UNIVERSITY OF THE PUNJAB

NOTIFICATION

It is hereby notified that the Syndicate at its meeting held on 17-12-2022 has approved the recommendations of the Academic Council made at its meeting dated 11-03-022 and 21-03-2022 respectively, regarding approval to Start MS & Ph.D. in Remote Sensing Program alongwith its Syllabi and Courses of Reading/Scheme of Studies at the Centre for Remote Sensing subject to the condition that there should not be overlapping in Courses and the said Programs shall be started after getting NOC from HEC and fulfillment of required faculty.

The Syllabi and Courses of Reading/Scheme of Studies for MS & Ph.D. in Remote Sensing are attached herewith, vide Annexure-A&B,

Sd/-
SHAHID JAVED
Registrar

Admin. Block,
Quaid-i-Azam Campus,
Lahore.

No. D/ 386 /Acad. **Dated: 11- 01 /2023.**

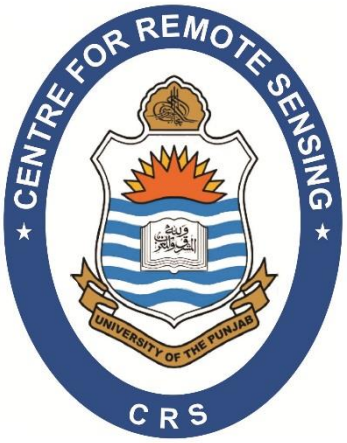
Copy of the above is forwarded to the following for information and further necessary action: -

1. Dean, Faculty of Sciences.
2. Incharge, Centre for Remote Sensing.
3. Chairperson, DPCC
4. Director, IT for placement at website.
5. Controller of Examinations
6. A.O (Statutes)
7. Secretary to the Vice-Chancellor
8. P.S. to Registrar
9. Assistant Syllabus

Assistant Registrar (Academic)
for Registrar

Scheme of Studies and Courses Outlines of

MS in Remote Sensing



Centre for Remote Sensing
University of the Punjab, Lahore

Program Title: MS in Remote Sensing
Department: Centre for Remote Sensing
Faculty: Faculty of Science

1. Centre for Remote Sensing: Mission

Centre for Remote Sensing is a nexus for research, education, and training in remote sensing & its allied disciplines and their applications. The centre aims to provide a hub for scientific research, collaborations, and incubation of ideas encapsulating the use of observational data from space borne, airborne and ground-based sensors and in-situ measurements of land, water and atmosphere of the Earth and the outer space.

The mandate of the Centre for Remote Sensing comprises of but not limited to:

i. Teaching, capacity building, and research related to Remote Sensing & its allied disciplines and their applications.
ii. Sensitize scientists, policy makers, administrators, and public the socio-economic benefits of remote sensing and its applications
iii. provide consultancy and technical assistance
iv. developing remote sensing applications to contribute to geospatial industry
v. the structure of databases from satellite imagery on timely basis in different areas and disciplines and making the information available to the public and private sector
vi. the development of decision support tools such as warning systems and long-term observatories
vii. Research Activities and projects
viii. these actions concern topics such as: landuse/landcover changes, climate change, desertification, oceanography

2. Introduction

Remote sensing is an emerging and demanding field in the technological era from national to international level. Remote Sensing field is inherently interdisciplinary, multifaceted, and complex. Degree Holders may find jobs at geospatial technology organizations, mapping companies, land surveying firms and public utilities or government departments. Remote sensing graduates may also find jobs at consulting firm and scientific laboratories, where they have the opportunity to enhance their skills in remote sensing technologies and techniques. Moreover, they may support scientists by conducting and designing remotely sensed data. For instance, they decide the optimal techniques, spectral bands, equipment etc.

3. Program Introduction

MS programme in Remote Sensing aims to promote research activities and projects to use space technology, remote sensing and geographic information science pertaining to land, water, and atmosphere of the Earth.

4. Program Objectives

1. Research and development advancement in Remote Sensing related scientific knowledge and skills and develop applications towards solving geospatial problems/issues.
2. Develop institutional and human capacity and produce skilled force to meet the needs of the industry and academia in Pakistan and abroad.
3. Contribute to, and lead Remote Sensing based research groups and professional teams in diverse application domains of Remote Sensing.
4. Promote multidisciplinary knowledge and skills in the allied and emerging areas of science and engineering.

5. Market Need / Rationale of the Program

a) ***Potential Students for the program***

An individual can join both the private sectors and can become a project manager, faculty member, research associate, remote sensing analyst, etc. Furthermore, remote sensing

applications are progressively used by private organizations that analysed data and satellites/drones' imagery for the government, research and academic libraries and, others. This programme shall provide opportunities of research and development for students having background in Space Science, GIS/Geomatics, Meteorology, Disaster Management, Environmental Sciences, Geography, Geology, Geophysics, Earth Sciences, Civil Engineers, Town Planning, City & Regional Planning, or other relevant fields.

b) ***Potential Employers***

The graduates from this centre can join any public sector or private organization using remote sensing and geospatial data such as Rescue-1122, NDMA, PDMAs, National Geospatial Services Pakistan, Pakistan Meteorological Department (PMD), NESPAK, Civil Aviation Authority (CAA), Pakistan Space and Upper Atmosphere Research Commission (SUPARCO), Water and Power Development Authority (WAPDA), International Water logging and Salinity Research Institute (IWASRI), Oil and Gas Development Company Limited (OGDCL), Survey of Pakistan, National Institute of Oceanography, Geological Survey of Pakistan, Forest Department, Agriculture/ Food Sector and other R&D Organizations, Revenue Department and Development Authorities, The Urban Units, Utilities Companies, Police Departments, National Highway Authority (NHA), Punjab Information Technology Board (PITB), International research and development organizations such as International Centre for Integrated Mountain Development (ICIMOD), Food and Agriculture Organization (FAO), World Wide Fund for Nature (WWF), World Food Program (WFP), UN Habitat, etc. and other research and development organizations after getting this degree in Remote Sensing.

c) ***Academic Projections***

This is a first-degree programme, in Pakistan, exclusively launched for Remote Sensing studies. Some other combined programmes have already been launched such as "Remote Sensing and GIS" by PU, NUST-Islamabad and GCU-Faisalabad in Pakistan. Internationally several universities and research centres including Centre for Remote Sensing (Boston University), Centre for Remote Sensing (University of Florida), Remote Sensing Research Centre (The University of Queensland) offer higher level degrees exclusively in Remote Sensing.

d) ***Faculty***

Currently, one PhD Associate Professor and 5 PhD Assistant Professors are available for this programme with core expertise in Remote Sensing and allied fields.

Name	Degree	Area of Specialization	Total
Dr. Syeda Adila Batool	PhD	Climate Change, Environmental Sciences	6
Dr. Zia ul Haq	PhD	Remote Sensing, Atmospheric Studies	
Dr. Shahid Parvez	PhD	Remote Sensing, Landuse/Landcover	
Dr. Asim Daud Rana	PhD	Remote Sensing, Landuse/Landcover	
Dr. Khalid Mahmood	PhD	Geospatial Technologies	
Dr. Salman Tariq	PhD	Remote Sensing, Land and Oceanic Studies	

e) Physical Facilities

A Remote Sensing Lab has been established, with the capacity of 40 students, as a part of National Centre of GIS and Space Applications which will be available for this programme. Other labs will be established in short period of time. Funds for a Library have been approved and it is in establishment phase.

6. Admission Eligibility Criteria

- **Years of Study completed**
  Minimum of 16 years of education with Science / Engineering background.

- **Program/Subject Studied**
  BS / MSc degree in Remote Sensing, Space Science, GIS, Geomatics, Photogrammetry, Geoinformatics, Meteorology, Disaster Management, Environmental Sciences, Geography, Geology, Geophysics, Earth Sciences, Civil Engineers, City & Regional Planning, Energy & Environment, Geo-environmental Conservation and Sustainable Development, Mountain Conservation or relevant subjects/disciplines as determined by the admission committee of the centre.

- **Percentage/CGPA**
  i. CGPA 3.0 (out of 4.0 in the Semester System) or First Division (in the Annual System) in BS/MSc/Equivalent is required
  ii. Other disciplines graduates will have to enroll in prerequisite/ deficiency courses as proposed by the Centre and as per HEC & PU prescribed guidelines.

- **Entry Test with minimum requirement (for local students)**
  University (CRS) test will be required. 40% entry test weightage.

- **Admission Formula**
  As per PU admission formula

7. Duration of the Program

4 Semesters (2 Years) comprising of 30 (24 theory + 6 research) Credit hours (extendable up to one year or 2 semesters)

- **Number of Seats**
  25

8. Categorization of Courses as per HEC Recommendation and Difference

Semester	Courses	Category (Credit Hours)					
		Core Courses	Basic Courses	Major Electives	Minor Electives	Any Other	Semester Load
1	4	9	0	3	0	0	(4*3) =12
2	4	9	0	3	0	0	(4*3) =12
3	0	0	0	0	0	Thesis	6
4	0	0	0	0	0	Thesis	
PU							
HEC Guidelines							
Difference (HEC &) PU	**0**	**0**	**0**	**0**	**0**	**0**	**0**

*Core: Compulsory, Basic: Foundation, Major Electives: Professional, Minor Electives: Specialization.
Note: The course/column heads are customizable according to nature and level of the program.

9. Scheme of Studies / Semester-wise workload

#	Course Code	Course Title	Course Type	Prerequisite	Credit Hours
Semester-I					
1	CRSC501	Remote Sensing and Digital Image Processing	Core	Nil	3 (2+1)
2	CRSC502	Meteorology and Atmospheric Remote Sensing	Core	CRSC501	3 (2+1)
3	CRSC503	Remote Sensing of Environment and Climate	Core	CRSC502	3 (2+1)
4	CRSEL	Elective-I	Major Elective	Nil	3 (2+1)
Credit hours				**12**	
Semester-II					
1	CRSC504	Remote Sensing Methods and Applications	Core	CRSC501	3 (2+1)
2	CRSC505	Research Methods	Core	Nil	3 (2+1)
3	CRSC506	Remote Sensing for Land and Oceanic Studies	Core	CRSC502	3 (2+1)
4	CRSEL	Elective-II	Major Elective	Nil	3 (2+1)
Credit hours				**12**	
Semester-III & IV					
1	CRST	Thesis			6
Total Credit hours				**30**	

Type of course may be core (compulsory), basic (foundation), major elective (professional), minor elective (specialization) etc.

Research Thesis/ Project/ Internship

6 credit hours in 2 semesters (2nd year / 3rd and 4th semesters)

10. Award of Degree

Degree awarding criteria will be followed as per PU and HEC guidelines

11. NOC from Professional Councils (if applicable)

Not applicable

12. Faculty Strength

CRS is newly established centre. Currently, the following faculty of Department of Space Science will be engaged in MS programme:

Degree	Area/Specialization	Total
PhD	1. Climate Change, Environmental Sciences 2. Remote Sensing, Atmospheric Studies 3. Remote Sensing, Landuse/Landcover 4. Remote Sensing, Landuse/Landcover 5. Geospatial Technologies 6. Remote Sensing, Land and Oceanic Studies	6
Total		**6**

13. Present Student Teacher Ratio in the Department

Not Applicable

14. Course Outlines separately for each course

Course Outline

Title	**Remote Sensing and Digital Image Processing**
Course Code	CRSC501
Semester	1
Credit hours	3 (2+1)
Learning Outcomes	After completing this course, the students will 1. Able to synthesize the potential of data captured from remotely sensed images that may be used as an interdisciplinary approach to spatial decision-making and problem solving 2. Familiarise the theoretical concepts of remote sensing and digital image processing 3. Acquire interactive practical to extract geoinformation using established/upcoming techniques and innovative approaches 4. Gain hands on experience on software for satellite image processing with the accuracy of the results and its relevancy for various applications
Suggested Readings	i. Bhatia, S. C. (2008). *Fundamentals of Remote Sensing*. Atlantic Publishers & Dist. ii. Dalezios, N. R. (2021). *Remote Sensing Applications in Environmental and Earth System Sciences.* CRC Press. iii. Jensen, J. R. (2015). *Introductory Digital Image Processing: A Remote Sensing Perspective*. Pearson. iv. Lillesand, T., Kiefer, R. W., & Chipman, J. (2015). *Remote Sensing and Image Interpretation*. John Wiley & Sons.
Contents	**Unit-I** 1.1. Introduction to remote sensing and digital image processing 1.2. Techniques of Image acquisition 1.3. Image characteristics and resolutions 1.4. Color representations and transforms 1.5. Image Histograms, and statistics 1.6. Geometric transformations/Georeferencing Technique **Unit-II** 2.1. Principles of image interpretation 2.2. Image enhancement techniques Scatter plot **Unit-III** 3.1. Principal component analysis 3.2. Decorrelation stretches 3.3. Spatial filtering techniques 3.4. Fourier transformation 3.5. Basic Image Compression techniques Different image file formats **Unit-IV** 4.1. Image classification techniques 4.2. Image merging and mosaicking techniques

	4.3. Remote Sensing integration with GIS and GPS 4.4. Hyperspectral Remote Sensing 4.5. Applications of Image Analysis 4.6. Limitations and future of Digital Image Processing Technique

Teaching-learning strategies		Class Lecture method, which includes seminars, discussions, assignments, and projects. (Audio-visual tools are used where necessary)			
Assessment Criteria	**Marks %**	Session	Mid	Final	Total %
		25	35	40	100
Assignments-Types and Number with calendar		Assignments will be given according to the choice of respective teacher but in general, four assignments should be given i.e., in the 2nd, 4th, 10th, and 12th week of a semester. * All assignments must be completed and presented on time.			
Assessment and Examinations		• The University's Semester Rules & Regulations will be followed • Class Attendance will be strictly observed as per the University Rules • Students are advised to keep the course outlines in record in their own interest for future reference and studies abroad • Students are advised to go through the rules and regulations governing their class attendance, display of Centre ID Card, use of mobile phones, eating/smoking, roaming, general behavior, etc. on the Campus • Any violation thereof is punishable under the relevant rules			

Title	**Meteorology and Atmospheric Remote Sensing**
Course Code	CRSC502
Semester	1
Credit hours	3 (2+1)
Learning Outcomes	After completing this course, the students will 1. Able to demonstrate sound understanding of the atmosphere and climate as integral part of the physical environment 2. Can integrate and use meteorological knowledge in the matrices of environmental research 3. Gain the knowledge of how geostrophic winds and cyclones are caused in the earth atmospheric system
Suggested Readings	i. Constantin Andronache. (2018). *Remote Sensing of Clouds and Precipitation.* Springer. ii. Craig, R. A. (2016). *The Upper Atmosphere: Meteorology and Physics.* Elsevier. iii. Dmitry Efremenko, Alexander A. Kokhanovsky. (2021). *Foundations of Atmospheric Remote Sensing*. Springer. iv. Kokhanovsky, A., & Tomasi, C. (2020). *Physics and Chemistry of the Arctic Atmosphere.* Springer Nature. v. Seinfeld, J. H., & Pandis, S. N. (2012). *Atmospheric Chemistry and Physics: From Air Pollution to Climate Change.* John Wiley & Sons.
Contents	**Unit-I** 1.1. Fundamentals of atmospheric science 1.2. Energy and mass conservation 1.3. Internal energy and entropy 1.4. Atmospheric water vapor **Unit-II** 2.1. Equations of motion 2.2. Hydrostatics 2.3. Phase oxidation 3.1. The ozone layer **Unit-III** 3.2. Fundamentals of biogeochemical cycles 3.3. Solar and terrestrial radiation 3.4. Radiative-convective equilibrium 3.5. Linear perturbation theory **Unit-IV** 4.1. Energy balance 4.2. Kinetic energy cycle 4.3. Thermodynamics 4.4. Dynamics of zonally symmetric and varying flow 4.5. Tropical dynamics 4.6. The planetary boundary layer **Unit-V** 5.1. Heterogeneous chemistry 5.2. Cloud microphysics 5.3. Cloud and aerosol absorption and scattering **Unit-VI** 6.1. Introduction to Atmospheric Remote Sensing 6.2. Satellite Meteorology and Remote Sensing

	6.3. Atmospheric Remote Sensing Systems

Teaching-learning strategies		Class Lecture method, which includes seminars, discussions, assignments, and projects. (Audio-visual tools are used where necessary)			
Assessment Criteria	**Marks %**	Session	Mid	Final	Total %
		25	35	40	100
Assignments-Types and Number with calendar		Assignments will be given according to the choice of respective teacher but in general, four assignments should be given i.e., in the 2nd, 4th, 10th, and 12th week of a semester. * All assignments must be completed and presented on time.			
Assessment and Examinations		• The University's Semester Rules & Regulations will be followed • Class Attendance will be strictly observed as per the University Rules • Students are advised to keep the course outlines in record in their own interest for future reference and studies abroad • Students are advised to go through the rules and regulations governing their class attendance, display of Centre ID Card, use of mobile phones, eating/smoking, roaming, general behavior, etc. on the Campus • Any violation thereof is punishable under the relevant rules			

Title	**Remote Sensing of Environment and Climate**
Course Code	CRSC503
Semester	1
Credit hours	3 (2+1)
Learning Outcomes	After completing this course, the students will 1. Able to synthesize the potential of remote sensing applications regarding to the environment and climate studies that may be used as an interdisciplinary approach to spatial decision-making and problem solving 2. Gain the theoretical background of how climate is changed over decades, pollution, weather phenomenon, and their impacts 3. Enable them to describe the consequences of climate change, and different approaches to mitigating it
Suggested Readings	i. Dr. Prasad S., Thenkabail, John G., Lyon, Professor Alfredo Huete. (2019). *Remote Sensing and Global Climate Change.* CRC press. ii. Kaku, K. (2019). *Satellite Remote Sensing for Disaster Management Support: A Holistic and Staged Approach Based on Case Studies in Sentinel Asia.* International Journal of Disaster Risk Reduction, 33, 417–432. iii. Nangyal, H., Khan, M. S. (2020). *Environmental Pollution, Biodiversity, and Sustainable Development: Issues and Remediation*. Apple Academic Press Inc. iv. Robin A. Vaughan, Arthur P. Cracknell. (2011). *Remote Sensing and Global Climate Change.* Springer.
Contents	**Unit-I** 1.1. Global climate change 1.2. Atmospheric Physics 1.3. Inversions 1.4. Electromagnetic Radiation **Unit-II** 2.1. Climate and understanding pollution 2.2. Pollution from space 2.3. Production, Transformation, Transport, and Removal of pollutants 2.4. Hazardous air pollutants **Unit-III** 3.1. Greenhouse effects 3.2. Water pollution-eutrophication 3.3. Monitoring and mapping of air pollution using Remote Sensing 3.4. Photochemical Smog 3.5. Internal Combustion Engines 3.6. Zeldovich Mechanism & Photochemistry **Unit-IV** 4.1. Aerosols and Remote Sensing 4.2. Remote Sensing based Observational Techniques & Acid Deposition 4.3. Remote Sensing of Ozone 4.4. Stratospheric Ozone Destruction 4.5. Natural Gas Production 4.6. Health and environmental effects

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Title	**Remote Sensing Methods and Applications**
Course Code	CRSC504
Semester	**2**
Credit hours	3 (2+1)
Learning Outcomes	After completing this course, the students will 1. Able to think and function as a practical professional applied remote sensing analyzer 2. Create and analyze Radar, LiDAR, UAV, Hyperspectral data images. 3. Able to respond flexibly towards restoration of problematic landcover/land use of specific areas
Suggested Readings	i. Borengasser, M., Hungate, W. S., & Watkins, R. (2007). *Hyperspectral Remote Sensing: Principles and Applications.* CRC Press. ii. Claudia Kuenzer, Stefan Dech (Editors). (2013). *Thermal Infrared Remote Sensing: Sensors, Methods, Applications.* Springer. iii. Eismann, M. T. (2012). *Hyperspectral Remote Sensing.* Society of Photo Optical. iv. Fernando Carvajal-Ramírez, Francisco Agüera-Vega, Patricio Martínez-Carricondo (Editors). (2021). *UAV Photogrammetry and Remote Sensing.* MDPI. v. John A. Richards. (2009). *Remote Sensing with Imaging Radar*. Springer. vi. Pinliang Dong and Qi Chen. (2018). *LiDAR Remote Sensing and Applications.* CRC Press, Taylor & Francis Group.
Contents	**Unit-I** 1.1. History of Radar Imaging 1.2. Introduction to Radar Imaging Geometries and Processing 1.3. Introduction to Synthetic Aperture Radar (SAR) 1.4. Principle of Interferometry **Unit-II** 2.1. Introduction to Interferometric Synthetic Aperture Radar 2.2. Polarimetric Synthetic Aperture Radar (PolSAR) 2.3. Radar Remote Sensing applications 2.4. Forestry, Urban, Water Surfaces and Terrain Mapping **Unit-III** 3.1. Introduction to Light Detection and Ranging (LiDAR) 3.2. LiDAR Background Working of Active Remote Sensing Systems 3.3. Discrete vs. Full Waveform LiDAR 3.4. LiDAR Piont Clouds 3.5. LiDAR Remote Sensing Application **Unit-IV** 4.1. Forest Canopy Height Measurements, Elevation Data Creation 4.2. Urban Planning, Introduction to UAV Remote Sensing Thoery and Principle 4.3. UAV Photogrammetry, Aerial Photography, UAV Remote Sensing Applications 4.4. Precision Agriculture Analysis 4.5. Urban Planning 4.6. Digital Elevation Models **Unit-V** 5.1. Introduction to Thermal Remote Sensing 5.2. Theory and Principles of Thermal Infrared Remote Sensing

	5.3. Thermal Remote Sensing Applications 5.4. Night-time Thermal Remote Sensing, 5.5. Land Surface Temperatures, Urban Heat Islands **Unit-VI** 6.1. Introduction to Hyperspectral Remote Sensing 6.2. Hyperspectral Cameras and systems 6.3. Hyperspectral Data mining and processing 6.4. Field spectroscopy, Creation of Spectral libraries 6.5. Applications of Hyperspectral Remote Sensing 6.6. Vegetation Species identification 6.7. Geological and Mineral Applications

Teaching-learning strategies		Class Lecture method, which includes seminars, discussions, assignments, and projects. (Audio-visual tools are used where necessary)			
Assessment Criteria	**Marks %**	Session	Mid	Final	Total %
		25	35	40	100
Assignments-Types and Number with calendar		Assignments will be given according to the choice of respective teacher but in general, four assignments should be given i.e., in the 2nd, 4th, 10th, and 12th week of a semester. * All assignments must be completed and presented on time.			
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Title	**Research Methods**
Course Code	CRSC 505
Semester	**2**
Credit hours	3 (2+1)
Learning Outcomes	After completing this course, the students will 1. Able to think and function as a prudent professional researcher 2. Able to understand main principles of research methodology 3. Gains the approach to solve research problems 4. Can make an appropriate choice of research methodology
Suggested Readings	i. Basudeb Bhatta. (2013). *Research Methods in Remote Sensing*. Springer. ii. Michael Köhl, Steen S. Magnussen, Marco Marchetti. (2006). *Sampling Methods, Remote Sensing and GIS Multiresource Forest Inventory*. Springer Patten, M. L., & Newhart, M. (2017). *Understanding Research Methods: An Overview of the Essentials.* Taylor & Francis. iii. Tan, W. (2017). *Research Methods: A Practical Guide for Students and Researchers*. World Scientific Publishing Company. iv. Walliman, N. (2018). *Research Methods*. Routledge.
Contents	**Unit-1** 1.1. Introduction to Advance Research Methods 1.2. Basic Concepts of Research 1.3. Research Ethics and Integrity 1.4. Critical appraisal **Unit-II** 2.1. Introduction to Quantitative Research 2.2. Study Designs and Methods 2.3. Analysis and Interpretation of Quantitative Data 2.4. Critical Appraisal of Quantitative Research **Unit-III** 3.1. Introduction to Qualitative Research 3.2. Study Designs and Methods 3.3. Analysis and Interpretation of Qualitative Data **Unit-IV** 4.1. Introduction to Mixed Methods Research 4.2. Study Designs and Methods 4.3. Analysis and Interpretation of Mixed Methods Data 4.4. Critical Appraisal of Mixed Methods Research **Unit-V** 5.1. Research Analysis 5.2. Report writing Group Verbal Presentations on Research Proposals

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Title	**Remote Sensing for Land and Oceanic Studies**
Course Code	CRSC506
Semester	**2**
Credit hours	3 (2+1)
Learning Outcomes	After completing this course, the students will 1. Able to understand marine aspects of environmental sciences 2. Develop their skills on synthesis and extension of the information provided in marine chemistry, geochemistry, physical oceanography, and biology
Suggested Readings	i. Bartlett, D. J., & Celliers, L. (2017). *Geoinformatics for Marine and Coastal Management.* Taylor & Francis Group. ii. Bhaskar Ramachandran, Christopher O. Justice, Michael J. Abrams. (2011). *Land Remote Sensing and Global Environmental Change.* Springer. iii. Rani, M., Seenipandi, K., Rehman, S., Kumar, P., & Sajjad, H. (2020). *Remote Sensing of Ocean and Coastal Environments.* Elsevier. iv. Wang, Y. (2009). *Remote Sensing of Coastal Environments*. CRC Press.
Contents	**Unit-I** 1.1. Origin of the Earth and its oceans 1.2. History of ocean use and oceanographic investigations 1.3. Geography and physiography of ocean basins 1.4. Evolution of ocean basins (plate tectonics) 1.5. Global ocean-atmosphere heat budget **Unit-II** 2.1. Solar heating and surface radiation 2.2. Evaporation and precipitation 2.3. Winds and transporting heat 2.4. Water vapour in the atmosphere and the effect of continent **Unit-III** 3.1. Remote Sensing based Land resource monitoring 3.2. wind-driven and thermohaline circulation, wind stress, temperature, and salinity 3.3. Coriolis force and friction, Transporting heat and salinity, Turbulence, and diffusive mixing 3.4. The water masses, Boundary layers 3.5. Profiles for temperature, salinity, density, light, and oxygen concentration, Oceanic sediment, and sediment transport mechanisms **Unit-IV** 4.1. Remote Sensing Oceanography 4.2. Physical characteristics of ocean water 4.3. Surface and subsurface circulation of ocean waters 4.4. Remote Sensing based detection of Ocean-atmosphere interactions (including climate, monsoons, hurricanes, and El Niño events) **Unit-VI** 5.1. Origin of oceanic currents 5.2. Coastlines and their management with Remote Sensing technologies 5.3. Marine organisms and their Remote Sensing based classification 5.4. Marine ecology and ecosystem description **Unit-VI**

	6.1. Oceanic resources (physical, chemical, and biological) 6.2. Marine pollution and its ecological effects, Ocean monitoring satellites 6.3. Ocean acidification and Carbon cycle Overview of oceanic satellite products: AQUA-MODIS, SeaWiFs, Copernicus, and VIIRS

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ELECTIVE COURSES

Title	**Artificial Intelligence Applications in Remote Sensing**
Course Code	CRSEL507
Credit hours	3 (2+1)
Learning Outcomes	After completing this course, the students will 1. Able to understand Artificial Intelligence with Python, the concepts, and algorithms at the foundation of modern artificial intelligence 2. Hands on experience of on basic search algorithms for problem solving 3. Think critically to address multifaceted scientific issues and environmental phenomenon
Suggested Readings	i. Alpaydin, E. (2016*). Machine Learning: The new AI*. MIT Press. ii. D. Jude Hemanth. (2020). *Artificial Intelligence Techniques for Satellite Image Analysis*. Springer. iii. Gustau Camps-Valls, Devis Tuia, Xiao Xiang Zhu, Markus Reichstein. *(2021). Deep Learning for the Earth Sciences: A Comprehensive Approach to Remote Sensing, Climate Science and Geosciences.* John Wiley & Sons, Inc. iv. Haupt S. E., Pasini A., Marzban, C. (2009). *Artificial Intelligence Methods in the Environmental Sciences.* Springer Nature. v. Yakoub Bazi, Edoardo Pasolli. (2021). *Advanced Deep Learning Strategies for the Analysis of Remote Sensing Images*. MDPI.
Contents	**Unit-I** 1.1. Basic Concept and types of AI, Branches of Artificial Intelligence (AI) 1.2. Types of Machine Learning 1.3. Supervised machine learning algorithms 1.4. Unsupervised machine learning algorithms 1.5. Logistic Regression, Decision Tree **Unit-II** 2.1. Support Vector Machine (SVM) 2.2. K-Nearest Neighbours 2.3. K-Mean Clustering 2.4. Random Forest model 2.5. Gender Classification (Project) **Unit-III** 3.1. Pre-processing the Remote Sensing Data 3.2. Techniques for Data Pre-processing 3.3. Labelling Data, Create, Read, Write Files in Python 3.4. External Libraries, NLTK **Unit-III** 4.1. Image processing 4.2. Remote Sensing Application of Artificial Intelligence 4.3. Neural Networks 4.4. Fuzzy Logic 4.5. Deep Learning

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Title	**Microwave Remote Sensing**
Course Code	CRSEL508
Credit hours	3 (2+1)
Learning Outcomes	After completing this course, the students will 1. Able to understand Radar Remote Sensing, electromagnetic wave propagation and interaction with natural materials 2. Practical implication of Synthetic Aperture Imaging and Radar Interferometry 3. Able to respond flexibly towards restoration of problematic landcover/land use of specific areas
Suggested Readings	i. Bishop, J. L., Bell, J. F., & Moersch, J. E. (2020). *Remote Compositional Analysis: Techniques for Understanding Spectroscopy, Mineralogy and Geochemistry of Planetary Surfaces.* Cambridge University Press. ii. Mandal, D., Bhattacharya, A., & Rao, Y. S. (2021). *Radar Remote Sensing for Crop Biophysical Parameter Estimation*. Springer. iii. Marghany, M. (2019). *Synthetic Aperture Radar Imaging Mechanism for Oil Spills.* Gulf Professional Publishing. iv. Richards, J.A., (2009). *Remote Sensing with Imaging Radar*. Springer.
Contents	**Unit-I** 1.1. Introduction and Overview of History of Radar 1.2. Radar Modalities 1.3. Electromagnetic spectrum 1.4. Radar system components **Unit-II** 2.1. Basic concepts: Range determination, Range resolution, Doppler frequency shift 2.2. Derivation and sources 2.3. Range-Doppler ambiguity 2.4. Radar Equation 2.5. Electromagnetic waves **Unit-III** 3.1. Maxwell's equations for time-harmonic fields 3.2. Poynting vector, Power flow, Polarization, Reflection, Transmission, 3.3. Attenuation in simple media, Waves in ionized media 3.4. Drude-Lorentz model 3.5. Radar Cross Section (RCS) and scattering 3.6. Calculation of RCS Scattering regimes: Optical, Rayleigh, Mie, Bragg condition 3.7. Polarization effects and the scattering matrix **Unit-IV** 4.1. Fundamentals of Radar Reception and Signal Processing 4.2. I and Q demodulation 4.3. Pulse-Doppler analysis, Matched Filter Ambiguity function, Pulse compression 4.4. Linear frequency modulation, Phase coding, Amplitude coding 4.5. Antenna fundamentals **Unit-V** 5.1. The elemental dipole radiator 5.2. Power pattern, Directivity Gain, Effective Area 5.3. Impedance Aperture antennas, and array antennas 5.4. Hard target detection Imaging radar 5.5. Weather radar

	Ionospheric radar and LIDAR/LADAR

Teaching-learning strategies		Class Lecture method, which includes seminars, discussions, assignments, and projects. (Audio-visual tools are used where necessary)			
Assessment Criteria	**Marks %**	Session	Mid	Final	Total %
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Title	**Web Applications of Remote Sensing and GIS**
Course Code	CRSEL509
Credit hours	3 (2+1)
Learning Outcomes	After completing this course, the students will 1. Able to understand the basic concepts of Web GIS 2. Able to integrate web applications with GIS 3. Hands-on experience on implementation of high-quality web mapping applications
Suggested Readings	i. Bolstad, P. (2005). *GIS Fundamentals: A First Text on Geographic Information Systems*. Xan Edu Publishing Inc. ii. Fu, P. (2020). *Getting to Know Web GIS*. Esri Press. iii. Liping Di, H. K. Ramapriyan. (2010). *Standard-Based Data and Information Systems for Earth Observation.* Springer. iv. Songnian Li, Suzana Dragicevic, Bert Veenendaal. (2017). *Advances in Web-Based GIS, Mapping Services and Applications.* Taylor & Francis Group. v. Taylor & Pimpler, E. (2013). *Programming ArcGIS 10.1 with Python Cookbook.* Packt Publishing Francis. vi. Yang, C. (2017). *Introduction to GIS Programming and Fundamentals with Python and ArcGIS*.
Contents	**Unit-I** 1.1. Introduction to Web GIS basics and applications 1.2. Cloud GIS 1.3. Web services overview 1.4. Volunteered geographic information 1.5. web editing and feature Service 1.6. Story maps and more web app templates **Unit-II** 2.1. ArcGIS Web App Builder 2.2. HTML5, ArcGIS JavaScript API, Mobile GIS 2.3. Real-time Web GIS 2.4. Online Spatial Analysis **Unit-III** 3.1. Build on-premises Web GIS with ArcGIS for Server 3.2. Map services 3.3. Web Services Standards & Interoperability 3.4. Remote Sensing Data formats for web applications 3.5. Web Based Remote Sensing Platforms 3.6. Remote Sensing open-source software's **Unit-IV** 4.1. Remote Sensing Data and Cloud computing 4.2. Remote Sensing Data processing and data mining

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Title	**Applied Environmental Statistics**
Course Code	CRSEL510
Credit hours	3 (2+1)
Learning Outcomes	After completing this course, the students will 1. Able to understand statistical analyses and modelling techniques for appropriate use in environmental applications 2. Advanced Statistical techniques will be integrated with environment 3. Practical skills for statistical analysis
Suggested Readings	i. Alexandra Gemitzi, Nikolaos Koutsias, Venkat Lakshmi. (2019.) *Advanced Environmental Monitoring with Remote Sensing Time Series Data and R.* CRC Press. ii. Bivand, R.S., Pebesma, E., Gomez-Rubio, V. (2013*). Applied Spatial Data Analysis with R, 2nd Edition.* Springer, Inc. iii. Brunsdon, C., Comber, L. (2018). *An Introduction to R for Spatial Analysis and Mapping, 2nd Edition.* Sage Publications. iv. Lander, J.P. (2017*). R for Everyone: Advanced Analytics and Graphics, 2nd Edition.* Pearson Education, Inc. v. Rani, A., Kumar, K., Singh, S.K., Sinha, N.K., Jena, R.K., Patra, H. (2021). *Remote Sensing Data Analysis in R, 1st edition*. CRC Press vi. Reimann, C., Filzmoser, P., Garrett, R., & Dutter, R. (2011). *Statistical Data Analysis Explained: Applied Environmental Statistics with R*. John Wiley & Sons.
Contents	**Unit-I** 1.1. Introduction to R, Downloading R, Installing R 1.2. Basic interface, Installing R libraries 1.3. Object types 1.4. Important basic function 1.5. Arithmetic operators 1.6. Basic mathematical functions **Unit-II** 2.1. Matrix operations 2.2. Base Graphics 2.3. Summary Statistics 1.2. Averages, Dispersion, Advanced graphics, ggplot, Moments, Skewness, Kurtosis 1.1. Normality (Bell shape) of data, 1.2. Concepts of probability and standard probability distributions, Concepts of sampling and sampling distribution of an estimator, Concepts of statistical inference, Covariance and Correlation, Regression models, Concepts of non-linear models, 1.3. Time series models, Spatial Models, Clustering, Real-world applications of Environmental Remotely Sensed data, 1.4. Remote Sensing Applications, such as hydrology, vegetation changes, land surface temperature, fire detection.

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Title	**Remote Sensing for Disaster Management and Risk Assessment**
Course Code	CRSEL511
Credit hours	3 (2+1)
Learning Outcomes	After completing this course, the students will 1. Able to utilize spatial data for GIS and remote sensing in disaster risk assessment and management 2. Application of practical implications of GIS/remote sensing datasets for post-disaster damage assessment
Suggested Readings	i. Abdalla, R., & Esmail, M. (2018). *WebGIS for Disaster Management and Emergency Response.* Springer. ii. Kaku, K. (2019). *An Introduction to Applying Satellite Remote Sensing to Disaster Management.* Cambridge Scholars Publishing. iii. Saied Pirasteh, Jonathan Li. (2017). *Global Changes and Natural Disaster Management: Geo-information Technologies*. Springer. iv. Tomaszewski, B. (2020). *Geographic Information Systems (GIS) for Disaster Management*. Routledge.
Contents	**Unit-I** 1.1. Disaster Management Related Concept 1.2. Terminologies and Frameworks 1.3. Overview of the role of GIS and Remote Sensing 1.4. Overview of Earth Observation systems and data availability **Unit-II** 2.1. Geospatial intelligence for crisis management 2.2. Climate Risk Management 2.3. Climate change projections 2.4. Decision support tools in Climate Risk Management Open-source Earth observation data and software **Unit-III** 3.1. Early warning systems and Information 3.2. Networks for major hazards 3.3. The geophysical, hydrological, and climatological disaster analysis 3.4. The meteorological, glaciological, and biological disaster analysis **Unit-IV** 4.1. Accessing Local Climate Scenarios and Climate Risk Mapping 4.2. Climate Risk Management Planning Processes at the national, sub-national and local levels 4.3. Landslide hazard mapping 4.4. Monitoring and modelling of Flood mapping 4.5. Drought mapping, monitoring & forecasting 4.6. Use of very high-resolution satellite images for post-disaster damage assessment 4.7. Case study on vulnerability assessment and Earthquake-induced post-disaster damage assessment

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Title	**Sustainable Energy and Environment**
Course Code	CRSEL512
Credit hours	3 (2+1)
Learning Outcomes	After completing this course, the students will 1. Explore key issues related to sustainable energy and climate change in the context of spatial and transport planning and the environment 2. Able to develop positive adaptation and mitigation strategies
Suggested Readings	i. Fernando Ramos Martins. (2021). *Assessment of Renewable Energy Resources with Remote Sensing*. MDPI ii. Helmis, C. G. (2012). *Advances in Meteorology, Climatology and Atmospheric Physics.* Springer. iii. Jr., J. A., & Yang, P. (2014). *Atmospheric Radiation: A Primer with Illustrative Solutions.* John Wiley & Sons. iv. Lander, J. P. (2017). *R for Everyone: Advanced Analytics and Graphics.* Addison Wesley Professional. v. N.D. Kaushika, K.S. Reddy, Kshitij Kaushik. (2016). *Sustainable Energy and the Environment: A Clean Technology Approach*. Springer. vi. Qihao Weng. (2016). *Remote Sensing for Sustainability*. CRC Press
Contents	**Unit-I** 1.1 Overview of climate change 1.2 General trend in energy consumption 1.3 present energy production technologies 1.4 Depleting and uneven distribution of natural resource 1.5 Traditional and Unconventional Energy Resources **Unit-II** 2.1 Solar energy resource: Sun-Earth relationship 2.2 Geometry: sun path and solar irradiance 2.3 Solar spectrum 2.4 Solar constant 2.5 Daily and seasonal variations 2.6 Effects of tilt angle **Unit-III** 3.1 Solar energy resource: Extra-terrestrial, global, direct, diffused radiation 3.2 Radiation on tilt surface 3.3 Measuring instruments 3.4 Flat plate collectors, their designs 3.5 Heat transfer, absorption, transmission of sun energy 3.6 Climate Change and Energy **Unit-IV** 4.1 International and National Energy Policies 4.2 Carbon capture and sequestration 4.3 Emerging Energy Technologies 4.4 Factors effecting carbon emissions 4.5 Sustainability of materials, Policy, regulations, and fiscal drivers 4.6 Renewable energy resources, local environmental features and the regional climate

	4.7 Nature of energy systems models and analysis 4.8 Response of Energy Systems and their Analysis Quantitative techniques **Unit-V** 5.1 Remote Sensing based Monitoring and targeting 5.2 Energy efficient Remote Sensing techniques and technologies 5.3 Remote Sensing based monitoring of Changes in natural ecosystems 5.4 Modelling and analysis of sustainable energy and environmental problems 5.5 Development of numerical Environmental models using Remote Sensing Methodologies 5.6 Advance Assessment tool for spatial and temporal analysis of sustainable energy sources 5.7 Remote Sensing Applications in Sustainable Energy 5.8 Remote Sensing applications on hydro, solar, wind and geothermal energy resources

Teaching-learning strategies		Class Lecture method, which includes seminars, discussions, assignments, and projects. (Audio-visual tools are used where necessary)			
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Title	**Numerical Weather Modelling and Forecasting**
Course Code	CRSEL513
Credit hours	3 (2+1)
Learning Outcomes	After completing this course, the students will 1. Able to interpret, understand, and analyse weather data, 2. Emphasis on conventional surface and upper-air data and the use of the datasets in current weather diagnostics 3. Hands-on experience on weather modelling and forecasting
Suggested Readings	i. Coiffier, J. (2011). *Fundamentals of Numerical Weather Prediction*. Cambridge University Press. ii. Frank S. Marzano, Guido Visconti. (2002). *Remote Sensing of Atmosphere and Ocean from Space: Models, Instruments and Techniques*. Kluwer Academic Publisher. iii. Lovejoy, S. (2019). *Weather, Macroweather, and the Climate: Our Random Yet Predictable Atmosphere.* Oxford University Press. iv. Rees, G., & Rees, W. G. (2013). *Physical Principles of Remote Sensing.* Cambridge University Press. v. Patrick Santurette, Christo Georgiev. (2005). *Weather Analysis and Forecasting: Applying Satellite Water Vapor Imagery and Potential Vorticity Analysis.* Academic Press.
Contents	**Unit-I** 1.1 Introduction of Aviation, Coastal, Convective Weather, Fog, and Low Stratus 1.2 Numerical Weather Modelling 1.3 Mesoscale and Satellite Meteorology 1.4 Tropical/Hurricanes, Hand analysis of surface and upper-air weather maps 1.5 Spatial and temporal cross-sections **Unit-II** 2.1 Thermodynamic diagrams 2.2 Meso-analyses and prognostic charts 2.3 Principles of synoptic meteorology 2.4 Introduction to computerized weather data, access, display, and analysis using meteorological software applications 2.5 Use of surface and upper-air data, satellite, and radar imagery, Numerical model output for weather forecasting **Unit-III** 3.1 Principles of weather briefing 3.2 Forecast decision-making 3.3 Architecture of Early Warning Systems, NWP processes and components 3.4 Fundamentals of NWP models 3.5 Governing equations, Filtering, and scaling 3.6 Vertical coordinates, Numerical methods to solve PDEs, Model type, resolution, and boundary conditions **Unit-IV** 4.1 Interpretation of Satellite Water Vapor Imagery 4.2 Interpretation of Synoptic Scale light and dark imagery features 4.3 Weather Forecasting and Remote Sensing Modelling 4.4 Data Assimilation and Remote Sensing programs

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Title	**Hydrological Modelling**
Course Code	CRSEL 514
Credit hours	3 (2+1)
Learning Outcomes	After completing this course, the students will 1. Able to perform hydrological modelling, an effective and essential tool for assessment, prediction and management of water resources, hydrological parameters, and water movement/demand/use scenarios 2. Advancements in geospatial technology and data have opened a new avenue of research and operational applications of hydrological modelling 3. Hands-on exercises on hydrological modelling
Suggested Readings	i. Frédéric Frappart, Luc Bourrel. (2018). *The Use of Remote Sensing in Hydrology.* MDPI. ii. Gert A. Schultz, Edwin T. Engman. (2000). *Remote Sensing in Hydrology and Water Management.* Springer. iii. Maidment, D. R., & Morehouse, S. (2002). *Arc Hydro: GIS for Water Resources.* ESRI Press. iv. Singh, V., & Fiorentino, M. (1996). *Geographical Information Systems in Hydrology.* Springer Science & Business Media. v. Yousuf, A., & Singh, M. (2021). *Watershed Hydrology, Management and Modelling*. CRC Press.
Contents	**Unit-I** 1.1 Introduction to hydrology 1.2 Type of hydrological models 1.3 Spatial and Non-spatial Data Inputs for Hydrological Modelling 1.4 Digital Elevation Model and its Derivatives **Unit-II** 2.1 Geospatial technology applications for water resources: an overview 2.2 Data and data quality 2.3 Lumped and distributed precipitation - runoff models 2.4 Snow/Glacier Melt-Runoff Modelling 2.5 Soil Erosion and Sediment Yield Modelling 2.6 Flood peak Estimation using Hydrological Modelling 2.7 River Flow Modelling using 1D Hydrodynamic **Unit-III** 3.1 Impact Climate Change on Hydrological Regime 3.2 Remote Sensing in Hydrological Modelling 3.3 Remote Sensing platform and datasets for hydrology 3.4 Remote Sensing and GIS systems in hydrological applications 3.5 Small scale water management system with the aid of Remote Sensing 3.6 Potential of Remote Sensing in water management **Unit-IV** 4.1 Floods, flood warning systems 4.2 flood zones, irrigation 4.3 Water channels 4.4 Snow hydrology 4.5 Simulation of land use changes **Unit-V** 5.1 Remote sensing of Land Use and Land Cover change detection 5.2 Remote Sensing Active and passive systems for Hydrological applications 5.3 Land surface temperature from thermal infrared data 5.4 Surface soil moisture

	5.5 Remote sensing of hydrometeorological states 5.6 Landscape roughness and vegetation cover 5.7 Snow cover and water equivalent 5.8 Remote sensing of hydrometeorological fluxes, Evapotranspiration, fractional vegetation cover, Hydrological Modelling parameters.

Teaching-learning strategies		Class Lecture method, which includes seminars, discussions, assignments, and projects. (Audio-visual tools are used where necessary)			
Assessment Criteria	**Marks %**	Session	Mid	Final	Total %
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Title	**Extra-terrestrial Remote Sensing**
Course Code	CRSEL 515
Credit hours	3 (2+1)
Learning Outcomes	Coursework will cover a broad range of areas including astrophysical techniques and computing, planetary science, stellar astrophysics, galaxies, and cosmology.
Suggested Readings	i. Carroll, B. W., & Ostlie, D. A. (2018). *An Introduction to Modern Astrophysics.* Cambridge University Press. ii. Kutner, M. L. (2016). *Astronomy: A Physical Perspective.* Cambridge University Press. iii. Shuanggen Jin. (2015). *Planetary Geodesy and Remote Sensing.* CRC PRESS. iv. R. A. Hanel, B. J. Conrath, D. E. Jennings, R. E. Samuelson. (2003). *Exploration of the Solar System by Infrared Remote Sensing*. Cambridge University Press. v. Ryden, B. S. (2017). *Introduction to Cosmology.* Cambridge University Press.
Contents	Introduction of Extra-terrestrial remote sensing, Dimensions and units, Order-of-magnitude problems, Scales in the Universe time and seasons, Astronomical coordinates, Kepler's Law, Photometry and spectroscopy, Electromagnetic spectra, Blackbody radiation, Telescopes, CCDs, and spectrometers, Extinction, Interstellar medium, Star formation, Determining the structure and rotation curve for the Milky Way, The galactic centre, Solar System, Binary Systems, Tidal Forces and the Earth Moon System, Fluid Mechanics, Hydrostatics and the Solar Wind Radiative Transfer, Thermal Radiation, Radiative Transfer, Thermal Radiation and the Sun, Physics Coordinators, Extra Terrestrial Remote Sensing and Geophysical Applications, Extra-terrestrial Influences on Remote Sensing in the Earth's Atmosphere, Modelling of the induced atmospheric disturbances using Remote Sensing Techniques, Detection of the extra-terrestrial radiation, Remote sensing of planetary properties, Biosignatures on extrasolar terrestrial planets, Active and Passive Remote Sensing in Extra Terrestrial Observations, Celestial observations and detection using Remote Sensing methods, Remote Sensing tools such as multi-hyper spectral sensors, Active sensing of planet surfaces using technologies such as SAR and LIDAR, Remote Sensing Applications for Planetary Surfaces, Planetary Remote Sensing mission and sensor.

Teaching-learning strategies		Class Lecture method, which includes seminars, discussions, assignments, and projects. (Audio-visual tools are used where necessary)			
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Checklist for a New Academic Program

Parameters	
1. Department Mission and Introduction	✓
2. Program Introduction	✓
3. Program Alignment with University Mission	✓
4. Program Objectives	✓
5. Market Need/ Rationale	✓
6. Admission Eligibility Criteria	✓
7. Duration of the Program	✓
8. Assessment Criteria	✓
9. Courses Categorization as per HEC Recommendation	✓
10. Curriculum Difference	✓
11. Study Scheme / Semester-wise Workload	✓
12. Award of Degree	✓
13. Faculty Strength	✓
14. NOC from Professional Councils (if applicable)	NA

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Incharge