BANASTHALI VIDYAPITH

Master of Technology (Remote Sensing)

Curriculum Structure

First Semester Examination, December-2019
Second Semester Examination, April/May-2020
Third Semester Examination, December-2020
Fourth Semester Examination, April/May-2021

BANASTHALI VIDYAPITH
P.O. BANASTHALI VIDYAPITH
(Rajasthan)-304022

July, 2019

148

No. F. 9-6/81-U.3

Government of India
Ministry of Education and Culture
(Department of Education)

New Delhi, the 25th October, 1983

N O T I F I C A T I O N

In exercise of the powers conferred by Section 3 of the University Grants Commission Act, 1956 (3 of 1956) the Central Government, on the advice of the Commission, hereby declare that Banasthali Vidyapith, P. O. Banasthali Vidyapith, (Rajasthan) shall be deemed to be a University for the purpose of the aforesaid Act.

Sd/-
(M. R. Kolhatkar)
Joint Secretary of the Government of India

N O T I C E

Changes in Bye-laws/Syllabi and Books may from time to time be made by amendment or remaking, and a Candidate shall, except in so far as the Vidyapith determines otherwise, comply with any change that applies to years she has not completed at the time of change.

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Programme Educational Objectives

Banasthali Vidyapith is an epitome of tradition and modernity. Vidyapith aims to preserve and inculcate the essential values and ideals of Indian culture. It believes in simple living and high thinking. Our educational ideology is based on the concept of fivefold education focusing on physical, practical, aesthetic, moral and intellectual aspects in order to develop a balanced personality.

Realizing the potential of Remote Sensing Technology in Natural Resource management, Banasthali Vidyapith, took the lead in establishing the first Remote Sensing M.Tech. Programme for Women in India to cater the human resource development in scientific field of remote sensing. M.Tech. students carried out their dissertation research at various esteemed institutions and multinational industries, i.e., ISRO, DRDO, and NIH.

The M.Tech. Remote Sensing programme offers a flexible and complete education in the field of Remote Sensing technology and Geoinformatics. Students will comprehend the major Earth surface imaging systems and Geomatics based research & development. The integrated Remote Sensing technology plays a major role in natural resource management and develops multidisciplinary research environment.

The main objectives of the M.Tech. Remote Sensing programme are:

- To strengthen the ability for assessing and solving the real-time geospatial problems.
- To inculcate skills for developing realistic solutions to the challenges of emerging field of earth observation technology.
- To provide an adequate professional and technical environment that assists both in academia and industries
- To acquire skills in leaning modern earth observation techniques such as SAR, hyper-spectral, thermal and LiDAR scanning for mapping, modeling and monitoring.
- To prepare students for solving complex engineering problems by using innovative research.

Programme Outcomes

After successful completion of the programme the students will be able to:

PO1: **Remote Sensing Knowledge**: Describe the standard principle and concepts of advance 'Earth Observation' (EO) Technologies that ensure the effective use of Geoinformatics based generic applications to solve concurrent global and regional environmental problems.

PO2: **Problem Analysis**: Formulate robust, generic and ubiquitous research methodologies and approaches based on 'close-to-far' range remote sensing technology to resolve issues associated with natural resources.

PO3: **Design/Development of Solutions**: Develop and distribute free tools and realistic solutions based on Geoinformatics that can assist in natural resource management, environmental resiliency and infrastructure to expedite information sharing, which can be adapted and tailored to societal needs.

PO4: **Conduct investigations of complex problems**: Implement the Geoinformatics based operational research methods and optimization techniques in the extension of Geospatial policy for both academia and industrial arena. Share professional acumen to provide intellectual solutions for the complex geospatial problems with valid conclusions.

PO5: **Modern tool usage**: Construct, relate, and implement suitable geospatial techniques, industrialized resources, and cutting-edge Information Technology (IT) tools to forecast and modeling to manifold engineering activities with generous societal benefits.

PO6: **Remote Sensing professionals and society**: Implement the contemporary technical information and improved understanding of mapping sciences to encourage the development of responsible societal applications of Remote Sensing, Geographical Information Systems (GIS) and associate technologies.

PO7: **Environment and sustainability**: Perceive and relate the acceleration and impact of earth observation science, resource use, which increased the urgency to obtain quantitative, timely information about the environment at a variety of scales in space and time.

PO8: **Professional ethics**: Identify the significance of transparency in sharing of geospatial information in terms of a national policy to ensure data availability, accessibility, and quality to meet development goals of national mapping and imaging agencies, in accordance with issues associated to national security and intellectual integrity.

PO9: **Individual and team work**: Contribute as a team leader as well as individual in multi-disciplinary research groups in order to achieve common goals. Offer rational decisions based on objectivity to solve complex geospatial problems.

PO10: **Communication**: Empathize with relative arguments derived by the professionals during execution of the various global technological events. Create, design and disseminate effective reports, scientific articles and deliver presentations from different platforms.

PO11: **Project management and finance**: Demonstrate considerate interactions and knowledge of the remote sensing technology in real-time project management. Implement principles of project management into fields of applied remote sensing and interdisciplinary environments.

PO12: **Life-long learning**: Develop an attitude to ensure independent learning with value-added motivation in promptly changing scenario of global technical competence. Retain life-long intellect based on attained technological skills for sustainable development.

Curriculum Structure

Master of Technology (Remote Sensing)

First Year

Semester - I

Course	Code	Course Name	L	T	P	C*
RS	504	Fundamentals of Geographic Information Sciences and Digital Cartography	4	0	0	4
RS	508	Principles of Remote Sensing	4	0	0	4
RS	515L	Remote Sensing Lab-I	0	0	6	3
RS	516L	Remote Sensing Lab-II	0	0	6	3
		Term Paper-I/Minor Project-I/ Seminar-I**	0	0	8	4
		Discipline Elective – I	4	0	0	4
		Discipline Elective - II	4	0	0	4
		Semester Total:	**16**	**0**	**20**	**26**

Semester – II

Course	Code	Course Name	L	T	P	C*
RS	503	Digital Image Processing	4	0	0	4
RS	507	Photogrammetry, Global Positioning Systems and Mobile Mapping	4	0	0	4
RS	517L	Remote Sensing Lab-III	0	0	6	3
RS	518L	Remote Sensing Lab-IV	0	0	6	3
		Term Paper-II/Minor Project-II/ Seminar-II **	0	0	8	4
		Discipline Elective - III	4	0	0	4
		Open Elective	4	0	0	4
		Semester Total:	**16**	**0**	**20**	**26**

Second Year

Semester - III

Course	Code	Course Name	L	T	P	C*
RS	603P	Project (Part - I)	0	0	48	24
		Reading Elective - I	0	0	0	2
		Semester Total:	**0**	**0**	**48**	**26**

Semester - IV

Course	Code	Course Name	L	T	P	C*
RS	604P	Project (Part - II)	0	0	48	24
		Reading Elective - II	0	0	0	2
		Semester Total:	**0**	**0**	**48**	**26**

List of Decipline Electives

Course	Code	Course Name	L	T	P	C*
RS	501	Applications of Remote Sensing	4	0	0	4
RS	502	Applied Statistics and Research Methodology	4	0	0	4
RS	511	Geospatial Entrepreneurship	4	0	0	4
RS	512	Geospatial Intelligence	4	0	0	4
RS	505	GIS Programming and Scripting	4	0	0	4
RS	506	Microwave, Thermal and Hyper Spectral Remote Sensing	4	0	0	4
RS	509	Spatial Database Systems, Analysis and Modeling	4	0	0	4
RS	510	Spatial Decision Support Systems	4	0	0	4

List of Reading Electives

Course	Code	Course Name	L	T	P	C*
RS	609R	Environmental Remote Sensing and Modeling	0	0	0	2
RS	610R	Geo-informatics for Resource Management	0	0	0	2
RS	611R	Geospatial Big Data: Challenges and Opportunities	0	0	0	2
RS	612R	Open Source Software, Services and Utility Application	0	0	0	2
RS	613R	Remote Sensing in Hydrology and Water Resources	0	0	0	2
RS	614R	Spatial Planning and Urban Development	0	0	0	2

*** L - Lecture hrs./week; T - Tutorial hrs./week; P-Project/Practical/Lab/All other non-classroom academic activities, etc. hrs./week; C - Credit Points of the Course**

**** RS 521P Term Paper – I**
RS 522P Term Paper – II
RS 513P Minor Project – I
RS 514P Minor Project – II
RS 519S Seminar – I
RS 520S Seminar – II

Student can opt open (Generic) elective from any discipline of the Vidyapith with prior permission of respective heads and time table permitting.

Every Student shall also opt for:
Five Fold Education: Physical Education I, Physical Education II, Five Fold Education: Aesthetic Education I, Aesthetic Education II, Five Fold Education: Practical Education I, Practical Education II one each semester

Five Fold Activities

Fine Arts		Physical Education and Sports	
BVFF 101	Classical Dance (Bharatnatyam)	BVFF 201	Aerobics
BVFF 102	Classical Dance (Kathak)	BVFF 202	Archery
BVFF 103	Classical Dance (Manipuri)	BVFF 203	Athletics
BVFF 104	Creative Art	BVFF 204	Badminton
BVFF 105	Folk Dance	BVFF 205	Basketball
BVFF 106	Music-Instrumental (Guitar)	BVFF 206	Cricket
BVFF 107	Music-Instrumental (Orchestra)	BVFF 207	Equestrian
BVFF 108	Music-Instrumental (Sarod)	BVFF 208	Flying - Flight Radio Telephone Operator's Licence (Restricted)
BVFF 109	Music-Instrumental (Sitar)	BVFF 209	Flying - Student Pilot's Licence
BVFF 110	Music-Instrumental (Tabla)	BVFF 229	Aeromodelling
BVFF 111	Music-Instrumental (Violin)	BVFF 210	Football
BVFF 112	Music-Vocal	BVFF 211	Gymnastics
BVFF 113	Theatre	BVFF 212	Handball
		BVFF 213	Hockey
Social Service and Extension Activities		BVFF 214	Judo
BVFF 301	Banasthali Sewa Dal	BVFF 215	Kabaddi
BVFF 302	Extension Programs for Women Empowerment	BVFF 216	Karate – Do
BVFF 303	FM Radio	BVFF 217	Kho-Kho
BVFF 304	Informal Education	BVFF 218	Net Ball
BVFF 305	National Service Scheme	BVFF 219	Rope Mallakhamb
BVFF 306	National Cadet Corps	BVFF 220	Shooting
		BVFF 221	Soft Ball
		BVFF 222	Swimming
		BVFF 223	Table Tennis
		BVFF 224	Tennis
		BVFF 225	Throwball
		BVFF 226	Volleyball
		BVFF 227	Weight Training
		BVFF 228	Yoga

Evaluation Scheme and Grading System

Continuous Assessment (CA) (Max. Marks)					End-Semester Assessment (ESA) (Max. Marks)	Grand Total (Max. Marks)
Assignment		Periodical Test		Total (CA)		
I	II	I	II			
10	10	10	10	40	60	100

In all theory, laboratory and other non classroom activities (project, dissertation, seminar, etc.), the Continuous and End-semester assessment will be of 40 and 60 marks respectively. However, for Reading Elective, only End semester exam of 100 marks will be held. Wherever desired, the detailed breakup of continuous assessment marks (40), for project, practical, dissertation, seminar, etc shall be announced by respective departments in respective student handouts.

Based on the cumulative performance in the continuous and end-semester assessments, the grade obtained by the student in each course shall be awarded. The classification of grades is as under:

Letter Grade	Grade Point	Narration
O	10	Outstanding
A+	9	Excellent
A	8	Very Good
B+	7	Good
B	6	Above Average
C+	5	Average
C	4	Below Average
D	3	Marginal
E	2	Exposed
NC	0	Not Cleared

Based on the obtained grades, the Semester Grade Point Average shall be computed as under:

$$SGPA = \frac{CC_1 * GP_1 + CC_2 * GP_2 + CC_3 * GP_3 + ---- + CC_n * GP_n}{CC_1 + CC_2 + CC_3 + ---- + CC_n} = \frac{\sum_{i=1}^{n} CC_i * GP_i}{\sum_{i=1}^{n} CC_i}$$

Where n is the number of courses (with letter grading) registered in the semester, CC_i are the course credits attached to the i^{th} course with letter grading and GP_i is the letter grade point obtained in the i^{th} course. The courses which are given Non-Letter Grades are not considered in the calculation of SGPA.

The Cumulative Grade Point Average (CGPA) at the end of each semester shall be computed as under:

$$CGPA = \frac{CC_1 * GP_1 + CC_2 * GP_2 + CC_3 * GP_3 + ---- + CC_n * GP_n}{CC_1 + CC_2 + CC_3 + ---- + CC_n} = \frac{\sum_{i=1}^{n} CC_i * GP_i}{\sum_{i=1}^{n} CC_i}$$

Where n is the number of all the courses (with letter grading) that a student has taken up to the previous semester.

Student shall be required to maintain a minimum of 4.00 CGPA at the end of each semester. If a student's CGPA remains below 4.00 in two consecutive semesters, then the student will be placed under probation and the case will be referred to Academic Performance Review Committee (APRC) which will decide the course load of the student for successive semester till the student comes out of the probationary clause.

To clear a course of a degree program, a student should obtain letter grade C and above. However, D/E grade in two/one of the courses throughout the UG/PG degree program respectively shall be deemed to have cleared the respective course(s). The excess of two/one D/E course(s) in UG/PG degree program shall become the backlog course(s) and the student will be required to repeat and clear them in successive semester(s) by obtaining grade C or above.

After successfully clearing all the courses of the degree program, the student shall be awarded division as per following table.

Division	CGPA
Distinction	7.50 and above
First Division	6.00 to 7.49
Second Division	5.00 to 5.99
Pass	4.00 to 4.99

CGPA to % Conversion Formula: % of Marks Obtained = CGPA * 10

First Semester

RS 504 Fundamentals of Geographic Information Sciences and Digital Cartography

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**4**	**0**	**0**	**4**

Learning Outcomes:

After the completion of this course, students should be able to:

- Differentiate GIS and science of map making, non-spatial vs. spatial data.
- Georeference the Topomaps and imagery and handle geospatial database.
- Describe concepts of database management system within spatial analytical framework.
- Design and frame initial requirements for WebGIS development.

Course Content:

Section A

Fundamental Geographic Concepts for GIS

Basic concepts about spatial information: Brief history and definition of GIS, Manual mapping Vs GIS mapping, Geometrical feature and real word Pictures, Variables- Points, Lines and Areas, Network and Surface, Application and Trends of GIS including Desktop GIS, Mobile GIS, Web GIS. Basic Objectives and Component of GIS – details of hardware, software and management

Map and Map Projection

Basic Concept, Categories of maps, Interpretation of topographic maps, Coordinate system, Polar and Cartesian, Map projections, Grouping of map Projections-Conical projection, Cylindrical projection, Azimuthal Projection; Mercator, Transverse Mercator, Polyconic, Lambert and UTM.

Geographical Data, Model and Data Input

Conceptual models of real world phenomena, Geographical data models; Fundamentals of data storage: entities or Fields, Information organization and data structure; Basic file structures, Tabular databases, Introduction to database system: Definition, Purpose, Data abstraction, Instances, Schema, Database Languages, database manager, RDBMS, keys. Advantages of databases, Types of Data Model-Hierarchical systems, Network systems, Relational systems and Object-oriented database systems (OODS); Entity relationship model, Attribute data query, SQL

Section B

Spatial Data Input and Editing

Spatial and Non-spatial data base, spatial data model: Geo relational Vector data model, Object based vector data model, Geodatabase, Raster data model, Hybrid relational database Vs Object orientation. Comparative analysis of spatial database, GIS data Requirement, sources and collection, Methods of data capture-scanning, digitization and associated errors; Conversion from other digital Sources, Attribute data input and management, creating digital data-remote sensing, GPS; data exchange; generating data from existing data; metadata; Different kinds of geospatial data, Topological relationships; Creation of topology and error correction, Edge matching, Data quality measurement and assessment, Digital output options.

Data Storage, Integration and Management

Data retrieval; Data compression; GIS and integration of other types of data; GIS and Remote Sensing data Integration, Image storage formats, Sources of errors in GIS database: Errors through processing, Errors associated with overlaying of polygons, Survey of available data, Public access to geographic information; Digital libraries, National & Global Standard - NSDI, GSDI; Global geospatial portals, OGC.

Section C

Introduction to Vector Data Analysis

Logical, Boolean, Arithmetical operation and function, Overlay operations (union and intersection), Feature base topological function –buffer, point in polygon, Layer based overlay analysis: Reclassification, point in polygon, line in polygon, polygon on polygon, (Eliminate, dissolve, clip, erase, split, identity, union and intersection)

Introduction to Raster Data Analysis

Raster Data base and structure, Local operations, Neighbourhood operations, Extended Neighbourhood, Zonal operations.

Recommended Books:

1. Burrough, P. A., & McDonnell, R. (1998). *Principles of Geographical Information Systems* (3rd ed.). New York, NY: Oxford University Press.
2. Chang, K. T. (2002). *Introduction to Geographic Information Systems* (3rd ed.). New Delhi, India: Tata McGraw Hill.
3. Clarke, K. C., Parks, B. O., & Crane, M. P. (Eds.). (2002). *Geographic Information Systems and Environmental modelling*. New Delhi, India: PHI Learning.
4. Drummond, J., Billen, R., Joao, E., & Forrest, D. (Eds.). (2006). *Dynamic and Mobile GIS.* New York, NY: CRC Press.
5. Harvey, F. (2008). *A Primer of GIS.* New York, NY: The Guilford Press.
6. Lo, C. P., & Yeung, A. K. W. (2005). *Concepts and Techniques of Geographic Information Systems* (2nd ed.). New Delhi, India: Prentice Hall India Learning.
7. Magwire, D. J., Goodchild, M. F., & Rhind, D. M. (1991). *Geographical Information Systems: Principles and Applications.* Harlow, England: Longman Scientific & Technical.

Suggested e-learning materials:

1. Introduction to GIS
   https://nptel.ac.in/courses/105102015/1
2. Spatial Analysis
   https://nptel.ac.in/courses/105102015/25
3. Introduction to geographic information systems, overlaying operations
   https://swayam.gov.in/courses/3691-introduction-to-geographic-information-systems
4. Digital Elevation Models and Applications
   https://swayam.gov.in/courses/4395-digital-elevation-models-and-applications
5. Interpolation
   https://nptel.ac.in/courses/105102015/14

RS 508 Principles of Remote Sensing

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**4**	**0**	**0**	**4**

Learning Outcomes:

After the completion of this course, students should be able to:

- Explain fundamental principles of earth observation or imaging.
- Differentiate various earth imaging satellites and sensors.
- Know the appropriate use of aerial photographs for different applications.
- Explain the importance of ground truthing and ground equipment's used in validation process.

Course Content:

Section A

Basic Principles and EMR Response

Definition of Remote Sensing: advantages and limitations, Electro-Magnetic Radiation (EMR)- spectrum properties, wavelength regions and their applications, Atmospheric interference and Atmospheric windows, Interaction of EMR with matter, Fundamentals of Radiometry: concept & laws, radiance, reflectance, Spectral signature and its response for Soil, Vegetation and Water; Ground Truthing, uses of ground data, equipment used.

Cameras and Sensor

Cameras and sensor classification: active and passive, optical – infrared sensors, microwave sensors, data reception and data product: ground segment organization, data product generation, georeferencing and resampling.

Section B

Photo Interpretation

Photo interpretation techniques, Fundamentals and elements of visual photo interpretation, Satellite image vs. Aerial photo interpretation, Digital and analog methods of Image Interpretation.

Digital Image Characteristics

Concepts of digital image and its characteristics, Spectral, Spatial, Radiometric and Temporal resolution, Image data storage and retrieval, Types of image displays, Look-up Tables (LUT) , Spatial profile and Spectral profile, Colour port and spectral band, B/W image,Gray Image, True/Pseudo Image and Standard False Colour Composite (FCC).

Section C

Platforms and Satellites

Evolution of Indian Space programme, Introduction to Weather, Communication and Earth Observation satellites systems: IRS series of satellites.

Global earth Observation Systems: Landsat, SPOT, IKONOS, QuickBird, Terra, Aqua, RADARSAT, NOAA, EO-1, Sentinel, RISAT, ASTER, Data dissemination sources.

Recommended Books:

1. Jensen, J. R. (2007). *Remote Sensing of the Environment - An Earth Resources Perspective* (2nd ed.). Upper Saddle River, NJ: Pearson Prentice Hall.
2. Joseph, G., & Jeganathan, C. (2018). *Fundamentals of Remote Sensing* (3rd ed.). Hyderabad, India: Universities Press.
3. Lillesand, T. M., Kiefer, R. W., & Chipman, J. W. (2003). *Remote Sensing and Image Interpretation* (5th ed.). New York, NY: John Wiley & Sons.
4. Moffitt, F. H., & Mikail, E. M. (1980). *Photogrammetry* (3rd ed.). New York, NY: Happer & Row.
5. Rampal, K. K. (1999). *Handbook of Aerial Photography and Interpretation.* New Delhi, India: Concept Publishing Company.
6. Sabins, F. F. (2002). *Remote Sensing-Principles and Interpretation* (3rd ed.). Long Grove, IL: Waveland press.

Suggested e-learning materials:

1. Introduction to Remote Sensing
   https://swayam.gov.in/courses/3612-introduction-to-remote-sensing
2. Basic Concepts of Remote Sensing
   https://nptel.ac.in/courses/105108077/

RS 515L Remote Sensing Lab – I

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**0**	**0**	**6**	**3**

Learning Outcomes:

After the completion of this course, students should be able to:

- Perform image fusion with different multispectral data and SAR data products.
- Generate spectral profiles for various LULC features, pre-process raw SAR images and explain their resolution components.
- Visualize indigenous as well as country outside agency SAR data products.
- Interpret satellite FCC images and aerial photographs, pre-process airborne-space borne raw imaging data products and their interpretation.

Course Content:

1. Introduction to ERDAS IMAGINE 2011
2. Study of the marginal information given on the C.D. ROM/Digital data
3. Import / Export of files using ERDAS IMAGINE 2011
4. Mosaic and Subset of imagery
5. Stacking of different layers
6. Map rectification of Topomaps using Keyboard or GPS data.
7. Geo-reference of the Topomaps and Imageries
8. Display, analysis and interpretation of black & white images, Gary image, Pseudo image and FCC
9. Study of the Spectral Signature of water, Built-up, Bare Soil, Vegetation, Plantation, Crop land, Snow and Cloud.

10. Overview of RS imaging online data portals and procurement of imagery (Thermal, Radar, and Hyperspectral).
11. Familiarization to the ISSDC, and procurement of available RS data products.
12. Familiarization to software tools for handling SAR, and Hyperspectral Datasets.
13. SAR metadata extraction and Visualization of (SLC and GRD Products).
14. SAR Image visual interpretation and comparative study with optical, hyperspectral and thermal imagery.
15. Radiometric terrain correction of SAR Data.
16. Speckle filtering of SAR Data.
17. SAR Image Fusion with Optical and Hyperspectral images.
18. Familiarization to the InSAR Data, Interferogram and their interpretation.
19. Familiarization to "Thermal data products" their visualization, and LST retrieval using thermal bands.
20. Familiarization to the Erdas Imagine "Spatial Modeler".
21. Hyperspectral data cube generation and its interpretation.
22. Hyperspectral Imagery profile and visual interpretation.

Recommended Books:

1. Baghdadi, N., & Zribi, M. (2016). *Microwave Remote Sensing of Land Surfaces - Techniques and Methods*. London, United Kingdom: ISTC Press-Elsevier.
2. Richards, J. A. (2009). *Remote Sensing with Imaging Radar*. Heidelberg, Germany: Springer
3. Thenkabail, P. S., Lyon, J. G., & Huete, A. (2011). *Hyperspectral Remote Sensing of Vegetation*. Boca Raton, FL: CRC Press.

4. Jensen, J. R. (2007). *Remote Sensing of the Environment - An Earth Resources Perspective* (2nd ed.). Upper Saddle River, NJ: Pearson Prentice Hall.

5. Joseph, G., & Jeganathan, C. (2018). *Fundamentals of Remote Sensing* (3rd ed.). Hyderabad, India: Universities Press.

6. Lillesand, T. M., Kiefer, R. W., & Chipman, J.W. (2003). *Remote Sensing and Image Interpretation* (5th ed.). New York, NY: John Wiley & Sons.

Suggested e-learning materials:

1. Sentinel Missions
   https://earth.esa.int/web/guest/missions/esa-operational-eo-missions
2. Hyperspectral Image
   Analysishttps://www.harrisgeospatial.com/Support/SelfHelpTools/Tutorials.asp
3. Optical - Radar Fusion
   http://community.hexagongeospatial.com/t5/Spatial-Recipes/Optical-Radar-Fusion/ta-p/752
4. Radar Courses
   https://earth.esa.int / web / guest / missions / esa – operational - eo missions / ers / instruments /sar / applications / radar-courses
5. ENVI Tutorials (Hyperspectral Image Analysis)
   https://www.harrisgeospatial.com/Support/SelfHelpTools/Tutorials.aspx
6. ERDAS Hexagone Geospatial Tutorials
   http://community.hexagongeospatial.com/t5/Spatial-Recipes/Optical-Radar-Fusion/ta-p/752
7. Introduction to Remote Sensing
   https://swayam.gov.in/courses/3612-introduction-to-remote-sensing
8. Basic Concepts of Remote Sensing
   https://nptel.ac.in/courses/105108077/

RS 516L Remote Sensing Lab – II

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**0**	**0**	**6**	**3**

Learning Outcomes:

After the completion of this course, students should be able to:

- Implement the knowledge about SQL in solving attribute queries.
- Analyze errors in spatial data and their removal.Design and produce the base map using map algebra, complex query generation.
- Write and describe .NET and Python scripting in their specified frameworks.
- Perform geo-processing using Python, and ArcGIS Server.
- Connect the desktop based GIS operation with real-time web operations and publishing newly generated geospatial maps on web.

Course Content:

1. Analog to Digital conversion -Scanning methods
2. Introduction to GIS software
3. Map Rectification, Define projection and Reprojection.
4. Digital database creation-Point features, Line features, Polygon features
5. Data Editing-Removal of errors -Overshoot & Undershoot, Snapping, Topology Creation
6. Vector Transformation - Affine and Polynomial, Co-ordinate definition. Map Bound.
7. Data collection and Integration, Non-spatial data attachment working with tables
8. Creation of Tables, Performing various actions over table, and Merging of tables by using primary key
9. Concept of SQL

10. Dissolving, Merging, Clipping, Intersection, Union, and Proximity Analysis
11. Spatial and Attribute query and Analysis
12. Map algebra / Math in Raster data
13. Layout generation and report
14. Updation of Toposheet from satellite imagery.
15. Digital Map preparation using Dot, Isopleth and Choropleth
16. .NET framework concepts.
17. Window forms application.
18. Console Programming.
19. Python concepts.
20. Conditional & Looping applications.
21. Concept of ArcPy.
22. Geo-processing with Python.
23. Introduction to ArcGIS server.
24. Creating GIS Server connectivity.
25. Map publishing on web.

Recommended Books:

1. Burrough, P. A., & McDonnell, R. (1998). *Principles of Geographical Information Systems* (3rd ed.). New York, NY: Oxford University Press.
2. Chang, K. T. (2002). *Introduction to Geographic Information Systems* (3rd ed.). New Delhi, India: Tata McGraw Hill.
3. Fu, P., & Sun, J. (2011). *WebGIS principles and applications*. New Delhi, India: ESRI press.

4. Zandbergen, P. A. (2013). *Python scripting for ArcGIS.* New Delhi, India: ESRI Press.

5. Zhuang, V., Wrazien, D. R., Wang, M., & Huang, X. (2005). *Programming ASP.NET for ArcGIS Server*. Florence, KY: Thomson Delmar Learning.

Suggested e-learning materials:

1. Introduction to GIS
   https://nptel.ac.in/courses/105102015/1
2. Spatial Analysis
   https://nptel.ac.in/courses/105102015/25
3. Introduction to geographic information systems, overlaying operations
   https://swayam.gov.in/courses/3691-introduction-to-geographic-information-systems
4. Digital Elevation Models and Applications
   https://swayam.gov.in/courses/4395-digital-elevation-models-and-applications
5. Interpolation
   https://nptel.ac.in/courses/105102015/14
6. VB.NET Programming
   Tutorialhttps://www.tutorialspoint.com/vb.net/index.htm
7. VBA Tutorial
   https://www.tutorialspoint.com/vba/index.htm
8. Algorithm and programming

   https://nptel.ac.in/courses/106106145/
9. Python – Tutorial
   https://www.tutorialspoint.com/python/index.htm

RS 521P/RS 513P/RS 519S Term Paper-I/Minor Project-I/Seminar-I

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**0**	**0**	**8**	**4**

Learning Outcomes:

After the completion, students should be able to:

- Identify and formulate the statements of the research problem and objectives related to earth system sciences, and geocomputation for effective geospatial solutions.
- Review existing literature relevant to the problem selected and explore the research gap.
- Collect various geospatial data products, required to carry out the research and formulate the methodology to solve the identified problem.
- Deliver an effective technical presentation on selected research problem and prepare the term paper/project/ seminar report.

Second Semester

RS 503 Digital Image Processing

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**4**	**0**	**0**	**4**

Learning Outcomes:

After the completion of this course, students should be able to:

- Explain sources of image degradation and their rectification.
- Describe various filtering operation and multispectral image enhancement techniques.
- Describe geospatial data dimensionality reduction techniques for fast and effective interpretation of the image variables.
- Describe utilization of artificial intelligence techniques for solving problems related to environmental monitoring and management.

Course Content:

Section A

Basic Principles

System design considerations, Sources of image degradation, Radiometric errors and corrections: Types of atmospheric correction - absolute and relative; atmospheric correction for hyperspectral imagery. Slope and aspect induced errors: topographic corrections - Minnaert method. Geometric errors and corrections: Interpolation: Spatial and Spectral. Image Enhancement techniques: Contrast stretching: Linear and non-linear methods.

Section B

Multi-Band Enhancement Techniques

Image gradient, thresholds and segmentation. Image Filtering: LPF, HPF, Directional, non-directional, Gradient, and Statistical filters, Edge detection, Band Ratio/Indices: vegetation, water, snow, and built-up indices; Factors

affecting development of band indices. Principal Component Analysis, Tasseled Cap Analysis. Image Texture analysis: Gray-Level Co-occurrence Matrix (GLCM).Frequency component, Fourier Transformation.

Pattern Recognition

Concept of Multi-spectral pattern recognition, Image Classification: Concepts, Spectral discrimination, Classifiers: Parametric and Non-Parametric; Methods: Unsupervised, Supervised, Object-oriented, and knowledge base classification; Accuracy Assessment: $\hat{K}$ statistics. Multi-temporal information extraction: concepts and considerations. Change detection analysis.

Section C

Advanced Techniques

Artificial intelligence and Machine Learning: concepts, techniques: Fuzzy logic, Artificial Neural Networks (ANN), Genetic Algorithms (GA). Image Fusion. Imaging spectroscopy for vegetation, Martian and Lunar surfaces: Mineral Spectra Extraction: concepts and considerations. LiDAR: Principles, Types, LiDAR Intensity, and Processing of LiDAR data. Terrestrial Laser Scanning (TLS).

Recommended Books:

1. Campbell, J. B., & Wynne, R. H. (2011). *Introduction to Remote Sensing* (5thed.). New York, NY: The Guilford Press.

2. Cracknell, A. P., & Hayes, L. (2007). *Introduction to remote sensing* (2nded.). Boca Raton, FL: CRC Press.

3. Dong, P., & Chen, Q. (2018). *LiDAR Remote Sensing and Applications*. Boca Raton, FL: CRC Press.

4. Jensen, J. R. (2007). *Remote Sensing of the Environment-An Earth Resources Perspective* (2nd ed.). Upper Saddle River, NJ: Pearson Prentice Hall.

5. Jensen, J. R., (2004). *Introductory Digital Image Processing: A Remote Sensing Perspective* (4th ed.), Glenview, IL: Pearson Education.

6. Lillesand, T., Kiefer, R. W., &Chipman, J. (2015). *Remote Sensing and Image Interpretation* (7th ed.). New York, NY: John Wiley & Sons.

7. Rencz, A. N., & Ryerson, R. A. (Eds.). (1999). *Manual of Remote Sensing: Remote Sensing for the Earth Sciences* (3rd ed. vol. 3). New York, NY: John Wiley & Sons.

8. Sabins, F. F. (2007). *Remote Sensing: Principles and Interpretation* (3rd ed.). Long Grove, IL: Waveland Press.

9. Shan, J., & Toth, C. K. (2018). *Topographic Laser Ranging and Scanning- Principles and Processing* (2nd ed.). Boca Raton, FL: CRC Press.

10. Tso, B., & Mather, P. M. (2009). *Classification methods for Remotely Sensed Data* (2nd ed.). Boca Raton, FL: CRC Press.

Suggested e-learning materials:

1. Image Processing
   http://geoinfo.amu.edu.pl/wpk/rst/rst/AppB/B4.html

2. Fundamentals of Satellite Remote Sensing
   https://arset.gsfc.nasa.gov

3. Digital Image Processing: Introduction to Object Recognition
   https://nptel.ac.in/courses/117105079/4

RS 507 Photogrammetry, Global Positioning Systems and Mobile Mapping

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**4**	**0**	**0**	**4**

Learning Outcomes:

After the completion of this course, students should be able to:

- Explain concepts related to aerial photography, planning and execution of photographic flights.
- Describe standard digital photogrammetric operations i.e., Ortho-rectification.
- Describe concepts related to aerial camera lenses, and digital terrain modeling.
- Integrate the knowledge about GPS.

Course Content:

Section A

Aerial Photography

Fundamentals of aerial photography, geometry of aerial photograph, Basic concepts of Perspective projection and Orthographic projection, Types of aerial photographs: Vertical and Oblique/High Oblique aerial photography Scale of photograph, Concept of stereoscope, Relief displacement and applications, tilt displacement, stereoscopic parallax, measurement of height difference from aerial photograph. Planning and execution of photographic flight, Computation of flight plan.

Aerial Film and Filters and Digital Photogrammetry

Basics of photography, Aerial cameras lenses, Filters and Films, Photographic scale: Object height and Length, Basic of Optics: Reflection & refraction and lens distortion; Photo mosaic, Ortho photo, Photograph co-ordinate and ground coordinate of Vertical and tilted photographs, Types of Photogrammetry Block adjustment, orthorectification, Digital Terrain Model, Terrain editing, Digital orthophotos.

Section B

Fundamentals of GPS and Its Components

Introduction of Global Positioning System, Control Segment, Space Segments, User Segment, GPS signals and data, Geopositioning – Basic concepts; NAVSTAR, GLONASS and GAGAN, GPS Positioning, **Satellite-based Augmentation System.**

Geodesy

Basics geodesy, Geoid/ datum/Ellipsoid-definition and basic concepts, Application of Geodesy, Coordinate system: Cartesian 3-D coordinate systems, Earth Centred, Earth Fixed X, Y and Z, Geographic Coordinate System Transformation, Geocentric Translation

Section C

Surveying Methods and Factors Affecting Accuracy

Satellite Geometry, Satellite signals and its strength, Number of satellites, Effects of Multi path, Ionosphere, Troposphere, Methods-Static & Rapid static, Kinematic-Real time kinematic, Survey: DGPS data processing.

Reference Station and Mobile Mapping

Selection of reference station, Reference station equipment- GPS receiver & GPS antenna. Mobile mapping basic concepts and applications, GPS application in surveying and mapping: Navigation military, Location based services, Vehicle tracking, Seismic Applications-Crustal deformation and tectonic movements. New Cellular mapping- Global System for Mobile Communication (GSM) and Code Division Multiple Access (CDMA) technology.

Recommended Books:

1. Drummond, J., Billen, R., Joao, E., & Forrest, D. (Eds.). (2006). *Dynamic and Mobile GIS.* New York, NY: CRC Press.

2. Gopi, S. (2005). *GPS and Surveying using GPS*. New Delhi, India: Tata McGraw-Hill.

3. Leick, A. (2004). *GPS Satellite Surveying* (3rd ed.). New York, NY: John Wiley & Sons.

4. Lillesand, T., Kiefer, R. W., & Chipman, J. (2015). *Remote Sensing and Image Interpretation* (7th ed.). New York, NY: John Wiley & Sons.

5. Moffitt F. H., & Mikail, E. M. (1980). *Photogrammetry* (3rd ed.). New York, NY: Happer & Row.

6. Rampal, K. K. (1999). *Handbook of Aerial Photography and Interpretation*. New Delhi, India: Concept.

7. Colwell, R. N. (1983). *Manual of Remote Sensing* (2nd ed. vol.1). Falls Church, VA: ASPRS.

8. Sabins, F. F. (2007). *Remote Sensing: Principles and Interpretation* (3rd ed.). Long Grove, IL: Waveland Press.

9. Terry, K. S. (2000). *Integrating GIS and the Global Positioning System.* New Delhi, India: ESRI Press.

Suggested e-learning materials:

1. Aerial Photography
   https://nptel.ac.in/courses/105104167/4

2. Photogrammetry
   https://nptel.ac.in/courses/105104100/18

3. Drone
   https://www.dronethusiast.com/tutorials

RS 517L Remote Sensing Lab – III

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**0**	**0**	**6**	**3**

Learning Outcomes:

After the completion of this course, students should be able to:

- Perform standard radiometric corrections on satellite imagery and calculate band indices for enhancement of the natural features on imagery.
- Classify the imagery using knowledge base for advanced mapping of LULC.
- Develop the Forecasting models for the crop production, flood hazards.
- Identify the suitable waste disposal sites, and Mapping the landslide hazard zonation maps.

Course Content:

1. De-hazing and noise reduction in RS imagery.
2. DN-Radiance-at sensor reflectance conversion of satellite imagery.
3. Retrieval of true planetary surface reflectance (i.e., atmospheric correction).
4. Derive band ratios/indices for multispectral and hyperspectral imagery.
5. Image Enhancement and filtering.
6. Data dimensionality reduction techniques (PCA, TCT).
7. RGB-to-HSV Transformation and interpretation.
8. Resolution merging and its assessment.
9. Unsupervised classification and accuracy assessment.
10. Supervised classification and accuracy assessment.

11. Object-Oriented classification.
12. Knowledge base classification.
13. Pre-processing of Hyperspectral data.
14. Atmospheric correction of hyperspectral data.
15. Spectral Mixture Analysis for Hyperspectral Data.
16. Land use \ land cover mapping.
17. Monitoring flood risk zones using satellite images.
18. Urban sprawl mapping of a township using satellite images.
19. Crop forecasting using multi-dates satellite images.
20. Application of remote sensing for identification of waste disposal sites.
21. Forest cover and density mapping using geospatial techniques.
22. Mapping landslide hazards in a region using satellite images.
23. Mapping of Forest Fire using Remote Sensing and GIS.
24. Identify Ground water potential zones using Geo spatial techniques.
25. Draught Zone identification using Remote Sensing and GIS.
26. Estimation of Land Surface Temperature using QGIS.

Recommended Books:

1. Dong, P., & Chen, Q. (2018). *LiDAR Remote Sensing and Applications*. Boca Raton, FL: CRC Press.
2. Jensen, J. R. (2007). *Remote Sensing of the Environment-An Earth Resources Perspective* (2nd ed.). Upper Saddle River, NJ: Pearson Prentice Hall.
3. Jensen, J. R., (2004). *Introductory Digital Image Processing: A Remote Sensing Perspective* (4th ed.), Glenview, IL: Pearson Education.

4. Sabins, F. F. (2007). *Remote Sensing: Principles and Interpretation* (3rd ed.). Long Grove, IL: Waveland Press.

5. Joshi, P.K., & Singh, T.P. (2011). *Geoinformatics for Climate Change Studies.* New Delhi, India: TERI Press.

6. Joshi, P.K., Pani, P., Mohapartra, S. N., & Singh, T.P. (2010). *Geoinformatics for Natural Resource Management*. New Delhi, India: Nova.

7. Lillesand, T. M., Kiefer, R. W., & Chipman, J. (2015). *Remote Sensing and Image interpretation* (7th ed.). New York, NY: John Wiley & Sons.

8. Roy, P. S., Westen, C. J. V., Jha, V. K., Lakhera, R. C., & Ray, P. K. C. (Eds.). (2000). *Natural disasters and their mitigation: a remote sensing perspective*. Dehradun, India: IIRS.

9. Schultz, G. A., & Engman, E. T. (2000).*Remote sensing in Hydrology and Water Management.* Berlin, Germany: Springer.

Suggested e-learning materials:

1. ENVI Tutorials : (Hyperspectral Image Analysis)
   https://www.harrisgeospatial.com/Support/SelfHelpTools/Tutorials.asp

2. Erdas Imaging Exercises with Sample Data Sets
   https://download.hexagongeospatial.com/en/downloads/imagine/erdas-imagine-remote-sensing-example-data

3. Applications Guide
   https://www.itc.nl/ilwis/applications-guide/

4. Data & Products
   http://glcf.umd.edu/data/

5. Bhuvan Portal
   http://ww12.bhuvan.com

6. Data & Products
   https://earthexplorer.usgs.gov/

7. Meteorological and Oceanographic Satellite Data Archival Centre https://www.mosdac.gov.in/
8. National Information System for Climate and Environment Studies https://nrsc.gov.in/nices
9. Agriculture Practices https://nptel.ac.in/courses/126104002/
10. Water Resources Information System http://www.india-wris.nrsc.gov.in/wrpinfo/index.php?title=Main_Page

RS 518L Remote Sensing Lab – IV

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**0**	**0**	**6**	**3**

Learning Outcomes:

After the completion of this course, students should be able to:

- Prepare the Ortho- images using Photogrammetry software's
- Collect geographic co-ordinates using DGPS and post-processing of the attributes using standard software's.
- Generate contour maps for the DEM generation.
- Describe and design the concept of spatial databases its components, models, mining, analysis and visualization.
- Acquire and apply the strength and applications of Arc model builder.

Course Content:

1. Stereovision exercise.
2. Preparation of ortho image using Leica Photogrammetry Suite
3. Contour generation using orthophoto or Images.
4. Introduction to GPS and initial setting.

5. Creating codes and attribute table in receiver.
6. Point data collection using GPS with different datum.
7. Line data collection using GPS and measurements.
8. GPS data collection for area calculation.
9. Post processing of the DGPS data.
10. GPS and GIS integrations output preparation.
11. Contour generation using GPS point data.
12. Image rectification using GPS coordinate data.
13. DEM generation using Interferometry.
14. Construction of 3D model.
15. Point pattern analysis.
16. Cluster analysis.
17. Geostatistics (Surface generation).
18. Network analysis.
19. Dynamic segmentation.
20. Terrain analysis.
21. Hydrological modelling.
22. Introduction to model builder.
23. Interactive model.

Recommended Books:

1. Gopi, S. (2005). *GPS and Surveying using GPS*. New Delhi, India: Tata McGraw-Hill.
2. Leick, A. (2004). *GPS Satellite Surveying*(3rd ed.). New York, NY: John Wiley & Sons.

3. Rampal, K. K. (1999). *Handbook of Aerial Photography and Interpretation*. New Delhi, India: Concept.

4. Colwell, R. N. (1983). *Manual of Remote Sensing* (2nd ed. vol.1). Falls Church, VA: ASPRS.

5. Terry, K. S. (2000).*Integrating GIS and the Global Positioning System.* New Delhi, India: ESRI Press.

6. Allen, D.W. (2011). *Getting to know ArcGIS Model builder*. New Delhi, India: ESRI Press.

7. Carter, G. B. (1994). *GIS for Geoscientists: Modeling with GIS*. Amsterdam, Netherlands: Elsevier.

8. Burrough, P. A., & McDonnell, R. (1998). *Principles of Geographical Information Systems* (3rded.). New York, NY: Oxford University Press.

9. Chang, K.T. (2002). *Introduction to Geographic Information Systems* (3rded.). New Delhi, India: Tata McGraw Hill.

Suggested e-learning materials:

1. Aerial Photography
   https://nptel.ac.in/courses/105104167/4

2. Photogrammetry
   https://nptel.ac.in/courses/105104100/18

3. Drone
   https://www.dronethusiast.com/tutorials

4. Digital Elevation Model and applications
   https://swayam.gov.in/courses/4395-digital-elevation-models-and-applications

5. Digital Elevation Model
   http://gazebosim.org/tutorials?tut=dem

6. Hydrologic Simulation Models
   https://nptel.ac.in/courses/105101002/36

RS 522P/RS 514P/RS 520S Term Paper-II/Minor Project-II/Seminar-II

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**0**	**0**	**8**	**4**

Learning Outcomes:

After the completion, students should be able to:

- Identify research problems related to the study domain.
- Apply the principles, tools and techniques to solve the selected complex geospatial problem.
- Analyze the research outcomes and suggest feasible/ practical solutions.
- Deliver an effective technical presentation on selected research problem and prepare the term paper/project/ seminar report.

Third Semester

RS 603P Project (Part - I)

Max. Marks : 100	L	T	P	C
(CA: 40 + ESA: 60)	0	0	48	24

Learning Outcomes:

After the completion, students should be able to:

- Select a relevant research topic related to social and engineering problems, natural disaster, decision support system etc. with integration of geospatial technologies.
- Evaluate and review significant existing literature of the topic selected.
- Collect various geospatial data products, required to carry out the research and formulate the methodology to solve the identified problem
- Deliver well-organized technical presentations and prepare the mid-term report.

Fourth Semester

RS 604P Project (Part - II)

Max. Marks : 100	L	T	P	C
(CA: 40 + ESA: 60)	0	0	48	24

Learning Outcomes:

After the completion, students should be able to:

- Select a relevant research topic related to social and engineering problems, natural disaster, decision support system etc. with integration of geospatial technologies.
- Apply the principles, tools and techniques to solve the problem.
- Process independent research to compute and resolve the chosen issue.

At the end the student should be able to design and carry out an experiment on her own and prepare the final technical report.

Evaluation Policy:

On satisfactory completion of the taught component of the course students will normally proceed for M.Tech. Project work which must be completed by the end of 2nd year. The project work will be evaluated by internal and external members. The Internal commitee of three members and external will evaluated the project, work asa report, presentation & viva-voce. The marks of the continuous assessment will be sent by the respective company/laboratory/industry etc. and internal members.

Discipline Electives

RS 501 Applications of Remote Sensing

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**4**	**0**	**0**	**4**

Learning Outcomes:

After the completion of this course, students should be able to:

- Identify the potentials of remote sensing in allied sectors.
- Describe trends in remote sensing applications.
- Apply remote sensing technology in natural resource and disaster management.
- Explain basics about Environmental Impact Assessment (EIA).

Course Content:

Section A

Introduction

Emergence of Remote Sensing technology in application areas, Understanding potentials of Remote Sensing in Defence Applications, Indian satellite missions with focused applications, recent trends in Remote Sensing applications.

Application in Land and Water Resource

Remote sensing in mapping Land use / land cover classification and monitoring, Crop forecasting, Forest resources management, soil taxonomy and degradation, geomorphology and surface mining on land resources, groundwater modelling, Water quality Monitoring, Reservoir sedimentation, Snow covers mapping and modelling approaches.

Section B

Application in Climate Change and Disaster Management

Concept of climate and weather, Climatic classification, Paleo-climate, Adaptation and vulnerability, mapping of landslide, Floods, Cyclones, Forest fire and Drought.

Application in Urban Planning

Mapping urban land use, Urban sprawl, Site selection for urban development, Urban Information System, Urban master plans, urban green spaces, 3 D city modelling, SMART city

Section C

Applicationin Geo-Technical Engineering

Digital Terrain Modelling, Geoinformatics in water harvesting site selection, Highways and Tunnel alignment studies.

Applicationin Environmental Management

Selection of disposal sites for industrial and municipal wastes, Solid waste management, Environmental Impact Assessment (EIA).

Recommended Books:

1. Jenson, J. R. (2000). *Remote Sensing of the environment-An Earth Resource Perspective* (2nd ed.). Upper Saddle River, NJ: Pearson Prentice Hall.
2. Joshi, P. K., & Singh, T. P. (2011). *Geoinformatics for Climate Change Studies.* New Delhi, India: TERI Press.
3. Joshi, P. K., Pani, P., Mohapartra, S. N., & Singh, T. P. (2010). *Geoinformatics for Natural Resource Management*. New Delhi, India: Nova.
4. Lillesand, T. M., Kiefer, R. W., & Chipman, J. (2015). *Remote Sensing and Image interpretation* (7th ed.). New York, NY: John Wiley & Sons.

5. Roy, P. S., Westen, C. J. V., Jha, V. K., Lakhera, R. C., & Ray, P. K. C. (Eds.). (2000). *Natural disasters and their mitigation: a remote sensing perspective*. Dehradun, India: IIRS.

6. Schultz, G. A., & Engman, E. T. (2000). *Remote Sensing in Hydrology and Water Management.* Berlin, Germany: Springer.

Suggested e-learning materials:

1. Applications Guide
   https://www.itc.nl/ilwis/applications-guide/
2. Data & Products
   http://glcf.umd.edu/data/
3. Bhuvan Portal
   http://ww12.bhuvan.com
4. Data & Products
   https://earthexplorer.usgs.gov/
5. Meteorological and Oceanographic Satellite Data Archival Centre
   https://www.mosdac.gov.in/
6. National Information System for Climate and Environment Studies
   https://nrsc.gov.in/nices
7. Agriculture Practices
   https://nptel.ac.in/courses/126104002/
8. Water Resources Information System
   http://www.indiawris.nrsc.gov.in/wrpinfo/index.php?title=Main_Page

RS 502 Applied Statistics and Research Methodology

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**4**	**0**	**0**	**4**

Learning Outcomes:

After the completion of this course, students should be able to:

- Formulate research problems using geo-statistical methods.
- Apply statistical knowledge to the geospatial variability.
- Define research problems and selection of survey methods.
- Writing project proposal for various funding agencies.

Course Content:

Section A

Data Distribution and Basic Statistics

Scope and importance of statistics, Source of data-primary and secondary, Collection of data-sampling methods; Random and systematic method; Organization of data-array, Frequency, Class intervals, Histograms, and distribution, Presentation of data-Tables, Diagrams; Geometric form (Bar diagrams, Pie-diagrams), Frequency diagrams (histogram, polygon), Arithmetic line graphs (time series graph); Data grouping, Geographical data- Discrete and continuous series, Scales of measurement, Measures of central tendency-Mean, Median, Mode, Quartiles, Arithmetic mean, Geometric mean, Harmonic mean, Quadratic mean and their interrelated relations; Measures of dispersion-Absolute dispersion (range, quartile deviation, mean deviation, standard deviation); Relative dispersion (Coefficient of quartile deviation, Coefficient of variation), Moments, Skewness, Kurtosis

Section B

Correlation, Probability and Hypothesis Testing

Correlation-meaning, Scatter diagram, standard deviation, Variance, Measures of Correlation-Karl Pearson's method (Two variables ungrouped data) Spearman's rank correlation methods.

Probability-Binomial, Normal, and Poisson distribution; Theory of Sampling - Sampling distributions of means and proportions, Standard errors, Confidence interval estimation for population means, Standard deviations, Testing of Hypothesis – Large and small sample test.

Basic Concept of Research Methodology

Definition of Research Problem, Identification of problems of regional and Local level, Considerations in selection of problem, Research process, Review of literature, Research objectives and research questions, Research scheme/design.

Section C

Data Collection, Analysis and Reports

Methods of data collection, Survey methods, Samples-Type and methods, Data processes and analysis, Reporting of results, References, Future scope of work.

Preparation of Research Projects

Writing of proposals, Objectives of project, Research hypothesis and design, Research Questions, Scope of project, Brain storming sessions, Finalization of methodology, Review of similar studies and present level of research, Time scheduling (PERT), Financial estimates, Submission of Proposal.

Project planning, Project activities/tasks, Feasibility, Resource requirements and allocation, Project management software, Project review, Project Completion-Quality assurance, Evaluation of individual tasks, Financial auditing, Problems and opportunities in Projects

Recommended Books:

1. Gupta, S. C., & Kapoor, V. K. (2000). *Fundamental of Mathematical Statistics* (10th ed.). New Delhi, India: S. Chand.
2. Gupta, S. L., & Gupta, H. (2011). *Research Methodology Text and Cases with SPSS Applications.* New Delhi, India: International book House.
3. Kothari, C. R. (2004). *Research Methodology Methods and Technique* (2nd ed.). New Delhi, India: New Age International.

4. Meyer, P. L. (1970). *Introductory Probability and Statistical Applications* (2nd ed.). Washington, WA: Addison-Wesley.

5. Spiegel, M. R. (2011). *Theory and Problems of Statistics* (4th ed.). New York, NY: McGraw Hills.

Suggested e-learning materials:

1. Sampling distribution
   https://nptel.ac.in/courses/111105041/23

RS 511 Geospatial Entrepreneurship

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**4**	**0**	**0**	**4**

Learning Outcomes:

After the completion of this course, students should be able to:

- Identify the elements of success of entrepreneurial ventures,
- Evaluate the effectiveness of different entrepreneurial strategies
- Interpret importance of the entrepreneurial infrastructure
- Recognise Geospatial technology for harnessing Innovation and Entrepreneurship

Course Content:

Section A

Concepts and theory of Entrepreneurship

Entrepreneurship- definition, Need and Significance of Entrepreneurship Development in Global contexts. Entrepreneurship Development – concepts, Process, Experience and strategies. Dynamics of Entrepreneurship Development, Entrepreneurs Skills and Competencies

Section B

Entrepreneurship Development

Characteristics and role demanded of an Entrepreneur, Process of Developing Entrepreneur Qualities Enterprise Launching & Resources: Government Programmes, Policies, Incentive and Institutional Networking for Enterprise setting, Steps of setting new Enterprise, Scanning Business Environment, Sensing Business opportunity & Identifying Product. Challenges of new startup.

Section C

Geospatial innovation and Entrepreneurship

Geospatial sciences for harnessing technological Innovation. Enterprise GIS Role of various national and state agencies, .Remote sensing and GIS component in Government of India PSU and in MNC. Case study of successful geospatial Entrepreneurs in India.

Recommended Books:

1. Sethi, A. (2016). *From Science to Startup: The Inside Track of Technology. Entrepreneurship*. Göttingen, Germany: Copernicus & Springer.
2. Westhead, P., & Wright, M.(2013). *Entrepreneurship. A very short introduction*. Oxford, UK: Oxford University Press.
3. Roger Tomlinson (2013) *Thinking About GIS: Geographic Information System Planning for Managers, Fifth Edition,* New York, NY : ESRI Press.

Suggested e-learning materials:

1. Entrepreneurship Development
   https://www.tutorialspoint.com/entrepreneurship_development/
2. Enterprise GIS
   https://www.esri.com/library/bestpractices/enterprise-gis.pdf

RS 512 Geospatial Intelligence

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**4**	**0**	**0**	**4**

Learning Outcomes:

After the completion of this course, students should be able to:

- Explain concepts and components of Geospatial Intelligence.
- Explain different aspects of spatial cognition and their characteristics.
- Describe multiple intelligence and discuss applications of geospatial technology in strategic planning and operations.
- Rationalize outlook of basic architecture of GEOINT.

Course Content:

Section A

Geospatial Intelligence: Introduction and Background

Geospatial intelligence (GEOINT): Definition, Introduction: perceptality and convergence of digital and physical worlds. Spatial Intelligence to Spatial Competence; Components of Spatial Intelligence: Identifying components of spatial thinking- spatial ability measures, examination of spatial expertise. Intelligence, Surveillance, and Reconnaissance (ISR); GEOINT Trends; GEOINT: Collection and platforms; Intelligence Tasking and Collection: TCPED approach; Automatic Target Recognition (ATR) and Remote Sensing: Introduction and basic architecture; GEOINT: Challenges /Hard problems; Uses of GEOINT.

Section B

Concepts of Spatial Cognition and Ontology

Spatial Cognition in Geographic Environment: Definition, Cognitive processing – Cognition, Perception, Moist Map, Images, Schemata, Conceptual - Propositions, Dual Coding Behavior, Cognitive Maps, Neural Networks. Spatial Search Processes - Introduction, Cognitive theories of search- Feature Integration Theory (FIT), Attention Engagement Theory

(AET), Guided Search Theory (GST). Similarity Judgment of Places. Spatial Cognition: as an Artificial Intelligence (AI) Perspective. Spatial Ontology: Introduction and Utility.

Section C

Multiple Intelligence: Concepts and Applications

Multiple intelligence (Multi - INT): Imagery Intelligence (IMINT), Signals Intelligence (SIGINT), Human Intelligence / Intelligence Gathering (HUMINT), Measurement and Signature Intelligence (MASINT), Open Source Intelligence (OSINT): Concept, value and application. Human Geography and GEOINT; Terrain Analysis and Aerial Photography in GEOINT; Distributed Geospatial Intelligence Network (DGInet); Command, Control, Communications, Computers, Information/Intelligence, Surveillance, Targeting Acquisition and Reconnaissance (C4ISTAR): Concept and Utility.

Recommended Books:

1. Waller, D., & Nadel, L. (Eds.). (2013). *Handbook of Spatial Cognition*. Washington, DC: American Psychological Association.
2. Vecchi, T., & Bottini, G. (Eds.). (2006). *Imagery and Spatial Cognition*. Amsterdam, Pennsylvania: PA: John Benjamin's.
3. Lloyd R. (1997). *Spatial Cognition Geographic Environments*. New York, NY : Springer.

Suggested e-learning materials:

1. Distributed Geospatial Intelligence Network (DGInet)
   https://www.esri.com/~/media/Files/Pdfs/industries/defense/pdfs/dgin.pdf
2. Multi-INT
   https://www.geospatialworld.net/article/multi-int-intelligence-effective-multi-sensor-data-fusion/
3. Human Geography and GEOINT
   https://info.publicintelligence.net/NGIA-HumanGeography.pdf

4. GEOINT Basic Doctrine
   https://geog.utah.edu/pdf/certificates/NGA-doctrine-GEOINT.pdf
5. Geospatial Intelligence and National Security
   https://gistbok.ucgis.org/bok-topics/geospatial-intelligence-and national-security

RS 505 GIS Programming and Scripting

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**4**	**0**	**0**	**4**

Learning Outcomes:

After the completion of this course, students should be able to:

- Describe object-oriented models and functional modeling in GIS Framework.
- Explain concepts of common language infrastructure and class library.
- Explain .NET and Python programming languages for geospatial tool development.
- Rationalize the concepts of WebGIS, Server, and geo-processing functionalities.

Course Content:

Section A

Introduction to Object Oriented

Introduction to Object Oriented modelling and Design**;** Definition object oriented (OO), Object modelling Concepts, OO methodology, OO themes, Introduction to OO modelling techniques: Modelling, modelling techniques, object model, Dynamic Model and Functional Model, relationship among models. Object Modelling: Object and Classes: Object modelling concepts in details: links, association, generalization, inheritance, metadata, etc. A sample Object Model**.**

Dynamic Modelling: Dynamic modelling concepts. A sample dynamic model, Relation of object and dynamic model with example.Functional Modelling: Functional Modelling Concepts, A sample functional model.

Section B

.NET Framework

Concept of .NET framework, Common Language Infrastructure, Base Class Library and Framework Class Library.

Visual Studio.NET – IDE, Languages Supported, Components. Visual Programming, VB.NET- Features, IDE- Menu System, Toolbars, Code Designer, Solution Explorer, Object Browser, Toolbox, Class View Window, Properties Window, Server Explorer, Task List, Output Window, Command Window.

Elements of Visual Basic .NET

Properties, Events and Methods of Form, Label, TextBox, ListBox, Combo Box, Radio Button, Button, Check Box, Progress Bar, Date Time Picker, Calendar, Picture Box, HScrollbar, VScroll Bar, Group Box, ToolTip, Timer.

Data Types, Keywords, Variables and Constants, Operators, Scope and accessibility of variables, Conditional Statements, Looping Statement, Arrays- Static and Dynamic.

Menus and toolbars, Built-In Dialog Boxes, InputBox, MsgBox Functions and Procedures- Built-In Functions/ User Defined Functions and Procedures.

Creating Classes, Objects, Fields, Properties, Methods, Events, Inheritance, Polymorphism, Constructors and Destructors, Exception handling.

Section C

Python Programming

Introduction to Python, variables, Built-In data types, statements and expressions, strings, lists, python objects, Conditional Statements, Looping Statement commenting scripts, Modules and packages, functions, classes.

Geoprocessing Python Scripts: Importing ArcPy, accessing data, accessing toolboxes, intersection, union and buffering, querying.

Web GIS Development

Introduction to Web GIS, Principles, Architecture - Web Server, Map Server and Data Server, Technologies for WebGIS applications, Scripting for serving maps, map editing and geo-processing functionalities for GIS server.

Recommended Books:

1. Fu, P., & Sun, J. (2011). *WebGIS principles and applications*. New Delhi, India: ESRI press.
2. Pimpler, E. (2013). *Programming ArcGIS 10.1 with python cookbook*. Birmingham, England: Packt.
3. Zandbergen, P. A. (2013). *Python scripting for ArcGIS.* New Delhi, India: ESRI Press.
4. Zhuang, V., Wrazien, D. R., Wang, M., & Huang, X. (2005). *Programming ASP.NET for ArcGIS Server*. Florence, KY: Thomson Delmar Learning.

Suggested e-learning materials:

1. VB.NET Programming Tutorial
   https://www.tutorialspoint.com/vb.net/index.htm
2. VBA Tutorial
   https://www.tutorialspoint.com/vba/index.htm
3. Algorithm and programming
   https://nptel.ac.in/courses/106106145/
4. Python – Tutorial
   https://www.tutorialspoint.com/python/index.htm

RS 506 Microwave, Thermal and Hyperspectral Remote Sensing

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**4**	**0**	**0**	**4**

Learning Outcomes:

After the completion of this course, students should be able to:

- Explain concepts and components of satellite radar imaging.
- Explain different microwave sensors data (SLC and GRD) and their characteristics.
- Describe pre-processing requirements and discuss SAR image processing techniques.
- Rationalize outlook of SAR, thermal, and hyperspectral images.

Course Content:

Section A

Concepts of Imaging RADAR

Concept of Microwave RS and its components: - Wavelength, Frequency, Pulse and Chirping of SAR Signals, Coherence, Scattering matrix, Looks, polarization. RAR/SAR Imaging Geometry and Concepts: - Directions: Azimuth and Range; Angles: Look, Depression, and Incident; Ranges: Slant and Ground; Resolutions: Range and Azimuth; Penetration of radar signals: Skin depth. Radar Relief Displacement: Layover, Foreshortening, Shadows. Antenna induced radiometric distortions.Radar Equation. Radar Image interpretation variables: Surface roughness, Dielectric properties, Backscattering, Speckles. Concepts of Radar Polarimetry, Interferometry, and Altimetry. GPR: Principals, scope, and interpretation of Radargrams.

Section B

Thermal Infrared Remote Sensing

Introduction to Thermal IR radiation Laws, Thermal properties of terrain: Thermal capacity, Thermal conductivity, Thermal Inertia. Thermal IR scanners and bands.Retrieval of LSE from RS Data: Definition of LSE, *r*, *e* and Apparent Emissivity, Characteristics of emissivity: Angular and Spectral variation of Emissivity. LST retrieval from TIRS data: Definition of LST, Definition of temperature for flat and rough surfaces, Single-Channel method of LST Retrieval, Difficulties in the estimation of LST from Space Measurement. Thermal Image Interpretation: Considerations.

Section C

Hyperspectral Remote Sensing

Spectral Radiometry – Principle, solid angle, Radiance Vs. Reflectance, Imaging Spectroscopy - Introduction, absorption processes – charge transfer, electronic and vibrational, Spectral library and Bank- concept, development, parameters controlling the spectra- spectral range, bandwidth, Full Width Half Maximum (FWHM), spectral sampling, S/N ratio, Bidirectional Reflectance Distribution Function (BRDF), Continuum removal, Imaging Spectrometers

Recommended Books:

1. Baghdadi, N., & Zribi, M. (2016). *Microwave Remote Sensing of Land Surfaces - Techniques and Methods*. London, United Kingdom: ISTC Press-Elsevier.

2. Borengasser, M., Hungate, W. S., & Watkins, R. (2007). *Hyperspectral Remote Sensing: Principles and Applications*. Boca Raton, FL: CRC Press.

3. Campbell, J. B., & Wynne, R. H. (2011). *Introduction to Remote Sensing* (5th ed.). New York, NY: The Guilford Press.

4. Henderson, F. M., & Lewis, A. J. (1998). *Principles & Applications of Imaging Radar - Manual of Remote Sensing* (3rd ed. vol. 2). Hoboken, NJ: John Wiley & Sons.

5. Jensen, J. R. (2007). *Remote Sensing of the Environment - An Earth Resources Perspective* (2nd ed.). Upper Saddle River, NJ: Pearson Prentice Hall.

6. Joseph, G., & Jeganathan, C. (2018). *Fundamentals of Remote Sensing* (3rd ed.). Hyderabad, India: Universities Press.

7. Richards, J. A. (2009). *Remote Sensing with Imaging Radar*. Heidelberg, Germany: Springer.

8. Thenkabail, P. S., Lyon, J. G., & Huete, A. (2011). *Hyperspectral Remote Sensing of Vegetation*. Boca Raton, FL: CRC Press.

9. Woodhouse, I. H. (2006). *Introduction to Microwave Remote Sensing.* Boca Raton, FL: CRC Press.

Suggested e-learning materials:

1. How Does SAR Works
   www.radartutorial.eu/20.airborne/ab07.en.html
2. History of Radar Imaging
   https://www.geos.ed.ac.uk/homes/ihw/timeline.html
3. Visual Introduction to radar imaging
   https://www.geos.ed.ac.uk/~ihw/hype/radar/intro2radar.html
4. Hyperspectral Image Analysis
   https://www.harrisgeospatial.com/Support/SelfHelpTools/Tutorials.asp

RS 509 Spatial Database Systems, Analysis and Modeling

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**4**	**0**	**0**	**4**

Learning Outcomes:

After the completion of this course, students should be able to:

- Statistically evaluate the spatial entities their topological, geometric, or geographic properties.
- Learn different analytic approaches.

- Describe and design the concept of spatial databases its components, models, mining, analysis and visualization.
- Apply the strength and applications of Arc model builder.

Course Content:

Section A

Advance Attribute Analysis

Basics Matrix: Addition, subtraction, multiplication, Identity, Determinant and Inverse, Linear equation solutions using matrix

Spatial Modeling

Spatial analysis concept: Distance, Adjacency, Interaction and neighbourhood Geospatial models- types and Modeling: Descriptive, prescriptive and predictive; Normalization, level of measurement, Introduction to modeling& flowcharting, Map algebra-operators & operations, Functional operations, Modeling essentials, Spatial interaction models. Conceptualizing the model, Model formulation, Conflict resolution and Prescriptive modeling, Model verification.

Section B

Spatial Analysis

Point Analysis: Coordinate, Distance – Nearest Neighbour Distance, Density – Quadrant and other methods

Geo-Statistics

Spatial Interpolation and Geostatistics: Local and global methods, Gravity model, Regression model, Pattern analysis, Moran's Index, Cluster analysis, Trend surface Analysis

Thiessen polygon, Density estimation, Inverse Distance Weight (IDW), Thin – plate Spline, Kriging – ordinary and Universal, Semivariogram; Spatial Autocorrelation.

Section C

Geocoding and Network Analysis

Address Geocoding, Optimum Routing, Closest facilities, Resource Allocation, Network Analysis, Dynamic Segmentation: Route, Section, Events and its application.

Digital Terrain

Terrain mapping: Source of existing elevation data, quality and standard of DEM data, Counting, Vertical profile, Hill shading, Slope, Aspect, Surface Curvature, Digital terrain visualization 2D and 3D; Application of Digital terrain models

Arc GIS Model Builder

Concepts of Model Builder, Model elements: Tools, Variables, Connectors, setting up Models, Executing Model, Model Validation, Model builder to create Tools – Advance techniques in Model Builder, Geoprocessing Techniques in Model Builder

Recommended Books:

1. Allen, D. W. (2011). *Getting to know ArcGIS Model builder*. New Delhi, India: ESRI Press.
2. Carter, G. B. (1994). *GIS for Geoscientists: Modeling with GIS*. Amsterdam, Netherlands: Elsevier.
3. Burrough, P. A., & McDonnell, R. (1998). *Principles of Geographical Information Systems* (3rd ed.). New York, NY: Oxford University Press.
4. Chang, K. T. (2002). *Introduction to Geographic Information Systems* (3rd ed.). New Delhi, India: Tata McGraw Hill.
5. Fotheringham, A. (1988). *Spatial Interaction Models: Formulations and Applications.* Dordrecht, Netherlands: Springer.

6. Laurini, R., & Thompson, D. (1998). *Fundamentals of Spatial Information Systems*. London, England: Academic Press.

7. Lo, C. P., &Yeung, A. K. W. (2005). *Concepts and Techniques of Geographic Information Systems* (2nd ed.). New Delhi, India: Prentice Hall of India.

8. MacDonald, A. (1999). *Building a Geodatabase.* Redlands, CA: ESRI Press.

9. Samet, H. (1990). *The Design and Analysis of Spatial Data Structures*. Washington, WA: Addison–Wesley.

10. Silberschats, A., & Korth, H. F. (1998). *Database System Concepts* (3rd ed.). New York, NY: McGraw-Hill.

11. Sullivan, D. O., & Unwin, D. (2010). *Geographic Information analysis* (2nd ed.). Hoboken, NJ: John Wiley & Sons.

12. Verbyla, D. L. (2002). *Practical GIS Analysis*. London, England: Taylor & Francis.

Suggested e-learning materials:

1. Digital Elevation Model and applications
   https://swayam.gov.in/courses/4395-digital-elevation-models-and applications

2. Digital Elevation Model
   http://gazebosim.org/tutorials?tut=dem

3. Hydrologic Simulation Models
   https://nptel.ac.in/courses/105101002/36

4. Model Builder
   http://desktop.arcgis.com/en/arcmap/10.3/analyze/modelbuilder/what-is-modelbuilder.htm

RS 510 Spatial Decision Support Systems

Max. Marks : 100	L	T	P	C
(CA: 40 + ESA: 60)	4	0	0	4

Learning Outcomes:

After the completion of this course, students should be able to:

- Study the spatial information systems developed for a specific problem or decision-making situation.
- Observe key concepts and theories underlying spatial information systems and technology trends.
- Explore and reform the solutions to spatial problems by generating a set of alternatives and selecting from among those that appear to be viable through multi criteria analytics.
- Illustrate and assess the emerging concepts that may impact spatial information system development and applications.

Course Content:

Section A

Introduction

GIS and decision support systems, SDSS definition and characteristics, Introduction to decision making process and decision support systems, Introduction of a frame work for planning and decision making, Spatial Decision Making, SDSS architecture.

Database Management

Data base management system, Model based management system, Graphical and tabular report generator, User interface.

Section B

Analysis and Decision Making

Principles and elements of multiple-criteria decision analysis, Spatial multiple criteria decision analysis, Main multiple-criteria evaluation methods/techniques, criteria, alternatives, weights, decision rules and sensitivity analysis. Spatial multiple criteria evaluation in planning and decision making.

Technology and Development

Development of DSS, Technology levels, Functions and roles, Status of SDSS, Open source tools.

Section C

SDSS Software and Its Applications

Classification of DSS software, Problem specific SDSS, Generic SDSS, Domain level SDSS, Desktop SDSS, Web-Based SDSS, SDSS applications in: natural resource management, environmental, urban, agriculture, utilities and business.

Recommended Books:

1. House, W. C. (1983). *Decision Support Systems.* New York, NY: Petrocelli.
2. Silberschatz, A., Korth, H. F., & Sudarshan, S. (2011). *Database System Concepts* (6thed.). New York, NY: McGraw Hill.
3. Malczewski, J. (1999). *GIS and Multicriteria Decision Analysis*. New York, NY: John Wiley & Sons.
4. Ramanathan, S. (2011). *Spatial Decision Support Systems: Principles and Practices.* Boca Raton, FL: CRC Press.
5. Sprague, R. H., & Carlson, E. D. (1982). *Building Effective Decision Support Systems.* Englewood Cliffs, NJ: Prentice-Hall.

Suggested e-learning materials:

1. Database Management Systems (DBMS)
   https://onlinecourses.nptel.ac.in/noc18_cs15/preview
2. Geographic Information and Analysis
   http://www.ncgia.ucsb.edu/

Reading Electives

RS 609R Environmental Remote Sensing and Modeling

Max. Marks : 100

L	T	P	C
0	0	0	2

Learning Outcomes:

After the completion of this course, students should be able to:

- Describe principles of environmental modeling and taxonomy of environmental models in the spatial sciences.
- Explain Remote Sensing applications to monitoring wetland dynamics and management of Ramsar sites.
- Apply concepts of remote sensing in urban biophysical environmental modeling and management.
- Explain methods and benefits of Environmental Impact Assessment (EIA).

Course Content:

Principles of environmental modeling. Taxonomy of environmental models in the spatial sciences.Basic concept, Environmental Impact Assessment (EIA): Basic concepts, method, and Benefit. Integrated Environmental Modeling (IEM): A vision and roadmap for the future. Sensitivity Analysis: Importance in environmental modeling. Spatial multi-criteria evaluation and environmental modeling.Application of remote sensing in solid waste

management, water pollution monitoring and air pollution monitoring. Remote Sensing of urban biophysical environment: components and "urban heat islands" monitoring. Remote Sensing applications to monitoring wetland dynamics: Functions and values of Ramsar Sites (India). Aboveground terrestrial biomass and carbon stock estimations from Multi-sensor remote sensing: Global carbon budgets and remote sensing. Ecological characterization of vegetation using multi-sensor remote sensing in the solar reflective spectrum. Principles and Practices of data fusion in multi-sensor remote sensing for environmental monitoring.

Recommended Books:

1. Brimicombe, A. (2009). *GIS, Environmental Modeling and Engineering* (2nd ed.). Boca Raton, FL: CRC Press.
2. Chang, N. B., &Bai, K. (2018). *Multisensor Data Fusion and Machine Learning for Environmental Remote Sensing*. Boca Raton, FL: CRC Press.
3. Joshi, P. K., & Singh, T. P. (2011). *Geoinformatics for Climate Change Studies*. New Delhi, India: TERI Press.
4. Joshi, P. K., Pani, P., Mohapartra, S. N., & Singh, T. P. (Eds.). (2010). *Geoinformatics for Natural Resource Management*. Punjab, India: Nova.
5. Reddy, G. P. O., & Singh, S. K. (Eds.). (2018). *Geospatial Technologies in land resource mapping, monitoring and management.* New York, NY: Springer-nature.
6. Skidmore, A. (2002). *Environmental Modelling with GIS and Remote Sensing.* London, United Kingdom: CRC Press.
7. Thenkabail, P. S. (2015). *Land Resources Monitoring, Modeling, and Mapping with Remote Sensing*. Boca Raton, FL: CRC Press.
8. Weng, Q. (2011). *Advances in Environmental Remote Sensing: Sensors, Algorithms, and Applications.* Boca Raton, FL: CRC Press.

Suggested e-learning materials:

1. Taxonomy of environmental models in the spatial sciences https://research.utwente.nl/en/publications/taxonomy-of-environmental-models-in-the-spatial-sciences
2. Ramsar Convention https://www.ramsar.org/about-the-ramsar-convention

RS 610R Geo-informatics for Resource Management

Max. Marks : 100	**L**	**T**	**P**	**C**
	0	**0**	**0**	**2**

Learning Outcomes:

After the completion of this course, students should be able to:

- Define resource classification systems for different natural and cultural resources.
- Explain methods related to natural resource inventory and mapping.
- Apply concepts of multiresolution approach for wildlife habitat assessment and corridor mapping.
- Explain the principles of biodiversity conservation, and essential ecosystem services for sustainable development.

Course Content:

Concepts of resources management in realms of environmental sustainability: criteria and classification systems, natural resources, Natural resources inventory and planning system in India:identification of local and regional problems, base map preparation, thematic mappingand resources monitoring; Geospatial techniques in desertification assessment and control; Multi-resolution approach for wildlife habitat modeling: Major causes-outcomes of Human-wildlife conflicts, concept of habitat connectivity, corridor, or GIS based habitat modelling, Habitat Suitability Index; The Illegal wildlife trade: issues and challenges, monitoring organizations (i.e.,

TRAFFIC: The wildlife trade monitoring network, WCCB-Wildlife Crime Control Bureau, India: Structure and function); Geoinformatics based identification of potential natural resources, their conservation and planning for Sustainable development; Biodiversity conservation: potential, benefits and essential ecosystem service; Application of GIS to biodiversity monitoring; United Nations Decade on Biodiversity (2011-2020)

Recommended Books:

1. Adams, C. E. (2016). *Urban Wildlife Management* (3rd ed.). Boca Raton, FL: CRC Press.
2. Conover, M. R. (2001). *Resolving Human-Wildlife Conflicts: The Science of Wildlife Damage Management.* Boca Raton, FL*:* CRC Press.
3. Fulbright, T. E., & Hewitt, D. G. (Eds.). (2007). *Wildlife Science: Linking Ecological Theory and Management Applications*. Boca Raton, FL: CRC Press.
4. Jenson, J. R. (2000). *Remote Sensing of the environment - An Earth Resource Perspective* (3rd ed.). Upper Saddle River, NJ: Pearson's Prentice Hall.
5. Singh, C. K. (2018). *Geospatial Applications for Natural Resources Management*. Boca Raton, FL: CRC Press.
6. Skidmore, A. (2002). *Environmental Modelling With GIS and Remote Sensing*. London, United Kingdom: CRC Press.
7. Thenkabail, P. S. (2015). *Land Resources Monitoring, Modeling, and Mapping with Remote Sensing*. Boca Raton, FL: CRC Press.

Suggested e-learning materials:

1. The Potential, Realized and Essential Ecosystem Service Benefits of Biodiversity Conservation
   http://www.gibbs-lab.com/wp-content/uploads/2015/09/
2. TRAFFIC
   https://www.worldwildlife.org/initiatives/traffic-the-wildlife-trade-monitoring-network
3. 2011-2020 Decade on Biodiversity
   https://www.cbd.int/2011-2020/

4. Habitat Connectivity Analysis
   https://waconnected.org/habitat-connectivity-analyses/
5. GIS based Corridor modelling
   http://corridordesign.org/designing_corridors/resources/gistools

RS 611R Geospatial BigData: Challenges and Opportunities

Max. Marks : 100

L	T	P	C
0	0	0	2

Learning Outcomes:

After the completion of this course, students should be able to:

- Describe trinity of understanding BigData.
- Describe geocomputation and massive remote sensing data handling and associated challenges.
- Apply concepts of parallel computing and Internet of Things (IoT) in Geospatial BigData handling.
- Explain recent technology trends in public dissemination of the real-time geospatial data and analysis.

Course Content:

Geospatial BigData: Introduction, Definition, trinity of understanding BigData, common and individual challenges. Geospatial data and virtual reality (VR) development: Augmented Reality, Mixed Reality, and Virtual Reality GIS (VR-GIS). Geospatial data, 4V's properties, and 3C's. Voxels: concepts and application in 3-D urban scene modeling. Internet of Things (IoT): Concept, real-time monitoring and ArcGIS GeoEvent Server. Spatial Online Analytical Processing (SOLAP): Introduction and applications in Geomatics. Geocomputation and Earth Observations: Introduction and concept of "Context-awareness" and "Geo-smart dust". Parallel computing and massive remote sensing data handling: concepts and terminology. Open Geospatial Data Consortium (OGC): Structure, initiatives and technology trends. United Nations - Global Geospatial Information Management (UN-GGIM): Genesis, Objectives, and Initiatives.

Recommended Books:

1. Nilanjan, D., Chintan, B., & Ashour, A. S. (Eds.). (2019). *Big Data for Remote Sensing: Visualization, Analysis and Interpretation.* New York, NY: Springer.

2. Plaza, A. J., & Chang, C. I. (Eds.). (2007). *High Performance Computing in Remote Sensing.* New York, NY: Chapman and Hall/CRC Press.

3. Swarnalatha, P., & Sevugan, P. (2018). *Big Data Analytics for Satellite Image Processing and Remote Sensing (Advances in Computer and Electrical Engineering).* New Delhi, India: IGI Global Press.

Suggested e-learning materials:

1. OGC A to Z
   http://www.opengeospatial.org/
2. OGC Tech Trends
   http://www.opengeospatial.org/OGCTechTrends
3. Virtual Reality Landscape
   https://www.intel.com/content/www/us/en/tech-tips-and-tricks/virtual-reality-vs-augmented-reality.html
4. The Changing Face of Geospatial Analytics
   https://tdwi.org/Articles/2015/11/17/Changing-Face-of-Geospatial-Analytics.aspx?Page=2
5. UN-GGIM
   http://ggim.un.org/about/
6. GeoEvent Server
   https://www.esri.com/en-us/arcgis/products/arcgis-geoevent-server
7. Parallel computing, concepts and terminology
   https://computing.llnl.gov/tutorials/parallel_comp/

RS 612R Open Source Software, Services and Utility Application

Max. Marks : 100

L	T	P	C
0	0	0	2

Learning Outcomes:

After the completion of this course, students should be able to:

- Describe current trends in remote sensing and GIS based open source software's.
- Understand role of Geospatial technologies in government projects.
- Familiarize with geo-statistical analysis in utility applications such as crime, PWD etc.
- Explain geo-statistical analysis to be used in utility applications.

Course Content:

Open source software in remote sensing and GIS (e.g., QGIS, SAGA, Grass, and ILWIS), Mobile GIS, Mobile GIS software, Location based services using mobile devices. National Centre of Geo-Informatics (NCoG), Indian National GIS Organization (INGO), geospatial technologies in Government projects such as Re-structured Accelerated Power Development and Reform Programme (R-APDRP), AGRIS, Jawaharlal Nehru National Urban Renewal Mission (JNNURM) and National Land Records Modernization Programme (NLRMP). Concept of Medical GIS, evolution of Medical GIS, Use of GIS in public health, Spatio-temporal behaviour of disease pattern, Health Services and GIS, Geostatistical analysis in Epidemiological studies, advances in medical GIS. Crime Pattern Theory, point pattern analysis, types of crime analysis, GIS in crime analysis, Multi criteria Decision, spatial and temporal analysis of Crime using GIS, Crime mapping software. Line of sight analysis, Signal strength mapping, GIS in asset management of Power/Electric, mobile tower planning, Line routing, load forecasting, utility/assets management in PWD.

Recommended Books:

1. Drummond, J. (2007). *Dynamic and Mobile GIS: Investigating Changes in Space and Time*. Boca Raton, FL: CRC Press.
2. Kurland, K. S., & Gorr, W. L. (2012). *GIS tutorial for Health* (4th ed.). New Delhi, India: ESRI Press.
3. Meehan, B. (2007). *Empowering Electric and Gas Utilities with GIS (Case Studies in GIS).* New Delhi, India: ESRI Press.
4. Peng, Z. R., & Tsou, M. H. (2003). *Internet GIS: Distributed Geographic Information Services for the Internet and Wireless Networks.* Hoboken, NJ: Wiley.

Suggested e-learning materials:

1. R-APDRP
   http://www.ipds.gov.in/Forms/Know_More.aspx
2. Geospatial technologies in Government projects
   https://www.digitalindia.gov.in/
3. QGIS
   https://qgis.org/en/site/
4. SAGA
   http://www.saga-gis.org/en/index.html

RS 613R Remote Sensing in Hydrology and Water Resources

Max. Marks : 100

L	T	P	C
0	0	0	2

Learning Outcomes:

After the completion of this course, students should be able to:

- Describe fundamentals related to satellite imaging based hydrological investigation.

- Apply hydro geomorphology based interpretation knowledge for the identification of potential ground water resources.
- Explain concepts of watersheds leading to its inventory and effective management.
- Explain methods of snow cover mapping based on hydrological and GIS based models.

Course Content:

Fundamental of hydrological cycle and its major components; Interception and infiltration: their role in water balance in catchments; Surface and ground water, classification of stream and rivers, type of aquifers, Movement of groundwater: Darcy's Law, Aquifer transmissivity/ transmissibility, storativity and effective hydraulic conductivity; intrinsic property of aquifer materials: porosity and permeability, specific yield and retention, depression storage and hydrological losses; parameters in hydrology and water resources currently available from satellite observation; GIS-based components for rainfall-runoff models. Water shedinventory and management: definition and scope, morphometric parameters, drainage network and patterns; Advances in remote sensing-based hydro-geomorphological interpretation: hydrological applications of data from GRACE satellites, SARAL-Altika data and inland water bodies, Quantitative Precipitation Estimates (QPE) based on remote sensing platforms. Significance of periodical and precise mapping of the snow covers for hydrological applications.

Recommended Books:

1. Pawlik, A. R., Pagliara, S., & Hradecky, J. (Eds.). (2017). *Open Channel Hydraulics, River Hydraulic Structures and Fluvial Geomorphology: For Engineers, Geomorphologists and Physical Geographers.* Boca Raton, FL: CRC Press.
2. Chang, N. B., & Hong, Y. (Eds.). (2017). *Multiscale Hydrologic Remote Sensing: Perspectives and Applications*. Boca Raton, FL: CRC Press.

3. Shaw, E. M., Beven, K. J., Chappell, N.A. & Lamb, R. (Eds.). (2010). *Hydrology in Practice* (4th ed.). London, United Kingdom: CRC Press.

4. Lyon, J. G. (2002). *GIS for Water Resource and Watershed Management*. London, United Kingdom: CRC Press.

Suggested e-learning materials:

1. Remote Sensing based QPE's
   http://satellite.imd.gov.in/dynamic/insat_3DR.htm
2. Movement of groundwater
   https://nptel.ac.in/courses/105103026/3
3. Hydrological cycle and its components
   http://www.fao.org

RS 614R Spatial Planning and Urban Development

Max. Marks : 100

L	T	P	C
0	0	0	2

Learning Outcomes:

After the completion of this course, students should be able to:

- Identify the potentials of remote sensing in allied sectors.
- Describe the land reforms in India.
- Apply spatial planning in effective urban management.
- Explain national and international initiatives for urban development sector.

Course Content:

Geo-informatics for human settlements and infrastructure, Evolution of human settlements,, Economic planning, SEZ's: Special Economic Zones in India;Land Use / Land Cover classification in India, Eco-Village Concept and Environment Information System (ENVIS). Rural development plan, City development plan, Urban Master Plan and guidelines, Urban

Population Dynamics, Housing problems and development: United Nations-Global Housing Strategy (UN-GHS), National Urban Housing and Habitat Policy, National Urban Information System (NUIS) - ISRO: Slum up-gradation: Key for overall urban development. Slum Networking Programme (SNP) in India. Land reforms in India: Vision for urban equity, inclusivity and opportunity, Concepts related to "Resilient City and Smart City". Town Planning Schemes, Urban Land Pooling Mechanism, Institutions for urban planning education, vision for national GIS (Indian context). Sustainable solutions: United Nations - Sustainable Development Goals (UN-SDG's) and United Nations Development Program, India - Millennium Development Goals (UNDP-MDG's). Spatial planning and climate change mitigation, Spatial planning strategies: (1) Macro-regions and metropolitan areas; (2) Meso-sub-regions, districts, and corridors; and (3) Micro-neighbourhoods, streets, and blocks.

Recommended Books:

1. Lavender, S., & Lavender, A. (2015). *Practical Handbook of Remote Sensing*. Boca Raton, FL: CRC Press.
2. Maarseveen, M. V., Martinez, J., & Flacke, J. (Eds.). (2019). GIS in Sustainable Urban Planning and Management: A Global Perspective. Boca Raton, FL: CRC Press.
3. Rashed, T., & Jurgen, C. (Eds.). (2010). *Remote Sensing for Urban and Suburban Areas.* London, United Kingdom: Springer.
4. Weng, Q., Quattrochi, D., & Gamba, P. E. (Eds.). (2018). *Urban Remote Sensing* (2nd ed.). Boca Raton, FL: CRC Press.

Suggested e-learning materials:

1. SEZ's in India
   http://sezindia.nic.in/
2. ISRO-NICES
   https://nrsc.gov.in/nices

3. India and the MDGs
http://www.in.undp.org/content/india/en/home/post-2015/mdgoverview.html

4. UN-Habitat's Strategic Plan
https://unhabitat.org/un-habitats-strategic-plan-2014-2019/

5. Housing & slum upgrading
https://unhabitat.org/urban-themes/housing-slum-upgrading/

6. Visions for Urban Equity, Inclusivity and Opportunity
https://relocal.eu/the-just-city-essays-visions-for-urban-equity-inclusivity-and-opportunity/

7. ENVIS
http://envis.nic.in/ENVIS_html/about.html

8. National Urban Information System (NUIS)
https://www.nrsc.gov.in/NUIS