Course Structure and Syllabus

Ph.D. Environmental Science

Academic Session 2022-23 onwards

(Updated syllabus in accordance with NEP 2020)

Department of Environmental Science

School of Earth Sciences

Central University of Rajasthan

Program Objectives

1. Create a researcher focused on interdisciplinary socio- ecological issues and application of sustainable approaches for addressing environmental concerns and challenges.
2. Train and provide hands-on training to students in modern tools and techniques to address environmental issues.
3. Prepare future manpower for designing, conducting independent researchin the area of their interest.

Program Outcomes

After successful completion of the program, the student will be

1. Able to work on various interdisciplinary aspects of the environment or sustainable development of society.
2. Able to handle recent tools and techniques to find the solution for various environmental challenges.
3. Able to work as an independent researcher to work for society and contribute to solutions to the environmental challenges.

Central University of Rajasthan
School of Earth Sciences
Ph.D. Environmental Science

Course Structure

No	Course Code	Title of the course	Type of Course	Credits
1	ENV701	Research Methodology	Core	4
2	ENV702	Research and Publication Ethics	Core	2
3	EDU705	Pedagogy for Higher Education	Core	3
4	ENV703	Practice-based Teaching Skills	Core	3
5	ENV731	Research Review Writing and Seminar	Elective	3
6	ENV732	Advance Analytical Techniques	Elective	3
7	ENV733	Water Resources and Climate Change	Elective	3
8	ENV734	Air Pollution, Monitoring, Control and Effects	Elective	3
9	ENV735	Environmental Microbiology & Biotechnology	Elective	3
10	ENV736	Nanotechnology: Environmental Applications	Elective	3
11	ENV737	Geospatial Technology for Environmental Management	Elective	3
12	ENV738	Advances in Glaciology	Elective	3

Total Credit Requirement: 21 (12 credits core courses + 9 credits elective course)
Elective Course (3 credits): the student has to select any three courses from the list of elective courses as per his/her requirement.

ENV701: Research Methodology (4 Credits)

School: School of Earth Sciences		**Batch: 2020-2021**	
Program: Ph.D. Environmental Science		**Current Academic Year: 2020-2021**	
1	Course Code	**EVS 701**	
2	Course Title	**Research Methodology**	
3	Credits	**4**	
4	Course Status	**Core**	
5	Course Objective	1. To develop an understanding of the basic framework of the research process 2. The course aims to augment the aptitude of research among students 3. To facilitate the students in understanding the tools and techniques of conducting thesis 4. To develop an understanding good laboratory practice.	
6	Course Outcomes **(CO)**	The student should be able to: **CO1.** Work on the identification of research questions, review the research literature. **CO2.** Identify different ways to collect and analyse qualitative and quantitative data **CO3.** Develop a good research proposal and further completion of thesis and research publications **CO4.** Understanding of good laboratory practices	
7	Course Description	Skills and knowledge related to research methodologies, data interpretation, and laboratory practices	
8	Outline syllabus		CO Mapping
	UNIT I **Research Basics**		**CO1/CO4**
	Research Basics: definition, purpose and types; Significance of research in applied sciences; Process of Research; Objectives and Dimensions of Research problem, Research questions, Research design; Tools of Research: Library, Field, Laboratory; Methods of research: Qualitative and Quantitative; Systematic review of literature in applied sciences; Critical literature survey- Science Indexes e.g. SCOPUS, Web of Science, Science Direct, Del Net.		
	UNIT II **Statistical Techniques**		**CO2/CO4**

	Research Basics; Data Types (primary and secondary data), collection methods; presentation (Graphical and diagrammatical); relevance, limitations, and cautions. Data Processing: checking, editing, coding, transcriptions, classification, and tabulation; Data analysis: meaning and methods; quantitative and qualitative analysis; Bivariate Data Analysis using Correlation and Regression analysis Analysis of time series, Interpolation, and Extrapolation; Statistical fallacies: Bias, Faulty generalization, inappropriate comparison, misuse of various tools like mean, median, mode, dispersion, correlation, technical errors; Theoretical distribution: Normal, Poisson, Binomial with application in various area/ disciplines; Sampling: types, steps; sampling errors, sampling of attributes (including Chi-square test), sampling of small and large sample variables (including ANOVA); Hypothesis Testing.			
	UNIT III **Data Analysis in Environmental Studies**			**CO3/CO4**
	Environmental sampling: Finite-population sampling, stratified random sampling, composite sampling, ranked set sampling, capture-recapture methods; Time series analysis: Trend estimation, autocorrelation function, autoregressive models, forecasting methods; Spatial statistics: Interpolation techniques, autocorrelation, Introduction of statistical packages: Calculation of various statistical parameters, tests, temporal and spatial data analysis, preparation of charts; Interpretation of statistical outputs in reports and papers.			
	UNIT IV **Good Laboratory Practices**			**CO4/CO4**
	Setting up experiment, laboratory safety measures, disposal of Hazardous/Poisonous/chemical and biological agent, laboratory waste disposal, Dealing with electrical and fire hazards			
9	Mode of Examination	Theory		
10	Weightage Distribution	Internal Assessment-I	Internal Assessment-II	End of Semester Examination
		20%	20%	60%
11	Suggested readings			
	1. *Jay L Devore: Probability and Statistics for Engineering and the Sciences: CENAGAGE, Learning. Print in India.* 2. *Rice, J.A. (2007): Mathematical Statistics and Data Analysis: CENAGAGE Learning Pvt. Ltd.* 3. *Spiegel M.R. and Stephens J.L. (2010) Statistics, Tata McGraw Hill.* 4. *Das N.G. (2011): Statistical Methods, Tata McGraw Hill.* 5. *Bernard A. Rosner (2011), Fundamentals of Biostatistics, 7th Ed., Cenagage Learning Pvt. Ltd.* 6. *L.W.Neuman.1997. Social Research Methods: Quantitative and Qualitative approaches. Allyn& Bacon. 560 pp6.* 7. *Vinay Kumar Srivastava. 2004. (ed) Methodology and Fieldwork, Oxford University Press, New Delhi* 8. *Dawson, Catherine, 2002, Practical Research Methods, New Delhi, UBS* 9. *Publishers'Distributors* 10. *Kothari, C.R.,1985, Research Methodology- Methods and Techniques, New Delhi,Wiley Eastern Limited.* 11. *Kumar, Ranjit, 2005, Research Methodology-A Step-by-Step Guide for Beginners (2nd Edition), Pearson Education.*			

ENV702

Course Title:

- **Research and Publication Ethics** (RPE)-Course for awareness about the publication ethics and publication misconducts.

Course Le\'el:

- 2 Credit course (30 hrs.)

Eligibility:

- M.Phil., Ph.D. students and interested faculty members *(It* will be made available to post graduate students at later date)

Fees:

- As per University Rules

Faculty:

- Interdisciplinary Studies

Qualifications of faculty members of the course:

- Ph.D. in relevant subject areas having more than IO years' of teaching experience

About the course

Course Code: CPE- RPE

Overview

- This course has total 6 units focusing on basics of philosophy of science and ethics, research integrity, publication ethics. Hands-on-sessions are designed to identify research misconduct and predatory publications. Indexing and citation databases, open access publications, research metrics (citations, h-index, Impact Factor, etc.) and plagiarism tools will be introduced in this course.

Pedagogy:

- Classroomom teaching, guest lectures, group discussions, and practical sessions.

Evaluation

- Continuous assessment will be done through tutorials, assignments, quizzes, and group discussions. Weightage will be given for active participation. The final written examination will be conducted at the end of the course.

Course structure

- The course comprises of six modules listed in table below. Each module has 4-5 units.

Modules	Unit title	Teaching hours
Theory		
RPE 01	Philosophy and Ethics	4
RPE 02	Scientific Conduct	4
RPE 03	Publication Ethics	7
Practice		
RPE 04	Open Access Publishing	4
RPE 05	Publication Misconduct	4
RPE 06	Databases and Research Metrics	7
	Total	**30**

Syllabus in detail

THEORY

- **RPE 01: PHILOSOPHY AND ETHICS (3 hrs.)**

1. Introduction to philosophy: definition, nature and scope, concept, branches
2. Ethics: definition, moral philosophy, nature of moral judgements and reactions

- **RPE 02: SCIENTIFICCONDUCT (5hrs.)**

1. Ethics with respect to science and research
2. Intellectual honesty and research integrity
3. Scientific misconducts: Falsification, Fabrication, and Plagiarism (FFP)
4. Redundant publications: duplicate and overlapping publications, salami slicing
5. Selective reporting and misrepresentation of data

- **RPE 03: PUBLICATION ETHICS (7 hrs.)**

1. Publication ethics: definition, introduction and importance
2. Best practices / standards setting initiatives and guidelines: COPE, WAME, etc.
3. Conflicts of interest
4. Publication misconduct: definition, concept, problems that lead to unethical behavior and vice versa, types
5. Violation of publication ethics, authorship and contributorship
6. Identification of publication misconduct, complaints and appeals
7. Predatory publishers and journals

PRACTICE

- **RPE 04: OPEN ACCESS PUBLISHING(4 hrs.)**

1. Open access publications and initiatives
2. SHERPA/RoMEO online resource to check publisher copyright & self-archiving policies
3. Software tool to identify predatory publications developed by SPPU
4. Journal finder / journal suggestion tools viz. JANE, Elsevier Journal Finder, Springer Journal Suggester, etc.

- **RPE 05: PUBLICATION MISCONDUCT (4hrs.)**

A. Group Discussions (2 hrs.)

1. Subject specific ethical issues, FFP, authorship
2. Conflicts of interest
3. Complaints and appeals: examples and fraud from India and abroad

B. Software tools (2 hrs.)

Use of plagiarism software like Turnitin, Urkund and other open source software tools

- **RPE 06: DATABASES AND RESEARCH METRICS (7hrs.)**

A. Databases (4 hrs.)

1. Indexing databases
2. Citation databases: Web of Science, Scopus, etc.

B. Research Metrics (3 hrs.)

1. Impact Factor of journal as per Journal Citation Report, SNIP, SJR, IPP, Cite Score
2. Metrics: h-index, g index, i10 index, altmetrics

References

Bird, A. (2006). *Philosophy of Science*. Routledge.

MacIntyre, Alasdair (1967) *A Short History of Ethics*. London.

P. Chaddah, (2018) Ethics in Competitive Research: Do not get scooped; do not get plagiarized, ISBN:978-9387480865

National Academy of Sciences, National Academy of Engineering and Institute of Medicine. (2009). *On Being a Scientist: A Guide to Responsible Conduct in Research: Third Edition*. National Academies Press.

Resnik, D. B. (2011). What is ethics in research & why is it important. *National Institute of Environmental Health Sciences*, 1–10. Retrieved from https://www.niehs.nih.gov/research/resources/bioethics/whatis/index.cfm

Beall, J. (2012). Predatory publishers are corrupting open access. Nature, 489(7415), 179–179. https://doi.org/10.1038/489179a

Indian National Science Academy (INSA), Ethics in Science Education, Research and Governance(2019), ISBN:978-81-939482-1-7. http://www.insaindia.res.in/pdf/Ethics_Book.pdf

ENV703

Course Title: Practice-Based Teaching

Course code: ENV703

Credits:03 (About 60 hours of practical teaching sessions and additional preparatory work to support the teaching)

Aim and Outline of the course:

The course is designed for the research scholars in the continuation of the foundation course of Pedagogy for higher education. As per the expectation of National Education Policy 2020, researchers need to be professionally equipped along with conceptual knowledge and understanding of Pedagogy. Developing teaching skills during the PhD will be a good value addition to a scholar's profile and will help them develop essential pedagogical /teaching skills required for their professional life.

This course is a practice-based course where a scholar is expected to be formally involved in various aspects of delivering a course and will include formal teaching sessions under the guidance of a supervisor.

Learning Outcomes: On completion of the course the participants will be able to:

- Prepare the Instructional plans for the given course
- Write Learning Outcomes for the planned learning event
- Design Learning Events as per the LO
- Deliver Lectures
- Formally speak in Public and make formal presentations
- Support the course instructors / teachers in various aspects of teaching, learning and assessment
- Give effective feedback and provide support to students

Pre-requisites: Successful completion of the course 'Pedagogy for Higher Education'

Contents:

The course contents will depend on the teaching requirement of subject specific discipline. The participant expected to be involved in the whole cycle of delivery of a course for which the following is suggested.

1. Developing Instructional Plans,
2. Writing Learning Outcomes for each session
3. Designing learning activities as per the Instructional Plan and LO
4. Design Cooperative and Collaborative Activities for the students.
5. Delivering Lectures and organizing Seminars,
6. Preparing Handouts / Learning Course Readers
7. Moderating Panel Discussions, Facilitating Group Discussions
8. Facilitating Practicals / Field Visits / Project work / Studio (as per the need)
9. Assessment - developing rubrics, preparing question papers of different types, and assessing answer scripts with written feedback, preparing results etc (for one formative and one summative Assessment)

10. Giving written and verbal feedback on presentations, assessment, reports etc (one-time only)
11. Writing Project Review Report (2 Reports)
12. Develop Open Educational Resources pool in the specific discipline
13. Conduct Seminar /conference and group discussions for the students. (3 Seminars/conference and 2 group discussions)
14. Writing and delivering formal public speeches like welcome notes, introducing speakers, vote of thanks etc. (2 in number from the mentioned activities)
15. Mentoring and Counselling students (5 students only)

Assessment: This will be a non-graded course. The participant will be awarded 'S' for satisfactory performance and 'NS' for non-satisfactory performance on completion of around 60 hours of practical teaching which may be a mix of classroom lectures, formal seminars, facilitating laboratory/studio/field sessions.

Note:

1. The 60 hours of practical teaching and the work on associated activities should ideally be done in one semester. However, these may be spread over two semesters also.
2. The contents listed above are representative in nature and will be balanced by the supervisor in a manner that the scholar is able to accomplish the tasks without feeling overburdened. It is suggested that the department and guide/instructor may take 60% of those activities (specifically designing learning course/hangouts, Instructional plan and Assessment) and may decide about the remaining 40 % of activities on their own. The teaching practice sessions may be spread over one or more courses.
3. The teaching practice should cover theoretical as well practical/studio classes. The allocation of the courses should be connected with the area of research being undertaken by the scholar and must be only a small part of a given course. It is not meant to replace the 'teaching load' of the supervisor.

Course code: EDU 705

Pedagogy for Higher Education (Already adopted by university)

Credits:03 (About 45 hours of interactive learning events that will include lectures, discussions with practice sessions and additional off the class self-learning activities)

Aim and Outline of the course:

The course is desi$_{gn}$ed for the research scholars (may call the prospective teacher ofhigher education or PhD Entrants) to join higher education institutes as professionals. A researcher generally engages in the teaching-learning process after completing their research and sometimes participates in teaching-learning during their research period as a teacher assistant. Therefore, it is required to give them exposure to the teaching-learning process for conceptual understanding and skill development.

This course will help them understand the teaching-learning process basics, curriculum and assessment, and classroom management. This course will also help scholars be more effective while presenting in seminars and conferences.

Besides developing conceptual knowledge ofpedagogy skills this course covers contemporary higher education issues like choice-based credit system, online learning, open-book examination, web-based and research-based pedagogical tools and MOOCs etc.

The scholars would develop insight into the significance of pedagogical knowledge and its implication in their professional life on completing the course. Thus the scholars who complete this course will be fully equipped to teach well immediately as they join any educational institute.

Learning Outcomes

On successful completion ofthis course the participants will be able to:

- Describe teaching-learning processes especially in context of higher education
- Develop an instructional plan as per the teaching strategy needed.
- Design learning events using different teaching methods
- Use activities and exercises as per the required teaching approach
- Develop web based and research-based pedagogical tool
- Explore the ways to handle diverse group oflearners in the classroom
- Use technology effectively to facilitate and support e-learning
- Prepare assessment rubric for achievement testing of students and portfolio
- **Demonstrate enhanced competency in communication with students**
- Use visual aids and technology in offline and online classes.
- **Make effective presentations in seminars and conferences.**
- Deliver lectures and facilitate discussions and other activities in the classroom situation.

Target Audiences

The course is designed as a compulsory course for the research scholars of all disciplines. However it may be useful for students of the masters programmes who may be taking this course as an elective to enhance their employability.

Prerequisite

The prerequisite for the course is a bachelor's degree in any discipline.

Course Content

1. **Overview of Teaching and Learning (6 hours)**
    a. Concept of Pedagogy, Andragogy and Heutagogy
    b. Understanding Teaching and related terms, the relationship with learning
    c. Understanding learner and learning cycle
    d. Taxonomy of teaching objectives (Revised Bloom's taxonomy),
    e. Writing learning outcomes

2. **Curriculum and Instruction (8 hours)**
    a. Curriculum: Concept and Facets,
    b. Credit Framework and Choice-based Credit System
    c. Instruction: Concept, Design and instructional media
    d. Developing Instructional Plans

3. **Teaching Strategies and Approaches (9 hours)**
    a. Expository vs Inquiry Strategy (shifting from behaviourism to constructivism)
    b. Individualized to small group/ large group Approaches,
    c. Scenario-Based, Online and Blended Approach, Introduction of MOOCs
    d. Designing Learning Events and Activities for Student Engagement
    e. Component of effective lectures delivery

4. **Pedagogical skills and tools (8 hours)**
    a. Concept of TPACK
    b. Pedagogical Skills - Scanning the class, starting a session, skill of achieving closure skills, skills to lead session, Skill to secure attention (switch over), scaffolding skills, time management, skill to handle challenging situations.
    c. Technological Skills- Using different apps and platforms for teaching, Use of Open Educational resources (OER), developing assignments and learning material using different apps and software
    d. Communication skills - Presenting in Public, Participating in Discussions and Formal Meetings

5. **Assessment and Evaluation (8 hours)**
    a. Concept of Assessment, Assessment for learning, of learning, as learning,
    b. Receiving and Giving Feedback
    c. Assessment rubrics, Assessment Portfolio, Reflective journal

d. Designing an Achievement test - Objective and Descriptive / Open book question paper
e. Grading System (Absolute, Relative, CGPA, Conversion of grades to percentage etc)
f. Conducting Examination, - Face to Face, Online Exams (Proctored and non-Proctored Exams)
g. Project Reviews and Viva-Voce Examinations

6. **Classroom Management (6 hours)**
    a. Organizing the Physical environment
    b. Managing learner's behaviour through action research
    c. Counselling, Guidance and Mentoring
    d. Effective Academic leadership
    e. Resource Management

Mode of Transaction

The content will transact through interactive lectures, activities, web lectures, assignments, discussions and seminars and practice sessions (video recorded to provide feedback).

Assessment: CIA and EoSE as per provisions of the university ordinances

NEW COURSE on Pedagogy for Higher Education DESIGNED by Dr Anjali Sharma and reviewed by following five experts from Education Domain:

Prof Saroj Sharma
Professor, School of Education,
Chairperson National Institute of Open School,new Delhi
Guru Govind Singh Indraprasth University, New Delhi

Prof. Gopal Krishna Thakur
Professor & Head
Department of Education
Department of Psychology
Mahatma Gandhi Antarrashtriya Hindi Vishwavidyalaya
(A Central University), Wardha – 442001, Maharashtra

Prof Amruth G Kumar
School of Education
Central University of Kerela

Prof. B. N. Panda
Professor of Education and Dean of Research
Dept. of Education
Regional Institute of Education (NCERT)
(A Govt. of India Autonomous Organization)
Bhubaneswar-751022,Odisha,India

ENV731: Research Review Writing and Seminar (3 Credits)

School: School of Earth Sciences		**Batch: 2022-2023**		
Program: Ph.D. Environmental Science		**Current Academic Year: 2020-2021**		
1	Course Code	**ENV703**		
2	Course Title	**Research Review Writing and Seminar**		
3	Credits	**3**		
4	Course Status	**Elective**		
5	Course Objective	1. To make students aware of research review writing. 2. To make students to present research review in seminar		
6	Course Outcomes **(CO)**	The student should be able to: **CO1.** Develop an understanding of the fundamentals of research review writing **CO2.** Develop research reading, writing, and presentation.		
7	Course Description	This course provides an advanced understanding of research reading, writing and presentation.		
8	Outline syllabus			CO Mapping
	Course should be undertake under the supervision of concerned supervisor in the related research area. student will review the relevant and latest research, review scientific reports to prepare review writeup. Research review should be presented and evaluated by the concern supervisor and evaluation committee by departmental seminar.			**CO1 and CO2**
9	Mode of Examination	Review writeup and Presentation		
10	Weightage Distribution	Internal Assessment-I	Internal Assessment-II	End of Semester Examination
		20%	20%	60%

ENV732: Advance Analytical Techniques (3 Credits)

School: School of Earth Sciences		**Batch: 2022-23**		
Program: Ph.D. Environmental Science		**Current Academic Year: 2022-23**		
1	Course Code	**ENV732**		
2	Course Title	**Advance Analytical Techniques**		
3	Credits	**3**		
4	Course Status	**Elective**		
5	Course Objectives	1. To make students aware of advance/emerging technologies used for environmental pollution monitoring and their control. 2. To introduce students to the current trends of sampling and modern analysis relevant to environmental sciences.		
6	Course Outcomes **(CO)**	The student should be able to: **CO1.** Critically evaluate and interpret experimental data and findings. **CO2.** Undertake the correct sample preparation and characterization prior to analysis by the chosen techniques or instruments. **CO3**. Process data from the complex instruments and demonstrate an understanding of the limitations and quality of the data. Justify the approach taken to data processing.		
7	Course Description	This course provides an advanced understanding of analytical techniques along with data quality.		
8	Outline syllabus			CO Mapping
	UNIT I **Introduction**			**CO1/CO2**
	Analytical tools in environmental science- sampling techniques and extraction processes			
	UNIT II **Fundamental Techniques**			**CO1/CO3**
	Principles and applications of Electro-analytical techniques, Separation Methods, Qualitative Optical Spectroscopic methods, Quantitative Optical Spectroscopic methods			
	UNIT III **Hyphenated Techniques and emerging applications**			**CO1/CO3**
	Mass Spectrometry (MS), Hyphenated techniques, Microscopic and surface analysis, Emerging technologies for environmental monitoring and pollution control			
	UNIT IV **Geospatial approach**			**CO2/CO3**
	Current trends of Remote Sensing and GIS applications in Environmental Science			
9	Mode of Examination	Theory		
10	Weightage Distribution	Internal Assessment-I	Internal Assessment-II	End of Semester Examination

		20%	20%	60%
11	Suggested readings			
	1. *Skoog, D.A., Holler, F., Crouch, S.R., Instrumental Analysis, Cenage Learning India Pvt. Ltd, New Delhi, 2007* 2. *Settle, F. Instrumental Techniques for Analytical Chemistry, Prentice-Hall, Inc., Englewood Cliffs, NJ, (1997).* 3. *Popek, E. P. Sampling and analysis of environmental pollutants: a complete guide, USA: Academic (2003).* 4. *Lillesand, T., Kiefer, R. W., & Chipman, J. Remote sensing and image interpretation. John Wiley & Sons, (2014).*			

ENV733: Water Resources and Climate Change (3 Credits)

School: School of Earth Sciences		**Batch: 2022-23**		
Program: Ph.D. Environmental Science		**Current Academic Year: 2022-23**		
1	Course Code	**ENV733**		
2	Course Title	**Water Resources and Climate Change**		
3	Credits	**3**		
4	Course Status	**Elective**		
5	Course Objective	1. The aim of the course is to develop linkage between climate change and water resources, including understanding, modelling and projection of hydrological processes at river basin scale. 2. To develop capability of various tools and techniques to use climate data and various processing methods.		
6	Course Outcomes **(CO)**	Student should be able to: **CO1.** Demonstrate an understanding of linkages between climate and water resources **CO2.** Set hydrological model for studying the impacts of climate change on water resources and hydrological processes		
7	Course Description	This course provides an advance understanding of analytical techniques along with data quality.		
8	Outline syllabus			CO Mapping
	UNIT I **Introduction**			**CO1**
	Elements of a watershed, hydrological cycle, hydro-meteorological variables and measurement; Elements of a watershed, hydrological cycle, hydro-meteorological variables and measurement.			
	UNIT II **Models**			**CO1/CO2**
	Rainfall-runoff modelling, land capability classification, use of remote sensing and GIS tools in database preparation, hydrological models- calibration and validation, application of rainfall-runoff model.			
	UNIT III **Impacts**			**CO1/CO2**
	Interlinking surface-groundwater, impact of landuse/landcover change on surface and groundwater resources, impact of climate change and water resources			
	UNIT IV **Scenarios and corrections**			**CO1/CO2**
	Regional and global climate models and scenarios, bias-correction techniques, spatial and temporal downscaling, uncertainty in hydrologic projections, hydro-climatic extremes			
9	Mode of Examination	Theory		
10	Weightage Distribution	Internal Assessment-I	Internal Assessment-II	End of Semester Examination

		20%	20%	60%
11	Suggested readings			
	1. *Burrough, P.A. and McDonnell, R.A. (1998) Principles of geographical information systems, Oxford University Press, Oxford, 327 pp.* 2. *Chow, V.T 1988, Applied Hydrology, Tata McGraw Hill Publishing Co.Longley, P.A., Goodchild, M.F., Maguire, D.J. and Rhind, D.W. (2005) Geographic* 3. *Information Systems and Science. Chichester: Wiley. 2nd edition.* 4. *Subramanya, K 2004, Engineering Hydrology, Tata McGraw-Hill, New Delhi.* 5. *Saeid Eslamian, Handbook of Engineering Hydrology: Modeling, Climate Change, and Variability*			

ENV734: Air Pollution, Monitoring, Control and Effects (3 Credits)

School: School of Earth Sciences		**Batch: 2022-23**
Program: Ph.D. Environmental Science		**Current Academic Year: 2022-23**
1	Course Code	**ENV734**
2	Course Title	**Air Pollution, Monitoring, Control and Effects**
3	Credits	**3**
4	Course Status	**Elective**
5	Course Objectives	1. To introduce major pollutants, present in air and sources 2. To provide knowledge of various sampling methodologies and pollution control technologies 3. Interaction of air pollution with atmospheric and meteorological variations. 4. To assess the effect of air pollution on plants and humans
6	Course Outcomes **(CO)**	Student should be able to: **CO1.** Students should able to learn about the effect of atmosphere and anthropogenic sources in air pollution **CO2.** Understand the basic theory and application of pollution monitoring and control devices. **CO3.** Understanding of atmospheric interaction with air pollutants causing the effect on formation and dispersion. **CO3.** Understanding the effect of air pollutants inducing stress on plant's growth, development, and Productivity and Plant bio-indicating measures. Also understanding effects on human's health
7	Course Description	Skills and knowledge related to air pollution, sources, interaction with atmospheric variations, and effects on plants and humans.
8	Outline syllabus	CO Mapping
	UNIT I **Air Pollutants: Types and Sources**	**CO1/CO4**
	Concepts of air pollution and sources, Primary and secondary air pollutants, Inorganic and organic air pollutants, aerosols, particulate matters; Future trends for urban pollution in developed and developing countries.	
	UNIT II **Monitoring and Control**	**CO2/CO4**
	Recent technologies for air sampling and analysis of persistent organic pollutants, Organic Carbon and Black carbon analysis, dose-response analysis, Air pollution control technologies-Settling chamber, cyclone separator, fabric filter, electrostatic precipitators; wet collector (scrubber); Methods of control of gaseous pollutants-condensation, absorption, adsorption, combustion and biological control systems, green belt, green bench, and carbon credits.	
	UNIT III **Atmospheric interaction with air pollution**	**CO3/CO4**

	Atmospheric dispersion and modelling, plume behaviour, Forces affecting vertical and horizontal movement of air, global and local circulation of air, microclimate, wind profiles, topographic effects; Meteorological factors affecting air pollution formation and dispersion, the stability of atmosphere using temperature profile, inversions, plume behaviour and calculation of plume rise, turbulent diffusion.			
	UNIT IV **Effect of air pollution on plants and humans**			**CO4/CO4**
	ROS production under air pollutants induced stress; Physiological and biochemical effects on plants, Effect on plant's growth, development and productivity; Adaptation strategies of plants under stress; Bio-indicating approach for air pollution identification. Health risk assessment, carcinogenic potencies, toxic equivalent factors (TEFs).			
9	Mode of Examination	Theory		
10	Weightage Distribution	Internal Assessment-I	Internal Assessment-II	End of Semester Examination
		20%	20%	60%
11	Suggested readings			
	1. *Baird, C. and Cann, M. Environmental Chemistry. W.H. Freeman and Company 2008.* 2. *Davis, M.L. and Cornwell, D.A. Introduction to Environmental Engineering. WCB/McGraw-Hill Publications.* 3. *Nevers, Noel De, Air Pollution Control Engineering, McGraw-Hill International Editions, 2000.* 4. *Ray, T.K. Air Pollution Control in Industries. Tech Books International, New Delhi.* 5. *Vallero, Daniel A. Fundamental of Air Pollution, Fourth Edition, Academic Press.* 6. *Lincoln Taiz and Eduardo Zeiger, Plant Physiology, 5th Edition, 2012* 7. *De Nevers, N., Air Pollution Control Engineering, 3rd edition Waveland Press Inc 2016.*			

ENV735: Environmental Biotechnology (3 Credits)

School: School of Earth Sciences		**Batch: 2022-23**
Program: Ph.D. Environmental Science		**Current Academic Year: 2022-23**
1	Course Code	**ENV735**
2	Course Title	**Environmental Biotechnology**
3	Credits	**3**
4	Course Status	**Elective**
5	Course Objectives	1. To impart knowledge about applications of biotechnology to environmental quality evaluation, monitoring, remediation of contaminated environments/ industrial effluents. 2. To understand various optimization techniques for biochemical engineering of culture experiments. 3. Understand the principles of bioremediation of synthetic organic pollutants, heavy metals and basic physiology of a microorganism during bioremediation and bio-refinery studies. 4. To understand the microbial physiology and enzyme kinetics for biodegradation and bio-refinery studies.
6	Course Outcomes **(CO)**	Student should be able to: **CO1.** The student should be able to understand the basic principles of the microbiology of environmental engineering systems for the treatment of various organic wastes. **CO2.** The student should be able to recognize and apply environmental biotechnology approaches in the treatment and disposal of organic wastes, production of biomaterials /integrated bio-refinery/ biofuels and pollution control through optimization techniques. **CO3.** Students will be able to understand the extremophiles and biosynthesis of fuel precursors & pigments. **CO4.** Students will gain a significant understanding of various stress coping mechanisms and strategies in response to heavy metal/ lanthanide exposure in addition to advanced bioremediation technologies.
7	Course Description	This course is designed to fulfil skills and knowledge related to the environmental biotechnology of heavy metal, lanthanide and POP's remediation and integrated bio-refinery (biofuel, enzymes, and pigments)
8	Outline syllabus	CO Mapping
	UNIT I **Environmental Biotechnology for Waste management**	**CO1/CO4**
	Introduction, the role of biotechnology in environment management, industrial waste management, advanced wastewater treatment, hazardous waste management, biomedical waste management, oil spill, PCBs, PAH, dioxins	
	UNIT II	**CO2/CO4**

	Bioprocess Engineering, Applications and Monitoring			
	Bioprocess engineering, optimization software, enzyme kinetics, purification, kinetics, applications, metagenomics, degradation of xenobiotics, environmental toxicity, assays, Photobioreactors/bioreactors			
	UNIT III **Physiology of valuable products and Extremophiles**			**CO3/CO4**
	Biofuel and pigment production using algae and bacteria. Biosynthetic routes of pigments and fuel precursors (fatty acids/lipids, carbohydrate, etc). Extremophiles and applications			
	UNIT IV **Physiology of heavy metals and Bioremediation**			**CO4/CO4**
	Lanthanide and heavy metal avoidance, tolerance and accumulation in microbes and macrophytes; and advanced bioremediation technologies.			
9	Mode of Examination	Theory		
10	Weightage Distribution	Internal Assessment-I	Internal Assessment-II	End of Semester Examination
		20%	20%	60%
11	Suggested readings			
	Suggested Readings 1. *Biochemical Engineering fundamentals, 2nd ed. By J E Bailey and D F Ollis, McGraw Hill, 1986.* 2. *Bioprocess Engineering Principles by Pauline M. Doran, Academic Press* 3. *Environmental Biotechnology by Indu Shekhar Thakur., IK International Pvt. Ltd.* 4. *Fundamentals of Enzymology by Nicholas C. Price & Lewis Stevens, 3rd edition, Oxford University press, New York.* 5. *Industrial Microbiology by CASIDA* 6. *Introduction to Bio-deterioration by D. Allsopp and K.J. Seal. ELBS/Edward Arnold.* 7. *Algae for Biofuels and Energy by Borowitzka, Michael A., Moheimani, Navid Reza. Springer Netherland. Springer Netherlands.DOI: 10.1007/978-94-007-5479-9*			

ENV736: Nanotechnology: Environmental Applications (3 Credits)

School: School of Earth Sciences		**Batch: 2022-23**
Program: Ph.D. Environmental Science		**Current Academic Year: 2022-23**
1	Course Code	**ENV736**
2	Course Title	**Nanotechnology: Environmental Applications**
3	Credits	**3**
4	Course Status	**Elective**
5	Course Objectives	1. Equip the students with the basic concepts and principles of nanoscience and nanotechnology 2. Provide a basic understanding of nanomaterial synthesis approaches and methods 3. Explain the theoretical basis of the techniques required for characterization of nanomaterials 4. Develop an understanding of varied applications of nanotechnology in the area of environmental remediation.
6	Course Outcomes **(CO)**	The student should be able to: **CO1.** Acquire knowledge relating to the fundamentals in the area of nanoscience & nanotechnology and understand the discipline's relevancy to human society **CO2.** Gain familiarity with different methods of nanomaterial synthesis **CO3**. Explain the suitability of characterization technique for identification of varied nano-related properties **CO4.** Apply fundamental concepts of nanotechnology to the problems of environmental pollution
7	Course Description	This course provides an overview of nanoscience including synthesis, characterization and properties of nanomaterials along with their application in the field of environmental cleanup.
8	Outline syllabus	CO Mapping
	UNIT I **Introduction**	**CO1/CO4**
	Nanoscience and Nanotechnology; Basics and scale of nanotechnology; History of nanotechnology; Nanoscale material classification; Properties of nanoparticles	
	UNIT II **Synthesis Methods**	**CO2/CO4**
	Introduction to 'Top-down' vs. 'Bottom-up' approach of synthesis; Physical, Chemical and Biological methods of nanomaterial synthesis; Pro and cons of synthesis methods	
	UNIT III **Characterization Techniques**	**CO3/CO4**
	Basic understanding of multiple techniques with special emphasis on characterization at nano scale - X-ray diffraction analysis; Fourier transform infrared spectroscopy; Raman spectroscopy; X-ray photoelectron spectroscopy; Transmission electron microscopy; Scanning electron microscopy; Atomic force microscopy; Vibrating sample magnetometry; Thermal gravimetric analysis.	

<table>
<tr><td></td><td colspan="3">UNIT IV
Environmental Application</td><td>CO4/CO4</td></tr>
<tr><td></td><td colspan="4">Role of nanoparticles in environmental clean-up; Application of nanomaterial for wastewater treatment, water disinfection, contaminated groundwater/ surface water and soil/sludge/sediment treatment; Remediation mechanisms; Potential risks, public health & environmental concerns; Case studies.</td></tr>
<tr><td>9</td><td>Mode of Examination</td><td colspan="3">Theory</td></tr>
<tr><td rowspan="2">10</td><td rowspan="2">Weightage Distribution</td><td>Internal Assessment-I</td><td>Internal Assessment-II</td><td>End of Semester Examination</td></tr>
<tr><td>20%</td><td>20%</td><td>60%</td></tr>
<tr><td>11</td><td colspan="4">Suggested readings</td></tr>
<tr><td></td><td colspan="4">Sellers K., Mackay C., Bergeson L.L., Clough S.R., Hoyt M., Chen J., Henry K., Hamblen J. Nano-technology and the environment, CRC Press, Taylor and Francis Group.
Shong C.W., Haur S.C., Wee A.T.S. Science at the Nanoscale - An Introductory Text Book, PAN Stanford Publishing.
Kane D.M., Micolich A., Roger P. Nanomaterials: Science and Applications. Pan Stanford, 2016.
Krishnamoorthy S. Nanomaterials: A Guide to Fabrication and Applications. CRC Press, 2015.
Haghi A.K., Zachariah A.K. and Kalariakkal N. Nanomaterials: Synthesis, Characterization and Applications. Apple Academic Press. 2013.</td></tr>
</table>

ENV737: Geospatial Technology for Environmental Management (3 Credits)

School: School of Earth Sciences		**Batch: 2022-23**
Program: Ph.D. Environmental Science		**Current Academic Year: 2022-23**
1	Course Code	**ENV738**
2	Course Title	**Geospatial Technology for Environmental Management**
3	Credits	**3**
4	Course Status	**Elective**
5	Course Objective	1. To expose students to applications of GIS and remote sensing in environmental management 2. To develop a sound basis for understanding the operation of GIS and Remote Sensing in environmental management. 3. To understanding the role played by technical experts, stakeholders and decision-makers 4. To demonstrate case studies of selected areas using GIS softwares.
6	Course Outcomes **(CO)**	The student should be able to: **CO1.** Acquire knowledge relating to the fundamentals in the area of Environmental Management and understand the discipline's relevancy to society **CO2.** Gain familiarity with different methods of Environmental monitoring and Management using geospatial tools. **CO3**. Explain the suitability of Geospatial technique for Environmental problems and sustainable management. **CO4.** Apply fundamental concepts of different ecosystems functioning with latest technological tools.
7	Course Description	This course provides an overview of Environmental Management with geospatial (Remote Sensing, GIS and GPS) tools with emphasis to environmental problems and their management.
8	Outline syllabus	CO Mapping
	UNIT I **Introduction**	**CO1/CO4**
	Environment & ecosystems, functions and types of ecosystems, ecosystem model concept, types of models of Ecosystems & Environmental applications.	
	UNIT II **Environmental Resources**	**CO2/CO4**
	Air, water and land resources, forest resources, forest biomass, forest inventory, types of sample plots, volume estimation, uncertainty in forest biomass estimation.	
	UNIT III **Environmental RS & GIS Techniques**	**CO3/CO4**
	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 IV **Environmental Management Applications**	**CO4/CO4**

	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.			
9	Mode of Examination	Theory		
10	Weightage Distribution	Internal Assessment-I	Internal Assessment-II	End of Semester Examination
		20%	20%	60%
11	Suggested readings			
	1. *Baretl, E.C. and Culis I.F. Introduction to Environmental Remote Sensing, second edition, Chapman and Hall, New York, 1993.* 2. *Lintz, J. and Simonent, D.S. Remote Sensing of environment Addision Wesley, Rading mars, 1976.* 3. *Jorgensen, Sven Erik. Handbook of environmental and ecological modeling. CRC Press. pp. 403–404. 1996.* 4. *Grant, William Edward & Swannack, Todd M. Ecological modeling: a common-sense approach to theory and practice. John Wiley & Sons. p. 74. 2008.* 5. *Hall, Charles A.S. & Day, John W. Ecosystem Modeling in Theory and Practice: An Introduction with Case Histories. University Press of Colorado. p. 9. 1990.*			

ENV738: Advances in Glaciology (3 Credits)

School: School of Earth Sciences		**Batch: 2022-23**
Program: Ph.D. Environmental Science		**Current Academic Year: 2022-23**
1	Course Code	**ENV738**
2	Course Title	**Advances in Glaciology**
3	Credits	**3**
4	Course Status	**Elective**
5	Course Objective	6. Conceptualization of glaciers, and its global importance. 7. Understanding of glaciological features. 8. Understanding of the heat budget process of the glacier. 9. Understanding of methods for glaciological measurements. 10. Knowledge of glaciological hazards like GLOF.
6	Course Outcomes **(CO)**	Student should be able to: **CO1.** Concept of glaciers, its types, characteristics, and importance. **CO2.** Knowledge of glacier and glaciological features. **CO3.** The knowledge of the heat budget of glaciers and its impact on glacial melting processes. **CO4.** Knowledge of different types of glaciological measurements. **CO5.** Knowledge of glaciological hazards.
7	Course Description	To develop a basic understanding of the glaciological process and various technical aspects related to glaciology, glacier dynamics, glaciological hazards.
8	Outline syllabus	CO Mapping
	UNIT I **Global Glacial Chronologies: Snow and Ice**	**CO1**
	Geological, Cenozoic and Recent glaciations, Causes of glaciations Formation and distribution of snow, Snowflakes, Snow measurement techniques, snow water equivalent, snowmelt estimation, Classification of deposited snow, Metamorphism process of deposited snow, Transformation of snow to ice in dry and wet conditions, Snow-firn-ice, Variation of density with depth, Rate of snow crystal growth, Structure of ice crystal, Deformation of a single crystal and polycrystalline ice	
	UNIT II **Glacier**	**CO1/CO2**
	Definition and types of glaciers, Zones in a glacier, Equilibrium line and its importance, Climatic significance, Determining equilibrium line altitude, Reconstructing former equilibrium line altitudes	
	UNIT III **Heat budget of a snowpack and glacier surface**	**CO3**
	Components of heat budget, Heat budget estimations and measurement process in the field, Heat budget on snow, glacier ice and debris	
	UNIT IVGlacier mass balance measurement and glaciological hazards	**CO4/CO5**

	Definition and mass balance terms, Measurement of glacier mass balance, Direct measurement, Remote sensing methods, Hydrological methods, Climatic calculations, Mass Balance gradients, Annual mass balance cycles, Mass balance of ice sheet **Glaciological hazards**: Glacial lake and its types, Conditions for the formation of glacial lakes, Glacial lake outburst flood (GLOF) and its causes, Glacial lake outburst floods in Himalaya, GLOF early warning system, Mitigation measures of GLOF			
9	Mode of Examination	Theory		
10	Weightage Distribution	Internal Assessment-I	Internal Assessment-II	End of Semester Examination
		20%	20%	60%
11	Suggested readings			
	1. *Paterson, W. S. B. (1969), The Physics of Glaciers, Third Edition, Perganon Press, Oxford, London, Edinburg.* 2. *Alen, M. H. J. (1992), Glaciers, Cambridge University* 3. *Douglass I. Benn and J. A. E. Davis (1998), Glacier and Glaciation, Dept. of Geography and Topo Science, University of Glasgow, UK* 4. *John Menzies, Modern and Past Glacial Environments, Revised Student Edition, Butterworth Heinemann, Oxford, Auckland* 5. *Nakawo, M. and N. Hayakawa (1998), Snow and Ice Science in Hydrology, Prepared for the 7th IHP Training Course on Snow Hydrology, Inst. for Hydrospheric-Atmospheric Sciences, Nagoya University and UNESCO.* 6. *Matthew R. Bennett and Neil F. Glasser (1996), Glacial Geology-Ice Sheets and Landforms, John Wiley and Sons Ltd. England.* 7. *Hambrey. M. (1994) Glacier Environments, UCL Press Limited, University College London.* 8. *Oerlemans, J. (1989), Glacier Fluctuations and Climatic Change. Kluwer (Dordrecht), 417 pp.*			