ADAMAS UNIVERSITY

SCHOOL OF BASIC AND APPLIED SCIENCES

DEPARTMENT OF GEOGRAPHY

Program Name:

M.Sc. (GEOINFORMATICS)

BATCH 2024-2025

Program Code: GEO4205

Total Credit: 100

Syllabus

(Syllabus modified as per the Board of Studies meeting held on 29th June 2024)

ADAMAS UNIVERSITY, KOLKATA
SCHOOL OF BASIC AND APPLIED SCIENCES
DEPARTMENT OF GEOGRAPHY

VISION OF THE UNIVERSITY

To be an internationally recognized university through excellence in interdisciplinary education, research and innovation, preparing socially responsible well-grounded individuals contributing to nation building

MISSION STATEMENTS OF THE UNIVERSITY

M.S 01: Improve employability through futuristic curriculum and progressive pedagogy with cutting-edge technology

M.S 02: Foster outcomes based education system for continuous improvement in education, research and all allied activities

M.S 03: Instill the notion of lifelong learning through culture of research and innovation

M.S 04: Collaborate with industries, research centers and professional bodies to stay relevant and up-to-date

M.S 05: Inculcate ethical principles and develop understanding of environmental and social realities

CHANCELLOR / VICE CHANCELLOR

ADAMAS UNIVERSITY, KOLKATA
SCHOOL OF BASIC AND APPLIED SCIENCES
DEPARTMENT OF GEOGRAPHY

VISION OF THE SCHOOL

To be recognised globally as a provider of education in Basic and Applied Sciences, fundamental and interdisciplinary research.

MISSION STATEMENTS OF THE SCHOOL

M.S 01: Develop solutions for the challenges in sciences through value-based science education.

M.S 02: Conduct research leading to innovation in sciences.

M.S 03: Nurture students into scientifically competent professionals in the usage of modern tools.

M.S 04: Foster in students, a spirit of inquiry and collaboration to make them ready for careers in teaching, research and corporate world.

DEAN (SoBAS)

ADAMAS UNIVERSITY, KOLKATA
SCHOOL OF BASIC AND APPLIED SCIENCES
DEPARTMENT OF GEOGRAPHY

VISION OF THE DEPARTMENT

To achieve excellence for imparting quality higher education and skills in Geography that can serve to the society adopting the changing versatility of job and research opportunities

MISSION STATEMENTS OF THE DEPARTMENT

M.S 01: Create highly qualified and employable geographers by imparting quality education and research aptitude

M.S 02: Enhance the skills of geoinformatics and data analysis along with encourage for entrepreneurship, innovativeness, self-learning in an interdisciplinary domain

M.S 03: To foster professional ethics and responsibilities for the organization, society and environment

M.S 04: To promote collaborations with industries, research institutes and experts for transmitting up-to-date knowledge, training, research skills and connection with the world

HOD, Geography DEAN (SoBAS)

ADAMAS UNIVERSITY, KOLKATA
SCHOOL OF BASIC AND APPLIED SCIENCES
DEPARTMENT OF GEOGRAPHY

NAME OF THE PROGRAMME: M.SC IN GEOINFORMATICS

PROGRAMME EDUCATIONAL OBJECTIVES (PEO)

PEO 01: Break down existing environmental problems into achievable sustainable solution.

PEO 02: Leverage professional capabilities by harnessing the advanced and evolving technology.

PEO 03: Posses an effective communication skills and become a true team worker with higher sense of ethics, value.

PEO 04: Exploring new and innovative ideas for research and innovation.

HOD, GeographyDEAN (SoBAS)

ADAMAS UNIVERSITY, KOLKATA
SCHOOL OF BASIC AND APPLIED SCIENCES
DEPARTMENT OF GEOGRAPHY

GRADUATE ATTRIBUTE / PROGRAMME OUTCOME (PO)

GA 01 / PO 01: Advanced Knowledge in Geoinformatics: Identify and explain principles, concepts, methods, and techniques relevant to geoinformation processing and earth observation for research and societal benefits.

GA 02 / PO 02: Specialized Knowledge for Future Research: Use and design models to simulate processes in the system earth with a spatial component and in-depth knowledge and research capabilities in, at least one particular applied field of geoinformatics.

GA 03 / PO 03: Analyse problems from a geospatial perspective: Analyse scientific and practical domain problems systematically and develop scientifically valid solutions for these problems in a societal context.

GA 04 / PO 04: Modern Research Skills for Spatial Data Analysis: Independently design and carry out research in the domain according to scientific quality standards**.** Manipulate, visualize and analyze maps and spatial data for a variety of purposes through geo-computation, digital cartography, programming, remote sensing and GIS techniques.

GA 05 / PO 05: Handling Modern Instruments and Field Project: Efficient in conducting field projects through designing field plans, data collection with various modern instruments and questionnaire survey, and project analysis.

GA 06 / PO 06: Advanced Writing Skills: Capable to write and design good quality articles, reports, research papers and thesis.

GA 07 / PO 07: Development of Communication Skill and Leaderships: Communicate both orally and in writing on findings of research work to specialists and non-specialists and develop quality for leadership, work in a group, and other extracurricular activities.

GA 08 / PO 08: Professional Development: Capable to compete in various competitive examinations for research (NET/SLET) and government jobs, and efficient to make a career as research project scientists and GIS Analysts.

GA 09 / PO 09: Ethics: Operate professionally and ethically in a multi-cultural environment and critically reflect on own and other's work.

GA 10 / PO 10: Life-long Learning: Recognize the need for, and acquire the ability to engage in independent and life-long learning in the broadest context of social, environmental, and technological changes.

HOD, GeographyDEAN (SoBAS)

ADAMAS UNIVERSITY, KOLKATA
SCHOOL OF BASIC AND APPLIED SCIENCES
DEPARTMENT OF GEOGRAPHY

PROGRAMME SPECIFIC OUTCOME (PSO)

PSO 01: Critical Thinking: Critical thinking of spatial processes and phenomenon of the natural world and human society, and application of geoinformatics for environmental protection and sustainable development.

PSO 02: Specialized Knowledge and Research: Specialized knowledge in the applied fields of geoinformatics and capabilities to design and carry out research in the domain of geospatial science

PSO 03: Modern Skill for Data Analysis: Expertise in modern skills for data analysis through geo-computation, geo-visualisation, programming, and geoinformatics to provide solutions for social and environmental problems, planning and management.

PSO 04: Professional Career Development: Make a good competitor to obtain better job opportunities in Competitive Examinations, Researcher, Teacher/Professor, Government employer, and Remote Sensing and GIS specialist.

HOD, GeographyDEAN (SoBAS)

School of Basic and Applied Sciences

Department of Geography

M.Sc. (Geoinformatics), Course Structure

I Semester

Subject Code	Subject	L	T	P	C
GEO21328	Geoinformatics I	3	0	0	3
GEO22329	Geoinformatics I Lab	0	0	6	4
GEO21303	Digital Image Processing	3	0	0	3
GEO22304	Digital Image Processing Lab	0	0	6	4
GEO22316	Open Source GIS Lab	0	0	6	4
GEO22327	Research Methodology	0	0	3	2
CSE22752	Basic Programming	2	0	4	4
	Total Credit	6	0	27	**24**

II Semester

Subject Code	Subject	L	T	P	C
GEO21330	Geoinformatics II	3	0	0	3
GEO22331	Geoinformatics II Lab	0	0	6	4
GEO22336	Advanced Photogrammetry Lab	0	0	6	4
GEO22332	Advanced Cartography and Surveying Lab	0	0	6	4
CSE22756	Database Management Systems	1	0	2	2
CSE22758	Python for Geospatial Analysis	0	0	6	4
ENG21111	Business Communication Basic	2	0	0	2
GEO25333	Term paper leading to Dissertation I	0	0	3	2
	Total Credit	5	0	30	**25**

III Semester

Subject Code	Subject	L	T	P	C
GEO21334	Geoinformatics III	3	0	0	3
GEO22335	Geoinformatics III Lab	0	0	6	4
GEO21338	Advanced Computing in Geoinformatics	3	0	0	3
GEO22339	Web GIS and Google Earth Engine	0	0	6	4
GEO22315	Spatial Data Science with R	0	0	6	4
CSE22757	JavaScript for Geospatial Applications	0	0	3	2
ENG21112	Business Communication Intermediate	2	0	0	2
GEO25337	Term paper leading to Dissertation II	0	0	3	2
GEO24325	Industry Internship	-	-	-	6
	Total	8	0	24	**30**

IV Semester

Subject Code	Subject		L	T	P	C
Advanced Elective Theory & Practical Courses (any one group)		Group				
GEO21317	Advanced Elective Theory: Geoinformatics Applications in Natural Resource Management	A	3	0	0	3
GEO22318	Advanced Elective Practical: Geoinformatics Applications in Natural Resource Management		0	0	6	4
GEO21319	Advanced Elective Theory: Geoinformatics Applications in Environment and Climate	B	3	0	0	3
GEO22320	Advanced Elective Practical: Geoinformatics Applications in Environment and Climate		0	0	6	4
GEO21321	Advanced Elective Theory: Geoinformatics Applications in Urban and Regional Planning	C	3	0	0	3
GEO22322	Advanced Elective Practical: Geoinformatics Applications in Urban and Regional Planning		0	0	6	4
GEO22340	Computer-Aided Design & BIM		0	0	6	4
ENG21113	Business Communication Advanced		2	0	0	2
GEO21341	Startup Skill Development		2	0	0	2
GEO25326	Dissertation and Comprehensive Viva		0	0	9	6
	Total		7	0	21	**21**

SEMESTER I

GEO21328	**Geoinformatics I**	L	T	P	C
Version 1.1	**Contact Hours – 45**	3	0	0	3
Pre-requisites/Exposure	Undergraduate level Geography knowledge				
Co-requisites					

Course Outcomes

On completion of this course, the students will be able to:

CO1: Recall the fundamental concepts of remote sensing, GIS, GPS, and GNSS.
CO2: Interpret different spatial and non-spatial data.
CO3: Apply different image processing and GIS techniques.
CO4: Categorize different platforms, sensors, and segments of GNSS.
CO5: Evaluate different methods of georeferencing and visual data interpretation.
CO6: Create different corrected spatial data.

Course Content

Unit 1: Fundamentals of Remote Sensing (15 hours)

Introduction to Remote Sensing, Remote sensing process: Physics of Remote Sensing: Electro Magnetic Radiation, EMR Theory, Energy sources, and Radiation principles: Energy interaction in the atmosphere: Energy interaction with earth surface features: Spectral reflectance of earth surface feature types; Types of Remote Sensing System – Characteristics of Optical, Thermal and Microwave, and Hyperspectral; Platforms, Orbits, Sensors, Concept of Resolution: Spatial, Spectral, Radiometric, and Temporal; Characteristic of Multispectral Earth Observation satellites; IRS, Landsat, Sentinel.

Unit II: Introduction to Digital Image Processing (10 hours)

Color image fundamentals – RGB, HSI models; Mosaicing, and Subsetting of Digital Images, Georeferencing – Single Image and Image-to-Image Georeferencing; Reproject; Elements of Visual Image Interpretation – Visual Data interpretation keys

Unit III: Introduction to Geographic Information System (10 hours)

Components of GIS; GIS data formats; Vector data structure – Spatial and non-spatial data; Concept of geodatabase; Coordinate systems and spatial reference. Digital Cartography and Thematic mapping: map composition and representation.

Unit IV: Introduction to GNSS and GPS (10 hours)

Introduction to earth's positioning system; Types and segments of global navigation satellite systems: GPS, GALILEO, GLONASS and GAGAN; Applications of GNSS

Recommended Readings:

1. Bhatta B., 2011: Remote Sensing and GIS, Oxford Publisher.
2. Campbell J. B., 2007: Introduction to Remote Sensing, Guildford Press.
3. Jensen J. R., 2004: Introductory Digital Image Processing: A Remote Sensing Perspective, Prentice Hall.
4. Joseph, G. 2005: Fundamentals of Remote Sensing, United Press India.

5. Lillesand T. M., Kiefer R. W. and Chipman J. W., 2004: Remote Sensing and Image Interpretation, Wiley. (Wiley Student Edition).
6. Fazal, S. 2008: GIS Basics, New Age International (P) Limited, Publishers, New Delhi
7. Harvey, F. 2008: A Primer of GIS: Fundamental Geographic and Cartographic Concepts, The Guilford Press, New York
8. Reddy, M.A. 2008. Remote Sensing and Geographical Information Systems, B S Publication, Hyderabad.
9. Sahu, K.C. 2007: Textbook of Remote Sensing and Geographical Information Systems, Atlantic Publishers, New Delhi.

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PSO 1	PSO 2	PSO 3	PSO 4
CO 1	1	1	2	1	2	2	3	1	2	1	2	1	2	1
CO 2	0	0	2	2	2	2	2	2	2	2	2	2	2	2
CO 3	1	2	2	1	2	3	2	1	2	1	3	1	1	1
CO 4	1	1	1	1	2	2	2	2	2	1	0	1	2	1
CO 5	1	1	0	2	2	3	2	1	2	2	2	2	2	2
CO 6	1	1	2	1	2	2	3	1	2	1	2	1	2	0

GEO22329	**Geoinformatics I Lab**	L	T	P	C
Version 1.1	**Contact Hours – 60**	0	0	6	4
Pre-requisites/Exposure	Undergraduate-level knowledge of GIS and RS				
Co-requisites	Basic knowledge of computer skills				

Course Outcomes

On completion of this course, the students will be able to
CO1: Recall the fundamental concepts of raster and vector database.
CO2: Interpret different physical and cultural features using different image interpretation keys.
CO3: Apply different image processing, GIS, and GPS data collection and representation techniques.
CO4: Categorize different projections and geoportal applications.
CO5: Evaluate different methods of georeferencing and visual data interpretation.
CO6: Create different thematic maps.

Course Content

Unit I: Introduction to satellite images (30 Hours)
Spectral bands, band combination, image registration (ground control point and image to image); Image interpretation keys using FCC, Interpretation of physical and cultural features.

Unit II: Introduction to Digital Image Processing (30 Hours)
Layer stacking/composite, Mosaicing, and Subsetting of Digital Images; True and false colour composites; Colour Transformation – RGB and HIS; Georeferencing – Single Image and Image-to-Image Georeferencing; Reproject, Visual Image Interpretation.

Unit III: Introduction to Geographic Information System (15 Hours)
Creation of vector database: point, line, and polygon, geopackage creation and attribute joining; measurement tools, changing projection, Thematic mapping: map composition and representation.

Unit IV: Introduction to GPS (15 Hours)
Principles of Global Positioning System (GPS); Collection of GPS data and mapping, Introduction to Geoportal Applications – Google Earth.

Laboratory Notebook and Viva Voce

Recommended Readings:

1. Bhatta B., 2011: Remote Sensing and GIS, Oxford Publisher.
2. Campbell J. B., 2007: Introduction to Remote Sensing, Guildford Press.
3. Jensen J. R., 2004: Introductory Digital Image Processing: A Remote Sensing Perspective, Prentice Hall.
4. Joseph, G. 2005: Fundamentals of Remote Sensing, United Press India.
5. Lillesand T. M., Kiefer R. W. and Chipman J. W., 2004: Remote Sensing and Image Interpretation, Wiley. (Wiley Student Edition).
6. Nag P. and Kudra, M., 1998: Digital Remote Sensing, Concept, New Delhi.
7. Rees W. G., 2001: Physical Principles of Remote Sensing, Cambridge University Press.

8. Singh R. B. and Murai S., 1998: Space-informatics for Sustainable Development, Oxford and IBH Pub.
9. Wolf P. R. and Dewitt B. A., 2000: Elements of Photogrammetry: With Applications in GIS, McGraw-Hill.
10. Wolf P. R. and Dewitt B. A., 2000: Elements of Photogrammetry: With Applications in GIS, McGraw-Hill.

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PSO 1	PSO 2	PSO 3	PSO 4
CO 1	1	1	2	1	2	2	3	1	2	1	2	1	2	1
CO 2	0	0	2	2	2	2	2	2	2	2	2	2	2	2
CO 3	1	2	2	1	2	3	2	1	2	1	3	1	1	1
CO 4	1	1	1	1	2	2	2	2	2	1	0	1	2	1
CO 5	1	1	0	2	2	3	2	1	2	2	2	2	2	2
CO 6	1	1	2	1	2	2	3	1	2	1	2	1	2	0

GEO21303	**Digital Image Processing**	L	T	P	C
Version 1.1	**Contact Hours – 45**	3	0	0	3
Pre-requisites/Exposure	Undergraduate-level knowledge of GIS and RS				
Co-requisites	Basic knowledge of computer skills				

Course Outcomes

On completion of this course, the students will be able to:
CO1: Define the different image processing techniques.
CO2: Compare between different image enhancement and classification methods.
CO3: Identify the advanced image processing concepts including image segmentation, fusion, etc.
CO4: Examine the effects of image preprocessing and enhancement techniques.
CO5: Appraise different classification, fusion, and change detection methods.
CO6: Construct enhanced images and classified thematic maps with desired accuracy.

Course Content

Unit I: Image Preprocessing (10 Hours)
Digital Image Data Formats – BIP, BIL, BSQ, Run-length Encoding; Types and Sources of Errors: Atmospheric, Radiometric, and Geometric – Image Rectification: Geometric Correction, Radiometric Correction – Atmospheric Correction, Relative, and Absolute Radiometric Correction; Noise Removal; RMS Error.

Unit II: Image Enhancement (12 Hours)
Contrast Manipulation – Gray level thresholding, level slicing, linear and non-linear contrast enhancement; Histogram processing – histogram matching and histogram equalization; Spatial and Frequency Domain – Spatial Filtering – Spatial Convolution Filtering – High Pass and Low Pass Filtering – Statistical filters – Minimum, Maximum, Median, Mean, Olympic – Edge Enhancement and Edge Detection Filters – Non-Linear Edge Enhancement Filters – Laplacian, Sobel, Roberts, Kirsch; Filtering in Frequency Domain – Fourier Transform – Band Ratioing, Spectral Indices, Principal Component Analysis. Kauth-Thomas Transformation.

Unit III: Digital Image Classification (12 Hours)
Unsupervised Classification – Chain Method, ISODATA, K-Means – Training Sites Selection and Statistical Information Extraction; Supervised Classifier – Minimum Distance to Means, Parallelepiped, Maximum Likelihood – Hybrid Classifiers – Classification Accuracy Assessment and Error Matrix GCP and ground validation of data/image

Unit IV: Advanced Digital Image Processing (11 Hours)
Object-based Classification; Image Segmentation – Types, Advantages, and Applications; Image Fusion – Multi-Temporal and Multi-Sensor Image Fusion – Digital Change Detection – Remote Sensing System Change Detection Considerations.

Text Book:

1. Rafael C. Gonzalez & Richard E. Woods – Digital Image Processing – Pearson Education- 2/e – 2004.
2. Bhatta B., 2011: Remote Sensing and GIS, Oxford Publisher.
3. Anil. K. Jain – Fundamentals of Digital Image Processing- Pearson Education-2003.

Recommended Readings:

1. Campbell J. B., 2007: Introduction to Remote Sensing, Guildford Press.
2. Cha, B., Dattaa, D., Majumdar (2001): Digital Image Processing Analysis, Prentice-Hall of India, New Delhi
3. Jensen J. R., 2004: Introductory Digital Image Processing: A Remote Sensing Perspective, Prentice Hall.
4. Jensen, J. R. (2005): Introductory Digital Image Processing, Prentice Hall, New Jersey
5. Joseph, G. 2005: Fundamentals of Remote Sensing, United Press India.
6. Lillesand, T. M., Kiefer, R. W. Chipman, J. W. (2008): Remote Sensing and Image Interpretation, John Wiley & Sons, New Delhi
7. Malay K. Pakhira, "Digital Image Processing and Pattern Recognition", First Edition, PHI Learning Pvt. Ltd., 2011.
8. Nag, P. Kudrat, M. (1998): Digital Remote Sensing, Concept Publishing Company, New Delhi
9. Rees W. G., 2001: Physical Principles of Remote Sensing, Cambridge University Press.
10. Richards, J. A, Jia,X.(1999):Remote Sensing and Digital Image Processing, Springer, Verlag Berlin
11. Sabins, F. F. (1996): Remote Sensing: Principles an Interpretation, W. H. Freeman Company, New York
12. Singh R. B. and Murai S., 1998: Space-informatics for Sustainable Development, Oxford and IBH Pub.
13. Willliam K Pratt, "Digital Image Processing", John Willey, 2002.

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PSO 1	PSO 2	PSO 3	PSO 4
CO 1	1	1	2	2	2	2	1	1	2	1	2	1	2	1
CO 2	1	0	2	2	2	2	2	2	1	2	2	2	2	2
CO 3	1	2	2	2	2	2	1	1	2	1	2	1	1	1
CO 4	1	1	1	3	2	3	1	2	2	1	1	0	2	1
CO 5	0	1	2	2	2	1	2	1	1	2	2	2	2	0
CO 6	1	1	2	1	2	3	1	1	2	1	2	1	2	1

GEO22304	**Digital Image Processing Lab**	L	T	P	C
Version 1.1	**Contact Hours – 90**	0	0	6	4
Pre-requisites/Exposure	Undergraduate level knowledge of GIS and RS				
Co-requisites	Basic knowledge of computer skills				

Course Outcomes

On completion of this course, the students will be able to:
CO1: Show the corrected and enhanced digital images.
CO2: Illustrate the difference between different image enhancement and classification approaches.
CO3: Apply various advanced image processing techniques including image segmentation, fusion, etc.
CO4: Distinguish the effects of image preprocessing and enhancement techniques.
CO5: Assess the accuracy of different classified outputs.
CO6: Construct enhanced images and classified thematic maps with desired accuracy.

Course Content

Unit I: Image Preprocessing (20 Hours)
Haze Correction; Noise Correction; Radiometric Correction: Sensor Callibration, Sun angle corrections and Atmospheric Correction: Absolute and Relative corrections;

Unit II: Image Enhancement in Spatial and Frequency Domain (20 Hours)
Histogram Matching; Histogram Equalization; Spatial Filtering – Spatial Convolution Filtering – High Pass and Low Pass Filtering; Edge Enhancement and Edge Detection Filters – Non-Linear Edge Enhancement Filters; Band Ratioing, Spectral Indices, Principal Component Analysis. Kauth-Thomas Transformation.

Unit III: Digital Image Classification (30 Hours)
Unsupervised Classification – ISODATA, K-Means – Training Sites Selection and Statistical Information Extraction; Supervised Classifier – Minimum Distance to Means, Parallelepiped, Maximum Likelihood – Hybrid Classifiers – Classification Accuracy Assessment and Error Matrix GCP and ground validation of data/image

Unit IV: Advanced Digital Image Processing (20 Hours)
Object-based Classification; Image Segmentation; Image Fusion – Multi-Temporal and Multi-Sensor Image Fusion – Digital Change Detection.

Laboratory Notebook and Viva Voce

Text Book:

1. Rafael C.Gonzalez & Richard E.Woods – Digital Image Processing – Pearson Education- 2/e – 2004.
2. Bhatta B., 2011: Remote Sensing and GIS, Oxford Publisher.
3. Anil.K.Jain – Fundamentals of Digital Image Processing- Pearson Education-2003.

Recommended Readings:

1. Campbell J. B., 2007: Introduction to Remote Sensing, Guildford Press.

2. Cha, B., Dattaa, D., Majumdar (2001): Digital Image Processing Analysis, Prentice-Hall of India, New Delhi
3. Jensen J. R., 2004: Introductory Digital Image Processing: A Remote Sensing Perspective, Prentice Hall.
4. Jensen, J. R. (2005): Introductory Digital Image Processing, Prentice Hall, New Jersey
5. Joseph, G. 2005: Fundamentals of Remote Sensing, United Press India.
6. Lillesand, T. M., Kiefer, R. W. Chipman, J. W. (2008): Remote Sensing and Image Interpretation, John Wiley & Sons, New Delhi
7. Malay K. Pakhira, "Digital Image Processing and Pattern Recognition", First Edition, PHI Learning Pvt. Ltd., 2011.
8. Nag, P. Kudrat, M. (1998): Digital Remote Sensing, Concept Publishing Company, New Delhi
9. Rees W. G., 2001: Physical Principles of Remote Sensing, Cambridge University Press.
10. Richards, J. A, Jia,X.(1999):Remote Sensing and Digital Image Processing, Springer, Verlag Berlin
11. Sabins, F. F. (1996): Remote Sensing: Principles an Interpretation, W. H. Freeman Company, New York
12. Singh R. B. and Murai S., 1998: Space-informatics for Sustainable Development, Oxford and IBH Pub.
13. Willliam K Pratt, "Digital Image Processing", John Willey, 2002.

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PSO 1	PSO 2	PSO 3	PSO 4
CO 1	0	1	2	1	2	3	1	1	2	1	2	1	2	1
CO 2	1	1	2	2	1	2	2	2	1	2	2	2	3	2
CO 3	2	2	2	1	3	2	0	1	2	1	2	1	1	1
CO 4	1	1	1	0	2	1	1	2	2	1	1	1	0	1
CO 5	0	1	2	2	3	2	2	1	1	2	3	2	2	2
CO 6	1	1	2	1	1	3	1	1	2	1	2	1	2	1

GEO22316	**Open Source GIS Lab**	L	T	P	C
Version 1.0	**Contact Hours – 45**	0	0	6	4
Pre-requisites/Exposure	Undergraduate level Geography / Science / Engineering education				
Co-requisites	Conversant with internet and computer applications.				

Course Outcomes

CO1: Recall the fundamental concepts of Open Source GIS and Database Management Systems.
CO2: Demonstrate the various functions available in QGIS, Saga GIS, PostGIS, and PostgreSQL.
CO3: Apply different Open Source GIS and Database Management Systems in geospatial applications.
CO4: Distinguish between the functions available in Open Source GIS and commercial GIS software packages.
CO5: Evaluate the significance of OpenStreet Map, Google Earth, and ISRO's Geoportal.
CO6: Create various spatial outputs using different Open Source GIS software packages.

Course Content

Unit I: Open Source GIS: QGIS (20 Hours)

Basic concepts of open source GIS, evolution of free and open source GIS, standard and protocol of open source GIS, Open Geospatial Consortium, introduction to QGIS, Georeferencing, vector creation, attribute joining and editing, vector and raster based Geoprocessing using QGIS, plugin and external software support with QGIS, layout preparation and map composition,

Unit II: Open Source GIS: Saga GIS (20 Hours)

introduction to Saga GIS, FCC creation, image subseting, image enhancement, data compression- PCA, image indices, image classification (unsupervised & supervised), accuracy assessment, change detection, layout creation.

Unit III: Open Source Database Management System (30 Hours)

Fundamental of Post GIS, relationship in between PostGIS and PostgreSQL, installation of PostGIS, creating a spatial database, loading spatial data, simple SQL, geometries, geometry construction functions, advanced geometry construction, spatial relationships, spatial joining, spatial joining based problem solving, spatial indexing and associated problem solving, validity, equality, linear referencing with PostGIS, nearest neighbour searching.

Unit IV: Geoportal Applications (30 Hours)

Geoportal Applications –Openstreet Map and ISRO Bhuvan Collection and retrieval of GNSS positions, preparation of maps from GNSS data, GNSS data; Introduction to, Identification of Spatiotemporal Change and elevation profiling from Google Earth, Working with ISRO Bhuvan Geoportal – Data extraction, vector overlay and data import.

Laboratory Notebook and Viva Voce

Recommended Readings:

1. Scott Madry., 2021: Introduction to QGIS, Locate press.
2. Hans van der Kwast, Kurt Menke., 2019: QGIS for Hydrological applications, Locate press.

3. Jensen J. R., 2004: Introductory Digital Image Processing: A Remote Sensing Perspective, Prentice Hall.
4. Joseph, G. 2005: Fundamentals of Remote Sensing, United Press India.
5. Lillesand T. M., Kiefer R. W. and Chipman J. W., 2004: Remote Sensing and Image Interpretation, Wiley. (Wiley Student Edition).
6. Olaya, V. 2004: A Gentle Introduction to SAGA GIS, can be access from http://www.saga-gis.org/en/index.html
7. Leo S. Hsu, Regina O. Obe, Leo Hsu ., 2011: PostGIS in Action, Manning Publications
8. Thomas J. Kraft, Stephen Vincent Mather, Paolo Corti., 2014: PostGIS Cookbook, Packt publications.

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PSO 1	PSO 2	PSO 3	PSO 4
CO 1	1	1	2	1	1	2	3	1	2	1	2	1	2	1
CO 2	1	1	2	2	2	3	2	2	2	2	2	2	3	2
CO 3	1	0	2	1	3	1	2	1	2	1	2	1	1	1
CO 4	0	1	1	1	2	3	1	2	3	1	2	1	0	1
CO 5	1	1	2	2	2	1	2	1	2	2	0	2	2	0
CO 6	1	1	2	1	2	3	3	1	2	1	2	1	2	1

GEO22327	**Research Methodology**	L	T	P	C
Version 1.1	**Contact Hours – 45**	0	0	3	2
Pre-requisites/Exposure					
Co-requisites					

Course Outcomes

On completion of this course, the students will be able to:
CO1: Recall the fundamental concepts of research objectives, process, hypothesis.
CO2: Compare different research types and data collection methods.
CO3: Organize literature review and samples.
CO4: Classify different sampling types and citation methods.
CO5: Evaluate research problems.
CO6: Construct questionnaire, research proposal, and literature review-based scientific research papers.

Course Content

Unit I: Fundamentals of Research (10 Hours)
Meaning of Research, Nature, and objectives of the research; Research Types: descriptive-analytical, pure-applied, conceptual-empirical, qualitative-quantitative; Motivations in Research; Writing corporate and scientific research reports

Unit II: Research Process (10 Hours)
Identification of research gap; Selection of research objectives; Literature Review: Conducting literature survey- searching literature, reviewing selected literature, developing theoretical and conceptual frameworks, Reporting literature review; Citation methods

Unit III: Data Collection Methods (20 Hours)
Preparation of questionnaire, Interview: Focus group, participant observation; Hypothesis/Research Question; Sampling- Concept and principles; Probability and Non-Probability sampling- types and criteria for selection; Sample size calculation and developing sampling Frames

Unit IV: Reading and Writing a Scientific Research Paper (20 Hours)
Writing a proposal of research (~2 pages) which will include (1) identifying the research problem; (2) providing background information; (3) listing objectives; and (4) describing data and methods.
Developing and implementing an idea related to a scientific research paper (Literature review based)

Recommended Readings:

1. Best and Kahn, Research Methodology, PHI Limited.
2. Kothari, C.R. Research Methodology (Methods and Techniques), New Age Publisher.
3. Kerlinger, Foundation of Research.
4. Fundamentals of modern statistical methods by Rand R. Wilcox.
5. Power Analysis for Experimental Research A Practical Guide for the Biological, Medical and Social Sciences by R. Barker Bausell, Yi-Fang Li Cambridge University Press.
6. Design of Experience: Statistical Principles of Research Design and Analysis, by Robert O. Kuehl Brooks/cole.

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PSO 1	PSO 2	PSO 3	PSO 4
CO 1	1	1	2	3	2	1	1	1	2	1	2	1	2	1
CO 2	0	1	2	2	2	3	2	2	1	2	2	3	2	2
CO 3	1	2	2	1	2	2	0	1	2	0	2	1	1	1
CO 4	1	1	1	3	2	3	1	2	2	1	1	1	2	1
CO 5	0	1	0	2	2	1	2	1	1	2	2	2	0	2
CO 6	1	1	2	3	2	3	1	1	2	1	2	1	2	1

CSE22752	Basic Programming	L	T	P	C
Version 1.0	Contact Hours – 45	2	0	4	4
Pre-requisites/Exposure	Basic knowledge and operating capability of computers				
Co-requisites	-				

Course Outcomes

On completion of this course, the students will be able to

CO1: Recall the fundamental concepts of computers, IT, MS Office.

CO2: Illustrate the various functions of MS Excel and Power Point.

CO3: Apply the various condition statements in Python.

CO4: Examine the utility of condition statements and data structure.

CO5: Appraise the significance of MS Excel, Power Point, and Python coding in the context of Geoinformatics.

CO6: Develop codes using Python on condition statements and data structures.

Course Content

Unit I: Basics of Computers and Information Technology (9 hours)

Definition and characteristics of computer, History and evaluation of computers, Components of computer systems: Input unit, Output Unit, Central processing unit (CPU): ALU, CU. Memory unit: RAM, ROM, HDD, SSD. Hardware: Physical components of computer, Software: System software (Operating system etc), application software. Data Representation and number system: Binary, Decimal, Octal, Hexadecimal. Introduction to information technology: the difference between information and data; common sources of Geoinformatics information. application of internet to Geoinformatics; introduction to networks, local area network devices, topologies, protocols, wide area networks, servers, hubs, nodes, moderns, internet, basic & advanced html, types of tags, document creations, linking, creating link list, handling images, tables and, style sheets.

Unit II: Microsoft Excel and Microsoft Power point (12 hours)

Introduction to the excel environment, understanding workbook, worksheet, cells, rows, columns and range. Formatting text (font, size, color), formatting numbers (currency, percentages, dates), aligning cell content and merging cells. Introduction to formulas and functions: using basic arithmetic operations (+, -, *, /), common functions: SUM, AVERAGE, COUNT, MIN, MAX. Sorting and filtering data. Concept of conditional formatting. Creating tables and managing tables. Creating basic charts. Data analysis tools: Pivot table.

Introduction to Microsoft Power Point: functions and exploring Power Point views; creating a presentation; delivering and printing a presentation; animations and slide show applications to Geoinformatics.

Unit III: Introduction to python (12 hours)

History and features of python, installing python and setting up the environment, introduction to python IDEs (Pycharm, Vscode, Jupyter notebook etc). Understanding python syntax and indentation. Basic operations: Arithmetic, comparison, logical. Declaring and initializing variables. Basic data types: integer, float, string, Boolean. Type conversion and casting. Input and output functions. Control structures: conditional statements: if, elif, else. Loops: for, while. Loop control statements: break, continue, pass.

Functions: Defining and calling functions, function arguments and return values, lambda functions. Modules and packages: importing modules, introduction standard libraries.

Unit IV: Python Data Structures (12 hours)

Lists: creating and accessing list elements, list operations (slicing, appending, inserting, removing), list comprehensions. Tuples: creating and accessing tuple elements. Basic tuple operations. Dictionaries: concept of key value pair, Dictionary methods: Adding, removing, updating items. Sets: union, intersection, difference. String: Creating and manipulating strings, string methods ('split()', 'join()', 'replace()', 'find()' etc), String formatting.

Recommended Readings:

1. Beekman, G. 1999, Computer Confluence: Exploring Tomorrow's Technology. Addison- Wesley, Reading, MA. (3rd. ed).
2. Willis H. Means 19087A content analysis of six introduction to computer science textbooks
3. ACM New York, NY, USA, 403 - 413
4. Beekman, G. George Beckman 2000 Tech Nation. Online. Internet. [March 14,]. Available www: http:// www.computerconfluence.com/about/tech.htm
5. Cheryl SchmidtComplete 19908, Computer Repair Textbook, Scott Jones, 22-408.
6. Dix, A., Finlay, J., Abowd, G., and Beale, R. 1999. Human-Computer Interaction. Prentice-Hall, Herts. UK. 67-089.
7. Goldberg, M. W. CALOS: Feb, 1997), First Results from an Experiment in Computer-Aided
8. Learning for Operating Systems, in Proceedings of the Twentyeighth SIGCSE Technical Symposium on Computer Science Education. ACM Press. 408-52.
9. Goldberg, M. W. WebCT and First Year Computer Science June, 1997: Student Reaction to and Use of a Web-Based Resource in First Year Computer Science, in Proceedings of the ACM's ITiCSE Conference on Integrating Technology into Computer Science Education. ACM Press. 127-129.
10. Shelly Cashman 2000, Course Technology. About Shelly Cashman Series. Online. Internet. [March 14,]. Available WWW: Http://www.scseries.com/about_sc.cf
11. Introducing Python- Modern Computing in Simple Packages – Bill Lubanovic, O,,Reilly Publication
12. Beginning Python: From Novice to Professional, Magnus Lie Hetland, Apress
13. Programming In Python, Dr. Pooja Sharma, BPB

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PSO 1	PSO 2	PSO 3	PSO 4
CO 1	1	1	2	1	2	2	3	1	2	1	2	1	2	1
CO 2	0	0	2	2	2	2	2	2	2	2	2	2	2	2
CO 3	1	2	2	1	2	3	2	1	2	1	3	1	1	1
CO 4	1	1	1	1	2	2	2	2	2	1	0	1	2	1
CO 5	1	1	0	2	2	3	2	1	2	2	2	2	2	2
CO 6	1	1	2	1	2	2	3	1	2	1	2	1	2	0

SEMESTER II

GEO21330	**Geoinformatics II**	L	T	P	C
Version 1.0	**Contact Hours – 45**	3	0	0	3
Pre-requisites/Exposure	Fundamentals of Geoinformatics, Digital Image Processing				
Co-requisites					

Course Outcomes

On completion of this course, the students will be able to:
CO1: Recall the fundamental concepts of spatial and network data.
CO2: Interpret the classified maps and other spatially processed data.
CO3: Apply different classification; single and multi-layer operations, and network analysis.
CO4: Categorize different machine learning based classification and grid-based operations.
CO5: Evaluate the spatial decision support systems.
CO6: Construct advanced classified maps, spatial, and network datasets in the context of spatial decision support system.

Course Content

Unit I: Advanced Image Classification Techniques (10 Hours)
Generic image classification & advanced classification methods – Object-based image classification; Machine learning-based classification (SVM, Random Forest, Decision Tree), concepts and techniques of accuracy assessment.

Unit II: Spatial Data Analysis (10 Hours)
Fundamentals of spatial data modelling: Distance and Directional Operations; Overview of Tools for Spatial Analysis – Vector Based: Overlay Operations, Single Layer Operations and Multilayer Operation - weighted overlay; Measuring Geographic Distributions - Spatial Analysis – Map Algebra and Grid Based Operations: Local, Focal, Zonal, and Global Analyses.

Unit III: Network Data Analysis (10 Hours)
Network Data Modelling - Evaluation of Network Complexity Using Alpha, Beta, Gamma Indices; Travelling Salesman Problem; Least Cost Path Analysis; Location-Allocation Analysis; Urban Transportation Planning Model.

Unit IV: Spatial Decision Support Systems (10 Hours)
Spatial Decision Support Systems, Multi criteria decision support system; Concepts of Agent-based modelling; Spatial Interpolation (deterministic and stochastic models).

Recommended Readings:

1. Jensen, J. R., 2013: Remote Sensing of the Environment, Pearson.
2. Tang, H. and Li, Z-L., 2014: Quantitative Remote Sensing in Thermal Infrared – Theory and Applications, Springer

3. Jensen J. R., 2004: Introductory Digital Image Processing: A Remote Sensing Perspective, Prentice Hall.
4. Vosselman, G. and Mass, H-G. (eds.), 2010: Airborne and Terrestrial Laser Scanning, CRC Press.
5. Lillesand T. M., Kiefer R. W. and Chipman J. W., 2004: Remote Sensing and Image Interpretation, Wiley.
6. Kalacska, M. and Sanchez-Azofeifa, G. A., 2008: Hyperspectral Remote Sensing of Tropical and Subtropical Forests, CRC Press.
7. van der Meer, F. D. and de Jong, S. M., 2002: Imaging Spectrometry – Basic Principles and Prospective Applications, Kluwer Academic Publishers.
8. Shan, J. and Toth, C. K. (eds.), 2018: Topographic Laser Ranging and Scanning – Principles and Processing, CRC Press.
9. Kluenzer, C. and Dech, S. (eds.), 2013: Thermal Infrared Remote Sensing – Sensors, Methods, Applications, Springer.
10. Quattrochi, D. A. and Luvall, J. C. (eds.), 2005: Thermal Remote Sensing in Land Surface Processes, CRC Press.
11. Chang, K-T., 2019: Introduction to Geographic Information Systems, McGraw Hill.
12. de Smith, M. J., Goodchild, M. F., Longley, P. A., 2018: Geospatial Analysis: A Comprehensive Guide to Principles, Techniques and Software Tools, Matador.
13. Haining, R., 2010: Spatial Data Analysis – Theory and Practice, Cambridge University Press.
14. Bailey, T. C. and Gatrell, A. C., 1995. Interactive Spatial Data Analysis, Routledge.
15. Burrough, P. A., McDonnell, R. A.and Lloyd, C. D., 2015: Principles of Geographical Information Systems, Oxford University Press.
16. Pick, J. B., 2008: Geo-business GIS in the Digital Organization, Wiley.
17. Singh, R. B. and Murai, S., 1998: Space-informatics for Sustainable Development, Oxford and IBH Pub.
18. Devillers, R. and Jeansoulin, R. (2006). Fundamentals of Spatial Data Quality, ISTE Ltd., USA.
19. Yue-hong Chou (1997). Exploring Spatial Analysis in Geographical Information System, Onword Press, Thomson Learning.
20. Berners-Lee, T. (1996). The World Wide Web: past, present and future. Cambridge, MA: Massachusetts Institute of Technology, Laboratory for Computer Science. http://www.w3.org/People/Berners-Lee/1996/ppf.html.
21. Jones, C. B., and R.S. Purves (2008). Web-based GIS. In The Handbook of Geographical Information Science, eds. J. P. Wilson and A. S. Fotheringham, 559-580. Oxford: Wiley Blackwell.

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PSO 1	PSO 2	PSO 3	PSO 4
CO 1	1	1	2	2	2	2	1	1	2	1	2	1	2	1
CO 2	1	0	2	2	2	2	2	2	1	2	2	2	2	2
CO 3	1	2	2	2	2	2	1	1	2	1	2	1	1	1
CO 4	1	1	1	3	2	3	1	2	2	1	1	0	2	1
CO 5	0	1	2	2	2	1	2	1	1	2	2	2	2	0
CO 6	1	1	2	1	2	3	1	1	2	1	2	1	2	1

GEO22331	**Geoinformatics** II Lab	L	T	P	C
Version 1.0	**Contact Hours – 90**	0	0	6	4
Pre-requisites/Exposure	Fundamentals of Geoinformatics Lab, Geospatial Analysis and its Applications Lab				
Co-requisites	-				

Course Outcomes

On completion of this course, the students will be able to:
CO1: Show the functioning of spatial (raster and vector) and network data.
CO2: Interpret the classified maps and other spatially processed data.
CO3: Apply different classification; single and multi-layer operations, and network analysis.
CO4: Categorize different machine learning based classification and vector operations.
CO5: Evaluate different geospatial models.
CO6: Create advanced classified maps, spatial, and network datasets in the context of geospatial modelling.

Course Content

Unit I: Advanced Image Classification Techniques (10 Hours)
Generic image classification & advanced classification methods - object based image classification and machine learning based classification (SVM, Random Forest, Decision Tree); accuracy assessment and change detection of multi-temporal data

Unit II: Advanced Vector Operations (30 Hours)
Overview of tools for spatial analysis – Vector-based overlay operations: Point-in polygon, line-in-polygon, polygon-in-polygon; Single layer operations: Feature identification, extraction, classification manipulation. Multilayer operation: Union, intersection, symmetrical difference, update, merge, append and dissolve; Topological corrections;

Unit III: Advanced Spatial Analysis Techniques (30 Hours)
Measuring Geographic Distributions: Mean centre, Median centre, and Standard Distance and SDE; Measuring pattern - Cluster and Outlier analysis; Hotspot analysis; Spatial Autocorrelation and Spatial Regression; Spatial analysis – Raster Based: Map algebra, grid-based operations, local, focal, zonal, and global functions.

Unit IV: Geospatial Modelling (30 Hours)
Site-Suitability Model; Multi-criteria decision analysis; weighted overlay; Evaluation of network complexity using Alpha, Beta, Gamma Indices; Types of network analysis: Least Cost Path Analysis; Location-Allocation Analysis.

Laboratory Notebook and Viva voce

Recommended Readings:

1. Chang, K-T., 2019: Introduction to Geographic Information Systems, McGraw Hill.
2. de Smith, M. J., Goodchild, M. F., Longley, P. A., 2018: Geospatial Analysis: A Comprehensive Guide to Principles, Techniques and Software Tools, Matador.
3. Haining, R., 2010: Spatial Data Analysis – Theory and Practice, Cambridge University Press.
4. Bailey, T. C., and Gatrell, A. C., 1995. Interactive Spatial Data Analysis, Routledge.

5. Burrough, P. A., McDonnell, R. A. and Lloyd, C. D., 2015: Principles of Geographical Information Systems, Oxford University Press.
6. Pick, J. B., 2008: Geo-business GIS in the Digital Organization, Wiley.
7. Singh, R. B., and Murai, S., 1998: Space-informatics for Sustainable Development, Oxford and IBH Pub.
8. Devillers, R. and Jeansoulin, R. (2006). Fundamentals of Spatial Data Quality, ISTE Ltd., USA.
9. Yue-hong Chou (1997). Exploring Spatial Analysis in Geographical Information System, Onward Press, Thomson Learning.
10. Berners-Lee, T. (1996). The World Wide Web: past, present, and future. Cambridge, MA: Massachusetts Institute of Technology, Laboratory for Computer Science. http://www.w3.org/People/Berners-Lee/1996/ppf.html.
11. Jones, C. B., and R.S. Purves (2008). Web-based GIS. In The Handbook of Geographical Information Science, eds. J. P. Wilson and A. S. Fotheringham, 559-580. Oxford: Wiley Blackwell.

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PSO 1	PSO 2	PSO 3	PSO 4
CO 1	0	1	2	1	2	3	1	1	2	1	2	1	2	1
CO 2	1	1	2	2	1	2	2	2	1	2	2	2	3	2
CO 3	2	2	2	1	3	2	0	1	2	1	2	1	1	1
CO 4	1	1	1	0	2	1	1	2	2	1	1	1	0	1
CO 5	0	1	2	2	3	2	2	1	1	2	3	2	2	2
CO 6	1	1	2	1	1	3	1	1	2	1	2	1	2	1

GEO22336	**Advanced Photogrammetry Lab**	L	T	P	C
Version 1.0	**Contact Hours – 90**	0	0	6	4
Pre-requisites/Exposure	UG level Cartography, Surveying and GIS knowledge				
Co-requisites	-				

Course Outcomes

On completion of this course, the students will be able to

CO1: Recall the fundamental concepts of aerial photographs and LiDAR technology.

CO2: Interpret the analog and digital photographs.

CO3: Identify the difference between digital and analog photogrammetry.

CO4: Inspect the role of photogrammetry and LiDAR technology in object height determination and ortho-photo generation.

CO5: Evaluate various applications of aerial photographs and LiDAR data.

CO6: Create analog and digital maps from analog and digital photographs and LiDAR data.

Course Content

Unit I: Introduction to photogrammetry (15 hours)

Introduction to aerial photography – Basic information and specifications of aerial photographs, Photogrammetric terms, applications, benefits, restrictions, and a little history metric vs. non-metric cameras, and photogrammetry camera types.

Unit II: Aerial photogrammetry (15 hours)

Geometric Characteristics of Aerial Photographs- Types of Aerial Photograph: Orthographic vs. perspective projection, Map vs. photograph, scale of photograph, determination the scale, relief displacement and its determination, parallax in photographs and measurement, stereoscopy.

Unit III Digital Photogrammetry (25 hours)

Transformation between image and object space: collinearity equations, Interior & exterior orientation, Space resection, Space forward intersection and limitations, Aerial triangulation and bundle block adjustment. Product generation: Ortho-photo and DTM generation: DTM/ DEM and DSM, Rectified photo, Orthophoto and True Orthophoto,

Unit IV LiDAR (20 hours)

Introduction, Laser characteristics, laser interaction with objects, Types of LiDAR systems: Terrestrial, airborne, static and dynamic, Altimetric LiDAR: topographic and bathymetric, single and multiple return, full waveform digitization. Components of a LiDAR system: INS/GNSS/LiDAR integration, LiDAR geo-location, accuracy of LiDAR components, error analysis, Airborne LiDAR surveys: Flight Planning, survey execution, Examples and applications of integrated LiDAR systems: MMS, Airborne LiDAR systems, UAVs. Integration of LiDAR with spectral data (camera): LiDAR data classification techniques, raw data to bald Earth, LiDAR Applications: building, tree, powerline extraction. Integrated systems (UAV, Car, Aircraft etc.): Applications: Mining, exploration, SLAM.

Recommended Readings:

1. Wolf P. R. and Dewitt B. A., 2000: Elements of Photogrammetry: With Applications in GIS, McGraw-Hill.
2. Wolf P. R. and Dewitt B. A., 2000: Elements of Photogrammetry: With Applications in GIS, McGraw-Hill.

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PSO 1	PSO 2	PSO 3	PSO 4
CO 1	1	1	2	1	1	2	3	1	2	1	2	1	2	1
CO 2	1	1	2	2	2	3	2	2	2	2	2	2	3	2
CO 3	1	0	2	1	3	1	2	1	2	1	2	1	1	1
CO 4	0	1	1	1	2	3	1	2	3	1	2	1	0	1
CO 5	1	1	2	2	2	1	2	1	2	2	0	2	2	0
CO 6	1	1	2	1	2	3	3	1	2	1	2	1	2	1

GEO22332	**Advanced Cartography and Surveying Lab**	L	T	P	C
Version 1.0	**Contact Hours – 90**	0	0	6	4
Pre-requisites/Exposure	UG level Cartography, Surveying knowledge				
Co-requisites	-				

Course Outcomes

On completion of this course, the students will be able to
CO1: Recall the basics of cartography, map projection, and surveying.
CO2: Explain the methods of basic and modern surveying techniques.
CO3: Identify the applications of map projection and surveying techniques.
CO4: Classify different map projection and surveying techniques.
CO5: Appraise the utility of map projection, basic, and modern surveying tools including GPS, DGPS, and Total Station.
CO6: Create various spatial outputs using different map projections and surveying instruments.

Course Content

Unit I: Basics of Map Projection (30 hours)

Cartography – scope, content, principles and development, Basic concepts — parallels & meridians, latitudes & longitudes, great circle, map projection, scale factor, deformations, orthodrome, loxodrome and geodesic (simple problems of distance and azimuth); co-ordinate system and location on globe and 2D planes, Drawing Graticules, Scale Variation and Scale Error, Mapping Countries, Continents, World with Geographical Features on –

A. Planer (Polar Zenithal Orthographic and Equal Area) Projections
B. Conical (Simple Conic – I, Bonne's, Polyconic, Sinusoidal, Simple Conic - II) Projections
C. Cylindrical (Equal-area and Orthomorphic) Projections
D. Conventional (Mollweide) Projections

Unit II: Basic Surveying (15 Hours)

Nature and Principles of Surveying; Types of Surveying, Basic concepts of Traversing, Triangulation, Trilateration, Levelling and Contouring (including solutions of related problems) with –

A. Prismatic Compass,
B. Dumpy Level
C. Preparing ground plan and determining height and distance of an object using Theodolite,

Unit III: Modern Surveying Solutions (15 Hours)

Surveying methods and mathematical implication of Total station, (Triangulation and Traversing method) surveying; Total Station Survey in field, downloading, processing and generation of survey plots using software.

Unit IV: GPS and DGPS Surveying (15 Hours)

Global Positioning System (GPS) survey: Basic principles and evolution; Handheld GPS Operation - feature collection, data transfer, , area calculation, data processing and generation of survey plots ; DGPS Survey - Components, types, and its accessories, surveying and data capture, Error Corrections, Integration with GIS

Recommended Readings:

1. Hussain. S.K. AND Nagaraj. M.S. 1992, Text Book of Surveying. S. Chand & Co. Ltd. New Delhi.
2. Ishtiaque, M. 1989: Practical Geography, Heritage Publishers, New Delhi.
3. Kanetkar. R.P. and Kulkarni. S.V. 1988, Surveying and Levelling, Part-I Pune Vaidyarthi Griha Prakashani, Pune.
4. Kanetkar, T.P., and S.V. Kulkarni. *Surveying and Levelling, Vol. 1 & 2*. Pune: Pune Vidyarthi Griha Prakashan, 2010.
5. Punmia, B.C., Ashok Kumar Jain, and Arun Kumar Jain. *Surveying: Principles and Applications*. New Delhi: Laxmi Publications, 2008.
6. Subramanian, R. *Surveying and Levelling*. Chennai: Oxford University Press, 2008.
7. Basak, N.N. *Advanced Surveying*. New Delhi: McGraw-Hill Education, 2010.
8. Punmia, Dr. B.C. *Surveying (Vol. 1, 2, 3)*. New Delhi: Laxmi Publications, 2017.
9. Chandra, A.M., and Vineet Kumar. *Modern Surveying Techniques*. New Delhi: CRC Press, 2023.
10. *Tiberius et.al. (2022) : Emerging Trends in Surveying and Mapping Technologies* - https://textbooks.open.tudelft.nl/textbooks/catalog/download/46/150/382?inline=1
11. Gopi. et. al. (2023): *Advanced Surveying*. New Delhi: Pearson Education.

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PSO 1	PSO 2	PSO 3	PSO 4
CO 1	1	1	2	3	2	1	1	1	2	1	2	1	2	1
CO 2	0	1	2	2	2	3	2	2	1	2	2	3	2	2
CO 3	1	2	2	1	2	2	0	1	2	0	2	1	1	1
CO 4	1	1	1	3	2	3	1	2	2	1	1	1	2	1
CO 5	0	1	0	2	2	1	2	1	1	2	2	2	0	2
CO 6	1	1	2	3	2	3	1	1	2	1	2	1	2	1

CSE22756	Database Management Systems	L	T	P	C
Version 1.0	Contact Hours – 30	1	0	2	2
Pre-requisites/Exposure	UG level knowledge of Concept and classification of data				
Co-requisites	-				

Course Outcomes

On completion of this course, the students will be able to

CO1: Recall the concepts of data and knowledge levels.

CO2: Illustrate the ideas of SQL and data normalization.

CO3: Apply the SQL and Join and Subqueries in database management systems.

CO4: Analyze the different functions of SQL and Subqueries.

CO5: Evaluate the utility of knowledge base and expert systems.

CO6: Elaborate the functioning of SQL, database, and normalization.

Course Content:

Unit I: Introduction to Database management system (8 hours)

Database concepts: Data vs information, Databse vs file system. DBMS architecture: single tier, two tier, three tier. Types of database model: Hierarchical model, Network model, Relational model, Object-oriented model. Relational data base model. ER models: Entity Set, Relation Ship Set, Cardinality Properties, Type of Entities. Keys: Primary key, Foreign key, Composite key. Relationships: one to one, one to many, many to many. Aggregation, Specialization and Generalization.

Unit II: Normalization (10 hours)

Relational database design: Integrity Constraint, Domain Constrain, Referential Integrity, Functional Dependencies, Closure of Set, Cover and Canonical Cover, Types of Anomalies, Armstrong's axioms, Extended Armstrong's axioms.

Data Base Decomposition: Domain and data dependency, Normal forms: 1NF, 2 NF, 3 NF, BCNF, Dependency preservation, Lossless design.

Unit III: Introduction to SQL (15 hours)

Data definition language (DDL). Data manipulation language (DML). Creating databases and tables. Alter tables. Dropping databases and tables. Insert data into table. Updating the data. Deleting data. Querying data: SELECT statement. SQL data types. Applying constrains: NOT NULL, UNIQUE etc. Common data types in SQL. Filtering data using WHERE clause. Comparison operator. Logical operator. BETWEEN, IN, LIKE and IS NULL. Sorting data using ORDER BY clause. Using LIMIT clause. Aggregate functions and grouping: COUNT, SUM, AVG, MAX, MIN functions. Using GROUP BY clause. Filtering groups with HAVING clause.

Unit IV: Joins and Subqueries (12 hours)

Types of joins: Inner join, Left (outer) join, Right (outer) join, Full (outer) join, cross join. Joining multiple tables. Subqueries and Nested Queries: Using subqueries in SELECT, FROM WHERE clause. Subqueries with EXISTS and NOT EXISTS. Using ANY and ALL with subqueries.

Recommended Readings:

1. Database System Concepts, 6th Edition by Abraham Silberschatz, Henry F. Korth, S. Sudarshan, McGraw-Hill

2. Principles of Database and Knowledge – Base Systems, Vol 1 by J. D. Ullman, Computer Science Press.
3. “Fundamentals of Database Systems”, 5th Edition by R. Elmasri and S. Navathe, Pearson Education
4. “Foundations of Databases”, Reprint by Serge Abiteboul, Richard Hull, Victor Vianu, Addison-Wesley.

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PSO 1	PSO 2	PSO 3	PSO 4
CO 1	1	1	2	1	2	2	3	1	2	1	2	1	2	1
CO 2	0	0	2	2	2	2	2	2	2	2	2	2	2	2
CO 3	1	2	2	1	2	3	2	1	2	1	3	1	1	1
CO 4	1	1	1	1	2	2	2	2	2	1	0	1	2	1
CO 5	1	1	0	2	2	3	2	1	2	2	2	2	2	2
CO 6	1	1	2	1	2	2	3	1	2	1	2	1	2	0

CSE22758	Python for Geospatial analysis	L	T	P	C
Version 1.0	Contact Hours – 45	0	0	6	4
Pre-requisites/Exposure	Basic knowledge of Programming Languages				
Co-requisites	Basic knowledge of python programming language				

Course Outcomes:

On completion of this course, the students will be able to:

CO1: Recall the fundamental concepts algorithms and statistics.

CO2: Illustrate different applications of ArcPy, NumPy, Pandas, GeoDataFrames, etc.

CO3: Apply different Python libraries.

CO4: Examine the utility of Python machine learning and real-world applications.

CO5: Evaluate Python coding in geoscience and geospatial data processing.

CO6: Develop Python codes for statistical and geoscientific analysis.

Course Content

Unit I: The application of machine learning in geoscience (9 hours)

Overview of machine learning and its relevance to geoscience. Types of machine learning: supervised, unsupervised and reinforcement learning. Case studies of machine learning applications in geoscience. Introduction to Numpy: arrays, array operations and basic functions. Statistical operations and linear algebra with Numpy. Introduction to Arcpy and its functionalities. Working with shapefiles and geodatabases. Spatial analysis and geoprocessing with Arcpy. Basics of Matplotlib: plotting, styling and customizing plots, creating geospatial visualizations. Introduction to Seaborn: Statistical data visualization.

Unit II: Statistics for geoscience (9 hours)

Introduction to statistics in geoscience. Types of data: qualitative vs quantitative, continuous vs discrete. Descriptive statistics: mean, median, mode, standard deviation, and variance. Introduction to data cleaning using Pandas: Handling of missing value: imputation, removal and interpolation. Detecting outliers and correcting outliers. Data preprocessing: scaling, normalization and transformation. Encoding categorical variables. Feature engineering for geoscientific data.

Unit III: Advanced geospatial data processing and analysis (15 hours)

Introduction to Geopandas: creating and manipulating GeoDataFrames. Spatial operations: joins, buffers and overlays. Introduction to image processing concepts: filtering, edge detection and thresholding. Python libraries for image processing: PIL, Opencv and scikit-image. Spatial data preprocessing: data cleaning and transformations. Handling large geospatial datasets. Mosaicking of images, handling image alignment and blending. Georeferencing: techniques for georeferencing images, applying transformation and projection. Map algebra: Raster data operations: local, focal, zonal and global.

Unit IV: The basics of machine learning and case studies (12 hours)

Introduction to regression and classification. Supervised machine learning algorithm: Linear regression, bivariate regression, Concept of correlation in machine learning, Logistic regression, decision trees, support vector machine. Introduction to clustering. Unsupervised machine learning algorithm: K means clustering, hierarchical clustering, and principle component analysis. Introduction to scikit-learn. Case study: Real world application of machine learning.

Recommended Readings:

1. Charles Dierbach, "Introduction to Computer Science using Python: A Computational Problem-Solving Focus, Wiley India Edition, 2013.
2. John V Guttag, "Introduction to Computation and Programming Using Python'', Revised and expanded Edition, MIT Press, 2013
3. Kenneth A. Lambert, "Fundamentals of Python: First Programs", CENGAGE Learning, 2012.
4. Paul Gries, Jennifer Campbell and Jason Montojo, "Practical Programming: An Introduction to Computer Science using Python 3", Second edition, Pragmatic Programmers, LLC,2013.

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PSO 1	PSO 2	PSO 3	PSO 4
CO 1	1	1	2	2	2	2	1	1	2	1	2	1	2	1
CO 2	1	0	2	2	2	2	2	2	1	2	2	2	2	2
CO 3	1	2	2	2	2	2	1	1	2	1	2	1	1	1
CO 4	1	1	1	3	2	3	1	2	2	1	1	0	2	1
CO 5	0	1	2	2	2	1	2	1	1	2	2	2	2	0
CO 6	1	1	2	1	2	3	1	1	2	1	2	1	2	1

ENG21111	Business Communication Basic	L	T	P	C
Version 1.0	**Contact Hours – 30**	2	0	0	2
Pre-requisites/Exposure	Basic knowledge of Programming Languages				
Co-requisites	Basic knowledge of python programming language				

Course Outcomes:

On completion of this course, the students will be able to:

CO1: Recall the fundamental concepts of Communicative English.

CO2: Illustrate the components of Communicative English.

CO3: Apply the grammatical knowledge in writing and speaking good English.

CO4: Examine the articles, prepositions, tense, voice, idioms, vocabulary etc. in writing and speaking good English.

CO5: Appraise the significance of advanced methods of communicative English skill development, including audio clipping, argumentative talks, etc.

CO6: Develop good communicative English skills.

Course Content

Unit I

Phonetics; Vowels; Consonants; Vocal cord systems; Speech organs; Oral sounds and nasal sounds; Phonology; Sound structure; Intonation; Understanding pronunciation; Pronouncing individual sounds; Practices.

Unit II Articles; Prepositions; Morphemes; Morphology; Understanding the word hierarchy; Inflection and derivation; Parts of Speech; Lexical ambiguity; Pluralization; Affixes; Learning vocabulary; Practice vocabulary.

Unit III

Tense; Voice changes; Narrations; Idioms; Putting words together; Formation of phrases; Different types of phrases; Putting the phrases together; Identify different phrases; Phrasal Verbs; Sentences formation; Sentence types; Sentence functions.

Unit IV

Reading short passages; Strategies to read effectively; Listening short audio clips; Strategies to listen effectively; Story telling demonstration; Listening practice; Speaking effectively; Strategies to speak effectively; Practice speaking on different topics.

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PSO 1	PSO 2	PSO 3	PSO 4
CO 1	0	1	2	1	2	3	1	1	2	1	2	1	2	1
CO 2	1	1	2	2	1	2	2	2	1	2	2	2	3	2
CO 3	2	2	2	1	3	2	0	1	2	1	2	1	1	1
CO 4	1	1	1	0	2	1	1	2	2	1	1	1	0	1
CO 5	0	1	2	2	3	2	2	1	1	2	3	2	2	2
CO 6	1	1	2	1	1	3	1	1	2	1	2	1	2	1

GEO25333	Term Paper Leading to Dissertation I	L	T	P	C
		0	0	3	2
Pre-requisites/Exposure	In depth knowledge on masters level special paper				
Co-requisites	English writing and communication skill				

Course Outcomes

On completion of this course, the students will be able to:
CO1: Recall the fundamental concepts of research objectives, process, hypothesis.
CO2: Compare different research types and data collection methods.
CO3: Organize literature review and samples.
CO4: Classify different sampling types and citation methods.
CO5: Evaluate research problems.
CO6: Construct the dissertation file with literature review and research objectives.

Course Content

Unit I: Review of Literature (15 Hours)

Unit II: Identifying the Research Questions & Objective of the study (15 Hours)

Unit II: Documentation and Presentation on Literature review and Viva (15 Hours)

Recommended Readings:

Good research articles published from reputed journals on their specific research domain.

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PSO 1	PSO 2	PSO 3	PSO 4
CO 1	1	1	2	1	1	2	3	1	2	1	2	1	2	1
CO 2	1	1	2	2	2	3	2	2	2	2	2	2	3	2
CO 3	1	0	2	1	3	1	2	1	2	1	2	1	1	1
CO 4	0	1	1	1	2	3	1	2	3	1	2	1	0	1
CO 5	1	1	2	2	2	1	2	1	2	2	0	2	2	0
CO 6	1	1	2	1	2	3	3	1	2	1	2	1	2	1

SEMESTER: III

GEO21334	**Geoinformatics III**	L	T	P	C
Version 1.0	**Contact Hours – 45**	3	0	0	3
Pre-requisites/Exposure	Fundamentals of Geoinformatics, Digital Image Processing				
Co-requisites					

Course Outcomes

On completion of this course, the students will be able to:

CO1: Define the terms thermal, microwave, hyperspectral, and LiDAR remote sensing.

CO2: Illustrate the concepts of thermal, microwave, hyperspectral, and LiDAR remote sensing.

CO3: Apply the various functions of thermal, microwave, hyperspectral, and LiDAR remote sensing.

CO4: Examine the utility of thermal, microwave, hyperspectral, and LiDAR remote sensing.

CO5: Evaluate application of thermal, microwave, hyperspectral, and LiDAR remote sensing in coal fire mapping, urban heat island studies, biomass estimation, object height determination.

CO6: Construct thermal, backscatter, classified images and digital surface models.

Course Content

Unit I: Thermal Remote Sensing (12 Hours)

Thermal Radiation Principles: Radiant vs. Kinetic Temperature; Blackbody Radiation law; Interaction of thermal radiation with terrain elements; Thermal infrared domain and atmospheric windows; Kirchhoff's law and Emissivity; Thermal infra-red sensors; Daytime and nighttime data acquisition; Pre-processing of thermal sensor data; TIR spectroscopy; Thermal sensing through UAV; Application of thermal remote sensing in forest fire, surface coal fire, and urban heat island studies.

Unit II: Microwave Remote Sensing (14 Hours)

Advantages and limitations of microwave remote sensing; Active and Passive Microwave Sensors; Wavelength, frequency, and pulse length; Geometric characteristics of SLAR images: azimuth and range direction, depression and incident angles, polarization, range and azimuth resolutions; RADAR relief displacement: foreshortening, layover, shadows, speckle; Concept and functioning of SAR; RADAR environmental considerations: surface roughness characteristics, electrical characteristics and moisture content, vegetation, water, and urban responses; RADAR Interferometry; Functioning of Ground Penetrating RADAR.

Unit III: Hyperspectral Remote Sensing (11 Hours)

Imaging spectrometry and hyperspectral cube; Spectral end member and spectral libraries; Atmospheric correction of hyperspectral images; n-dimensional visualization; Spectral Angle Mapper Classification; Minimum Noise Fraction; Pixel Purity Index; Spectral Feature Filtering; Spectral Unmixing; Applications of hyperspectral remote sensing in forestry, geology, and urban studies.

Unit IV: LiDAR Remote Sensing (8 Hours)

Basic components and physical principles of LiDAR scanning system; Airborne and spaceborne laser profilers; Advantages and limitations of airborne laser scanning; Digital Surface Models; LiDAR accuracy; Canopy surface height mapping; Terrestrial Laser Scanning System; Building extraction and 3D reconstruction.

Recommended Readings:

1. Jensen, J. R., 2013: Remote Sensing of the Environment, Pearson.
2. Tang, H. and Li, Z-L., 2014: Quantitative Remote Sensing in Thermal Infrared – Theory and Applications, Springer
3. Jensen J. R., 2004: Introductory Digital Image Processing: A Remote Sensing Perspective, Prentice Hall.
4. Vosselman, G. and Mass, H-G. (eds.), 2010: Airborne and Terrestrial Laser Scanning, CRC Press.
5. Lillesand T. M., Kiefer R. W. and Chipman J. W., 2004: Remote Sensing and Image Interpretation, Wiley.
6. Kalacska, M. and Sanchez-Azofeifa, G. A., 2008: Hyperspectral Remote Sensing of Tropical and Subtropical Forests, CRC Press.
7. van der Meer, F. D. and de Jong, S. M., 2002: Imaging Spectrometry – Basic Principles and Prospective Applications, Kluwer Academic Publishers.
8. Shan, J. and Toth, C. K. (eds.), 2018: Topographic Laser Ranging and Scanning – Principles and Processing, CRC Press.
9. Kluenzer, C. and Dech, S. (eds.), 2013: Thermal Infrared Remote Sensing – Sensors, Methods, Applications, Springer.
10. Quattrochi, D. A. and Luvall, J. C. (eds.), 2005: Thermal Remote Sensing in Land Surface Processes, CRC Press.

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PSO 1	PSO 2	PSO 3	PSO 4
CO 1	1	1	2	3	2	1	1	1	2	1	2	1	2	1
CO 2	0	1	2	2	2	3	2	2	1	2	2	3	2	2
CO 3	1	2	2	1	2	2	0	1	2	0	2	1	1	1
CO 4	1	1	1	3	2	3	1	2	2	1	1	1	2	1
CO 5	0	1	0	2	2	1	2	1	1	2	2	2	0	2
CO 6	1	1	2	3	2	3	1	1	2	1	2	1	2	1

GEO22335	Geoinformatics III Lab	L	T	P	C
Version 1.0	Contact Hours – 90	0	0	6	4
Pre-requisites/Exposure	Fundamentals of Geoinformatics Lab, Digital Image Processing Lab				
Co-requisites	-				

Course Outcomes

On completion of this course, the students will be able to:
CO1: Show the fundamental concepts of thermal, microwave, hyperspectral, and LiDAR remote sensing.
CO2: Interpret the thermal, microwave, hyperspectral images, and LiDAR point cloud data.
CO3: Apply the various tools of thermal, microwave, hyperspectral, and LiDAR remote sensing.
CO4: Analyze the utility of thermal, microwave, hyperspectral, and LiDAR remote sensing.
CO5: Evaluate application of thermal, microwave, hyperspectral, and LiDAR remote sensing in coal fire mapping, urban heat island studies, biomass estimation, object height determination.
CO6: Construct thermal, backscatter, classified images and digital surface models.

Course Content

Unit I: Thermal Remote Sensing (25 Hours)

Generation of brightness temperature map; Determination of Surface Emissivity from NDVI; Estimation of Land Surface Temperature; Delineation of Urban Heat Islands, Surface Coal Fire Mapping.

Unit II: Microwave Remote Sensing (25 Hours)
Intensity and Phase; Thermal Noise and Border Noise Correction of microwave images; Calibration and Co-registration; Terrain Correction and Back-Scatter Image Generation; Applications in Soil Moisture and Above Ground Biomass studies.

Unit III: Hyperspectral Remote Sensing (25 Hours)
Browsing image spectra and comparison with the library spectra; Removal of residual calibration errors; End member selection and Spectral Angle Mapper Classification; Spectral feature fitting and analysis; MNF Transformation; Identification of spectrally pure pixels; n-dimensional visualization; Spectral Unmixing; Vegetation hyperspectral analysis.

Unit IV: LiDAR Remote Sensing (15 Hours)
Point cloud data visualization; Generation elevation model from Point Cloud Data; Terrain hill shade analysis.

Unit V: Laboratory Notebook and Viva voce

Recommended Readings:
1. Jensen, J. R., 2013: Remote Sensing of the Environment, Pearson.
2. Tang, H. and Li, Z-L., 2014: Quantitative Remote Sensing in Thermal Infrared – Theory and Applications, Springer
3. Jensen J. R., 2004: Introductory Digital Image Processing: A Remote Sensing Perspective, Prentice Hall.

4. Vosselman, G. and Mass, H-G. (eds.), 2010: Airborne and Terrestrial Laser Scanning, CRC Press.
5. Lillesand T. M., Kiefer R. W. and Chipman J. W., 2004: Remote Sensing and Image Interpretation, Wiley.
6. Kalacska, M. and Sanchez-Azofeifa, G. A., 2008: Hyperspectral Remote Sensing of Tropical and Subtropical Forests, CRC Press.
7. van der Meer, F. D. and de Jong, S. M., 2002: Imaging Spectrometry – Basic Principles and Prospective Applications, Kluwer Academic Publishers.
8. Shan, J. and Toth, C. K. (eds.), 2018: Topographic Laser Ranging and Scanning – Principles and Processing, CRC Press.
9. Kluenzer, C. and Dech, S. (eds.), 2013: Thermal Infrared Remote Sensing – Sensors, Methods, Applications, Springer.
10. Quattrochi, D. A. and Luvall, J. C. (eds.), 2005: Thermal Remote Sensing in Land Surface Processes, CRC Press.

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PSO 1	PSO 2	PSO 3	PSO 4
CO 1	1	1	2	1	2	2	3	1	2	1	2	1	2	1
CO 2	0	0	2	2	2	2	2	2	2	2	2	2	2	2
CO 3	1	2	2	1	2	3	2	1	2	1	3	1	1	1
CO 4	1	1	1	1	2	2	2	2	2	1	0	1	2	1
CO 5	1	1	0	2	2	3	2	1	2	2	2	2	2	2
CO 6	1	1	2	1	2	2	3	1	2	1	2	1	2	0

GEO 21338	**Advanced Computing in Geoinformatics**	L	T	P	C
Version 1.0	**Contact Hours – 45**	3	0	0	3
Pre-requisites/Exposure	Basic knowledge of Machine Learning and Image Processing				
Co-requisites	-				

Course Outcomes:

On completion of this course, the students will be able to:

CO1: Define the various concepts and components of deep learning.
CO2: Classify different deep learning algorithms.
CO3: Apply various machine learning and deep learning algorithms in water resources, forestry, agriculture, and urban planning.
CO4: Examine the role of advanced computing, machine learning, and deep learning in water resources, forestry, agriculture, and urban planning.
CO5: Evaluate the various advanced computing techniques and deep learning algorithms.
CO6: Compile the applications of advanced computing in water resources, forestry, agriculture, and urban planning.

Course Content

Unit I: Fundamental concepts of Deep Learning (10 hours)

Concept of GeoAI; Introduction to Deep Learning – Model Training, Model Inferencing, Exploratory Analysis; Machine Learning vs. Deep Learning; Working principles of deep learning with special reference to ANN, CNN, RNN, and DNN.

Unit II: Applications of Advanced Computing in Water Resources (8 hours)

Applications of machine learning and deep learning – runoff simulation; flood forecasting; flood susceptibility and risk analysis; ground water potential mapping; ground water quality modelling.

Unit III: Applications of Advanced Computing in Forestry and Agriculture (9 hours)

Applications of machine learning and deep learning – forest detection and area classification; species mapping; biomass estimation; forest fire risk analysis; crop classification; yield modelling; disease detection.

Unit IV: Applications of Advanced Computing in Urban Planning (8 hours)

Applications of machine learning and deep learning – urban land use planning; urban growth modelling; urban heat island studies; cloud computing for smart cities.

Recommended Readings:

1. Cresson, R. 2020. Deep Learning for Remote Sensing Images with Open Source Software. CRC Press.

2. Lary, D.J., Alavi, A.H., Gandomi, A.H., and Walker, A.L. 2016. Machine learning in geosciences and remote sensing. Geoscience Frontiers. 7. 3-10.

3. Dtissibe, F.Y., Ari, A.A.A., Abboubakar, H., Njoya, A.N., Mohamadou, A., Thiare, O. 2024. A comparative study of Machine Learning and Deep Learning methods for flood forecasting in the Far-North region, Cameroon. Scientific African. 23. e02053.

4. Mohammadi, B. 2021. A review on the applications of machine learning for runoff modeling. Sustainable Water Resources Management. 7. 98.

5. Madhuri, R., Sistla, S., and Raju, K.S. 2021. Application of machine learning algorithms for flood susceptibility assessment and risk management. Journal of Water and Climate Change. 12. 2608-2623.

6. Haggerty, R., Sun, J., Yu, H., and Li, Y. 2023. Application of machine learning in groundwater quality modeling – A comprehensive review. Water Research. 233. 119745.

7. Lee, S., Hyun, Y., Lee, S., and Lee, M-J. 2020. Groundwater potential mapping using remote sensing and GIS-based machine learning techniques. Remote Sensing. 12. 1200.

8. Rihan, M., Bindajam, A.A., Talukdar, S., Shahfahad, Naikoo, M.W., Mallick, J., and Rahman, A. 2023. Forest fire susceptibility mapping with sensitivity and uncertainty analysis using machine learning and deep learning algorithms. Advances in Space Research. 72. 426-443.

9. Saha, S., Bera, B., Shit, P.K., Bhattacharjee, S., and Sengupta, N. 2023. Prediction of forest fire susceptibility applying machine and deep learning algorithms for conservation priorities of forest resources. Remote Sensing Applications: Society and Environment. 29. 100917.

10. Talebiesfandarani, S. and Shamsoddini, A. 2022. Global-scale biomass estimation based on machine learning and deep learning methods. Remote Sensing Applications: Society and Environment. 28. 100868.

11. Lukas, J., Kolb, S., Heinbuch, J., Willig, L., Plankenbühler, T., Müller, D., and Karl, J. 2023. Image-based biomass characterization: Comparison of conventional image processing and a deep learning approach. Fuel. 341. 127705.

12. Anand, A., Pandey, M.K., Prashant K. Srivastava, P.K., Gupta, A., and Khan, M.L. 2021. Integrating multi-sensors data for species distribution mapping using deep learning and envelope models. Remote Sensing. 13. 3284.

13. Sothe, C., De Almeidaa, C.M., Schimalskib, M.B., Liesenbergb, V., La Rosac, L.E.C., Castroc, J.D.B. and Feitosac, R.Q. 2019. A comparison of machine and deep-learning algorithms applied to multisource data for a subtropical forest area classification. International Journal of Remote Sensing. 41. 1943-1969.

14. Machichi, M.A., El Mansouri, l, Imani, Y., Bourja, O., Lahlou, O., Zennayi, Y., Bourzeix, F., Houmma, I.H., and Hadria, R. 2023. Crop mapping using supervised machine learning and deep learning: a systematic literature review, International Journal of Remote Sensing, 44. 2717-2753.

15. Klompenburga, T.V., Kassahuna, A., and Catal, C. 2020. Crop yield prediction using machine learning: A systematic literature review. Computers and Electronics in Agriculture. 177. 105709.

16. Bouguettaya, A., Zarzour, H., Kechida, A., and Taberkit, A.M. 2022. Deep learning techniques to classify agricultural crops through UAV imagery: a review. Neural Computing and Applications. 34. 9511–9536.

17. Gharaibeh, A.A., Jaradat, M.A., and Kanaan, L.M. 2023. A Machine Learning Framework for Assessing Urban Growth of Cities and Suitability Analysis. Land. 12. 214.

18. Gómez, J.A., Patiño, J.E., Duque, J.C. and Passos, S. 2020. Spatiotemporal modeling of urban growth using machine learning. Remote Sensing. 12. 109.

19. Chaturvedi, V., and de Vries, W.T. 2021. Machine learning algorithms for urban land use planning: A review. Urban Science. 5. 68.

20. Shi, W., Goodchild, M.F., Batty, M., Kwan, M-P., and Zhang, A. (eds.). 2021. Urban Informatics. Springer.

21. Addas, A. 2023. Machine learning techniques to map the impact of urban heat island: Investigating the city of Jeddah. Land. 12. 1159.

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PSO 1	PSO 2	PSO 3	PSO 4
CO 1	1	1	2	2	2	2	1	1	2	1	2	1	2	1
CO 2	1	0	2	2	2	2	2	2	1	2	2	2	2	2
CO 3	1	2	2	2	2	2	1	1	2	1	2	1	1	1
CO 4	1	1	1	3	2	3	1	2	2	1	1	0	2	1
CO 5	0	1	2	2	2	1	2	1	1	2	2	2	2	0
CO 6	1	1	2	1	2	3	1	1	2	1	2	1	2	1

GEO22339	**Web GIS and Google Earth Engine**	L	T	P	C
Version 1.0	**Contact Hours – 90**	0	0	6	4
Pre-requisites/Exposure	Basic knowledge of GIS and Java Script				
Co-requisites	Basic knowledge of computer skills				

Course Outcomes

On completion of this course, the students will be able to

CO1: Recall the basic concepts of web GIS and GEE.
CO2: Interpret the interactive and dynamic maps.
CO3: Identify the components of web and map services and GEE.
CO4: Categorize the applications of web GIS and GEE.
CO5: Evaluate the web services standards and interoperability.
CO6: Create web layers, interactive and dynamic maps.

Course Content (45 hours)

Unit I: Web GIS Basics and Application (20 Hours)
Web GIS basics and applications; Cloud GIS - Geoweb Services and Geoportal Application; Create web layers, maps and Smart mapping, Runtime SDK

Unit II: Web Service and VGI (25 Hours)
Web services overview, volunteered geographic information, web editing and feature Service; Publish and use hosted feature services to collect VGI; Overview of Leaflet library for interactive maps.

Unit III: Introduction to GEE (20 hours)

Introduction to Google Earth Engine; Filtering and displaying image data; Import and Export Raster and Vector Data; Image filtering

Unit IV: Spatial Data Analysis using GEE (25 hours)

Calculating spectral indices: assessing vegetation, water, glacier, burnt area, and built-up area; Time series data analysis; Iteration; Digital Image Classification - traditional and advanced classifiers; Estimation of Land Surface Temperature.

Laboratory Note Book and Viva Voce

Recommended Readings:

1. Pinde Fu, 2015, Getting to Know Web GIS. ESRI Press. Redlands, CA. ISBN-13: 978-1589483842 ISBN-10: 1589483847.
2. Android Programming Tutorials: Easy-To-Follow Training-Style Exercises on Android Application Development. CommonsWare, LLC, 2009. 0981678025.

3. Cardille, J.A., Crowley, M.A., Saah, D., and Clinton, N.E. (eds.) 2024. Cloud-Based Remote Sensing with Google Earth Engine – Fundamentals and Applications. Springer.
4. Kumar, L. and Mutanga, O. (eds.) 2019. Google Earth Engine Applications. MDPI.

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PSO 1	PSO 2	PSO 3	PSO 4
CO 1	0	1	2	1	2	3	1	1	2	1	2	1	2	1
CO 2	1	1	2	2	1	2	2	2	1	2	2	2	3	2
CO 3	2	2	2	1	3	2	0	1	2	1	2	1	1	1
CO 4	1	1	1	0	2	1	1	2	2	1	1	1	0	1
CO 5	0	1	2	2	3	2	2	1	1	2	3	2	2	2
CO 6	1	1	2	1	1	3	1	1	2	1	2	1	2	1

GEO22315	Spatial Data Science with R	L	T	P	C
Version 1.0	Contact Hours – 45	0	0	6	4
Pre-requisites/Exposure	Knowledge of Programming language, Basic knowledge of GIS				
Co-requisites	-				

Course Outcomes

On completion of this course, the students will be able to:
CO1: Recall the basics of R programming, remote sensing, GIS.
CO2: Demonstrate various data manipulation, visualization, remote sensing, and GIS functions in R.
CO3: Apply R programming in different remote sensing, GIS, and spatial statistical analyses.
CO4: Examine the advantages of R programming in handling and visualizing spatial data.
CO5: Assess the utility of R programming in performing spatial and statistical analyses.
CO6: Develop different spatial outputs using R programming.

Course Content

Unit I: Basics of R programming
Introduction of R programming, data types, variables, vectors, scalars, data frames, lists, matrices, arrays, classes, arithmetic and boolean operators and values, structures, control statements, loops, recursion, Scoping Rules, Loop functions.

Unit II: Data manipulation and data visualisation
Functions, math functions, linear algebra operation, probability distributions: normal, binomial, poisson; graphics: creating graphs, customizing graphs box plot, histogram, pie graph, line chart, scatterplot.

Unit III: Basic Remote Sensing and GIS function in R (10 Hours)
Setting up R: Setting up RStudio, Introduction to RStudio, Package installations, File Organization, Working directory; GIS and RS Data handling in R: Read raster data in R, projection assignment, reprojection, resampling, preparation of FCC in R, subseting, band arithmetic; development of different indices (NDVI, NDBI, NDWI etc.) with Landsat 5, Landsat 8, Aster and MODIS data; Read vector data in R, explore .shp file attributes in R, basic visualisation with .shp file, splitting and merging of .shp file, Spatial Attribute Analysis.

Unit IV: Spatial Statistics with R (10 Hours)
Point Pattern Analysis and Hotspot Mapping; Areal Pattern analysis and - Moran's I; Gettis's G; Spatial correlation and Spatial prediction

Recommended Readings:

1. Bivand, R. S., Pebesma, E. J., Gómez-Rubio, V., & Pebesma, E. J. (2008). Applied spatial data analysis with R (Vol. 747248717, pp. 237-268). New York: Springer.
2. Wickham, H., & Grolemund, G. (2016). R for data science: import, tidy, transform, visualize, and model data. " O'Reilly Media, Inc.".
3. Xie, Y., Allaire, J. J., & Grolemund, G. (2018). R markdown: The definitive guide. CRC Press.
4. Irizarry, R. A. (2019). Introduction to data science: data analysis and prediction algorithms with R. CRC Press.

5. Lillesand T. M., Kiefer R. W. and Chipman J. W., 2004: Remote Sensing and Image Interpretation, Wiley.(Wiley Student Edition).
6. Singh R. B. and Murai S., 1998: Space-informatics for Sustainable Development, Oxford and IBH Pub.
7. Anselin, L., & Rey, S. J. (2010). Perspectives on spatial data analysis. In Perspectives on Spatial Data Analysis (pp. 1-20). Springer, Berlin, Heidelberg.
8. Alvi, Z. 1995: Statistical Geography-Methods & Application, RawatPublications,Jaipur.
9. Croxton, F.E., Cowden, D.J. & Klein, S 1969: Applied General Statistics, PrenticeHall of India Pvt. Ltd.,New Delhi

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PSO 1	PSO 2	PSO 3	PSO 4
CO 1	1	1	2	1	1	2	3	1	2	1	2	1	2	1
CO 2	1	1	2	2	2	3	2	2	2	2	2	2	3	2
CO 3	1	0	2	1	3	1	2	1	2	1	2	1	1	1
CO 4	0	1	1	1	2	3	1	2	3	1	2	1	0	1
CO 5	1	1	2	2	2	1	2	1	2	2	0	2	2	0
CO 6	1	1	2	1	2	3	3	1	2	1	2	1	2	1

CSE22757	JavaScript for Geospatial Applications	L	T	P	C
Version 1.0	Contact Hours – 45	0	0	3	2
Pre-requisites/Exposure	Basic knowledge of Programming Language				
Co-requisites	-				

Course Outcome

On completion of this course, the student will be able to:
CO1: Recall the fundamental concepts of data types and Java scripting.
CO2: Illustrate the various statements and event handlers.
CO3: Apply the various condition statements.
CO4: Examine the utility of condition statements and event handlers.
CO5: Evaluate various advanced topics, e.g. GeoJSON, Mapbox, GEE API, etc..
CO6: Develop codes using JavaScript on condition statements, object, and event handling.

Course Content

Unit I: JavaScript Fundamentals (9 hours)

Introduction to JavaScript: Client-side Scripting and Server-side scripting; importance of Java Script, Creating Sample Program; Data Type and Operators; Various Data Type and its importance Understanding and Using Types of Operators;

Unit II: JavaScript Statements (12 hours)

If Else and Switch case, var, Iterative Mechanisms: Various Lopping Mechanism, Understanding Loops. While Loop, for loop, for…in, Loop Control: Break, Comment and Continue Core JavaScript: Array, Number, Boolean, Date Function, Math, Number, Object, String, RegExp.

Unit III: Basics and Essential Tools (12 hours)

Introduction to Geospatial Data and JavaScript; Working with GeoJSON, Creating and manipulating GeoJSON data, Introduction to Leaflet: Basic map setup with Leaflet, adding markers and layers to the map, Displaying GeoJSON data on a Leaflet map, Leaflet Advanced Features, Handling user interactions (click, hover); Introduction to APIs, Integrating APIs for Geospatial Data: Fetching data from external APIs (e.g., OpenStreetMap, Google Maps, Real-Time Weather Data Visualization);

Unit IV: Advanced Topics and Practical Applications (12 hours)

Introduction to Mapbox GL JS: Overview of Mapbox GL JS, Basic map setup with Mapbox, Styling and customizing Mapbox maps, Adding layers and sources; Integrating Google Maps with JavaScript: Overview of Google Maps JavaScript API, Setting up and configuring Google Maps, Adding markers, polylines, and polygons, Customizing the map with styles and layers; Using Google Earth with JavaScript: Google Earth Engine API setup, Importing and visualizing geospatial data;

Laboratory Notebook and Viva Voce

Recommended Reading:

1. Eloquent JavaScript: A Modern Introduction to Programming, Marijn Haverbeke
2. JavaScript: The Definitive Guide (6^{th}), Davis Flanagan, O'Reilly

3. Learn JavaScript VISUALLY, Ivelin Demirov, Nai Inc.
4. Leaflet.js Essentials, Paul Crickard III
5. Mastering JavaScript High Performance, Chad R. Adams
6. Google Maps JavaScript API Cookbook, Alper Dincer and Balkan Uraz
7. Learning Three.js: The JavaScript 3D Library for WebGL, Jos Dirksen

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PSO 1	PSO 2	PSO 3	PSO 4
CO 1	1	1	2	3	2	1	1	1	2	1	2	1	2	1
CO 2	0	1	2	2	2	3	2	2	1	2	2	3	2	2
CO 3	1	2	2	1	2	2	0	1	2	0	2	1	1	1
CO 4	1	1	1	3	2	3	1	2	2	1	1	1	2	1
CO 5	0	1	0	2	2	1	2	1	1	2	2	2	0	2
CO 6	1	1	2	3	2	3	1	1	2	1	2	1	2	1

ENG21112	Business Communication Intermediate	L	T	P	C
Version 1.0	**Contact Hours – 30**	2	0	0	2
Pre-requisites/Exposure	Basic knowledge of Programming Languages				
Co-requisites	Basic knowledge of python programming language				

Course Outcomes:

On completion of this course, the students will be able to:

CO1: Recall the intermediate concepts of Communicative English.

CO2: Illustrate the components of Communicative English.

CO3: Apply the grammatical knowledge in writing and speaking good English.

CO4: Examine the articles, prepositions, tense, voice, idioms, vocabulary etc. in writing and speaking good English.

CO5: Appraise the significance of advanced methods of communicative English skill development, including audio clipping, argumentative talks, etc.

CO6: Develop good communicative English skills.

Course Content

Unit 1

Verbs; Types of verbs; Use of verbs; Constructing sentences from verbs; Subject-verb agreement; Speech errors; Speech acts; Understanding speech, pronunciation, vocabulary from audio/video clips;

Unit 2

Intermediate level vocabulary; Synonyms and antonyms; Introducing syntax; Rules to form sentences; Forming complex sentences; Understanding ambiguous phrases and sentences; One word substitution; Stopping mental translations; Strategies to speak fluently and confidently.

Unit 3

Narratives; One to one communication; Introducing oneself; Classroom discussion; Interview demonstration; Intermediate speaking practices; Telling about yourself; Telling about your hobbies, education, job and passion; Breaking the ice.

Unit 4

Listening larger audio clips; Listening to discussion; Listening business communication; Listening exercises; Practice speaking after listening; Identifying the main theme of the discussion/debate.

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PSO 1	PSO 2	PSO 3	PSO 4
CO 1	1	1	2	1	2	2	3	1	2	1	2	1	2	1
CO 2	0	0	2	2	2	2	2	2	2	2	2	2	2	2
CO 3	1	2	2	1	2	3	2	1	2	1	3	1	1	1
CO 4	1	1	1	1	2	2	2	2	2	1	0	1	2	1
CO 5	1	1	0	2	2	3	2	1	2	2	2	2	2	2
CO 6	1	1	2	1	2	2	3	1	2	1	2	1	2	0

GEO25337	Term Paper Leading to Dissertation II	L	T	P	C
		0	0	3	2
Pre-requisites/Exposure	In depth knowledge on masters level special paper				
Co-requisites	English writing and communication skill				

Course Outcomes

On completion of this course, the students will be able to:
CO1: Recall the fundamental concepts of research objectives, process, hypothesis.
CO2: Explain different research methods.
CO3: Organize literature review and samples.
CO4: Compare between primary and secondary data.
CO5: Evaluate research problems based on the collected data analysis.
CO6: Construct the documents and presentation on research data and methodology.

Course Content

Unit I: Methodology Selection (10 Hours)

Unit II: Collection of Primary & Secondary Data (15 Hours)

Unit III: Preliminary data analysis (20 Hours)

Unit IV: Documentation and Presentation on Research Data and Methodology and Viva (15 Hours)

Recommended Readings:

Good research articles published from reputed journals on their specific research domain.

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PSO 1	PSO 2	PSO 3	PSO 4
CO 1	1	1	2	2	2	2	1	1	2	1	2	1	2	1
CO 2	1	0	2	2	2	2	2	2	1	2	2	2	2	2
CO 3	1	2	2	2	2	2	1	1	2	1	2	1	1	1
CO 4	1	1	1	3	2	3	1	2	2	1	1	0	2	1
CO 5	0	1	2	2	2	1	2	1	1	2	2	2	2	0
CO 6	1	1	2	1	2	3	1	1	2	1	2	1	2	1

GEO24325	**Industry Internship**	L	T	P	C
Version 1.0	**Contact Hours – 150**	0	0	10	5
Pre-requisites/Exposure	Undergraduate knowledge of Geography				
Co-requisites	-				

Course Outcomes

On completion of this course, the students will be able to:
CO1: Recall the fundamental concepts, tools, and techniques of geoinformatics relevant to real-world applications during internship.
CO2: Explain the process, workflows, and methodologies employed in the host organization's geospatial projects.
CO3: Apply tools and techniques of geoinformatics to solve domain-specific problems encountered during the internship.
CO4: Analyze geospatial datasets and project requirements to identify challenges and propose viable solutions within the internship context.
CO5: Appraise the effectiveness of geospatial methods and tools used in the internship and suggest improvements or alternative approaches.
CO6: Develop and present a comprehensive internship report detailing the objectives, methods, results and recommendations based on internship experience.

Course Content

(150 Hours)

An Industry Interaction Report to be prepared and submitted individually by each student, based on actual industrial interaction and visits, done jointly or in groups with other students.
Word Limit = 4000 (maximum) excluding Tables and Appendix (Computer typed, Line Spacing = 1½, Arial Narrow / Times New Roman / Helvetica 10 / 11/ 12)

Time allotted for Viva Voce / Examinee = 15 minutes (maximum)

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PSO 1	PSO 2	PSO 3	PSO 4
CO 1	0	1	2	1	2	3	1	1	2	1	2	1	2	1
CO 2	1	1	2	2	1	2	2	2	1	2	2	2	3	2
CO 3	2	2	2	1	3	2	0	1	2	1	2	1	1	1
CO 4	1	1	1	0	2	1	1	2	2	1	1	1	0	1
CO 5	0	1	2	2	3	2	2	1	1	2	3	2	2	2
CO 6	1	1	2	1	1	3	1	1	2	1	2	1	2	1

SEMESTER: IV

GEO21317	**Advanced Elective Theory: Geoinformatics Applications in Natural Resource Management**	L	T	P	C
Version 1.0	**Contact Hours – 45**	3	0	0	3
Pre-requisites/Exposure	Undergraduate-level knowledge of RS GIS and Hydrology				
Co-requisites	Basic knowledge of computer skills				

Course Outcomes

On completion of this course, the students will be able to:
CO1: Recall the concepts of soil, mineral, forest, water, marine, and coastal resources.
CO2: Demonstrate the different natural resource models like soil erosion, rainfall-runoff, shoreline change, etc.
CO3: Apply the knowledge of remote sensing and GIS in natural resource management.
CO4: Examine the factors and components of natural resource management.
CO5: Assess the utility of geoinformatics in managing natural resources.
CO6: Discuss the role of remote sensing and GIS in land and mineral classification, groundwater potential identification, biomass estimation, carbon sequestration, coastal erosion and accretion.

Course Content

Unit I: Soil and Mineral Resources (12 Hours)
Fundamental concepts of soil: soil forming factors and processes, soil profile, physical and chemical properties of soil, soil classification; Land suitability classification; Soil erosion modeling; Classification of mineral resources; Spectral signatures of rocks and minerals

Unit II: Water Resources (15 Hours)
Hydrologic cycle; Estimation of various components of hydrological cycle; Spectral properties of water; Drainage basin – delineation and codification of watershed; Morphometric analysis; Hydrological Modelling – Rainfall-runoff modeling – USDA-NRCS-CN Method; Groundwater potential identification

Unit III: Forest Resources (10 Hours)
Types of forests with special reference to India; Application of Geoinformatics in deforestation, forest fire, biodiversity, biomass estimation, and carbon sequestration

Unit IV: Marine and Coastal Resources (8 Hours)
Coastal landforms; Factors controlling marine and coastal resources: tides and waves, temperature and salinity of oceans; Coastal erosion, and accretion, shoreline change modeling

Recommended Readings:
1. Marzano, F. A., and Visconti, G., Remote Sensing of Atmosphere and Ocean from Space: Models, Instruments and Techniques, Kluwer Academic Publishers -2002.

2. Rani, M., Seenipandi, K., Rehman, S. and Kumar, P., Remote Sensing of Ocean and Coastal Environments, Elsevier -2020.
3. Fransklin, S. E., Remote Sensing for Sustainable Forest Management, Lewis -2001.
4. Mulders, M. A., Remote Sensing in Soil Science, Elsevier -2012.
5. Gert A. Schultz, Edwin T. Engman, Remote Sensing in Hydrology and Water Management, Springer Berlin Heidelberg -2011.
6. S. K. Gupta, Modern Hydrology and Sustainable Water Development, John Wiley and Sons – 2010.
7. K. Ramamohan Reddy, B. Venkateswara Rao, C. Sarala, Hydrology and Watershed Management, Allied Publishers – 2014.
8. Andrew Skidmore, Environmental Modelling with GIS and Remote Sensing, CRC Press- 2017
9. Dorota Swiatek, Stefan Ignar, Modelling of Hydrological Processes in the Narew Catchment, Springer Berlin Heidelberg – 2013
10. Tim Davie, Fundamentals of Hydrology Second edition, Taylor and Francis -2018
11. Prof. Dawei Han, Concise Hydrology, Createspace Independent Pub – 2010
12. L. Asawa, Irrigation and Water Resources Engineering, New Age International-2008.

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PSO 1	PSO 2	PSO 3	PSO 4
CO 1	1	1	2	1	1	2	3	1	2	1	2	1	2	1
CO 2	1	1	2	2	2	3	2	2	2	2	2	2	3	2
CO 3	1	0	2	1	3	1	2	1	2	1	2	1	1	1
CO 4	0	1	1	1	2	3	1	2	3	1	2	1	0	1
CO 5	1	1	2	2	2	1	2	1	2	2	0	2	2	0
CO 6	1	1	2	1	2	3	3	1	2	1	2	1	2	1

GEO22318	**Advanced Elective Practical: Geoinformatics Applications in Natural Resource Management**	L	T	P	C
Version 1.0	**Contact Hours – 90**	0	0	6	4
Pre-requisites/Exposure	Undergraduate-level knowledge of RS GIS and Hydrology				
Co-requisites	Basic knowledge of computer skills				

Course Outcomes

On completion of this course, the students will be able to:
CO1: Define soil, mineral, forest, water, marine, and coastal resources.
CO2: Demonstrate the different natural resource models like soil erosion, rainfall-runoff, shoreline change, etc.
CO3: Apply remote sensing and GIS tools and functions in natural resource management with special reference to SWAT, HEC GEO RAS, etc.
CO4: Examine the factors and components of natural resource management.
CO5: Evaluate different geospatial models in natural resource management.
CO6: Discuss the role of remotely sensed data in mineral mapping, hydrological modelling, fire risk zone mapping, biomass estimation, coastal erosion and accretion mapping.

Course Content

Unit I: Soil and Mineral Resources (15 Hours)
Estimation of soil moisture from optical and microwave images; Soil Erosion Modelling using RUSLE; Mineral mapping.

Unit II: Water Resources (40 Hours)
Use of remotely sensed data to study different hydrological components, Watershed analysis using GIS platform, GIS-based Hydrological Modelling using Soil and Water Assessment Tool (SWAT); GIS based Flood Modelling using HEC GEO RAS and HEC RAS

Unit III: Forest Resources (15 Hours)
Deforestation mapping; Fire risk zone mapping; Forest biomass estimation.

Unit IV: Marine and Coastal Resources (20 Hours)
Coastal erosion and accretion mapping; Shoreline change modeling; Mapping of chlorophyll contents of the oceans.

Laboratory Notebook and Viva Voce

Recommended Readings:

1. Marzano, F. A., and Visconti, G., Remote Sensing of Atmosphere and Ocean from Space: Models, Instruments and Techniques, Kluwer Academic Publishers -2002.
2. Rani, M., Seenipandi, K., Rehman, S. and Kumar, P., Remote Sensing of Ocean and Coastal Environments, Elsevier -2020.
3. Fransklin, S. E., Remote Sensing for Sustainable Forest Management, Lewis -2001.
4. Mulders, M. A., Remote Sensing in Soil Science, Elsevier -2012.

5. Arnell, N.W., 1996: Global Warming, River Flows and Water Resources. John Wiley and Sons, Chichester, United Kingdom,
6. Braga, B.P.F. and L.C.B. Molion, 1999: Assessment of the impacts of climate variability and change on the hydrology of South America. In: Impacts of Climate Change and Climate Variability on Hydrological Regimes [van Dam, J.C. (ed.)]. UNESCO, International Hydrology Series, Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA,
7. D ö l l , P. and S. Siebert, 2001: Global Modeling of Irrigation Wa t e r Requirements. University of Kassel, Kassel, Germany.
8. David K. Pickard, E. M. Tory (auth.), Ian B. MacNeill, Gary J. Umphrey, A. Ian McLeod (eds.): Advances in the Statistical Sciences, 1986: Stochastic Hydrology: Volume IV Festschrift in Honor of Professor V. M. Joshi's 70th Birthday, Springer Netherlands
9. Ven Chow, David Maidment, Larry Mays, 1988: Applied Hydrology, McGraw-Hill Science
10. James J. Sharp and Peter G Sawden (Auth.), 1984: Basic Hydrology, Butterworth-Heinemann
11. Bellie Sivakumar (auth.), 2017: Chaos in Hydrology: Bridging Determinism and Stochasticity, Springer Netherlands
12. Nicolas G. Adrien, 2003: Computational Hydraulics and Hydrology: An Illustrated Dictionary, CRC Press
13. Gour-Tsyh (George) Yeh (auth.): 1999, Computational Subsurface Hydrology: Fluid Flows, Springer US

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PSO 1	PSO 2	PSO 3	PSO 4
CO 1	1	1	2	3	2	1	1	1	2	1	2	1	2	1
CO 2	0	1	2	2	2	3	2	2	1	2	2	3	2	2
CO 3	1	2	2	1	2	2	0	1	2	0	2	1	1	1
CO 4	1	1	1	3	2	3	1	2	2	1	1	1	2	1
CO 5	0	1	0	2	2	1	2	1	1	2	2	2	0	2
CO 6	1	1	2	3	2	3	1	1	2	1	2	1	2	1

GEO21319	**Advanced Elective Theory: Geoinformatics Applications in Environment and Climate**	L	T	P	C
Version 1.0	**Contact Hours – 45**	3	0	0	3
Pre-requisites/Exposure	Undergraduate level Geography knowledge or science or technological knowledge.				
Co-requisites					

Course Outcomes

On completion of this course, the students will be able to:

CO1: Define environmental monitoring, disaster management, climate change, and satellite meteorology.
CO2: Illustrate the concepts of pollution, degradation, climate variables, etc.
CO3: Utilize the remote sensing and GIS tools in environmental monitoring, disaster management, and climate change.
CO4: Distinguish between types of natural disasters and climate models.
CO5: Assess the utility of geoinformatics in environmental monitoring, disaster management, and climate change studies.
CO6: Elaborate the approaches of climate change studies based on satellite meteorology.

Course Content

Unit I: Environmental Monitoring (15 Hours)
Point source pollution mapping, non-point source pollution modeling; Eutrophication and water quality mapping, groundwater contamination studies; sea surface temperature and saline water intrusion analysis; oil slicks tracing and monitoring; Aerosol remote sensing, air quality indexing and mapping, dynamic air pollution modeling, mapping and measuring troposphere pollutants, spread and dispersion of smoke plumes from industries; Land/soil degradation mapping, soil erosion modeling solid waste management – introduction, classification and environmental problems.

Unit II: Disaster Management (10 Hours)
Man-made disasters: introduction and types; Natural disasters – introduction and types; Role of remote sensing and GIS in disaster management.

Unit III: Climate change and analysis (10 Hours)
Global energy budget; Natural causes of climate change; The role of human activity on climate change; Impacts of climate change on the environment and essential climate variables – land, water, ocean; Effect of land use and land cover changes on climate change analysis; Climate sensitivity, Radiative forcing; Climate Models: Energy Balance Models, Two dimensional Statistical Dynamic Models; GCM and RCM; Carbon sequestration and climate change; General circulation models.

Unit IV: Satellite Meteorology (10 Hours)
Indian remote sensing satellites dedicated for Meteorology, Passive microwave technique: Global Precipitation Measurement mission (GPM), Active (radar) microwave techniques: Synthetic aperture radar (SAR), Tropical Rainfall Measuring Mission (TRMM); Indian Monsoon studies using satellite remote sensing.

Recommended Readings:

1. Bhatta B., 2011: Remote Sensing and GIS, Oxford Publisher
2. Campbell J. B., 2007: Introduction to Remote Sensing, Guildford Press
3. Jensen J. R., 2004: Introductory Digital Image Processing: A Remote Sensing Perspective, Prentice Hal
4. Joseph, G. 2005: Fundamentals of Remote Sensing, United Press India.
5. Lillesand T. M., Kiefer R. W. and Chipman J. W., 2004: Remote Sensing and Image Interpretation, Wiley. (Wiley Student Edition)
6. Nag P. and Kudra, M., 1998: Digital Remote Sensing, Concept, New Delhi.
7. Rees W. G., 2001: Physical Principles of Remote Sensing, Cambridge University Press.
8. Singh R. B. and Murai S., 1998: Space-informatics for Sustainable Development, Oxford and IBH Pub.
9. Kevin. Sene. (2017). Hydrometeorology: Forecasting and Applications. Springer
10. Shuttleworth, W. J. (2012). Terrestrial hydrometeorology. John Wiley & Sons
11. McGuffie, K., & Henderson-Sellers, A. (2014). The climate modelling primer, John Wiley & Sons
12. Washington, W. M., & Parkinson, C. (2005), Introduction to three-dimensional climate modelling University science books
13. William J. Sutherland (2006): Ecological Census Techniques Edited by Cambridge 2nd edition
14. Lagacherie Philippe, McBratney Alex and Voltz Marc(2006) : Digital Soil Mapping :An Introductory Perspective, Elsevier
15. Scull, P.; J. Franklin, O.A. Chadwick & D. McArthur (June 2003). Predictive soil mapping - a review

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PSO 1	PSO 2	PSO 3	PSO 4
CO 1	1	1	2	1	2	2	3	1	2	1	2	1	2	1
CO 2	0	0	2	2	2	2	2	2	2	2	2	2	2	2
CO 3	1	2	2	1	2	3	2	1	2	1	3	1	1	1
CO 4	1	1	1	1	2	2	2	2	2	1	0	1	2	1
CO 5	1	1	0	2	2	3	2	1	2	2	2	2	2	2
CO 6	1	1	2	1	2	2	3	1	2	1	2	1	2	0

GEO22320	**Advanced Elective Practical: Geoinformatics Applications in Environment and Climate**	L	T	P	C
Version 1.0	**Contact Hours – 90**	0	0	6	4
Pre-requisites/Exposure	Undergraduate level Geography knowledge or science or technological knowledge.				
Co-requisites					

Course Outcomes

On completion of this course, the students will be able to:

CO1: Show the environmental, climate, hydro-meteorological database.
CO2: Interpret the spatial database related to environmental, climate, and hydro-meteorological studies.
CO3: Apply different remote sensing and GIS based tools and models in environmental, climate, and hydro-meteorological studies.
CO4: Examine different environmental, climate, and hydro-meteorological models and statistical analyses.
CO5: Evaluate the consistency and errors in the database related to environmental, climate, and hydro-meteorological studies.
CO6: Construct spatial maps and compile database related to environmental, climate, and hydro-meteorological studies.

Course Content

Unit I: Application of Geoinformatics in environmental studies (40 Hours)
Different sources of pollution data, pollution mapping of air, water and soil using geoinformatics: monitoring, mapping and modeling; statistical analysis of environmental impacts of land use change; Landscape structure - patches, corridors and mosaics;, Measuring metrics (Shannon's Diversity Index and Simpson Diversity Index); Urban heart island monitoring using different remote sensing data sets, Sky view factor, LCZ mapping; Saline water intrusion modelling: GALDIT model; Application of Geoinformatics in disaster management.

Unit II: Climate data analysis and validation (25 Hours)
Instrumentation and measurement of precipitation, evaporation and evapotranspiration, soil moisture, stream discharge; Homogeneity and consistency checking of data, Errors in meteorological data; Hypothesis Testing, Correlation analysis, Multivariate regression analysis, Autocorrelation, Parameter estimation; Analysis of the impact of land use and land cover changes on climate.

Unit III: Satellite Hydro-Meteorology (25 Hours)
Introduction to Google Earth Engine (GEE), Cloud computation of big data: MODIS data product of Land surface temperature, Climatic data, Evapotranspiration, TRMM rainfall data, and Soil moisture data analysis; Applications of satellite data in monsoon variability study.

Recommended Readings:

1. Bhatta B., 2011: Remote Sensing and GIS, Oxford Publisher.
2. Campbell J. B., 2007: Introduction to Remote Sensing, Guildford Press.

3. Jensen J. R., 2004: Introductory Digital Image Processing: A Remote Sensing Perspective, Prentice Hall.
4. Joseph, G. 2005: Fundamentals of Remote Sensing, United Press India.
5. Lillesand T. M., Kiefer R. W. and Chipman J. W., 2004: Remote Sensing and Image Interpretation, Wiley. (Wiley Student Edition).
6. Nag P. and Kudra, M., 1998: Digital Remote Sensing, Concept, New Delhi.
7. Rees W. G., 2001: Physical Principles of Remote Sensing, Cambridge University Press.
8. Singh R. B. and Murai S., 1998: Space-informatics for Sustainable Development, Oxford and IBH Pub.
9. Kevin. Sene. (2017). Hydrometeorology: Forecasting and Applications. Springer.
10. Shuttleworth, W. J. (2012). Terrestrial hydrometeorology. John Wiley & Sons.
11. McGuffie, K., & Henderson-Sellers, A. (2014). The climate modelling primer. John Wiley & Sons.
12. Washington, W. M., & Parkinson, C. (2005). Introduction to three-dimensional climate modeling. University science books.
13. William J. Sutherland (2006): Ecological Census Techniques Edited by Cambridge 2nd edition
14. Lagacherie Philippe, McBratney Alex and Voltz Marc (2006) : Digital Soil Mapping :An Introductory Perspective, Elsevier
15. Scull, P.; J. Franklin, O.A. Chadwick & D. McArthur (June 2003). Predictive soil mapping - a review.

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PSO 1	PSO 2	PSO 3	PSO 4
CO 1	1	1	2	2	2	2	1	1	2	1	2	1	2	1
CO 2	1	0	2	2	2	2	2	2	1	2	2	2	2	2
CO 3	1	2	2	2	2	2	1	1	2	1	2	1	1	1
CO 4	1	1	1	3	2	3	1	2	2	1	1	0	2	1
CO 5	0	1	2	2	2	1	2	1	1	2	2	2	2	0
CO 6	1	1	2	1	2	3	1	1	2	1	2	1	2	1

GEO21321	**Advanced Elective Theory: Geoinformatics Applications in Urban and Regional Planning**	L	T	P	C
Version 1.0	**Contact Hours – 45**	3	0	0	3
Pre-requisites/Exposure	Undergraduate level knowledge of urban geography, regional planning and development and settlement geography				
Co-requisites	-				

Course Outcomes

On completion of this course, the students will be able to
CO1: Recall the basics of urban planning, infrastructure, governance, and emergency management.
CO2: Illustrate the determinants and approaches of urban planning and infrastructure management with special reference to smart cities.
CO3: Identify the role of geoinformatics in urban planning, infrastructure, and governance.
CO4: Categorize different urban models and urban environmental laws.
CO5: Evaluate the significance of SDSS, PSS, and master plan in urban and regional planning.
CO6: Discuss and **compile** the importance of geoinformatics in urban emergency management with the help of different case studies on earth quake, flood, fire, and terrorist attacks.

Course Content

Unit I: Modelling and Urban Planning (15 Hours)
Urbanization and history of urban space: determinants of urbanization, processes and forms, modern urban spaces and types, urban morphology – urban landscape and landuse, Concept of urban planning; elements of urban structure (networks, buildings, open spaces etc.); Urban Planning: Plans – planning needs, types of plans, urban and regional planning; LU/LC mapping Urban Planning: Zoning of Land Use, Zonal Land Use Plan. Role of Models in Planning - Systems view of planning and use of quantitative models in planning, principles for designing and model formulation, Evaluation of Models and its application in planning; Role of GIS in urban planning - GIS, Spatial Decision Support Systems (SDSS), And Planning Support Systems (PSS) in Urban Planning.

Unit II: Urban Infrastructure Management (10 hours)
Urban aesthetics: terms and concepts in urban aesthetics, content and development of an urban aesthetic plan, urban designing schemes and evaluation, Urban forms and designing: standard and regulatory control on urban design and forms, Urban Sprawl; impact of technology and role of urban designing in planning process, Landscape assessment and evaluation: Open space and landscape planning, planning consideration with new projects like expressway, river roads, abandoned quarries, tree plantation and street furniture and utility. Site selection for urban development, site suitability analysis for utilities and civic amenities, interim master plan, Master Plan

Unit III: Infrastructure, Governance and Smart City (12 Hours)
Urban infrastructure – elements of infrastructure, land requirement and rights; Urban renewal and rehabilitation; Urban governance and Urban legislation: planning and development; urban conservation and restoration; Urban Environmental Laws and concerns; Technology and E-governance, Sustainable urban planning: Sustainable planning for different scales and emergence of new urbanism and smart growth, Smart cities: Concepts, typologies approaches and characteristics, smart city planning in developed

and developing economy – critical evaluation on economic and financial viability; Smart city mission in India, Future urbanism and vision.

Unit IV: Applied Urban Planning and Emergencies Management (8 hours)

Urban disaster and need for planning; Urban vulnerability and infrastructure resilience – case study and discussion with respect to earth quake, flood, fire, terrorist attacks, and transport-planning for ambulances, and emergency services, GIS modeling for Hazard risk and emergencies management

Recommended Readings:

1. Abdul Razak, M. (2004) Mobility patterns and strategies used for spatial access to work of the squatter households in the peri-urban Delhi, India. Paper presented at the International
2. Abu-Lughod, J. and Hay, R. Jr. (1977): Third World Urbanisation, Maarouta Press.
3. Abu-Lughod, J. L. (1999) New York, Chicago, LosAngeles: America's Global Cities. Minneapolis, MN: University of Minnesota Press.
4. AIILSG (All India Institute of Local Self Government) (2004) Transforming Mumbai into a world class city. AIILSG, Mumbai.
5. Allen J. Scott (ed.), (2001): Global City Regions, Trends, Theory & Policy, Oxford University Press.
6. Allwinkle, S., & Cruickshank, P. (2011). Creating smart-er cities: An overview. Journal of Urban Technology, 18(2), 1–16.
7. Amin, A., & Thrift, N. (2002). Cities: Reimagining the Urban, London: Polity, Bates, J. (2012). ''This is what modern deregulation looks like'': Co-optation and contestation in the shaping of the UK's Open Government Data Initiative. The Journal of Community Informatics, 8(2).
8. Banerjee-Guha, S. (1997) Spatial Dynamics of International Capital. Hyderabad: Orient Longman.
9. Banerjee-Guha, S. (2002a) Metropolitan dominance and regional disparity in India: observations from relevant planning measures of Japan, Visiting Research Fellow Series No. 358, Instituteof Developing Economics, Japan External Trade Organization.
10. Banerjee-Guha, S. (2002b) Shifting cities: urban restructuring in Mumbai, Economic and Political Weekly, pp. 121–128.
11. Banerjee-Guha, S. (2008) Space relations of global capital and significance of new economic enclaves: SEZs in India, Economic and Political Weekly, 43(47), pp. 51–61.
12. Batty, M., Axhausen, K. W., Giannotti, F., Pozdnoukhov, A.,Bazzani, A., Wachowicz, M., et al. (2012). Smart cities of the future. European Physical Journal Special Topics, 214(1), 481–518.
13. Beaverstock, J. V., Smith, R. G. and Taylor, P. J.(1999) A roster of world cities, Cities, 16, pp. 445–458.
14. Bowker, G., & Star, L. (1999). Sorting things out: Classification and Its consequences. Cambridge: MIT Press.
15. Boyd, D.,&Crawford, K. (2012). Critical questions for big data, Information, Communication and Society, 15(5), 662–679.
16. Cadene, P. and Marius-Gnanou, K. (2004) Peri urban dynamics: around the Indian metropolises: some findings from the Chennai experience, Paper presented at the International workshop on 'Peri-urban Dynamics',National University of Singapore, December.
17. Carter, H (1972): The Study of Urban Geography, Edward Arnold.
18. CIDCO (City and Industrial Development Corporation of Maharashtra) (1973) A report on the development of New Bombay, Bombay
19. Clarke, D. (1982): Urban Geography: An Introductory Guide, Groom Helm.
20. D'Monte, D. (2002) Ripping the Fabric: The Decline of Mumbai and Its Mills. New Delhi: Oxford University Press.
21. David Harvey (1985): The Urbanization of Capital, John Hopkins University Press.

22. Dea´k, C. and Schiffer, S. (2007) Sa˜o Paulo: the metropolis of an elite society, in: K. Segbers (Ed.) The Making of Global City Regions: Johannesburg, Mumbai/Bombay, Sa˜o Paulo, and Shanghai, pp. 85–112. Baltimore, MD: Johns Hopkins University Press.
23. Dodge, M., &Kitchin, R. (2004). Flying through code/space: The real virtuality of air travel. Environment and Planning A, 36(2), 195–211.
24. Dodge, M., &Kitchin, R. (2005). Codes of life: Identification codes and the machine-readable world. Environment and Planning D: Society and Space, 23(6), 851–881.
25. Dodge, M., &Kitchin, R. (2007a). The automatic management of drivers and driving spaces. Geoforum, 38(2), 264–275.
26. Dodge, M., &Kitchin, R. (2007b). Outlines of a world coming in existence': Pervasive computing and the ethics of forgetting, Environment and Planning B, 34(3), 431–445.
27. Dupont, V. (2004) Peri-urban dynamics: population, habitat and environment on the peripheries of large Indian metropolises. Introductory paper at the International Workshop on 'Periurban Dynamics', National University of Singapore, December.
28. Dupont, V. (2005) Peri-urban dynamics: population, habitat and environment on the peripheries of large Indian metropolises: review of concepts and general issues. Occasional Paper No. 14, Centre de Sciences Humaines, New Delhi.
29. Dutton, W. H., Blumler, J. G., & Kraemer, K. L. (1987). Wired cities: Shaping future communication. New York: Macmillan.
30. Edward Soja (2000): Postmetropolis, Critical Studies of cities and Regions, Blackwell Publisher Ltd.
31. F. S. Hudson," Geography of Settlements", and Evans Ltd. Estover, Plymouth PL 6 7 PZ UK
32. G. K. Bandopadhyaya , "Text Book of Town Planning".
33. G. P. Chapman, A.K. Dutt and R.W. Bradnock (ed.) (1999): Urban growth & Development in Asia, Vol.2: Living in the Cities, Ashgate Publishing Ltd.
34. Gugler. J. (ed.)(1988): The Urbanisation of the Third World, O.U.P
35. Haque, U. (2012). What Is a City that It Would Be 'Smart'? Volume #34: City in a Box. http://volumeproject.org/blog/ 2012/12/21/volume-34-city-in-a-box
36. Harvey, D.(1973): Social Justice and the City, Arnold
37. King A. D. (1990): Global Cities, Routledge.
38. Latham, D. McCormack, K. McNamara, D. McNeill (2009): Key Concepts in Geography, Sage.
39. Marcuse, P. and Kempen, R.V. (eds.),(2000): Globalizing Cities: A New Spatial Order, Blackwell.
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41. Pieterse E, (2008): City Futures, Confronting the Crisis of Urban Development, Zed Books Ltd, London and New York.
42. Sassen, S. (1991): The Global City, Princeton University Press.
43. Short, J. R. (1996): The Urban Order, Basil Bleckwell.
44. Simmonds, R. and Hack, G. (2000): Global City Regions, Spon Press.
45. Smith, N. (1996): The New Urban Frontier, Routledge

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PSO 1	PSO 2	PSO 3	PSO 4
CO 1	0	1	2	1	2	3	1	1	2	1	2	1	2	1
CO 2	1	1	2	2	1	2	2	2	1	2	2	2	3	2
CO 3	2	2	2	1	3	2	0	1	2	1	2	1	1	1
CO 4	1	1	1	0	2	1	1	2	2	1	1	1	0	1
CO 5	0	1	2	2	3	2	2	1	1	2	3	2	2	2
CO 6	1	1	2	1	1	3	1	1	2	1	2	1	2	1

GEO22322	**Advanced Elective Practical: Geoinformatics Applications in Urban and Regional Planning**	L	T	P	C
Version 1.0	**Contact Hours – 90**	0	0	6	4
Pre-requisites/Exposure	Undergraduate level knowledge of field studies, data collection techniques and analysis				
Co-requisites	Familiar with the GIS, RS and statistical software				

Course Outcomes

On completion of this course, the students will be able to:

CO1: Define urban data and population infrastructure.

CO2: Illustrate the functioning of exploratory analysis and decision support systems in urban and regional planning.

CO3: Utilize various plans and decision-making models to solve critical urban problems.

CO4: Examine the role of remote sensing and GIS in urban and regional planning.

CO5: Recommend spatial solutions to critical problems related to urban and population infrastructure.

CO6: Develop mini projects and case studies on solid and municipal waste management, educational services, population accessibility to market resources, utility mapping, etc.

Course Content

Unit I: Urban data query – methods and techniques (15 Hours)

Instrument development and validation for urban-centric field visits and perception mappings; Techniques of preparing base maps using RS and GIS environments; including the concepts of scales, components and detailing for various levels of plans like regional plan, city plan, zoning plan, and local area plan

Unit II: Exploratory Analysis (15 Hours)

Urban landuse-land cover classification, change detection, and accuracy assessment; Simulating Intraurban Land Use Dynamics; cellular automaton and markov model; classification and identification of metropolitan regions

Unit III: Population-Infrastructure: Critical Problems and Solutions (30 Hours)

Location-Allocation Problems – spatial distribution of basic infrastructural facilities (education/health/finance) and deficiency – critical evaluation– practical solutions. Site suitability modelling using GIS; Land use and transportation forecasting and modeling; Retail and local service activity location models; hotspot modelling and spatio-temporal analysis of urban events.

Unit IV: Decision-support in urban planning with some case studies (30 hours)

Introduction to decisions making models (qualitative, quantitative and hybrid) and its application in urban studies; Mini project and case studies on solid and municipal waste management/educational services and population accessibility/market resource and utility mapping/health services and utility mapping/urban climate and human comfortability/ hazard and disaster management – natural and man-made.

Laboratory Notebook and Viva voce

Recommended Readings:

1. Bernhardsen, Tor (2002): Geographical Information Systems: An Introduction, Third Edition, John
2. Monkhouse, F. J. and H. R. Wilkinson, (1971): Maps and Diagrams, Methuen & Co. Ltd., London.
3. Barrett, E.G. and Curtis, L.F. (1992): Fundamentals of Remote Sensing in Air Photo-interpretation, McMillan, New York.
4. Berry, B.J.L. and Marble, D.F. (1968): Spatial Analysis – A reader in statistical Geography, Prentice Hall, Englewood Cliffs, New Jersey.
5. Clarke, Keith C. (1998): Getting Started with Geographic Information Systems, Prentice-Hall Series in Geogl. Info. Science, Prentice-Hall, Inc. N.J.
6. Jonson. R. J. (2003): Remote Sensing of the Environment-An Earth Resources Perspective, Pearson
7. Vallentine G. Clifford N. (2010), Key Methods in Geography, Sage
8. Wicox, P.R. (2003), Applying Contemporary Statistical Techniques, Academic Press, Amsterdam
9. Wiiey& Sons, Inc., New York.Burrough, Peter A and McDonnell, R.A. (1998): Principles of Geographical Information Systems, Oxford University Press, Mumbai.
10. Wilson A. G. and Bennet, R. J., (1985), Mathematical Methods in Geography and Planning, John Wiley and Sons, New York.
11. Yeates, M. (1974): An Introduction to Quantitative Analysis in Human Geography, McGraw Hill Book Co., New York.

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PSO 1	PSO 2	PSO 3	PSO 4
CO 1	1	1	2	1	1	2	3	1	2	1	2	1	2	1
CO 2	1	1	2	2	2	3	2	2	2	2	2	2	3	2
CO 3	1	0	2	1	3	1	2	1	2	1	2	1	1	1
CO 4	0	1	1	1	2	3	1	2	3	1	2	1	0	1
CO 5	1	1	2	2	2	1	2	1	2	2	0	2	2	0
CO 6	1	1	2	1	2	3	3	1	2	1	2	1	2	1

GEO 22340	**Computer-Aided Design & BIM**	L	T	P	C
Version 1.0	**Contact Hours – 90**	0	0	6	4
Pre-requisites/Exposure	Basic knowledge of GIS and CAD				
Co-requisites	-				

Course Outcomes:

On completion of this course, the students will be able to:

CO1: Define the various concepts and components of CAD and BIM.
CO2: Interpret the CAD and BIM data.
CO3: Apply CAD techniques and GEE codes to identify various spatial features with special reference to building footprint, LULC, LST, etc.
CO4: Categorize various functions and tools of CAD and BIM.
CO5: Assess the utility of CAD-based data management and mapping.
CO6: Develop maps and images using CAD and BIM techniques.

Course Content

Unit I: Map Making and Data Analysis using CAD (20 hours)

Connecting data from multiple sources; Styling map features; Zooming and changing display; Creating map features; Object identification from data table; Object editing; Legend making; Map publishing; Exploring data portals; Data Analysis – Visualization of surface data; Data analysis with external information using Join function; Proximity analysis; Report generation.

Unit II: Data Management using CAD (25 hours)

Data Management – Data conversion from drawing layers to feature classes; Drawing Layer Export; Connection to parcel data; Splitting a polygon feature; Connection to external database; Calculation; Theme creation; Publish to MapGuide.

Unit III: Building Information Modelling (20 hours)

Concepts and benefits of BIM; Agile Project Management; Building Management System; Project-based Learning and use of simulated projects; BIM Implementation and Procurement Routes

Unit IV: Building Footprint Mapping using CAD (25 hours)

Building footprint mapping from satellite images, aerial and drone photographs, and OpenStreet Maps; Role of AI in building footprint mapping.

Recommended Readings:

1. AutoCAD Map 3D Tutorials. Autodesk.

2. Ellis, R. and Martin, R. 2018. A Practical Guide to AutoCAD Map 3D 2019. CADapult Press

3. Dastbaz, M. et al. (eds) 2017. Building Information Modelling, Building Performance, Design and Smart Construction. Springer

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PSO 1	PSO 2	PSO 3	PSO 4
CO 1	1	1	2	3	2	1	1	1	2	1	2	1	2	1
CO 2	0	1	2	2	2	3	2	2	1	2	2	3	2	2
CO 3	1	2	2	1	2	2	0	1	2	0	2	1	1	1
CO 4	1	1	1	3	2	3	1	2	2	1	1	1	2	1
CO 5	0	1	0	2	2	1	2	1	1	2	2	2	0	2
CO 6	1	1	2	3	2	3	1	1	2	1	2	1	2	1

ENG21113	**Business Communication Advanced**	L	T	P	C
Version 1.0	**Contact Hours – 30**	2	0	0	2
Pre-requisites/Exposure	Basic knowledge of Programming Languages				
Co-requisites	Basic knowledge of python programming language				

Course Outcomes:

On completion of this course, the students will be able to:

CO1: Recall the advanced concepts of Communicative English.

CO2: Illustrate the components of Communicative English.

CO3: Apply the grammatical knowledge in writing and speaking good English.

CO4: Examine the articles, prepositions, tense, voice, idioms, vocabulary etc. in writing and speaking good English.

CO5: Appraise the significance of advanced methods of communicative English skill development, including audio clipping, argumentative talks, etc.

CO6: Develop good communicative English skills.

Course Content

Unit 1

Advanced vocabulary; Participation in debate competition; Public speaking; Question-answer; Reading larger texts; Talk about sports, politics, climate etc.; Interview demonstration, maintaining eye contacts, body language, sitting postures, opening sentences, attempting questions.

Unit 2

Understanding contexts; Use contextually relevant vocabulary; Understanding the principles of speaking effectively; Speaking correctly and confidently; Defending your answers/arguments; Strategies to Speak confidently and clearly; Practice correct pronunciation.

Unit 3

Discussing a wide variety of topics; Taking up an argument; Over coming communication barriers; Listening to Ted talks, movie clips, audio clips; Business discussion; Enhancing communitive English.

Unit 4

Understanding speaking skills; Ways to improve speaking skills; Practice speaking; Develop communicative English.

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PSO 1	PSO 2	PSO 3	PSO 4
CO 1	1	1	2	1	2	2	3	1	2	1	2	1	2	1
CO 2	0	0	2	2	2	2	2	2	2	2	2	2	2	2
CO 3	1	2	2	1	2	3	2	1	2	1	3	1	1	1
CO 4	1	1	1	1	2	2	2	2	2	1	0	1	2	1
CO 5	1	1	0	2	2	3	2	1	2	2	2	2	2	2
CO 6	1	1	2	1	2	2	3	1	2	1	2	1	2	0

GEO21341	Startup Skill Development	L	T	P	C
Version 1.0	Contact Hours – 30	2	0	0	2
Pre-requisites/Exposure	Basic knowledge of Business Communication				
Co-requisites	Basic knowledge of Business Communication Skills				

Course Outcomes:

On completion of this course, the students will be able to:

Upon completion of this course, students will be able to:

CO1: Remember fundamental concepts and terminologies of entrepreneurship, startups, and business models.

CO2: Understand the processes and stages of startup development, including ideation, market analysis, and fundraising.

CO3: Apply geoinformatics knowledge to develop innovative and practical solutions for startup ventures.

CO4: Analyze market trends, customer needs, and competitive landscapes to identify viable business opportunities.

CO5: Evaluate business models, funding strategies, and risk management plans for geospatial startups.

CO6: Create a preliminary startup business plan or proposal tailored to the geoinformatics domain.

Course Content

Unit 1: Introduction to Startups and Entrepreneurship (5 hours)

Entrepreneurship: Definition, types, and characteristics, Understanding startups: Definitions, lifecycle, and types, Role of innovation and technology in startups, Importance of geoinformatics in entrepreneurial ventures, Challenges and opportunities in geospatial startups.

Unit 2: Business Ideation and Market Analysis (10 hours)

Generating and validating ideas for geospatial startups, understanding market dynamics and customer needs, Basics of market research and competitor analysis, Identifying gaps in the geospatial domain for startup opportunities, case studies of successful geoinformatics startups.

Unit 3: Business Models, Funding, and Legal Frameworks (10 hours)

Types of business models (B2B, B2C, SaaS, etc.) in geospatial startups, Basics of financial planning, bootstrapping, and fundraising, Venture capital, angel investors, and government funding schemes, Intellectual property rights (IPR) and legal considerations for startups, the role of incubators, accelerators, and startup ecosystems.

Unit 4: Startup Execution and Strategic Planning (5 hours)

Developing a business plan: Vision, mission, and goals; risk management and strategic decision-making; marketing, branding, and customer acquisition strategies; scaling up: Operational and team-building strategies; preparing a prototype and pitching to investors.

References

1. Blank, S., & Dorf, B. (2020). The Startup Owner's Manual: The Step-by-Step Guide for Building a Great Company. Wiley.
2. Ries, E. (2011). The Lean Startup: How Today's Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses. Crown Business.
3. Osterwalder, A., & Pigneur, Y. (2010). Business Model Generation: A Handbook for Visionaries, Game Changers, and Challengers. Wiley.
4. Sarasvathy, S. D. (2001). Effectuation: Elements of Entrepreneurial Expertise. Edward Elgar Publishing.
5. Startup India Portal (https://www.startupindia.gov.in/): Guidelines, funding schemes, and resources.
6. Articles and case studies on geospatial startups (e.g., DroneDeploy, Planet Labs, Mapbox).

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PSO 1	PSO 2	PSO 3	PSO 4
CO 1	1	1	2	3	2	1	1	1	2	1	2	1	2	1
CO 2	0	1	2	2	2	3	2	2	1	2	2	3	2	2
CO 3	1	2	2	1	2	2	0	1	2	0	2	1	1	1
CO 4	1	1	1	3	2	3	1	2	2	1	1	1	2	1
CO 5	0	1	0	2	2	1	2	1	1	2	2	2	0	2
CO 6	1	1	2	3	2	3	1	1	2	1	2	1	2	1

GEO25326	Dissertation and Comprehensive Viva	L	T	P	C
Version 1.0	Contact Hours – 150	0	0	9	6
Pre-requisites/Exposure	In-depth knowledge of master's level special paper and research methodology				
Co-requisites	Statistics and GIS software knowledge and writing skill				

Course Outcomes

On completion of this course, the students will be able to:
CO1: Recall and compile fundamental concepts, tools, theories, and models of geoinformatics necessary for formulating research questions.
CO2: Demonstrate a comprehensive understanding of geoinformatics methods and their relevance to solving complex real-world spatial problems..
CO3: Apply appropriate geoinformatics tools and techniques to design and conduct a structured research project.
CO4: Analyze geospatial datasets and project requirements to identify challenges and propose viable solutions within the internship context.
CO5: Evaluate existing literature, methodologies, and data quality to identify research gaps and justify the research approach.
CO6: Construct a well-structured dissertation report, including objectives, database, methodologies, results, discussion, limitation, future scope, and conclusion, adhering to academic and industrial standards.

Course Content

Dissertation (150 Hours)
Dissertation Paper comprises an Object–specific goal–oriented Geographical Study based on the following types: 1) those which test a hypothesis or theory, as virtually all aspects of Geography have theories attached to them, 2) those which compare the geographical characteristics of two places or phenomena. A variation on this theme is a comparison of the geographical characteristics of one place or phenomena at two or more stages of time, i.e., a study of changes over time, and 3) those which study a geographical problem related to the habitat, economy and society of people.

1) Each Examinee shall prepare a Dissertation Paper individually under the supervision of a Departmental Faculty on his / her own chosen Theme.
2) The Report must be documented in triplicate (1 = examinee, 2 = seminar library, 3 = supervisor) under the following Heads – *Introduction & Conceptual Background; Statement of the Problem; Objectives of Study; Literature Review; Methodology including data / information / map collection; Location of the Study Area; Analysis, Display and Interpretation of Data (relating to each Objective separately); and Conclusion.*
3) The Dissertation Paper should contain *Acknowledgement, Preface, Table of Content, List of Tables,*
4) *List of Figures, List of Photographs, List of References, Appendix, and Bibliography/ Reference.*
5) Pages containing Illustrations (Sketches, Graphs, Diagrams, Maps, Photographs, etc.) = 25
6) (maximum).
7) Word Limit = 8000 (maximum) excluding Tables and Appendix (Computer typed, Line Spacing
8) = 1½, Arial Narrow / Times New Roman / Helvetica 10 / 11 / 12).
9) Each Examinee shall submit a copy of the Report before the actual day of Examination (to be

10) announced by the convener each year).
11) Each Examinee shall present his / her Paper before an audience comprising Internal / External
12) Examiners and others on the day of Examination using OHP or LCD Projector (maximum 25 slides about —
13) c*oncept / idea / theme; major objectives; methodology; study area; observations and analysis; conclusion*).
14) Time allotted for each presentation = 20 minutes (maximum).
15) Marks on Report and Presentation shall be separately awarded by the Internal and External
16) Examiners and then averaged.

Recommended Readings:

Good research articles published from reputed journals on their specific research domain.

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PSO 1	PSO 2	PSO 3	PSO 4
CO 1	1	1	2	2	2	2	1	1	2	1	2	1	2	1
CO 2	1	0	2	2	2	2	2	2	1	2	2	2	2	2
CO 3	1	2	2	2	2	2	1	1	2	1	2	1	1	1
CO 4	1	1	1	3	2	3	1	2	2	1	1	0	2	1
CO 5	0	1	2	2	2	1	2	1	1	2	2	2	2	0
CO 6	1	1	2	1	2	3	1	1	2	1	2	1	2	1

	PO 01	PO 02	PO 03	PO 04	PO 05	PO 06	PO 07	PO 08	PO 09	PO 10	PSO 01	PSO 02	PSO 03	PSO 04
GEO21328	**0.83**	**1.00**	**1.50**	**1.33**	**2.00**	**2.33**	**2.33**	**1.33**	**2.00**	**1.33**	**1.83**	**1.33**	**1.83**	**1.17**
CO 1	1	1	2	1	2	2	3	1	2	1	2	1	2	1
CO 2	0	0	2	2	2	2	2	2	2	2	2	2	2	2
CO 3	1	2	2	1	2	3	2	1	2	1	3	1	1	1
CO 4	1	1	1	1	2	2	2	2	2	1	0	1	2	1
CO 5	1	1	0	2	2	3	2	1	2	2	2	2	2	2
CO 6	1	1	2	1	2	2	3	1	2	1	2	1	2	0
	PO 01	**PO 02**	**PO 03**	**PO 04**	**PO 05**	**PO 06**	**PO 07**	**PO 08**	**PO 09**	**PO 10**	**PSO 01**	**PSO 02**	**PSO 03**	**PSO 04**
GEO22329	**0.83**	**1.00**	**1.50**	**1.33**	**2.00**	**2.33**	**2.33**	**1.33**	**2.00**	**1.33**	**1.83**	**1.33**	**1.83**	**1.17**
CO 1	1	1	2	1	2	2	3	1	2	1	2	1	2	1
CO 2	0	0	2	2	2	2	2	2	2	2	2	2	2	2
CO 3	1	2	2	1	2	3	2	1	2	1	3	1	1	1
CO 4	1	1	1	1	2	2	2	2	2	1	0	1	2	1
CO 5	1	1	0	2	2	3	2	1	2	2	2	2	2	2
CO 6	1	1	2	1	2	2	3	1	2	1	2	1	2	0
	PO 01	**PO 02**	**PO 03**	**PO 04**	**PO 05**	**PO 06**	**PO 07**	**PO 08**	**PO 09**	**PO 10**	**PSO 01**	**PSO 02**	**PSO 03**	**PSO 04**
GEO21303	**0.83**	**1.00**	**1.83**	**2.00**	**2.00**	**2.17**	**1.83**	**1.33**	**1.67**	**1.33**	**1.83**	**1.17**	**1.83**	**1.00**
CO1	1	1	2	2	2	2	1	1	2	1	2	1	2	1
CO2	1	0	2	2	2	2	2	2	1	2	2	2	2	2
CO3	1	2	2	2	2	2	1	1	2	1	2	1	1	1
CO4	1	1	1	3	2	3	1	2	2	1	1	0	2	1
CO5	0	1	2	2	2	1	2	1	1	2	2	2	2	0
CO6	1	1	2	1	2	3	1	1	2	1	2	1	2	1
	PO 01	**PO 02**	**PO 03**	**PO 04**	**PO 05**	**PO 06**	**PO 07**	**PO 08**	**PO 09**	**PO 10**	**PSO 01**	**PSO 02**	**PSO 03**	**PSO 04**
GEO22304	**0.83**	**1.17**	**1.83**	**1.17**	**2.00**	**2.17**	**1.17**	**1.33**	**1.67**	**1.33**	**2.00**	**1.33**	**1.67**	**1.33**
CO1	0	1	2	1	2	3	1	1	2	1	2	1	2	1
CO2	1	1	2	2	1	2	2	2	1	2	2	2	3	2
CO3	2	2	2	1	3	2	0	1	2	1	2	1	1	1

CO4	1	1	1	0	2	1	1	2	2	1	1	1	0	1
CO5	0	1	2	2	3	2	2	1	1	2	3	2	2	2
CO6	1	1	2	1	1	3	1	1	2	1	2	1	2	1
	PO 01	**PO 02**	**PO 03**	**PO 04**	**PO 05**	**PO 06**	**PO 07**	**PO 08**	**PO 09**	**PO 10**	**PSO 01**	**PSO 02**	**PSO 03**	**PSO 04**
GEO22316	**0.83**	**0.83**	**1.83**	**1.33**	**2.00**	**2.17**	**2.17**	**1.33**	**2.17**	**1.33**	**1.67**	**1.33**	**1.67**	**1.00**
CO1	1	1	2	1	1	2	3	1	2	1	2	1	2	1
CO2	1	1	2	2	2	3	2	2	2	2	2	2	3	2
CO3	1	0	2	1	3	1	2	1	2	1	2	1	1	1
CO4	0	1	1	1	2	3	1	2	3	1	2	1	0	1
CO5	1	1	2	2	2	1	2	1	2	2	0	2	2	0
CO6	1	1	2	1	2	3	3	1	2	1	2	1	2	1
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
GEO22327	**0.67**	**1.17**	**1.50**	**2.33**	**2.00**	**2.17**	**1.17**	**1.33**	**1.67**	**1.17**	**1.83**	**1.50**	**1.50**	**1.33**
CO1	1	1	2	3	2	1	1	1	2	1	2	1	2	1
CO2	0	1	2	2	2	3	2	2	1	2	2	3	2	2
CO3	1	2	2	1	2	2	0	1	2	0	2	1	1	1
CO4	1	1	1	3	2	3	1	2	2	1	1	1	2	1
CO5	0	1	0	2	2	1	2	1	1	2	2	2	0	2
CO6	1	1	2	3	2	3	1	1	2	1	2	1	2	1
	PO 01	**PO 02**	**PO 03**	**PO 04**	**PO 05**	**PO 06**	**PO 07**	**PO 08**	**PO 09**	**PO 10**	**PSO 01**	**PSO 02**	**PSO 03**	**PSO 04**
CSE22752	**0.83**	**1.00**	**1.50**	**1.33**	**2.00**	**2.33**	**2.33**	**1.33**	**2.00**	**1.33**	**1.83**	**1.33**	**1.83**	**1.17**
CO1	1	1	2	1	2	2	3	1	2	1	2	1	2	1
CO2	0	0	2	2	2	2	2	2	2	2	2	2	2	2
CO3	1	2	2	1	2	3	2	1	2	1	3	1	1	1
CO4	1	1	1	1	2	2	2	2	2	1	0	1	2	1
CO5	1	1	0	2	2	3	2	1	2	2	2	2	2	2
CO6	1	1	2	1	2	2	3	1	2	1	2	1	2	0
	PO 01	**PO 02**	**PO 03**	**PO 04**	**PO 05**	**PO 06**	**PO 07**	**PO 08**	**PO 09**	**PO 10**	**PSO 01**	**PSO 02**	**PSO 03**	**PSO 04**
GEO21330	**0.83**	**1.00**	**1.83**	**2.00**	**2.00**	**2.17**	**1.33**	**1.33**	**1.67**	**1.33**	**1.83**	**1.17**	**1.83**	**1.00**
CO1	1	1	2	2	2	2	1	1	2	1	2	1	2	1

CO2	1	0	2	2	2	2	2	2	1	2	2	2	2	2
CO3	1	2	2	2	2	2	1	1	2	1	2	1	1	1
CO4	1	1	1	3	2	3	1	2	2	1	1	0	2	1
CO5	0	1	2	2	2	1	2	1	1	2	2	2	2	0
CO6	1	1	2	1	2	3	1	1	2	1	2	1	2	1
	PO 01	**PO 02**	**PO 03**	**PO 04**	**PO 05**	**PO 06**	**PO 07**	**PO 08**	**PO 09**	**PO 10**	**PSO 01**	**PSO 02**	**PSO 03**	**PSO 04**
GEO22331	**0.83**	**1.17**	**1.83**	**1.17**	**2.00**	**2.17**	**1.17**	**1.33**	**1.67**	**1.33**	**2.00**	**1.33**	**1.67**	**1.33**
CO1	0	1	2	1	2	3	1	1	2	1	2	1	2	1
CO2	1	1	2	2	1	2	2	2	1	2	2	2	3	2
CO3	2	2	2	1	3	2	0	1	2	1	2	1	1	1
CO4	1	1	1	0	2	1	1	2	2	1	1	1	0	1
CO5	0	1	2	2	3	2	2	1	1	2	3	2	2	2
CO6	1	1	2	1	1	3	1	1	2	1	2	1	2	1
	PO 01	**PO 02**	**PO 03**	**PO 04**	**PO 05**	**PO 06**	**PO 07**	**PO 08**	**PO 09**	**PO 10**	**PSO 01**	**PSO 02**	**PSO 03**	**PSO 04**
GEO22332	**0.83**	**0.83**	**1.83**	**1.33**	**2.00**	**2.17**	**2.17**	**1.33**	**2.17**	**1.33**	**1.67**	**1.33**	**1.67**	**1.00**
CO1	1	1	2	1	1	2	3	1	2	1	2	1	2	1
CO2	1	1	2	2	2	3	2	2	2	2	2	2	3	2
CO3	1	0	2	1	3	1	2	1	2	1	2	1	1	1
CO4	0	1	1	1	2	3	1	2	3	1	2	1	0	1
CO5	1	1	2	2	2	1	2	1	2	2	0	2	2	0
CO6	1	1	2	1	2	3	3	1	2	1	2	1	2	1
	PO 01	**PO 02**	**PO 03**	**PO 04**	**PO 05**	**PO 06**	**PO 07**	**PO 08**	**PO 09**	**PO 10**	**PSO 01**	**PSO 02**	**PSO 03**	**PSO 04**
CSE22756	**0.67**	**1.17**	**1.50**	**2.33**	**2.00**	**2.17**	**1.17**	**1.33**	**1.67**	**1.17**	**1.83**	**1.50**	**1.50**	**1.33**
CO1	1	1	2	3	2	1	1	1	2	1	2	1	2	1
CO2	0	1	2	2	2	3	2	2	1	2	2	3	2	2
CO3	1	2	2	1	2	2	0	1	2	0	2	1	1	1
CO4	1	1	1	3	2	3	1	2	2	1	1	1	2	1
CO5	0	1	0	2	2	1	2	1	1	2	2	2	0	2
CO6	1	1	2	3	2	3	1	1	2	1	2	1	2	1
	PO 01	**PO 02**	**PO 03**	**PO 04**	**PO 05**	**PO 06**	**PO 07**	**PO 08**	**PO 09**	**PO 10**	**PSO 01**	**PSO 02**	**PSO 03**	**PSO 04**

CSE22758	0.83	1.00	1.50	1.33	2.00	2.33	2.33	1.33	2.00	1.33	1.83	1.33	1.83	1.17
CO1	1	1	2	1	2	2	3	1	2	1	2	1	2	1
CO2	0	0	2	2	2	2	2	2	2	2	2	2	2	2
CO3	1	2	2	1	2	3	2	1	2	1	3	1	1	1
CO4	1	1	1	1	2	2	2	2	2	1	0	1	2	1
CO5	1	1	0	2	2	3	2	1	2	2	2	2	2	2
CO6	1	1	2	1	2	2	3	1	2	1	2	1	2	0
	PO 01	PO 02	PO 03	PO 04	PO 05	PO 06	PO 07	PO 08	PO 09	PO 10	PSO 01	PSO 02	PSO 03	PSO 04
ENG21111	0.83	1.00	1.83	2.00	2.00	2.17	1.33	1.33	1.67	1.33	1.83	1.17	1.83	1.00
CO1	1	1	2	2	2	2	1	1	2	1	2	1	2	1
CO2	1	0	2	2	2	2	2	2	1	2	2	2	2	2
CO3	1	2	2	2	2	2	1	1	2	1	2	1	1	1
CO4	1	1	1	3	2	3	1	2	2	1	1	0	2	1
CO5	0	1	2	2	2	1	2	1	1	2	2	2	2	0
CO6	1	1	2	1	2	3	1	1	2	1	2	1	2	1
	PO 01	PO 02	PO 03	PO 04	PO 05	PO 06	PO 07	PO 08	PO 09	PO 10	PSO 01	PSO 02	PSO 03	PSO 04
GEO25333	0.83	1.17	1.83	1.17	2.00	2.17	1.17	1.33	1.67	1.33	2.00	1.33	1.67	1.33
CO1	0	1	2	1	2	3	1	1	2	1	2	1	2	1
CO2	1	1	2	2	1	2	2	2	1	2	2	2	3	2
CO3	2	2	2	1	3	2	0	1	2	1	2	1	1	1
CO4	1	1	1	0	2	1	1	2	2	1	1	1	0	1
CO5	0	1	2	2	3	2	2	1	1	2	3	2	2	2
CO6	1	1	2	1	1	3	1	1	2	1	2	1	2	1
	PO 01	PO 02	PO 03	PO 04	PO 05	PO 06	PO 07	PO 08	PO 09	PO 10	PSO 01	PSO 02	PSO 03	PSO 04
GEO21334	0.83	0.83	1.83	1.33	2.00	2.17	2.17	1.33	2.17	1.33	1.67	1.33	1.67	1.00
CO1	1	1	2	1	1	2	3	1	2	1	2	1	2	1
CO2	1	1	2	2	2	3	2	2	2	2	2	2	3	2
CO3	1	0	2	1	3	1	2	1	2	1	2	1	1	1
CO4	0	1	1	1	2	3	1	2	3	1	2	1	0	1
CO5	1	1	2	2	2	1	2	1	2	2	0	2	2	0

CO6	1	1	2	1	2	3	3	1	2	1	2	1	2	1
	PO 01	**PO 02**	**PO 03**	**PO 04**	**PO 05**	**PO 06**	**PO 07**	**PO 08**	**PO 09**	**PO 10**	**PSO 01**	**PSO 02**	**PSO 03**	**PSO 04**
GEO22335	**0.67**	**1.17**	**1.50**	**2.33**	**2.00**	**2.17**	**1.17**	**1.33**	**1.67**	**1.17**	**1.83**	**1.50**	**1.50**	**1.33**
CO1	1	1	2	3	2	1	1	1	2	1	2	1	2	1
CO2	0	1	2	2	2	3	2	2	1	2	2	3	2	2
CO3	1	2	2	1	2	2	0	1	2	0	2	1	1	1
CO4	1	1	1	3	2	3	1	2	2	1	1	1	2	1
CO5	0	1	0	2	2	1	2	1	1	2	2	2	0	2
CO6	1	1	2	3	2	3	1	1	2	1	2	1	2	1
	PO 01	**PO 02**	**PO 03**	**PO 04**	**PO 05**	**PO 06**	**PO 07**	**PO 08**	**PO 09**	**PO 10**	**PSO 01**	**PSO 02**	**PSO 03**	**PSO 04**
GEO21338	**0.83**	**1.00**	**1.50**	**1.33**	**2.00**	**2.33**	**2.33**	**1.33**	**2.00**	**1.33**	**1.83**	**1.33**	**1.83**	**1.17**
CO1	1	1	2	1	2	2	3	1	2	1	2	1	2	1
CO2	0	0	2	2	2	2	2	2	2	2	2	2	2	2
CO3	1	2	2	1	2	3	2	1	2	1	3	1	1	1
CO4	1	1	1	1	2	2	2	2	2	1	0	1	2	1
CO5	1	1	0	2	2	3	2	1	2	2	2	2	2	2
CO6	1	1	2	1	2	2	3	1	2	1	2	1	2	0
	PO 01	**PO 02**	**PO 03**	**PO 04**	**PO 05**	**PO 06**	**PO 07**	**PO 08**	**PO 09**	**PO 10**	**PSO 01**	**PSO 02**	**PSO 03**	**PSO 04**
GEO22339	**0.83**	**1.00**	**1.83**	**2.00**	**2.00**	**2.17**	**1.33**	**1.33**	**1.67**	**1.33**	**1.83**	**1.17**	**1.83**	**1.00**
CO1	1	1	2	2	2	2	1	1	2	1	2	1	2	1
CO2	1	0	2	2	2	2	2	2	1	2	2	2	2	2
CO3	1	2	2	2	2	2	1	1	2	1	2	1	1	1
CO4	1	1	1	3	2	3	1	2	2	1	1	0	2	1
CO5	0	1	2	2	2	1	2	1	1	2	2	2	2	0
CO6	1	1	2	1	2	3	1	1	2	1	2	1	2	1
	PO 01	**PO 02**	**PO 03**	**PO 04**	**PO 05**	**PO 06**	**PO 07**	**PO 08**	**PO 09**	**PO 10**	**PSO 01**	**PSO 02**	**PSO 03**	**PSO 04**
GEO22315	**0.83**	**1.17**	**1.83**	**1.17**	**2.00**	**2.17**	**1.17**	**1.33**	**1.67**	**1.33**	**2.00**	**1.33**	**1.67**	**1.33**
CO1	0	1	2	1	2	3	1	1	2	1	2	1	2	1
CO2	1	1	2	2	1	2	2	2	1	2	2	2	3	2
CO3	2	2	2	1	3	2	0	1	2	1	2	1	1	1

CO4	1	1	1	0	2	1	1	2	2	1	1	1	0	1
CO5	0	1	2	2	3	2	2	1	1	2	3	2	2	2
CO6	1	1	2	1	1	3	1	1	2	1	2	1	2	1
	PO 01	**PO 02**	**PO 03**	**PO 04**	**PO 05**	**PO 06**	**PO 07**	**PO 08**	**PO 09**	**PO 10**	**PSO 01**	**PSO 02**	**PSO 03**	**PSO 04**
CSE22757	**0.83**	**0.83**	**1.83**	**1.33**	**2.00**	**2.17**	**2.17**	**1.33**	**2.17**	**1.33**	**1.67**	**1.33**	**1.67**	**1.00**
CO1	1	1	2	1	1	2	3	1	2	1	2	1	2	1
CO2	1	1	2	2	2	3	2	2	2	2	2	2	3	2
CO3	1	0	2	1	3	1	2	1	2	1	2	1	1	1
CO4	0	1	1	1	2	3	1	2	3	1	2	1	0	1
CO5	1	1	2	2	2	1	2	1	2	2	0	2	2	0
CO6	1	1	2	1	2	3	3	1	2	1	2	1	2	1
	PO 01	**PO 02**	**PO 03**	**PO 04**	**PO 05**	**PO 06**	**PO 07**	**PO 08**	**PO 09**	**PO 10**	**PSO 01**	**PSO 02**	**PSO 03**	**PSO 04**
ENG21112	**0.67**	**1.17**	**1.50**	**2.33**	**2.00**	**2.17**	**1.17**	**1.33**	**1.67**	**1.17**	**1.83**	**1.50**	**1.50**	**1.33**
CO1	1	1	2	3	2	1	1	1	2	1	2	1	2	1
CO2	0	1	2	2	2	3	2	2	1	2	2	3	2	2
CO3	1	2	2	1	2	2	0	1	2	0	2	1	1	1
CO4	1	1	1	3	2	3	1	2	2	1	1	1	2	1
CO5	0	1	0	2	2	1	2	1	1	2	2	2	0	2
CO6	1	1	2	3	2	3	1	1	2	1	2	1	2	1
	PO 01	**PO 02**	**PO 03**	**PO 04**	**PO 05**	**PO 06**	**PO 07**	**PO 08**	**PO 09**	**PO 10**	**PSO 01**	**PSO 02**	**PSO 03**	**PSO 04**
GEO25337	**0.83**	**1.00**	**1.50**	**1.33**	**2.00**	**2.33**	**2.33**	**1.33**	**2.00**	**1.33**	**1.83**	**1.33**	**1.83**	**1.17**
CO1	1	1	2	1	2	2	3	1	2	1	2	1	2	1
CO2	0	0	2	2	2	2	2	2	2	2	2	2	2	2
CO3	1	2	2	1	2	3	2	1	2	1	3	1	1	1
CO4	1	1	1	1	2	2	2	2	2	1	0	1	2	1
CO5	1	1	0	2	2	3	2	1	2	2	2	2	2	2
CO6	1	1	2	1	2	2	3	1	2	1	2	1	2	0
	PO 01	**PO 02**	**PO 03**	**PO 04**	**PO 05**	**PO 06**	**PO 07**	**PO 08**	**PO 09**	**PO 10**	**PSO 01**	**PSO 02**	**PSO 03**	**PSO 04**
GEO24325	**0.83**	**1.00**	**1.83**	**2.00**	**2.00**	**2.17**	**1.33**	**1.33**	**1.67**	**1.33**	**1.83**	**1.17**	**1.83**	**1.00**
CO1	1	1	2	2	2	2	1	1	2	1	2	1	2	1

CO2	1	0	2	2	2	2	2	2	1	2	2	2	2	2
CO3	1	2	2	2	2	2	1	1	2	1	2	1	1	1
CO4	1	1	1	3	2	3	1	2	2	1	1	0	2	1
CO5	0	1	2	2	2	1	2	1	1	2	2	2	2	0
CO6	1	1	2	1	2	3	1	1	2	1	2	1	2	1
	PO 01	**PO 02**	**PO 03**	**PO 04**	**PO 05**	**PO 06**	**PO 07**	**PO 08**	**PO 09**	**PO 10**	**PSO 01**	**PSO 02**	**PSO 03**	**PSO 04**
GEO21317	**0.83**	**1.17**	**1.83**	**1.17**	**2.00**	**2.17**	**1.17**	**1.33**	**1.67**	**1.33**	**2.00**	**1.33**	**1.67**	**1.33**
CO1	0	1	2	1	2	3	1	1	2	1	2	1	2	1
CO2	1	1	2	2	1	2	2	2	1	2	2	2	3	2
CO3	2	2	2	1	3	2	0	1	2	1	2	1	1	1
CO4	1	1	1	0	2	1	1	2	2	1	1	1	0	1
CO5	0	1	2	2	3	2	2	1	1	2	3	2	2	2
CO6	1	1	2	1	1	3	1	1	2	1	2	1	2	1
	PO 01	**PO 02**	**PO 03**	**PO 04**	**PO 05**	**PO 06**	**PO 07**	**PO 08**	**PO 09**	**PO 10**	**PSO 01**	**PSO 02**	**PSO 03**	**PSO 04**
GEO22318	**0.83**	**0.83**	**1.83**	**1.33**	**2.00**	**2.17**	**2.17**	**1.33**	**2.17**	**1.33**	**1.67**	**1.33**	**1.67**	**1.00**
CO1	1	1	2	1	1	2	3	1	2	1	2	1	2	1
CO2	1	1	2	2	2	3	2	2	2	2	2	2	3	2
CO3	1	0	2	1	3	1	2	1	2	1	2	1	1	1
CO4	0	1	1	1	2	3	1	2	3	1	2	1	0	1
CO5	1	1	2	2	2	1	2	1	2	2	0	2	2	0
CO6	1	1	2	1	2	3	3	1	2	1	2	1	2	1
	PO 01	**PO 02**	**PO 03**	**PO 04**	**PO 05**	**PO 06**	**PO 07**	**PO 08**	**PO 09**	**PO 10**	**PSO 01**	**PSO 02**	**PSO 03**	**PSO 04**
GEO21319	**0.67**	**1.17**	**1.50**	**2.33**	**2.00**	**2.17**	**1.17**	**1.33**	**1.67**	**1.17**	**1.83**	**1.50**	**1.50**	**1.33**
CO1	1	1	2	3	2	1	1	1	2	1	2	1	2	1
CO2	0	1	2	2	2	3	2	2	1	2	2	3	2	2
CO3	1	2	2	1	2	2	0	1	2	0	2	1	1	1
CO4	1	1	1	3	2	3	1	2	2	1	1	1	2	1
CO5	0	1	0	2	2	1	2	1	1	2	2	2	0	2
CO6	1	1	2	3	2	3	1	1	2	1	2	1	2	1

GEO22320	0.83	1.00	1.50	1.33	2.00	2.33	2.33	1.33	2.00	1.33	1.83	1.33	1.83	1.17
CO 1	1	1	2	1	2	2	3	1	2	1	2	1	2	1
CO 2	0	0	2	2	2	2	2	2	2	2	2	2	2	2
CO 3	1	2	2	1	2	3	2	1	2	1	3	1	1	1
CO 4	1	1	1	1	2	2	2	2	2	1	0	1	2	1
CO 5	1	1	0	2	2	3	2	1	2	2	2	2	2	2
CO 6	1	1	2	1	2	2	3	1	2	1	2	1	2	0
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PSO1	PSO2	PSO3	PSO4
GEO21321	0.83	1.00	1.83	2.00	2.00	2.17	1.33	1.33	1.67	1.33	1.83	1.17	1.83	1.00
CO1	1	1	2	2	2	2	1	1	2	1	2	1	2	1
CO2	1	0	2	2	2	2	2	2	1	2	2	2	2	2
CO3	1	2	2	2	2	2	1	1	2	1	2	1	1	1
CO4	1	1	1	3	2	3	1	2	2	1	1	0	2	1
CO 5	0	1	2	2	2	1	2	1	1	2	2	2	2	0
CO 6	1	1	2	1	2	3	1	1	2	1	2	1	2	1
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PSO1	PSO2	PSO3	PSO4
GEO22322	0.83	1.17	1.83	1.17	2.00	2.17	1.17	1.33	1.67	1.33	2.00	1.33	1.67	1.33
CO1	0	1	2	1	2	3	1	1	2	1	2	1	2	1
CO2	1	1	2	2	1	2	2	2	1	2	2	2	3	2
CO3	2	2	2	1	3	2	0	1	2	1	2	1	1	1
CO4	1	1	1	0	2	1	1	2	2	1	1	1	0	1
CO5	0	1	2	2	3	2	2	1	1	2	3	2	2	2
CO6	1	1	2	1	1	3	1	1	2	1	2	1	2	1
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PSO1	PSO2	PSO3	PSO4
GEO22340	0.83	0.83	1.83	1.33	2.00	2.17	2.17	1.33	2.17	1.33	1.67	1.33	1.67	1.00
CO 1	1	1	2	1	1	2	3	1	2	1	2	1	2	1
CO 2	1	1	2	2	2	3	2	2	2	2	2	2	3	2
CO 3	1	0	2	1	3	1	2	1	2	1	2	1	1	1
CO 4	0	1	1	1	2	3	1	2	3	1	2	1	0	1

CO 5	1	1	2	2	2	1	2	1	2	2	0	2	2	0
CO 6	1	1	2	1	2	3	3	1	2	1	2	1	2	1
ENG21113	**0.67**	**1.17**	**1.50**	**2.33**	**2.00**	**2.17**	**1.17**	**1.33**	**1.67**	**1.17**	**1.83**	**1.50**	**1.50**	**1.33**
CO 1	1	1	2	3	2	1	1	1	2	1	2	1	2	1
CO 2	0	1	2	2	2	3	2	2	1	2	2	3	2	2
CO 3	1	2	2	1	2	2	0	1	2	0	2	1	1	1
CO 4	1	1	1	3	2	3	1	2	2	1	1	1	2	1
CO 5	0	1	0	2	2	1	2	1	1	2	2	2	0	2
CO 6	1	1	2	3	2	3	1	1	2	1	2	1	2	1
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO 10**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
GEO21341	**0.83**	**1.00**	**1.50**	**1.33**	**2.00**	**2.33**	**2.33**	**1.33**	**2.00**	**1.33**	**1.83**	**1.33**	**1.83**	**1.17**
CO 1	1	1	2	1	2	2	3	1	2	1	2	1	2	1
CO 2	0	0	2	2	2	2	2	2	2	2	2	2	2	2
CO 3	1	2	2	1	2	3	2	1	2	1	3	1	1	1
CO 4	1	1	1	1	2	2	2	2	2	1	0	1	2	1
CO 5	1	1	0	2	2	3	2	1	2	2	2	2	2	2
CO 6	1	1	2	1	2	2	3	1	2	1	2	1	2	0
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO 10**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
GEO25326	**0.83**	**1.00**	**1.83**	**2.00**	**2.00**	**2.17**	**1.33**	**1.33**	**1.67**	**1.33**	**1.83**	**1.17**	**1.83**	**1.00**
CO1	1	1	2	2	2	2	1	1	2	1	2	1	2	1
CO2	1	0	2	2	2	2	2	2	1	2	2	2	2	2
CO3	1	2	2	2	2	2	1	1	2	1	2	1	1	1
CO4	1	1	1	3	2	3	1	2	2	1	1	0	2	1
CO5	0	1	2	2	2	1	2	1	1	2	2	2	2	0
CO6	1	1	2	1	2	3	1	1	2	1	2	1	2	1