No. 6-38/2024 (Ph.D. Course Work) HPU (Acad.)
Himachal Pradesh University, Summer Hill, Shimla-5
(NAAC Accredited "A" Grade University)
"Academic Branch",

Dated: 19 AUG 2024

To

1. The Dean, Faculty of Life Sciences, HPU, Shimla-5
2. The Controller of Examinations, HPU, Shimla-5.
3. The D.R. Exam. (PG) HPU, Shimla-5.
4. The D.R. Eval./Re-Eval./Conduct, HPU, Shimla-5.
5. The D. R. Secrecy, HPU, Shimla-5. **(with 2 spare copies.)**
6. The S.O. Exam (**M.Sc. Environment Science**) HPU, Shimla-5.
7. The Librarian, HPU Main Library, Shimla-5.
8. The Incharge, Computer Centre, Examination Wing (PG), HPU, Shimla-5.

Subject: *Complimentary copy of* ***syllabus of General Instruction and course curriculum for Ph.D Environmental Science.***

Sir/Madam,

I am sending herewith complimentary copy of ***syllabus of General Instruction and course curriculum for Ph.D Environmental Science*** *as per annexure,* duly approved by the Standing Committee of Academic Council in its meeting held on 27.07.2024 vide On Spot item No. 6, on the recommendations of the concerned Board of Studies and Faculty for its implementation from the Academic Session 2024-25 onwards.

Yours faithfully,

19/8/24

Deputy Registrar (Acad.)
HP University Shimla-5.

Endst. No. Even Dated: 19 AUG 2024

Copy to:

1. The Chairman, Department of Environment Science, HPU, Shimla-5 for information and **send the soft copy in PDF format to web Admin, HPU, Shimla-5 immediately.**
2. The Web Admin, HPU, Shimla-5, with the request to upload this letter with syllabus on the website.
3. The Dealing Assistant Meeting (Acad.), HPU, Shimla-5, for information.
4. Guard file.

19/8/24

Deputy Registrar (Acad.)

for Guard file.

Chairman
Deptt. Of Env. Science
H.P. University, Shimla

Annexure- N

GENERAL INSTRUCTIONS
&
COURSE CURRICULUM

FOR

Ph.D. in Environmental Science
(Effective from Academic Session 2024-2025)

DEPARTMENT OF ENVIRONMENTAL SCIENCE

HIMACHAL PRADESH UNIVERSITY
(NAAC Accredited "A" Grade University)
SUMMERHILL, SHIMLA-171005
HIMACHAL PRADESH, INDIA

Chairman
Deptt. Of Env. Science
H.P. University, Shimla

HIMACHAL PRADESH UNIVERSITY
(NAAC ACCREDITED "A" GRADE UNIVERSITY)
OFFICE OF THE DEAN OF STUDIES
SHIMLA-171005

No. 1-60/2023-HPU(DS)- Dated: Shimla-5, the 09th May, 2023

NOTIFICATION

On the recommendations of the Standing Committee of Academic Council vide item No.1 in its meeting held on 04.02.2023, the Executive Council vide Additional Supplementary item No.6 of its meeting held on 06.04.2023 has approved the adoption of University Grants Commission (Minimum Standards and Procedures for Award of Ph.D. Degree) Regulations, 2022 dated 07.11.2022 and 10.11.2022 (Annexure "A") in toto for its implementation in HP University from the session 2023-24.

Dean of Studies

Endst. No. : 1-60/2023-HPU(DS)- Dated : Shimla-5, the 9th May, 2023

Copy for Information and necessary action to:-

1. All the Deans of Faculties, HPU, Shimla-5.
2. All the Chairpersons/Directors, Teaching Departments/Institutes, HPU, Shimla-5.
3. The Principal, H.P. University centre for Evening Studies, HPU, Shimla-5.
4. The Dean Students' welfare, HPU, Shimla-5.
5. The Director, International Students' Welfare, HPU, Shimla-5.
6. The Controller of Examinations, HPU, Shimla-5.
7. The Chief Warden, HPU, Shimla-5.
8. The Director ICDEOL/DIS,HPU, Shimla-5.
9. Director, H.P.U Regional Centre Khaniara, Dharamshala), Distt. Kangra.
10. The Deputy Registrar (Secrecy), HPU, Shimla-5.
11. The Assistant Registrar (Admn) & Assistant Registrar (Academic), HPU, Shimla-05.
12. The Web Admin H.P University, Shimla-5 with the request to upload the same on the University website.
13. The Spl. P.S. to the Vice-Chancellor, HPU, Shimla-5 for the kind information of the latter please.

Dean of Studies

Chairman
Deptt. Of Env. Science
H.P. University, Shimla

Annexure-N

DEPARTMENT OF ENVIRONMENTAL SCIENCE
HIMACHAL PRADESH UNIVERSITY
SUMMER HILL, SHIMLA-171 005
Ph.D ENVIRONMENTAL SCIENCE PROGRAMME

GENERAL INSTRUCTIONS/GUIDELINES FOR EXECUTION OF CURRICULUM

1. All candidates admitted to the Ph.D. programme at the Department of Environmental Science have to complete a minimum of 12 credits.

   There will be four (4) courses in Ph.D. Environmental Science Programme. The students have to take3 compulsory courses **[PhDES-101, PhDES-102, PhDES-103]** and at least one additional course out of five **elective courses [PhDES -104(i),Ph DES -104(ii), PhDES -104(iii), PhDES -104(iv), PhDES -104 (v)].**
2. A Ph.D. scholar must obtain a minimum of 55% marks or its equivalent grade in the UGC 10-point scale in the course work to be eligible to continue in the programme and submit his or her thesis.
3. The detailed syllabi for the courses offered by the Department are appended with a list of suggested readings.

Outline of the Course work for Ph.D. Environmental Science

Course Code	Title of the Course	Max. Marks	Credits
PhDES -101 (Common with all disciplines under Faculty of Life Sciences)	Research Methodology(Compulsory)	100	4
PhDES -102 (Common with all disciplines under Faculty of Life Sciences)	Research and Publication Ethics (Compulsory)	50	2
PhDES -103	Environmental Monitoring and Techniques	50	2
Elective Course (any one)			
PhDES -104 (i)	Air quality Modeling and Management	100	4
PhDES -104 (ii)	Climate Change and Green Technology	100	4
PhDES -104 (iii)	Bioremediation	100	4
PhDES -104 (iv)	Cryosphere Studies	100	4
PhDES -104 (v)	Geospatial Technology for Environment Management	100	4
Total Marks/ Credits		**300**	**12**

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PROGRAMME OUTCOMES

After completion of this program, the learners will have:

- Thorough understanding of environmental problems at local, regional and global level;
- Gained skills to apply the knowledge to the environmental challenges before the society
- Expanded research insight and developed critical thinking on contemporary instrumentation and analytical techniques related to environmental sciences;
- Acquired the sense of responsibility to safeguard the environment and application of knowledge for effective decision-making with regard to environmental problems Knowledge about different facets of local, regional and global environmental problems.
- Acquired environmental monitoring and data analysis skills with exposure to the environmental pollution control know-hows knowledge and skills desirable for the environmental management with abilities and aptitudes in the preparation, planning and implementation of environmental projects

Ph.D. in Environmental Science (Compulsory Course)

COURSE: PhDES-101 (Common with all disciplines under Faculty of Life Sciences)

RESEARCH METHODOLOGY

		L	T	P	C
		4	0	0	4
Theory: 60 Credit Hours		*Theory examination: 100 marks*			

NOTE: Instructions for setting question paper

Examiner will **set nine** questions in total covering the entire syllabus. However, there will be **one compulsory** question containing twenty parts [One mark each], besides two questions from each of the four Units. The students will attempt **five questions** in total by selecting one question from each unit and the compulsory question. All questions shall carry equal marks (20 marks each).

UNIT-I **(15 hours)**

Foundation of Research: Meaning, objectives of research; criteria of good research; basic steps of research; Qualitative and Quantitative Research.

Problem Identification & Formulation: selection of research problem.

Hypothesis: Qualities of a good Hypothesis, Null & Alternative Hypothesis, Hypothesis Testing, Logic & Importance

Review of related literature: Meaning, necessity and sources.

UNIT-II **(15 hours)**

Research process and Experiment Design: Concept and Importance in Research, features of a good research design, Exploratory Research Design concept, types and uses, Descriptive Research Designs concept, types and uses, Concept of Independent & Dependent variables.

Research Report: Writing preliminaries, main body of research, references and bibliography

Research and Development of Projects: Project formulation, National and international funding agencies for R & D projects, proposal submission, Intellectual Property Right (IPR).

UNIT-III **(15 hours)**

Sampling: Meaning and types of sampling; Probability and Non-Probability, Practical considerations in sampling and sample size.

Tools and Techniques of Data Collection: questionnaire, schedule, interview, observation, case study, survey *etc*. statistics and its significance in research.

Data Analysis: Frequency distribution, measures of central tendency, measures of dispersion, correlation, regression analysis, test of significance (Z-test, t-test, Chi-square test, F-test).

UNIT-IV **(15 hours)**

Use of Tools / Techniques for Research: Search engines: NCBI, PubMed, Google Scholar, Thomson Reuters, SCI etc, Reference Management Software like Zotero/Mendeley, Software for paper formatting like LaTeX/MS Office. Bioinformatics tools and applications.

Course Objectives:

i. To provide basic framework and guidelines for researchers to clearly and define research problems, hypotheses, and objectives.

Course Learning Outcomes:

i. Will help the researchers to identify the most appropriate research design, sampling technique, and data collection and analysis methods.

ii. Researchers will be able to understand and comprehend the basics of research methodology and applying them in their research.

Suggested books

1. Council of Biology Editors –CRE Style Manual, American Institute of Biological Sciences, Washington. D.C.
2. Effective Writing for Engineers, Managers, Scientists: Tichy AJ.
3. Scientific and Technical papers: Tribcase SF.
4. How to write and publish a scientific paper: Day RA.

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Ph.D. in Environmental Science (Compulsory Course)

COURSE: PhDES -102 (Common with all disciplines under Faculty of Life Sciences))

RESEARCH AND PUBLICATION ETHICS

L	T	P	C
2	0	0	2

Theory: 30 Credit Hours | *Theory examination: 50 marks*

NOTE: Instructions for setting question paper

Examiner will **set nine** questions in total covering the entire syllabus. However, there will be **one compulsory** question containing ten parts [One mark each], besides two questions from each of the four Units. The students will attempt **five questions** in total by selecting one question from each unit and the compulsory question. All questions shall carry equal marks (10 marks each).

UNIT-I **(8 hours)**

Philosophy, ethics and scientific conduct: Introduction to philosophy: definition, nature and scope, concept, branches

Ethics: Definition, moral philosophy, Nature of moral judgements and reaction;

Scientific conduct: Ethics with respect to science research, intellectual honesty and research integrity; Scientific misconduct: Falsification, fabrication and plagiarism; Redundant publications: Duplicate and overlapping publications, salami slicing; Selective reporting & misrepresentation of data.

UNIT-II **(7 hours)**

Publication ethics: Definition, introduction and importance, best practices/ standards setting initiatives and guidelines [COPE, WAME etc.], conflict of interest.

Publication misconduct: Definition, concept, problem that lead to unethical behaviour and vice versa, and types; conflict of interest; violation of publication ethics, authorship and contribution ship.; Identification of publication misconduct, complaints and appeals.

UNIT-III **(8 hours)**

Open-access Publishing & publication misconduct: Open-access publications and initiatives, SHERPA/ RoMEO online resource to check publisher copyright and self-archiving policies, software tools to identify predatory publications developed by SPPU; journal finder/ journal suggestion tools viz. JANE, Elsevier Journal finder, Springer Journal *etc*.

Publication misconduct: Group discussion: Subject specific ethical issues,, FFP, authorship; Conflict of interest; complains and appeals: Examples and fraud from India and abroad.

Software tools: Use of plagiarism check software's like Turnitin, Urkund and other open-source software tools.

UNIT-IV **(7 hours)**

Databases and Research metrics: Databases - Indexing databases, and Citation databases: Web of Science, Scopus *etc*.

Research Matrices: Impact factor of a journal as per citation report, SNIP, SJR, IPP, Cite Score & Research Interest (Research Gate).

matrices: H-index, I-Index *etc*.

Course Objectives:

i. To provide students with the fundamental knowledge of basics of philosophy of science, ethics in research and publication.
ii. Concept and understanding of predatory publication, indexing, citation databases, open-access publications and research matrices such as citations, h-index, i-index, impact factor, research interest score etc.
iii. Guide and mentor students in using plagiarism checking tools for a valid and ethical research.
iv. To prepare an evaluation report of a manuscript/ article.

Course Learning Outcomes:

i. The students will be able to know and practice ethical principles involved in research work and in publication that will help in maintaining integrity and credibility of scientific literature.

Suggested books

1. The Ethics of Teaching and Scientific Research by Miro Todorovich; Paul Kurtz, Sidney Hook.
2. Research Ethics Publication Approaches by Brbara H Stanley; Joan E, Sieber; Gary R. Midbow.
3. Research Methods in Applied Sciences: An Integrated Approach to Design and Analysis by; Morgan Lawrence Erlbaum Associates.
4. Ethics and Values in Industrial –Organizational Psychology by Joel Lefkowitz. Wiley Publishers.

Ph.D. in Environmental Science (Compulsory Course)

COURSE: PhDES -103

ENVIRONMENTAL MONITORING AND TECHNIQUES

		L	T	P	C
		2	0	0	2
Theory: 30 Credit Hours		*Theory examination: 50 marks*			

NOTE: Instructions for setting question paper

Examiner will **set nine** questions in total covering the entire syllabus. However, there will be **one compulsory** question containing ten parts [One mark each], besides two questions from each of the four Units. The students will attempt **five questions** in total by selecting one question from each unit and the compulsory question. All questions shall carry equal marks (10 marks each).

UNIT-I **(7 hours)**

Sampling methodologies: Sampling methodologies: Air, Water and Soil, Sampling protocols-Selection of sites, Time and frequency for sampling, Preservation, Storage and Handling of samples.

UNIT-II **(8 hours)**

Sampling and Pollution control devices: Air sampling pumps, filters, sorbent tubes, impingers, continuous Emission Monitoring Systems (CEMS), real-time gas analyzers, Cyclone separators, Electrostatic Precipitators, wet scrubbers, Catalytic converters, Biofilters, Photocatalytic oxidation, Zero Liquid Discharge (ZLD) Systems, Ultrafiltration (UF) and Nanofiltration (NF) Systems, High volume sampler

UNIT-III **(8 hours)**

Major tools used in environmental monitoring: Leaching tests-TCLP, SPLP, LEAF and immunoassay. Gas Chromatograph (GC), GC-MS, HPLC,FTIR, X-ray diffraction, XRF, XRD, ICP-MS, ICP-AES, ICP-OES,NAA.

UNIT-IV **(7 hours)**

Role of Remote sensing in Environmental monitoring: Remote sensing devices, Land use/land cover mapping, vegetation monitoring, and urban sprawl assessment, Remote sensing software (e.g., ENVI, ERDAS, QGIS), Case studies of remote sensing in environmental studies.

Course Objectives:

i. To develop a deeper understanding of the principles involved behind the working of different instruments used in Environmental Science research.
ii. To make researchers able to utilize scientific learning for expanding their research aptitude.

Course Learning Outcomes:

i. Students will be able to learn all the basic and advanced techniques used in research.
ii. Students will understand the proficiency in monitoring techniques

Suggested books

i. Advances in Air Quality Monitoring and Assessment by Thomas Maggos (2021)
ii. Air Pollution Control Engineering" by Noel de Nevers (2022):
iii. Environmental Monitoring: Pollution, Water Quality, and Methods" by Dr. Sanjay Sharma
iv. Techniques in Water Quality Monitoring" edited by Dr. Arun Sharma and Dr. Priya Mishra

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Ph.D. in Environmental Science (Elective Course)

COURSE: PhDES-104 (i)

AIR QUALITY MODELLING AND MANAGEMENT

L	T	P	C
4	0	0	4

Theory: 60 Credit Hours

Theory examination: 100 marks

NOTE: Instructions for setting question paper

Examiner will **set nine** questions in total covering the entire syllabus. However, there will be **one compulsory** question containing twenty parts [One mark each], besides two questions from each of the four Units. The students will attempt **five questions** in total by selecting one question from each unit and the compulsory question. All questions shall carry equal marks (20 marks each).

UNIT-I **(15 hours)**

Air quality monitoring: Definition of Air Pollution Classification, sources and grouping of air pollutants, Design of air pollution sampling network-Sampling methodologies for ambient air-Sampling site selection criteria-Ambient air monitoring for particulate matter, gaseous pollutants and volatile organic compounds-Sampling and analysis

UNIT-II **(15 hours)**

Air pollution meteorology: Meteorological aspects of air pollution-Atmospheric and adiabatic lapse rates-Wind speed and direction and preparation of wind rose-Atmospheric stability and stability classification-Inversions-Mixing Height -meteorological instruments for air pollution studies-Wind speed, temperature turbulence and upper air measurements- Remote sensing technologies

UNIT-III **(15 hours)**

Air quality modelling: Basics of air quality modelling-Gaussian Dispersion Modelling-Different kinds of modelling-Source parameters-meteorological parameters-Dispersion Coefficients-Specific applications of air quality modelling-Software application in air quality modelling- Uncertainty arc sensitivity analysis-Calibration and validation of models-Performance evaluation of models.

UNIT-IV **(15 hours)**

Air quality management: Air quality and control strategies –Air pollution control technology for particulate matter- Control technology for gaseous pollutants- assimilation capacity based regional air quality management-National and international scenario.

Course objectives:

i. The course objectives has three components i.e., sources of air pollution, pathways (air pollutants transformation and transport) and receptors.
ii. Students would get an insight into the dispersion of air pollution in the atmosphere.
iii. To discuss the various types of air pollution control equipment and their design principles and limitation.

Course learning outcomes:

i. Students will able to understand the air quality monitoring techniques
ii. Students will able to understand air quality modelling principles.
ii. Students will able to understand air quality modelling principles

Suggested books

1. Air Pollution: Measurement, Modelling, and Mitigation" by R.M. Harrison and R.E. Hester
2. "Air Quality Management" by Ian Colbeck and Mukesh Khare
3. "Air Pollution Control Engineering" by Noel de Nevers
4. "Urban Air Quality: Measurement, Modelling and Management" edited by Ranjeet S. Sokhi and Mukesh Khare

Ph.D. in Environmental Science (Elective Course)
COURSE: PhDES-104 (ii)
CLIMATE CHANGE AND GREEN TECHNOLOGY

		L	T	P	C
		4	0	0	4
Theory: 60 Credit Hours		*Theory examination: 100 marks*			

NOTE: Instructions for setting question paper
Examiner will **set nine** questions in total covering the entire syllabus. However, there will be **one compulsory** question containing twenty parts [One mark each], besides two questions from each of the four Units. The students will attempt **five questions** in total by selecting one question from each unit and the compulsory question.All questions shall carry equal marks (20 marks each).

UNIT-I **(15 hours)**

Drivers of climate change: greenhouse gases, aerosols – reflective and black carbon, land use changes. Energy balance, feed-back processes in climate system, concepts of global warming potential (GWP), radiative forcing, Impact of Climate Change on weather and climatic patterns, ice caps, glaciers, agriculture, vegetation, biodiversity, sea level, tourism and their implications.

UNIT-II **(15 hours)**

Imperatives of clean technology in the context of mitigation and adaptation measures: CDM concept, CDM scenario in India, CDM projects sector-wise, National Action Plan on Climate Change, sustainable habitat, concept of green architecture, Carbon trading; carbon credits; Carbon sequestration; Carbon Footprint. Issues of Energy security, Agro meteorological application for climate resilient agriculture, Food Security and Social security.

UNIT-III **(15 hours)**

Overview of green chemistry: principles of sustainable and green chemistry, Waste minimization andclimate change, Introduction to nano-materials and green nanotechnology Nano-medical application of green nanotechnologies.

UNIT-IV **(15 hours)**

Green technology in industries: fuel cell and electric vehicles, solar energy and hydrogen production, energy from alternate sources, solar photovoltaic technology; biofuel production (bio-ethanol and biodiesel) Biomass, prevention/ minimization of hazardous/ toxic products, production of biodegradable materials, concept of green building

Course Objectives:

i. Understanding of the scientific basis of climate change, including its causes, mechanisms, and evidence
ii. To highlight the role of green technology in promoting sustainable development and reducing environmental impact.

Course Learning Outcomes:

i. Students will able to understand climate change fundamentals.
ii. Students will able to discuss the principles and applications of green technologies in various sectors, including energy, transportation, agriculture, and construction

Suggested Books

1. Botkin, Daniel B. and Keller, Edward A., 2007.Environmental Science: Earth as a Living Planet. 6th ed. John Wiley and Sons, USA.
2. Burroughs, W.J., 2007. Climate Change: A Multidisciplinary Approach. 2nd ed. Cambridge University Press.
3. Sharma, B. K., 2001. Environmental Chemistry, Krishna Prakashan Media Pvt. Ltd. Meerut.
4. Sodhi, G. S., 2006. Fundamental concepts of environmental Chemistry, Narosa Publishing House, New Delhi.

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Ph.D. in Environmental Science (Elective Course)

COURSE: PhDES-104 (iii)

BIOREMEDIATION

L	T	P	C
4	0	0	4

Theory: 60 Credit Hours

Theory examination: 75 marks
Internal assessment: 25 marks
Total marks: 100 marks

NOTE: Instructions for setting question paper
Examiner will **set nine** questions in total covering the entire syllabus. However, there will be **one compulsory** question containing twenty parts [One mark each], besides two questions from each of the four Units. The students will attempt **five questions** in total by selecting one question from each unit and the compulsory question.All questions shall carry equal marks (20 marks each).

UNIT-I **(15 hours)**

Bioremediation Definition – Principles of bioremediations, Factors of bioremediation- Bioaugmentation for bioremediation, Bioreactors, Remediation technologies - in situ and ex situ bioremediation- Advantages and disadvantages of bioremediation- Phytoremediation Technology for Soil decontamination.

UNIT-II **(15 hours)**

Microbial systems for bioremediation: Genetic responses of microorganisms to the presence of pollutants- Application of genetically engineered microorganisms for waste management- Biological Treatment Technologies for Metals Remediation -Bioleaching and Biomagnification – Bioaccumulation.

UNIT-III **(15 hours)**

Microbial transformation reactions: Microbial detoxification- bioremediation systems and processes-Microbial cleaning of gases- insitu bioremediation - lab scale bio treatability-Oxidation/Reduction Processes -Biological Methylation -Case studies.

UNIT-IV **(15 hours)**

Advances in microbial remediation- Sequestering Carbon Dioxide -Bio monitoring -Application of Microbial Enzymes -Bio membrane Reactors. Bioremediation of herbicides, pesticides, hydrocarbons, oil spills, organic and inorganic pollutants

Course Objectives:

i. Practicing in presenting information about the uses of organisms in bioremediation
ii. Practicing in collecting information about bioremediation strategies

Course Learning Outcomes:

i. Students will able to learn bioremediation principles.
ii. Students will able to learn application of bioremediation techniques.
iii. Students will able to learn advances in microbial remediation.

Suggested Books

1. Bioremediation: Applied microbial solutions for real world environment clean up" - Atlas R.M. and Philip J (Eds) - I edition. Amer Society of Microbiology, 2005
2. R.A. and Philp J. (2005).Applied Microbial Solutions for Real-World Environmental Cleanup. ASM, Washington, D.C., USA.
3. Singh A., and Ward O.P.(2004). Applied Bioremediation and Phytoremediation. Springer Verlag BerlinHeidelberg, Germany. Atlas
4. Singh A., Kuhad R.C. and Ward O.P. (2009). Advances in Applied Bioremediation. Springer-Verlag Berlin Heidelberg, German

Ph.D. in Environmental Science (Elective Course)
COURSE: PhDES-104 (iv)
Cryosphere Studies

		L	T	P	C
		4	0	0	4
Theory: 60 Credit Hours		*Theory examination: 75 marks* *Internal assessment: 25 marks* *Total marks: 100 marks*			

NOTE: Instructions for setting question paper
Examiner will set nine questions in total covering the entire syllabus. However, there will be one compulsory question containing twenty parts [One mark each], besides two questions from each of the four Units. The students will attempt five questions in total by selecting one question from each unit and the compulsory question. All questions shall carry equal marks (20 marks each).

UNIT-I **(15 hours)**

Components of the cryosphere and their time scales: Cold-arid environment, Snow and Ice morphometric characteristics, Physics of snow and ice, Ice sheets, sea ice, permafrost, Distribution of snow, ice and glacier (past and present).
Cryosphere changes, mass and energy balance: Glacier change controlling factors and formation, Mass balance, Energy Budget, Meteorological factors/controls, Snow and ice melting process.

UNIT-II **(15 hours)**

Glacier distribution, glaciation and recent changes: Past glaciation and paleo-climate studies, Glacial and inter-glacial cycles, Little Ice Age, Isostatic adjustment of glaciers, Landscape alteration by glaciation, Recent changes. Glacier, water resources and natural disasters.

UNIT-III **(15 hours)**

Snow and Ice: role in regional hydrology: Subsurface hydrology, Mountain Glaciated River basins, Natural hazards by glacier and snow, e.g. GLOF, avalanche, cloudburst etc., Future water resources changes. Glacier, Frozen Ocean and future changes. Seas ice dynamics, Ice shelf, ice stream, sea ice, ocean currents and climate, Polar region cryosphere and their future perspectives, Nutrient cycling and life systems

UNIT-IV **(15 hours)**

Case studies: Case study of mass and energy balance in a Himalayan glacier, Case study of disaster: e.g. GLOF and avalanche, Case study of paleoclimate studies, e.g. ice and lake core-based climate reconstruction, Case study of Polar glaciers, e.g. Arctic and Antarctica, Synthesis.

Course Objectives:
i. The main objective this course is to study about the cryosphere system and how it influences the changes within the atmosphere.
ii. To foster, promote and sustain a scientific culture in the snow and glacier studies.
iii. To study the impact of climate change on glaciers.

Course Learning Outcomes:
i. Understand the distribution and characteristics of ice sheets, glaciers, sea ice, snow cover, and permafrost.
ii. Analyze the role of the cryosphere in the global climate system.
iii. Understand socioeconomic impacts of cryospheric changes on human communities, especially those in cold regions

Suggested Readings

1. The Cryosphere: Shawn J. Marshall
2. Glaciers and Glaciation: Douglas Benn and David J.A. Evans
3. Glacier Change in the Greater Himalaya Region: From the 19th to the 21st Century" by Umesh K. Haritashya, Anil V. Kulkarni, and Andreas Kääb
4. Himalayan Cryosphere: Past and Presentedited by Anil V. Kulkarni and Vinod Tewari

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Ph.D. in Environmental Science (Elective Course)

COURSE: PhDES-104 (v)

GEOSPATIAL TECHNOLOGY FOR ENVIRONMENTAL MANAGEMENT

L	T	P	C
4	0	0	4

Theory: 60 Credit Hours

Theory examination: 75 marks
Internal assessment: 25 marks
Total marks: 100 marks

NOTE: Instructions for setting question paper
Examiner will **set nine** questions in total covering the entire syllabus. However, there will be **one compulsory** question containing twenty parts [One mark each], besides two questions from each of the four Units. The students will attempt **five questions** in total by selecting one question from each unit and the compulsory question. All questions shall carry equal marks (20 marks each).

UNIT-I **(15 hours)**

Introduction: Environment & ecosystems, functions and types of ecosystems, ecosystem model concept, types of models of Ecosystems & Environmental applications, Environmental Resources: Air, water and land resources, forest resources, forest biomass, types of sample plots, volume estimation, and uncertainty in forest biomass estimation.

UNIT-II **(15 hours)**

Environmental RS & GIS Techniques: Fundamentals of geospatial (Remote Sensing, GIS and GPS) technology: definition, advantages, limitations, concept and principles, environmental resource satellite sensors, classification methods, advances with Hyperspectral, RADAR & LIDAR.

UNIT-III **(15 hours)**

Interaction between light and matter Characteristics of aerial photographs Visual interpretation of aerial photographs and satellite imageries Instruments used in interpretation Path and Row Index Maps, software ArcGIS.

UNIT-IV **(15 hours)**

Geospatial based applications in environmental management, multilevel remote sensing and ground data to estimate forest biomass, advance tools in RS & GIS for assessment of biomass, carbon pool and flux assessment, carbon sequestration and impacts on climate change, environmental concerns: Case studies.

Course Objectives:

i. To expose students to applications of GIS and remote sensing in environmental management.
ii. To develop a sound basis for understanding the operation of GIS and Remote Sensing in environmental management.

Course Learning Outcomes:

i. Students will able develop capability to handle remote sensing and GIS tools in environmentalmanagement.
ii. Students will able to understand the applications of GIS in Environmental Sciences.

Suggested Books

1. Burrough, P. A., 1988. Principles of Geographical Information System for Land Resource Assessment, Oxford Univ. Press. 1986 Curran, P. J. Principles of Remote Sensing, ELBS, Longman Inc.
2. Jensen, J. R., 1986 Digital Image Processing, Prentice Hall, New York.
3. Jensen, J. R., 2003.Remote Sensing of the Environment, Pearson Education, Singapore.
4. Lilles and T.M. and Kiefer R.W. Remote Sensing and Image Interpretation,