for coastal zones:** Coastal data sources: Satellite imagery, LiDAR, bathymetry; Data collection methods: Field surveys, buoys; Spatial analysis techniques for coastal data: Elevation modeling, shoreline analysis, habitat mapping.

Unit-III
**Coastal Hazards:** Storm surges, erosion, tsunamis; Global warming and Sea-level rise - impact on coastal zones; coastal vulnerability assessment Vulnerability assessment using geospatial data: Population density, land use, infrastructure. Coastal hazard preparedness – coastal protection, education and awareness of coastal communities.

Unit-IV
**Human activity and coastal environment** – deforestation, Agriculture/aquaculture, pollution and coastal structures, and their effect on coastal zones; Coastal vegetation; shelter belts; coastal aquifers; freshwater-seawater interface. Morphology of Indian coasts.

Unit-V
**Coastal Zone Management**–concepts, models and information systems Coastal Regulations Zones (CRZ) and Coastal Management Zones (CMZ): Indian context Application of remote sensing in coastal zone studies; Role of Geographic Information Systems in coastal zone studies.

Textbooks:
2. Deltas, Coleman, J.M., Continuing education PublicationCo.Inc.1976
5. Introduction to Marine Geology and Geomorphology, King, C.A.M., Edward Arnold,1974
d. PLANETARY REMOTE SENSING

UNIT I
Universe and solar system: Origin of Universe - Big Bang, Steady state and Inflationary hypothesis, Illustris model, Solar System - planets, satellites, asteroids, meteorites and comets and internal differentiation of the planets; general features of Terrestrial planets.

Unit II
Earth as a reference material: Geology and geophysics of terrestrial planets: Mars, Venus and Mercury; Jupiter, Uranus and Saturn and their satellites; physical properties, composition, mineralogy and petrology of the Moon.

UNIT III
Planetary atmosphere: Exo-and Endogenic processes associated with origin and internal evolution of planets – planetary volcanism, craters, impact of cratering processes, mineralogy and petrology; thermal, seismic and magnetic properties, and chronological techniques.

UNIT IV
Remote sensing techniques applicable to planetary geology: Approaches to remote sensing analysis of the composition of planetary surfaces, applications derived from interaction of electromagnetic radiation (X-ray, gamma-ray, visible, near-IR, mid-IR, radar) with geologic materials.

UNIT V
Past, present and future planetary exploration missions: Analyses and Interpretation of data gathered through various missions: identification of surface and morphological features.

References:
RS 1.6 REMOTE SENSING LAB-I

(A) REMOTE SENSING
1. Map reading - Survey of India Topo sheets.
2. Importing Satellite/Aerial Data from various sources
3. Geometric Corrections and Rectifications
4. Satellite Image Interpretation of various Terrestrial Features.
5. Preparation of Base Map from Survey of India Topo sheets
6. Thematic Mapping (Geomorphology, Forestry, Urban, Waterbodies)

(B) PHOTOGRAMMETRY
7. Use of Pocket & Mirror Stereoscope, parallax bar and measurement of distance and height.
8. Differential parallax measurement and contouring by parallax bar method
9. Digital Photogrammetry project creation and orientations (Internal & External)
10. Bundle Block Adjustment and 3D surface generation DEM
11. Orthophoto Generation
List of Exercises

1. Introduction to GIS software (ArcGIS, QGIS)
2. Georeferencing and rectifying aerial imagery, Toposheets
3. Digitizing and editing spatial data.
4. Data Querying.
5. Vector Data Analysis
6. Raster Data Analysis
7. Terrain Analysis with DEM
8. Map Layout
9. Surface hydrology Analysis
10. Network Analysis
11. Image Classification (Supervises and Unsupervised)
12. Model Builder
Audit course

RS 1.8. SPATIAL DATA SCIENCE

Unit-I
Introduction: Data Science; Fundamentals of Python, Python Libraries for Data Science; Data: Database Tables, Data Frame, Data preparation; Math: Linear functions, Plotting functions, Slope and Intercept.

Unit-II
Advanced Statistics: Linear Regression, Regression Table, Regression Info., Regression Coefficients, Regression P-Value, Regression R-Squared, Linear Regression Case; Stat Z-Table, Stat T-table.

Unit-III
Spatial Data, Manipulation, And Visualization: Spatial Data Science and its Applications; Importance of Spatial Thinking and Analysis; Spatial databases; Data types and sources in spatial data science, Data preprocessing and cleaning for spatial datasets, Spatial data structures and indexing, Cartographic principles and effective map design, Interactive mapping tools and libraries (Leaflet, Mapbox).

Unit-IV
Spatial Analysis Techniques & Geostatistics And Spatial Regression: Exploratory spatial data analysis (ESDA) methods; Spatial autocorrelation and spatial weights matrices; Point pattern analysis and spatial clustering; Spatial interpolation techniques (Kriging, IDW, etc.)
Principles of Geostatistics and Variogram analysis; Ordinary least squares (OLS) regression vs. spatial regression; Spatial regression models (Spatial Lag, Spatial Error, etc.); Model interpretation and spatial diagnostics.

Unit-V
Spatial Machine Learning & Advanced Spatial Applications: Introduction to Machine Learning algorithms for spatial data; Unsupervised learning (clustering, dimensionality reduction) with spatial data; Supervised learning (classification, regression) in spatial context; Deep learning for remote sensing and image analysis.
Applications: Spatial epidemiology and disease mapping; Urban planning and spatial decision-making; Environmental and ecological analysis; Location-based services and business analytics; Geospatial web services and APIs.

Textbook:

Additional Resources:
1. Online tutorials for GIS software (e.g., ArcGIS, QGIS)
2. Code snippets and examples in Python/R for spatial data analysis
3. Academic papers and research articles on spatial data science applications.
SECOND SEMESTER
RS 2.1 PYTHON AND JAVASCRIPT PROGRAMMING

Unit-I
**Foundations of Python Programming:** Introduction to programming concepts and Python's role. Setting up the Python development environment. Python syntax and basic data types (variables, strings, numbers). Control structures: if statements and loops (while, for). Input and output handling in Python.

Unit-II
**Core Programming Concepts and Data Manipulation:** Functions: definition, parameters, return values, and scope. **Lists and Tuples:** creation, indexing, slicing, and methods. String manipulation and formatting. **File handling:** reading, writing, and working with files. Comprehensive exercises combining functions and data manipulation.

Unit-III
**Advanced Python Concepts**
- **Dictionaries and Sets:** key-value pairs, unique elements, and methods.
- **Exception handling:** try-except blocks, raising exceptions. Introduction to modules and libraries. Introduction to object-oriented programming (OOP) concepts. **File handling in Python:** reading and writing files. Error handling and exceptions in Python. Introduction to web development concepts. Creating simple web pages using HTML and CSS. **Introduction to Flask:** Building a basic web application with Python.

Unit-IV
**JavaScript Fundamentals, DOM Manipulation and Event Handling**

Unit-V
**Advanced JavaScript Concepts**
- **Functions:** definition, parameters, return values, and scope.
- **Asynchronous JavaScript:** callbacks, promises, and async/await. Fetching data from APIs using JavaScript. Introduction to frontend frameworks (e.g., React or Vue.js). Building a dynamic web application using JavaScript.

**Textbooks:**

**Additional Resources:**
1. [https://www.w3schools.com/python/](https://www.w3schools.com/python/)
RS 2.2 DIGITAL IMAGE PROCESSING

Unit-I

Unit-II
Image Enhancement: Linear and non-linear Contrast enhancement techniques, density slicing, pseudo color images, spatial enhancement techniques (convolution filtering), spectral enhancement techniques, Image algebra, PCA, and data fusion techniques.

Unit-III
Image Classification Techniques: Supervised Classification, Training set - Statistical computation, understanding feature space & scatter plots, signature purity & separability, Signature Baye's decision rule, non-parametric & parametric classification techniques, minimum distance rule, Parallelepiped algorithm, maximum like-hood method, unsupervised and hybrid classification techniques, classification analysis - confusion matrix, error analysis & kappa coefficient, Analysis of Multi-Temporal series and change detection.

Unit-IV
Advanced classification techniques: Learning methods, Object, Texture, Object based Fuzzy, ANN and SVM classification techniques, sub-pixel mixture analysis; Object Oriented Image Classification.

Unit-V
Image Processing: Segmentation - Methods, MDL, Watershed, Mean-shift, Edge detection; Spectral indices - Vegetation indices, water-related indices, Indices related to cloud properties, Google Earth Engine platform for satellite data processing.

Text Books:

Reference Books:
5. https://nptel.ac.in/courses/105/107/105107160/
RS 2.3 Program Elective-III

a. WATER RESOURCES DEVELOPMENT

Unit-I
**River Valley Project Planning:** Purpose of planning, stages in the planning process, benefit-cost ratio, advantages of river valley projects, classification of reservoirs, technical aspects in river valley project planning- engineering surveys, geological investigations, hydrological investigations, selection of site for a reservoir, remote sensing applications in river valley project planning.

Unit-II
**Geo-Engineering Consideration for Investigation of Hydel Resources:** Introduction, application of remote sensing data for site selection, type of information – lithology, structure, types of lineaments, unconsolidated material, watershed characteristic, study of surface drainage, study of river geometrics, study of sedimentation, soil erosion survey, location and extent of landslides, location of field check points and the necessity and planning of future surface geophysical investigations in the reservoir and dam sites. economic factors, supply of construction material, access route location.

Unit-III
**River Morphology:** Introduction, early history, geomorphological approach, key definitions; graded stream, base level, laminar flow, turbulent flow, gradient, discharge, sinuosity, wavelength, natural level, sandbar/braided bar, meander cutoff, oxbow lake, point bar. Paleochannel/ abandoned channel, types of river, river engineering aspects, meandering: bends, crossing, transitional sections, meanders and its relationship to hydrological variables (empirical approach), braiding, straight, river behaviour and its plan form, bank material, remote sensing approach- data, methodology, instruments

Unit-IV
**Evaluation of Water Management in Irrigation Command Area:** Geoinformatics for efficient water management in irrigation systems - agricultural crop land inventory, assessment of water resources, estimation of irrigation water requirement, estimation of agricultural crop areas, status of irrigation water supply and irrigation water demand.

Unit-V
**Environmental Impact Assessment of River Valley Project:** Importance of River Valley Project, concept of environment – environment, environmental impact, environmental impact assessment, environmental benefits of river valley project - hydro-electric power, irrigation, drinking water supply, flood control, navigation. adverse environmental impact of river valley projects - submergence of agricultural land and human settlement, loss of forest, waterlogging problem, water pollution effect to flora and fauna. Remote Sensing as a tool in EIA of River Valley Projects – Monitoring, deforestation and afforestation in the river valley, identification of erosion prone areas, reservoir sedimentation, irrigation command area development, water pollution.
Text Books:

Reference Books:
4. The Social and Environmental Effects of Large Dams by E. Goldsmith & N. Nittildyard.
b. WATER RESOURCES MANAGEMENT

Unit-I

Unit-II
Reservoir Sedimentation: Introduction, effects of reservoir sedimentation, sediment deposition in reservoir, sediment distribution in reservoir, Remote Sensing and GIS based reservoir sedimentation studies. Discussion on a case study to compute reservoir volumes, including loss of storage capacity due to sedimentation using RS and GIS.

Unit-III

Unit-IV
Site Suitability Analysis for Water Harvesting Structures – Introduction, decision rules in suitable site selection for water harvesting structures as per IMSD guidelines. Input GIS layers; DEM, classified slope map, soil map, runoff potential map, buffer maps for proximity analysis, geological map, etc. GIS analysis for site selection.

Unit-V
Spatial information systems: Introduction, organization and design of spatial and non-spatial data in water resources engineering. - characterization of spatial information systems, data quality, the time element, spatial objects. Spatial data models; raster and vector data models, Attribute data; spatial attributes, non-spatial attributes, attribute tables. Design of data base and its use and management in hydrology applications. Discussion on a case study.

Text Books:

Reference Book:
c. WATER RESOURCES ASSESSMENT

Unit-I
Water Resources Assessment: Introduction to the role of remote sensing, water sector perspective. Water resources issues, minor irrigation tank inventory, snow-melt runoff forecasting, flood management, evaluation of water management in irrigation command area, watershed prioritisation for conservation planning.

Unit-II

Unit-III

Unit-IV
Surface Water Inventory: Surface water resources, interaction of light and water, Visible data and LiDAR for water depth and penetration Studies. Identification of surface water – Sensors and their mapping capabilities. Applications of remote sensing for the identification of water bodies; Visual Methods and digital techniques.

Unit-V
Snowmelt Runoff Forecasting: Introduction, Model types and their use for various hydrologic applications -Energy Balance Method.

Text Books:

Reference Books:
Introduction: Hydrology – definition and its importance, hydrological cycle, water budgeting, water demand estimation, surface water bodies, water content in ocean, sea, ice, lakes, dams, tanks, rivers and ground, water resource scenario in India, RS and GIS applications in water resources development and management.

Meteorology, Glaciology and Surface Fresh Water: Rainfall mapping, potential and actual evapo-transpiration, atmospheric water content, cloud mapping, rain forecasting, water quality parameters, cyclone forecasting; Glaciology: monitoring of snow melt and snow formation, snowmelt runoff estimation, estimation of damages; Surface Fresh Water: river diversion studies, site suitability for surface storages and hydro-electric power plants, storage yield analysis and reservoir sizing.

Hydrograph analysis: infiltration, effective rainfall, design storm, direct runoff hydrograph, unit hydrograph theory, derivation of runoff hydrograph from unit hydrograph; runoff analysis, rational method, NRCS approach, derivation of UG for ungauged catchments, synthetic unit hydrograph.

Flood and drought studies: flood frequency analysis, floodplain zoning, estimation of flood for different frequencies, flood forecasting, drought assessment and monitoring.

Irrigation and Watershed: Mapping and monitoring of catchment and command areas, land irrigability mapping, agriculture water demand estimation for different crops, tank information system, wetland mapping, siltation mapping; Watershed: delineation, morphometric analysis, rainfall-surface runoff model, reservoir sedimentation, water-harvesting structures, watershed development planning, mapping of drought prone areas.

Text Books:
1. GIS for Water Resources and Watershed Management - John G Lyon
4. Developments In Water Science – Water Resources Systems Planning and Management - Jain S.K and Singh V.P.

Reference Books:
1. Water, Wastewater and Storm Water Systems - U.M. Shamsi
2. Introduction to Environmental Remote Sensing – Barrett E C
RS 2.4 Program Elective-IV

a. URBAN & REGIONAL STUDIES

Unit-I


Unit-II


Unit-III


Unit-IV


Unit-V


Textbooks & References:
2. C.J.G. Morris (2005), Urban Heat Islands and Climate Change – Melbourne, Australia. School of
b. GEOLOGICAL REMOTE SENSING

Unit-I


Unit-II

**Data Processing and Analysis for Geosciences:** Digital image enhancement techniques for geological applications. Hyperspectral image processing for rock and mineral characterization. Interferometric SAR data analysis for geological applications. Applications of DEM and DTM for geological and geomorphological studies.

Unit-III


Unit IV

**Remote Sensing applications in Applied and Tectonic Geomorphology:** Overview of geomorphological studies with emphasis on basic and applied geomorphological mapping. Glacial dynamics and climate change studies: monitoring of glacier and glacial lakes dynamics, impact of climate change and glacial hazards (GLOFs, Surging Glaciers and Avalanche). Earthquake Geology: Active Tectonics studies by geomorphological, geophysical (GPR and MASW: Ground Penetrating Radar and Multi-channel Analysis of Surface Waves) and geodetic techniques (DInSAR and GNSS) techniques.

Unit V

**Application of Remote Sensing and GIS in Engineering Geology and Ground water**
Overview of engineering geology, rock strength and environmental impact assessment. Mapping, monitoring and modelling of landslides. Hydrogeological properties and groundwater prospect Zonation (RGNDWM), introduction to groundwater modelling in geospatial environment, assessment of change in groundwater storage using spaceborne (GRACE, INSAR) and in-situ (Geophysical & groundwater level) observations.

**Textbooks & References:**
c. GIS FOR UTILITIES

Unit-I
Introduction to Utilities and Geoinformatics. Introduction to utility sectors (water, electricity, gas, telecommunications). Historical context: How utilities have evolved and the role of technology. Significance of geoinformatics in utility management. Benefits and challenges of using geospatial technologies in utilities.

Unit-II
Overview of data collection technologies used in utility mapping. (Remote sensing, Aerial Surveys, GPS, LiDAR, Ground Surveys). Data sources specific to utility sectors. IoT Sensors. Data Integration Techniques for Utility mapping.

Unit-III

Unit-IV

Unit-V

Textbooks:
d. GIS FOR TRANSPORTATION ENGINEERING

Unit-I
Traffic Engineering Studies and Analysis: Objectives, Sampling in traffic studies, sample size; Data collection, analysis and interpretation - Spot speed, Speed and delay, Volume, Origin – destination, Parking. Concept of PCU, Factors affecting capacity and level of service, Types of maneuvers and conflict points.

Unit-II
GIS based Spatial Analysis and Modeling: GIS and spatial Analysis; Urban sprawl; GIS Analytical functions; Coupling Transportation Analysis and Modeling with GIS; Customizing GIS; Supporting Advanced Transportation Analysis in GIS.

Unit-III
Transportation Planning using GIS: Travel Demand Estimation-Application of GIS, Traffic Analysis Zone (TAZ) and screen lines, Four Stage Planning Process (Brief description only), Network representation of a transportation System, Shortest Path determination, GIS based Transportation Planning, Spatial and Non spatial data for land use and transportation.

Unit-IV

Unit-V
GIS – T Data Models: Data Domains and Data Modeling in GIS – T; Data Modeling and Design Issues; Graph Theory and Network Analysis; Network representation of a Transportation System; Linear referencing methods and systems; Transportation Data Models for ITS. GIS-T applications: Scope of TransCAD and EMME in Transportation Planning (Introduction only).

Text Books:

Reference Books:
RS 2.5 DIGITAL IMAGE PROCESSING PRACTICAL

1. Introduction to ERDAS Imagine Software. (Importing data, Visualization)
2. Image stacking, subsetting, Mosaicking, and Image statistics
3. Georeferencing / Image rectification (Map rectification, Map to Image, Image to Image)
4. Image Enhancement Techniques (Histogram equalization, Contrast Enhancement, Density Slicing)
5. Image Filtering Techniques (High pass, Low pass, Edge Enhancement)
6. Principal Component Analysis, Image Fusion techniques
7. Image Indices
8. Image Classification (Unsupervised, Supervised)
9. Change detection studies
10. Accuracy Assessment.
RS 2.6 PYTHON & JAVASCRIPT PRACTICAL

(A) PYTHON PRACTICALS

1. Read a Geo-TIFF image using rasterio and display it using matplotlib
2. Calculate basic statistics (mean, median, standard deviation) of pixel values in a satellite image
3. Generate a histogram to visualize the distribution of pixel values in a satellite image
4. Apply histogram equalization to enhance the contrast of a satellite image
5. Apply a Gaussian filter to reduce noise and smooth a satellite image
6. Calculate NDVI from a multi-band satellite image and visualize it as a grayscale image
7. Perform image differencing to detect changes between two satellite images and visualize the change map
8. Read and visualize a shapefile using geopandas
9. Perform a spatial query (e.g., point in polygon) on a shapefile
10. Implement a simple supervised classification using pixel values and reference data to classify a satellite image.

(B) JAVASCRIPT PRACTICALS

1. Create an interactive map using Leaflet.js and add a georeferenced satellite image as a raster layer.
2. Add multiple image bands as layers to the Leaflet map and allow users to toggle layers on and off.
3. Implement a slider to control the transparency of image layers, enabling users to visualize different bands simultaneously.
4. Enhance the map with markers representing specific points of interest and display additional information when clicking on them.
5. Calculate NDVI using JavaScript and pixel values from image bands and display NDVI values on the map using color gradients.
6. Display two images side by side and visualize the changes between them using a slider that transitions between images and highlights changes
7. Integrate a search feature to find specific locations on the map and display coordinates and related information for the selected location.
8. Enable users to explore a time series of satellite images using a slider that updates the map with images corresponding to the selected time period.
9. Implement custom polygon drawing functionality on the map and calculate statistics within the drawn polygon area.
10. Combine multiple features from previous exercises to create a comprehensive remote sensing web application, including image display, NDVI computation, change detection, and interactive features.
1. SAR data download and preprocessing.
2. Generation of interferogram and coherence from SAR imagery.
3. Data fusion of SAR and optical datasets.
4. Thermal data analysis (Calibration and atmospheric corrections, UHI).
5. Spectral signature analysis with hyperspectral data.
6. LIDAR data processing, classification and DTM, DSM generation.
7. Multi-sensor data fusion.
8. Time series analysis.
9. UAV data processing.
Audit Course

RS 2.8 CLOUD-BASED GEOSPATIAL ANALYSIS

**Introduction:** Google Earth Engine (GEE) is a cloud-based platform for planetary scale geospatial data analysis and communication. By placing more than 17 petabytes of earth science data and the tools needed to access, filter, perform, and export analyses in the same easy to use application, users are able to explore and scale up analyses in both space and time without any of the hassles traditionally encountered with big data analysis. Constant development and refinement have propelled GEE into one of the most advanced and accessible cloud-based geospatial analysis platforms available, and the near real time data ingestion and interface flexibility means users can go from observation to presentation in a single window.

**Exercises:**
2. Understanding band combinations and image visualizations
3. Calculating Spectral Indices (NDVI, NDWI)
4. Image Classification
5. Classification Validation & Accuracy Assessment
6. Monitoring Vegetation changes over time
7. Working with SAR data in Google Earth Engine

**References:**
1. [https://spatialthoughts.com/courses/google-earth-engine/](https://spatialthoughts.com/courses/google-earth-engine/)
2. [https://tutorials.geemap.org/](https://tutorials.geemap.org/)
THIRD SEMESTER

RS 3.1 Program Elective-V
a. DRONE & UAV REMOTE SENSING

Unit I
**Introduction:** UAV Remote Sensing and surveying - Historical Development. Types of Drones/UAVs. Basic components of a Drone/UAU system. Basics of aerodynamics relevant to drones.

Unit 2:
**Payloads and Onboard Sensors:** Payloads on Drones. Sensors-RGB, Multispectral, Hyperspectral, Thermal and LIDAR sensors. Advantages and Disadvantages.

Unit 3:

Unit 4:
**Data Processing:** Data collection and storage from UAVs. Basics of point clouds and digital elevation models (DEMs). Image stitching. Generation of Ortho mosaics, Digital elevation models, Point Clouds and 3D models.

Unit 5:

Text Books:

Reference Books:
b. CLIMATE CHANGE STUDIES

Unit-I
Fundamentals of Climate: Introduction to climate science and global climate systems; Historical climate change trends and observations; Climate models and climate change scenarios; Understanding climate change impacts on ecosystems and societies.

Unit-II
Remote Sensing Sensors and GIS for Climate Studies and Methods: Selection criteria for Remote Sensing sensors in climate studies; Various sensors and data types for climate study. Advanced GIS techniques for climate analysis: spatial analysis, geoprocessing, and modeling; Spatial data management and integration in climate research; GIS-based climate modelling approaches; Case studies on GIS applications in climate studies.

Unit-III
Monitoring Climate Variables: Remote sensing applications for monitoring climate variables: Temperature monitoring using thermal infrared data; Precipitation estimation from satellite data; Vegetation health assessment using NDVI; Sea-level rise monitoring with radar altimetry; GIS-based climate variable monitoring techniques; Integration of Remote sensing and GIS for comprehensive climate monitoring.

Unit-IV
Climate Change Preparedness and Adaptation: Climate vulnerability assessment: identifying at-risk regions and populations; Developing climate adaptation strategies at the local and regional levels; Climate resilience planning and policy development; Incorporating GIS-based data and tools into adaptation strategies.

Unit-V
Advanced Trends in Remote Sensing and GIS: Hyperspectral remote sensing and its applications in climate monitoring; Lidar technology and its role in assessing climate-related phenomena (e.g., forest canopy heights, coastal erosion); Machine learning and AI applications in climate modeling; Advanced spatial statistics for climate analysis. Climate Change Data Visualization: Effective data visualization techniques for communicating climate data; Creating interactive GIS-based climate maps and dashboards; Storytelling with data: Crafting compelling narratives on climate change impacts through visualization; Data visualization tools and software for climate change monitoring.

Text Books:
1. Climate Change Science: A Modern Synthesis by G. Thomas Farmer and John Cook
2. Remote Sensing and Image Interpretation by Thomas Lillesand, Ralph W. Kiefer, and Jonathan Chipman
3. GIS Fundamentals: A First Text on Geographic Information Systems by Paul Bolstad
5. Climate Resilience and Adaptation Planning: An Integrated Approach by Rohit Jigyasu and Mariko Sato
6. Advanced Remote Sensing: Terrestrial Information Extraction and Applications by Shunlin Liang and Xiaowen Li
c. HEALTH GIS

Unit-I
**Introduction to GIS and Public Health:** Introduction to GIS and its applications in public health. Basic concepts of spatial data and geographic information. Public health challenges and the role of GIS. Importance of geospatial analysis in understanding public health issues. Overview of GIS software and tools used in public health research.

Unit-II
**Data Collection and Management in Public Health GIS:** Data sources for public health GIS: health data, demographic data, environmental data. Data collection methods: surveys, remote sensing, GPS. Data preprocessing and georeferencing techniques. Data quality and data integration challenges in public health GIS.

Unit-III
**Spatial Analysis for Public Health:** Spatial interpolation techniques for health data visualization. Disease mapping and hotspot analysis. Proximity analysis: buffer zones and spatial relationships. Accessibility analysis for healthcare facilities and services.

Unit-IV

Unit-V

**Textbooks:**
1. "GIS for the Health Professions" by Terry A. Bloyd and Gary A. Spoelma.

**Additional Resources:**
1. Public health datasets, case studies, and real-world examples.
2. Online tutorials and resources for GIS and public health integration.
3. GIS software documentation and tutorials.
d. AIRBORNE AND TERRESTRIAL LIDAR

Unit-I

Unit-II

Unit-III

Unit-IV

Unit-V

Text Books:
Reference Books:


iii. Percival, H.F. Small unmanned aircraft systems for low-altitude aerial surveys. J. Wildl. Manage
RS 3.2 Open Elective
a. WebGIS Development

Unit-I

Unit-II

Unit-III

Unit-IV

Unit-V

Textbooks:
1. "Leaflet.js Essentials" by Paul Crickard III
2. "Full Stack Web Development with Node.js" by Colin J. Ihrig and Adam Bretz.

Additional Resources:
1. Online tutorials, documentation, and resources for web development and WebGIS
2. Access to web mapping libraries and APIs (e.g., Leaflet.js, Mapbox, OpenLayers)
3. Code editors or integrated development environments (IDEs) for web development.
b. SPATIAL DATA WAREHOUSING AND DATA MINING

Unit-I
Introduction to Data Warehousing and Big Data: Data warehousing fundamentals: Data warehousing architecture, Data warehousing vs. traditional databases. Big data concepts: The 5 Vs of big data (Volume, Velocity, Variety, Veracity, Value, Challenges in handling geospatial big data. Remote Sensing and GIS applications: Use cases where data warehousing and big data are crucial, Geospatial analytics in disaster management and urban planning

Unit-II
Data Warehousing for Geospatial Data: Design principles of data warehouses: Star schema and snowflake schema, Fact and dimension tables in geospatial context. ETL processes for geospatial data: Data extraction techniques for remote sensing imagery, Transformation and geospatial data preparation, Loading geospatial data into data warehouses. Data modelling and schema design: Designing geospatial data models, Handling metadata and spatial indexes. Spatial OLAP (Online Analytical Processing) for geospatial data analysis: Multidimensional data cubes for geospatial insights.

Unit-III
Big Data Management and Storage: Scalable storage solutions: Distributed file systems (e.g., Hadoop HDFS), Cloud-based storage for geospatial big data. NoSQL databases for geospatial applications: Document-based (e.g., MongoDB) and column-family databases (e.g., Cassandra), Geospatial indexing and querying. Handling spatiotemporal data: Data compression techniques for efficient storage, Time-series data storage and retrieval.

Unit-IV
Data Mining Techniques for Geospatial Analysis, Data mining concepts and algorithms: Clustering techniques (e.g., k-means, DBSCAN) for spatial pattern recognition, Classification algorithms (e.g., decision trees, SVM) for land cover mapping, Association rule mining for spatial relationships. Spatial data preprocessing: Data reduction and sampling methods, Outlier detection and treatment. Geospatial data visualization: Effective visualization techniques for spatial data’ Interpretation of data mining results using maps and plots.
Unit-V


Textbooks:

1. Data Warehousing Fundamentals for IT Professionals" by Paulraj Ponniiah.
4. NoSQL for Mere Mortals by Dan Sullivan.
5. “Data Mining: Concepts and Techniques” by Jiawei Han, Micheline Kamber, and Jian Pei.
6. “Principles of Data Mining” by Max Bramer.

Reference Material:

6. “Spatial Data Mining and Geographical Knowledge Services” edited by Shuliang Wang, Lixin Li, and Zhong Su.
7. “Data Mining for Geoinformatics: Methods and Applications” edited by Guido Cervone and Jessica Lin.
c. SPATIAL RELATIONAL DATABASE MANAGEMENT SYSTEMS

Unit-I
Introduction to SRDBMS: Evolution and history of spatial databases. Key components of SRDBMS architecture. Comparative analysis of popular SRDBMS platforms (e.g., PostgreSQL/PostGIS, Oracle Spatial, Microsoft SQL Server). Spatial data standards and formats (e.g., OGC standards, GeoJSON, Shapefile). Case studies of SRDBMS applications in remote sensing and GIS projects.

Unit-II
Designing Geospatial Databases: Advanced data modeling for spatial databases. Hierarchical, network, and object-oriented data models, Schema design for multidimensional spatial data, Spatial data quality and accuracy considerations in database design, Spatial indexing techniques (e.g., R-tree, Quadtree) and their implementation, Denormalization strategies for optimizing geospatial queries, Practical exercises in geospatial database design and normalization.

Unit-III
Data Management in SRDBMS: Data loading and transformation for geospatial datasets: ETL processes for remote sensing data. Spatial data loading tools and best practices. Managing large volumes of geospatial data: Data partitioning and sharding, Data compression techniques, Versioning and change detection in geospatial databases Security models, and access control for spatial data. Hands-on experience in data management tasks using SRDBMS.

Unit-IV
Querying and Analysis with SRDBMS: Advanced SQL for spatial data. Spatial query operators (e.g., ST_Contains, ST_Intersects), Geospatial functions and expressions, Combining spatial and non-spatial queries. Spatial analysis with SRDBMS: Buffering and proximity analysis, Spatial joins and overlays, Network analysis and routing. Geospatial data visualization techniques: Creating dynamic maps and reports, Integration with GIS software (e.g., QGIS, ArcGIS), Querying and analyzing geospatial data.

Unit-V
Textbooks:
3. "PostGIS in Action" by Regina O. Obe and Leo S. Hsu.

Reference Material:
3. "Principles of Geographic Information Systems" by Peter A. Burrough and Rachael A. McDonnell.
7. "PostGIS in Action" by Regina O. Obe and Leo S. Hsu.
9. "Data Mining for Geoinformatics: Methods and Applications" edited by Guido Cervone and Jessica Lin.
d. DIGITAL CARTOGRAPHY

Unit-I

Unit-II
Map Elements and Layout. Advanced Map Projections: Conic, cylindrical, and azimuthal projections, Equal-area vs. conformal projections, Specialized projections for thematic mapping (e.g., Albers Equal Area, Lambert Conformal Conic). Layout Design: Grids and graticules for map organization, Legends for complex datasets, Design principles for multi-map layouts (e.g., atlas design).

Unit-III
Data Visualization and Representation. Multivariate Mapping: Techniques for representing multiple variables on a single map, Bivariate and multivariate symbolization, Use of small multiples and thematic maps with insets. Advanced Data Classification: Beyond basic classification methods, including natural breaks, quantile, and custom classification, Dynamic classification for web mapping, Spatial statistics for data-driven classification Geovisualization: Time-series visualization and animation, 3D modeling and terrain representation, Virtual reality (VR) and augmented reality (AR) in cartography.

Unit-IV
OpenSource Mapping Tools: In-depth exploration of QGIS and other open-source GIS software, Customization and extensions in open-source mapping environments. Web Mapping APIs and Libraries: Introduction to JavaScript-based mapping libraries (e.g., Leaflet, OpenLayers), Creating custom web maps with interactivity and user-driven features, Mobile Mapping: Collecting and editing geospatial data in the field, Integration of mobile mapping apps with cloud-based GIS platforms, Augmented reality (AR) applications for mobile mapping.

Unit-V
Big Data in Cartography: Handling and visualizing large geospatial datasets, Big data analytics and spatial data mining, Scalable mapping solutions for big data. AI and Machine Learning in Cartography: Automated feature detection and extraction, Machine learning for image classification and object recognition, Incorporating AI-driven insights into cartographic design. Emerging Technologies: Location-based services (LBS) and real-time mapping, Blockchain and geospatial applications, The role of 5G and IoT in digital cartography.
**Text Books:**

1. *Thematic Cartography and Geo visualization* by Terry A. Slocum, Robert B. McMaster, Fritz C. Kessler, and Hugh H. Howard
2. *Map Design for Visual Learners* by Jon Kimerling, Aileen R. Buckley, Phillip C. Muehrcke, and Juliana O. Muehrcke
3. *Web Cartography: Map Design for Interactive and Mobile Devices* by Ian Muehlenhaus
5. *GIS Tutorial 1: Basic Workbook* by Wilpen L. Gorr and Kristen S. Kurland
6. *Cartography: Visualization of Spatial Data* by Menno-Jan Kraak