UNIVERSITY OF KERALA

FOUR YEAR UNDERGRADUATE PROGRAMME
(FYUGP)

SYLLABUS

MAJOR DISCIPLINE:

ENVIRONMENTAL SCIENCES

MAY 2024

About the programme:

Environmental science is an interdisciplinary field of study encompassing aspects of physics, chemistry, biology, geography, and other disciplines. It aims to understand the environment and how humans impact it. Environmental science is focused on a holistic understanding of Earth's systems, which aims to learn from the past, comprehend the present, and influence the future. It studies how physical, chemical and biological processes maintain and interact with life and how humans affect nature. In the era of global warvulming and climate change, this subject holds importance for solving the anthropogenic induced climate related issues. As Environmental Science is at the crossroads of the natural sciences, it provides an enriching alternative to a single-subject honours degree. It can open the door to an exciting range of career options. The FYUG programme in Environmental Science applies a broad interdisciplinary perspective to understanding how the world works. This approach enables us to tackle pressing problems, such as ensuring that human needs are met sustainably so that everyone has access to clean water and air and the resources required for agriculture and industrial activity.

No.	Program Outcomes (POs)
PO-1	**Critical thinking** ○ analyze information objectively and make a reasoned judgment ○ draw reasonable conclusions from a set of information, and discriminate between useful and less useful details to solve problems or make decisions ○ identify logical flaws in the arguments of others ○ evaluate data, facts, observable phenomena, and research findings to draw valid and relevant results that are domain-specific
PO-2	**Complex problem-solving** ○ solve different kinds of problems in familiar and no-familiar contexts and apply the learning to real-life situations ○ analyze a problem, generate and implement a solution and to assess the success of the plan ○ understand how the solution will affect both the people involved and the surrounding environment

PO-3	**Creativity** ○ produce or develop original work, theories and techniques ○ think in multiple ways for making connections between seemingly unrelated concepts or phenomena ○ add a unique perspective or improve existing ideas or solutions ○ generate, develop and express original ideas that are useful or have values
PO-4	**Communication skills** ○ convey or share ideas or feelings effectively ○ use words in delivering the intended message with utmost clarity ○ engage the audience effectively ○ be a good listener who can understand, respond and empathize with the speaker ○ confidently share views and express himself/herself
PO-5	**Leadership qualities** ○ work effectively and lead respectfully with diverse teams ○ build a team working towards a common goal ○ motivate a group of people and make them achieve the best possible solution. ○ help and support others in their difficult times to tide over the adverse situations with courage
PO-6	**Learning 'how to learn' skills** ○ acquire new knowledge and skills, including 'learning how to learn skills, that are necessary for pursuing learning activities throughout life, through self-paced and self-directed learning ○ work independently, and identify appropriate resources required for further learning ○ acquire organizational skills and time management to set self-defined goals and targets with timelines ○ inculcate a healthy attitude to be a lifelong learner

PROGRAM SPECIFIC OUTCOMES		
PSO1	**Understanding**	Students should demonstrate a comprehensive understanding of the Earth's environmental systems, including the atmosphere, hydrosphere, lithosphere, and biosphere, and their interactions.
PSO2	**Knowledge**	Students should be able to identify and analyze contemporary environmental issues such as climate change, biodiversity loss, pollution, and resource depletion, and understand their underlying causes and consequences.
PSO3	**Analytical Skills**	Graduates should possess strong analytical skills to collect, interpret, and evaluate environmental data using appropriate scientific methods and techniques.
PSO4	**Problem-Solving Skills**	Students should be capable of developing and implementing solutions to environmental problems through critical thinking, creativity, and interdisciplinary approaches.
PSO5	**Policy regulations**	Graduates should be familiar with environmental laws, regulations, and policies at local, national, and international levels, and understand their implications for environmental management and sustainability.
PSO6	**Scientific Communication**	Graduates should be effective communicators capable of presenting complex environmental information clearly and persuasively to diverse audiences, including policymakers, stakeholders, and the general public.

PROGRAM STRUCTURE
Four Year Undergraduate Program in Environmental Sciences

Course Code	Course Title	Hours per week L/T/P	Specialisation stream
	SEMESTER I		
UK1DSCENS100	Fundamentals of Environmental Science	3/0/2	
UK1DSCENS101	Ecology and Ecosystem Dynamics	3/0/2	
UK1DSCENS102	Fundamentals of Environmental Chemistry	3/0/2	
UK1MDCENS100	Ecological History	3/0/0	
UK1MDCENS101	Environmental Education	3/0/0	
	SEMESTER II		
UK2DSCENS100	Natural Resources and Conservation	3/0/2	
UK2DSCENS101	Environmental Geology	3/0/2	
UK2DSCENS102	Environmental Meteorology and Climate Change	3/0/2	
UK2MDCENS100	Environmental Ethics	3/0/0	
UK2MDCENS101	Intellectual Property Rights	3/0/0	
	SEMESTER III		
UK3DSCENS200	Environmental Microbiology and Biotechnology	3/0/2	
UK3DSCENS201	Environmental Pollution	3/0/2	
UK3DSCENS202	Energy and Environment	3/0/2	
UK3DSEENS200	Wetland Ecology	4/0/0	Ecology and Environment
UK3DSEENS201	Ecohydrology	3/0/2	Water Conservation and Sustainable Agriculture
UK3DSEENS202	Forest Ecology	3/0/2	Ecology and Environment
UK3DSEENS203	Fundamentals of Climate Change	3/0/2	Climate Change and Sustainability
UK3DSEENS204	Solid Waste Management	3/0/2	Climate Change and Sustainability
UK3MDCENS200	Environmental Data Analytics	3/0/2	
UK3MDCENS201	Environmental Forensics	2/0/2	
UK3VACENS200	Green Architecture	3/0/0	
UK3VACENS201	Environmental Health and Safety	2/0/1	

	SEMESTER IV		
UK4DSCENS200	Biodiversity and Conservation	3/0/2	
UK4DSCENS201	Current Environmental Issues	3/0/2	
UK4DSEENS200	Natural and Integrated Farming	3/0/2	Water Conservation and Sustainable Agriculture
UK4DSEENS201	Waste Water Treatment Methods	3/0/2	Climate Change and Sustainability
UK4DSEENS202	Urban Ecology	3/0/2	Ecology and Environment
UK4DSEENS203	Marine Ecology	3/0/2	Ecology and Environment
UK4DSEENS204	Global Climate Change	4/0/0	Climate Change and Sustainability
UK4INTENS200	Summer Internship (Mandatory)		
UK4SECENS200	Fundamentals of Geospatial Technology	2/0/2	
UK4SECENS201	Water Quality Monitoring	2/0/2	
UK4VACENS200	Water Conservation Methods	2/0/2	
UK4VACENS201	Green Chemistry	2/0/2	
UK4VACENS203	Environmental Governance	3/0/0	
	SEMESTER V		
UK5DSCENS300	Environmental Impact Assessment	4/0/0	
UK5DSCENS301	Sustainable Development	4/0/0	
UK5DSCENS302	Environmental Hazards and Risk Management	3/0/2	
UK5DSCENS303	Environmental Planning	3/0/2	
UK5DSEENS300	Renewable Energy	3/0/2	Climate Change and Sustainability
UK5DSEENS301	Water Resource Management	3/0/2	Water Conservation and Sustainable Agriculture
UK5DSEENS302	Bioremediation	4/0/0	Climate Change and Sustainability
UK5SECENS300	Environmental Auditing	3/0/2	
UK5SECENS301	Environment and Green Marketing	3/0/0	
	SEMESTER VI		
UK6DSCENS300	Environmental Toxicology	3/0/2	
UK6DSCENS301	Research Methods in Environmental Sciences	4/0/0	
UK6DSCENS302	Techniques in Environmental Sciences	3/0/2	
UK6DSCENS303	Wildlife Protection and Management	3/0/2	
UK6DSEENS300	Sustainable Agriculture	3/0/2	Water Conservation and Sustainable

			Agriculture
UK6DSEENS301	Green Products and Entrepreneurship	3/0/2	Climate Change and Sustainability
UK6DSEENS302	Restoration Ecology	3/0/2	Ecology and Environment
UK6DSEENS303	Soil Conservation	3/0/2	Water Conservation and Sustainable Agriculture
UK6DSEENS304	Waste to Energy	4/0/0	Climate Change and Sustainability
UK6SECENS301	Remote Sensing and Digital Image Processing	3/0/2	
UK6SECENS302	Applications of Environmental Impact Assessment	4/0/0	
UK6SECENS303	Ecotourism	2/0/2	
UK6VACENS300	Environmental Management Systems and ISO 14001	2/0/2	
	SEMESTER VII		
UK7DSCENS400	Ecological Modelling	4/0/0	
UK7DSCENS401	Pollution Management and Control	3/0/2	
UK7DSCENS402	Artificial Intelligence in Environmental Management	4/0/0	
UK7DSCENS403	Waste Management Techniques	3/0/2	
UK7DSCENS404	Environmental Economics	3/0/2	
UK7DSCENS405	Climate Change: Mitigation and Adaptation	3/0/2	
UK7DSCENS406	Ecosystem Services	3/0/2	
UK7DSEENS400	Climate Risk and Vulnerability	3/0/2	Climate Change and Sustainability
UK7DSEENS401	Nanotechnology for Environmental Remediation	3/0/2	Climate Change and Sustainability
UK7DSEENS402	Environmental and Geospatial Data Analytics	3/0/2	
	SEMESTER VIII		
UK8RPHENS400	Research Project		
UK8CIPENS400	Internship Project		

Specialisation may be given if the student completes any four courses in the Stream.

	Stream 1 Ecology and Environment
UK3DSEENS200	Wetland Ecology
UK3DSEENS202	Forest Ecology
UK4DSEENS202	Urban Ecology
UK4DSEENS203	Marine Ecology
UK6DSEENS302	Restoration Ecology
	Stream 2 Water Conservation and Sustainable Agriculture
UK3DSEENS201	Ecohydrology

UK4DSEENS200	Natural and Integrated Farming
UK5DSEENS301	Water Resource Management
UK6DSEENS300	Sustainable Agriculture
UK6DSEENS303	Soil Conservation
	Stream 3 Climate Change and Sustainability
UK3DSEENS203	Fundamentals of Climate Change
UK4DSEENS204	Global Climate Change
UK5DSEENS300	Renewable Energy
UK6DSEENS301	Green Products and Entrepreneurship
UK7DSEENS400	Climate Risk and Vulnerability
	Stream 4 Waste Management and Environmental Remediation
UK3DSEENS204	Solid Waste Management
UK4DSEENS201	Waste Water Treatment Methods
UK5DSEENS302	Bioremediation
UK6DSEENS304	Waste to Energy
UK7DSEENS401	Nanotechnology for Environmental Remediation

Semester I

Discipline	**ENVIRONMENTAL SCIENCE**				
Course Code	UK100DSCENV				
Course Title	**Fundamentals of Environmental Science**				
Type of Course	**DSC**				
Semester	First				
Academic Level	100 - 199				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5
Pre-requisites	1. Basic knowledge of biology, chemistry, and earth science concepts; 2. Familiarity with environmental issues at local, national, and global levels.				
Course Summary	The Fundamentals of Environmental Science course provides students with a foundational understanding of ecological principles and environmental challenges, while emphasizing hands-on learning experiences to develop practical skills for addressing real-world issues. Through this course, students gain the knowledge and tools necessary for pursuing careers in environmental science and sustainability. This course addresses the need for closely-mentored practical and field experience for undergraduate students interested in research, as well as science teaching and communication with multiple audiences				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Fundamentals of Environment**	**10**
	1	Earth and surface process	1
	2	Physics and Chemistry of Environment	2
	3	Biosphere: Atmosphere, Hydrosphere and Lithosphere	2
	4	Energy and Environment	2
	5	Multidisciplinary areas: Geology, Economics, Microbiology, Remote sensing and GIS	3
II		**Ecology and Ecosystems**	**12**
	6	Ecosystem: Definition and Characteristics	1
	7	Structure and Functions of Ecosystems: Productivity and decomposition	3
	8	Ecosystem Energetics: Energy flow and nutrient cycling	3
	9	Ecosystem Dynamics: Population, community interactions, and ecological succession	2
	10	Biodiversity and conservation	3
III		**Environmental Pollution and Management**	**12**
	11	Air Pollution and Management	3
	12	Water Pollution and Management	3
	13	Soil Pollution and Management	3
	14	Noise pollution and Management	2
	15	Global Environmental Issues	1
IV		**Emerging trends in Environmental Science: Basics**	**12**
	16	Disaster management	2
	17	Environmental Impact Assessment	2
	18	Environmental Biotechnology	2
	19	Environmental laws and policies	2
	20	Environment and Sustainable development	2
	21	Green initiative of environmental protection	2
V		**Field and Laboratory Study**	**9**
	22	**Ecosystem study:** Visit a nearby ecosystem to observe biodiversity and human impact.	3
	23	**Vegetation Analysis**: Conduct a vegetation survey to identify plant species diversity.	3
	24	**Water Quality Monitoring**: Monitor water quality in nearby rivers or streams to understand aquatic ecosystem health.	3
	25	**Open Ended**	**15**

Books and References:

1. Bharucha, E. 2021. Text Book of Environmental Studies. University Press (India) Pvt. Ltd.,
2. Chiras, D.D. (2009). Environmental science. Jones & Bartlett Publishers.
3. Etherington, J.R. (1975). Environment and plant ecology. John Wiley & Sons Ltd.

4. Mishra D.D, 2010, Fundamental Concepts in Environmental Studies; S Chand & Company
5. Rajagopalan, 2015, Environmental studies, Oxford University Press
6. Mahua Basu and Xavier Savarimuthu SJ, 2017, Cambridge University Press
7. Purnima Das and Chubanaro Aier, 2023, Environmental Studies: for BA, B. Com and BSc. 1st semester of Nagaland university, Global net Publications
8. Krishna Gopal Bhattacharya, Arunima Sarma, 2015, Comprehensive environmental studies, Oxford, England: Alpha Science International Ltd.
9. Michael Allaby, 2000, Basics of environmental science, Routledge, London; New York
10. Y. K. Singh 2006, Environmental Sciences, New Age International Pvt. Ltd.

Course Outcomes

No.	**Upon completion of the course the graduate will be able to**	**Cognitive Level**	**PSO addressed**
CO-1	Demonstrate mastery of core ecological and physical science concepts. Understand different parts of the biosphere interact with and affect each other and provides the necessary environmental conditions for survival	R, U	PSO-1,2
CO-2	Analyse interactions within the context of specific habitats and judge how the habitat shapes the distribution and abundance of species. Judge how organism function, ecosystem context and interactions within and across trophic levels influence the flow of energy, recycling of matter in communities and ecosystems.	R, U	PSO-3,4
CO-3	Analyse the phenomena of climate change impacting human health by developing an understanding of different types of mitigation measures.	Ap, An	PSO-1,3,4
CO-4	Understand the need for interdisciplinary approaches to address complex environmental challenges. Prepare students to engage with current and future environmental issues effectively.	U, E	PSO-4,8,9
Co-5	Gain experience developing ecological hypotheses and designing observational and experimental studies in field and laboratory settings.	Ap, An, C	PSO-4,9

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Credits: 3:0:1 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
1	Basic knowledge of environment	PSO-1,2	R, U	F, C	10	-
2	Status and dynamics of ecosystem study	PSO-3,4	R, U	C, P	8	-
3	Current status of global environment	PSO-1,3,4	Ap, An	C, M	12	-
4	Explain multidisciplinary aspects of Environmental Sciences	PSO-4,8,9	U, E	F, C, M	10	-
5	Field and laboratory exposure of students	PSO-4,9	Ap, An, C	P, M	20	15

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	P O5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	3	3	-	-	-	-						
CO 2	3	3	-	-	-	-						
CO 3	-	-	3	-	2	2						

CO 4	3	3	-	2	-	-		2				
CO 5	-	1	-	-	-	-		3	3			
CO 6	3	3	-	-	-	-						

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2		✓		✓
CO 3	✓			✓
CO 4		✓		✓
CO 5		✓	✓	✓

Discipline	Environmental Science				
Course Code	**UK1DSCENS101**				
Course Title	Ecology and Ecosystem Dynamics				
Type of Course	**DSC**				
Semester	First				
Academic Level	100 to 199				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5
Pre-requisites	1. Knowledge of the basic concepts of environmental sciences 2. Knowledge of biology and zoology				
Course Summary	The main objective of this course is to impart knowledge on the different ecological concepts and disciplines of ecology. Students will be introduced to understand the ecosystem, population and community ecology and its relevance for the environmental segments and factors. The course introduces the students to understand the interactions of organisms and their environments and the consequences of these interactions for population, community, and ecosystems functional dynamics. This will help the students to apply the fundamentals of ecology for forming the foundation of ecological theories.				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Introduction to Ecology**	**8**
	1	Ecology definition, Scope of ecology, concepts of ecology and environment	2
	2	Autecology; synecology; landscape, habitat, eco zones, biosphere, ecosystems	2
	3	Ecosystem stability, resistance and resilience	2
	4	Components of environment-atmosphere, hydrosphere, lithosphere, biosphere	2
II		**Ecosystem**	**15**
	5	Definition, concepts, characteristics, ecosystem Structure -abiotic components: light, temperature, pressure, precipitation, humidity, wind, fire; biotic components: producers, consumers and decomposers	4
	6	Ecosystem function -food chain, food web, ecological pyramids-pyramid of numbers, biomass, energy and inverted pyramids.	3
	7	Types of ecosystem: Terrestrial ecosystem –tundra, taiga, grassland; deserts, forests; their characteristics, flora and fauna	3
	8	Aquatic ecosystem-Fresh (lentic, lotic), Intertidal, and marine; their characteristics, flora and fauna.	5
III		**Community ecology**	**15**
	9	Characteristics of a community, composition, structure and development of community	2

	10	Ecotone, edge effect, ecological dominance, niche, guild, ecological equivalence, key stone species,	2
	11	Succession –definition, concept, causes of succession ;types of succession-primary, secondary, allogeneic, autogenic, autotrophic and heterotrophic succession	3
	12	General process of succession-nudation, invasion, competition, reaction, stabilization, Types of succession	3
	13	Theories of succession-mono climax, poly climax and climax-pattern hypothesis	1
	14	Concepts of adaptation under various environmental conditions, mechanism of adaptation to environmental stresses	2
	15	Ecological adaptation of animals-hydrocoles, mesocoles and xerocoles	1
	16	Limiting factors-concept, laws of limiting factors,	1
IV	**Population ecology and ecological interactions**		**10**
	17	Population characteristics-Population size, density, dispersion, natality, mortality, age structure, life tables	2
	18	Biotic potential, r and k selection, survivorship curve	2
	19	Population growth- geometric, exponential and logistic; density-dependant and density independent	1
	20	Limits to growth; Concept of carrying capacity	2
	21	Ecological Interactions- Relationship among organisms, positive, negative and neutral interactions	3
V	**Restoration ecology**		**4**
	22	Definition of Restoration Ecology ;Need for Restoration; Purpose of Ecological Restoration	1
	23	Approaches to Ecological Restoration- Ecological and Agronomical, Socio-economic and cultural dimension, Revegetation and Regeneration	3
	24	**Practicum/Field visit**	**8**
	25	**Open Ended**	**15**

References

1. Chapman,J.L. and Reiss,M.J.2005.Ecology,principles and applications, Cambridge University Press, London
2. Cooke, G. D. (2005). Restoration and management of lakes and reservoirs. 3rd edition. CRC Press, Boca Raton, FL.
3. Dash,M.C.(1994).Fundamentals of Ecology,Tata Mc Graw Hill,New Delhi.
4. Davy, A. J. and M. R. Perrow. (2002). Handbook of ecological restoration. Cambridge University Press, Cambridge, UK, New York.
5. Livingston, R. (2005). Restoration of aquatic systems. CRC Press.
6. Meethu Gupta.(2020).Fundamentals of Environmental Biology.Wiley India.
7. Odum,E.P. (1971).Fundamentals of Ecology, W.B.Saunder Company,Philadelphia
8. Sharma P.D. (1996) Environmental Biology, Rastogi Publications, Meerut

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Explain the basic concepts of ecology and components of environment	U	PSO-1,2
CO-2	Describe the structure, function and different types of ecosystem	R, U	PSO-1,2
CO-3	Explain the community ecology, succession and ecological adaptations	U,R,	PSO-3,5,6
CO-4	Explain the population characteristics, growth, carrying capacity and ecological interactions	U,R,A	PSO-1,2,4,8
CO-5	Explain ecosystem management practices that can mitigate and restore systems that have been affected adversely by human activity.	R,U,Ap	PSO-8,9

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Credits: 3:0:1 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)	Open Ended
CO-1	Explain the basic concepts of ecology and components of environment	PSO-1,2	U	U	9		3
CO-2	Describe the structure, function and different	PSO-1,2	R, U	R, U	10		3

	types of ecosystem						
CO-3	Explain the community ecology, succession and ecological adaptations	PSO-3,5,6	U,R,	U,R,	14		3
CO-4	Explain the population characteristic, growth, carrying capacity and ecological interactions	PSO-1,2,4,8	U,R,A	U,R,A	13		3
CO-5	Explain ecosystem management practices that can mitigate and restore systems that have been affected adversely by human activity.	PSO-8,9	R,U,Ap	R,U,Ap	6	8	3

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9	PO4	PO5	PO6
CO 1	3	3	-	-	-	-	-	-	-	-	-	-

CO 2	3	3	-	-	-	-	-	-	-	-	-	-
CO 3	-	-	3	-	2	2	-	-	-	-	-	-
CO 4	3	3	-	2	-	-	-	2	-	-	-	-
CO 5	-	1	-	-	-	-	-	3	3	-	-	-

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓
CO 5		✓		✓

Discipline	**ENVIRONMENTAL SCIENCES**
Course Code	**UK1DSCENS102**
Course Title	**Fundamentals of Environmental Chemistry**
Type of Course	**DSC**
Semester	First
Academic Level	100-199

Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5

Pre-requisites	1. Basic knowledge of Chemistry 2. Understanding of the concepts of Environmental Sciences
Course Summary	In this course, the students will study the chemistry of the air, water, and soil, and how anthropogenic activities affect this. Specifically, students learn and understand the sources, reactions, transport, effects, and fates of chemical species in air, water, and soil environments, and the effects of technology thereon. After completing this course, the students will acquire analytical skills with respect to different environmental spheres, capacity building in undertaking different on site tasks entrusted to them. The students can experience advanced levels of awareness regarding environmental pollution help design pilot projects related to pollution monitoring and abatement.

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Introduction to Environmental Chemistry**	**10**
	1	Concept and Scope of Environmental Chemistry	2
	2	Major environmental segments	3
	3	Natural cycles of the environment - Hydrological cycle, Carbon cycle, Oxygen cycle, Nitrogen cycle, Phosphorous cycle, Sulphur cycle	3
	4	Impact of man on nutrient cycles	2
II		**Atmosphere**	**15**
	5	Composition of the atmosphere, layers of the atmosphere	2
	6	Earth's radiation balance	1
	7	Particles, radicals and ions in the atmosphere	1
	8	Stratospheric chemistry – Oxygen and ozone chemistry,	2
	9	Greenhouse effect/ global warming, chlorofluorocarbons, Ozone depletion, Minimizing future emissions of greenhouse gases.	3
	10	Tropospheric chemistry - The principle of reactivity in the troposphere, The tropospheric oxidation of methane	2
	11	Photochemical smog, Rain , snow and fog chemistry, Formation and composition of acid rain, Atmospheric aerosols	3
	12	Oxidation of atmospheric SO2.	1
III		**Hydrosphere**	**15**
	13	Water resources, Global distribution of water	3
	14	Gases in water, Organic matter in water.	3

	15	Physical chemistry and composition of sea water and fresh water on land.	3
	16	pH,pE and pH- pE diagrams of selected elements.	3
	17	Complexation in natural water and waste water	3
IV		**Lithosphere**	**10**
	18	Weathering of rocks- physical, chemical and biological processes	2
	19	Factors controlling the formation of soil	2
	20	Soil profile and classification of soil	2
	21	Composition of soil-organic and inorganic components in soil, water and air in soil	2
	22	Micro and macro nutrients, nitrogen pathways and NPK in soil. Acid base and ion exchange reactions in soil	2
V		**Toxic organic chemicals and heavy metals**	**10**
	23	Pesticides- classification, degradation, pollution due to pesticides. Organochlorine pesticides - structure and chemistry, DDT,	5
	24	Organophosphates and carbamate insecticides - structure and chemistry; Natural and Green insecticides -sources, target insects. Heavy metals - Speciation and toxicity of heavy metals, Bioaccumulation of heavy metals	10
	25	Open ended	15

REFERENCES

1. Barceló, Damià, Kostianoy, Andrey, G. (2020).The Handbook of Environmental Chemistry, Book series. Springer(Pub).
2. Dara, S.S. (1993). A Text Book of Environmental Chemistry and Pollution Control.S. Chand, NewDelhi
3. James E. Girard (2011), Principles of Environmental Chemistry, James and Bartlett, NewDelhi.
4. Spiro, T.S. and Stiglicini, W.M. (2002). Chemistry of the Environment, Prentice Hall of India Pvt.Ltd.
5. Environmental Chemistry by C. Baird, et al., (4th Edition), W. H. Freeman and Company, New York, 2009
6. Manahan, S. E. (2004), Environmental Chemistry, Lewis Publishers, New York.

<u>Course Outcomes</u>

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Understand the nature, reactivity and environmental fates of toxic organic chemicals, pollution due to pesticides	U	PSO1, PSO2
CO-2	Define the basic environmental conversion units	R	PSO1

CO3	Understand the chemistry of the stratospheric and tropospheric processes	U	PSO1, PSO2
CO4	Address major environmental issues such as ozone depletion, green house effect, anthropogenic climate change and air pollution	U	PSO4
CO5	Recognize the importance of environmental changes, demonstrate an understanding of theoretical and practical environmental issues	An	PSO3

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Credits: 3:0:1 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
1	Understand the nature, reactivity and environmental fates of toxic organic chemicals, pollution due to pesticides	PSO1, PSO2	U	F, C	L	P
2	Define the basic environmental conversion units	PSO1	R	P	L	
3	Understand the chemistry of the stratospheric and tropospheric processes	PSO1, PSO2	U	F, C	L	
4	Address major environmental issues such as ozone depletion, green house effect, anthropogenic climate change and air pollution	PSO4	U	M	L	

5	Recognize the importance of environmental changes, demonstrate an understanding of theoretical and practical environmental issues	PSO3	An	F	L	P

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	1	-	-	-	-	-	1	-	-	-	-	-
CO 2	2	3	-	-	-	-	-	-	-	-	-	-
-CO 3	-	-	1	-	-	-	-	-	-	-	-	-
CO 4	-	-	2	3	-	-	-	2	-	1	1	-
CO 5	-	1	-	-	-	-	-	2	-	-	-	-
CO 6	-	-	-	3	-	-	-	-	-	--	-	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments

- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓
CO 5		✓		✓
CO 6			✓	

Discipline	**ENVIRONMENTAL SCIENCES**				
Course Code	**UK1MDCENS100**				
Course Title	**ECOLOGICAL HISTORY**				
Type of Course	**MDC**				
Semester	First				
Academic Level	100 - 199				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	3	3 hours	-	-	3
Pre-requisites	The learner should be able to appreciate the Environment and should have the initiative to understand the history of Environment and Environment activities				
Course Summary	The course is intended to mold the learner to be concerned about nature. It will help the learner to familiarize with the history of the environment in global and Indian concepts. It will make the learner to be aware of diverse developments and their impacts on nature. The course gives the learner an idea about the various policies related to the environment at various points in the history of India. The course provides the learner with concerns about nature-human relationships and the impacts of human activities on nature.				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Basics of Environmental History**	**4**

	1	Definition of Environmental History	1
	2	Emergence of Environmental History as a branch of History	1
	3	Political and Cultural Dimensions of Environmental History	1
	4	Geographical background of the Indian Subcontinent	1
II		**The context of Colonial India and Medieval India**	**5**
	5	Pre-colonial scenario	1
	6	Environmental Policies in Ancient India (Vedic culture, panchaphoothas, Kautilya's Arthasasthra, Manu's Forest protection, The Asoka's pillar Edicts) and drawbacks	2
	7	Mughal Rulers (Nature parks, gardens, fruit orchards), Babar's Account, Abdul Qadir Badauni, Akbar's Efforts	2
III		**British India**	**8**
	8	Plundering of resources, Legalized Exploitation	1
	9	Establishment of Industries	1
	10	Shore Nuisance (Bombay and Colaba) Act 1853	1
	11	The Oriental Gas Company Act, 1857, The North India Canal and Drainage Act, 1873	2
	12	The Indian Easements Act, 1882, the Indian Fisheries Act, 1897, the Bombay Smoke Nuisance Act, 1912, and the Bengal Smoke Nuisance Act, 1905	2
	13	The Indian Penal Code (IPC), 1860 in Chapter 14 (Sections 268 to 291), The Criminal Procedure Code (Sections 133 to 144)	1
IV		**Independent India**	11
	14	Constitution of India	1
	15	The Factories Act, 1948, The Damodhar Valley Corporation (Prevention of Pollution of Water) Regulation Act, 1948, The Mines Act, 1952, River Boards Act, 1956	2
	16	United Nations Conference on Human Environment in 1972	1
	17	Pitamber Committee, National Committee on Environmental Planning and Coordination (NCEPC)	2
	18	Department of Science and Technology by Ministry of Science and Technology	1
	19	Constitutional Mandates (Article 48-A, Article 51-A(g), Article 21, Public Interest Litigations (PIL))	2
	20	Environmental Movements (Narmada Bachao Andolan, Save Silent Valley Movement, Jungle Bachao Andolan, Tehri Dam Movement)	2
V		**Modern India**	**17**
	21	National Council for Environmental Policy and Planning, 1972 which evolved into MoEF and later MoEFCC, Central Pollution Control Board and SPCBs i.e. State Pollution Control Boards)	3
	22	The Policy Statement for Abatement of Pollution and the National Conservation Strategy and Policy Statement on Environment and Development, 1992	2
	23	The EAP (Environmental Action Programme) was formulated in 1993	1

	24	National Environmental Policy, 2006, Post-NEP 2006	2
	25	Open ended	9

References

1. Cronon, W. (1993). The uses of environmental history. *Environmental history review*, *17*(3), 1-22.
2. Fisher, M. H. (2018). *An environmental history of India: from earliest times to the twenty-first century* (Vol. 18). Cambridge University Press.
3. Gadgil, M., & Guha, R. (1993). *This fissured land: an ecological history of India*. Univ of California Press.
4. Hughes, J. D. (2016). *What is environmental history?* John Wiley & Sons.
5. McNeill, J. R. (2003). Observations on the nature and culture of environmental history. *History and theory*, *42*(4), 5-43.
6. Ravi Rajan, S. (2014). A history of environmental justice in India. *Environmental Justice*, *7*(5), 117-121.
7. Sivaramakrishnan, K. (2008). Science, environment and empire history: comparative perspectives from forests in colonial India. *Environment and History*, *14*(1), 41-65.
8. Stein, B. (2010). *A History of India* (Vol. 9). John Wiley & Sons.

Course Outcomes

No.	**Upon completion of the course, the graduate will be able to**	**Cognitive Level**	**PSO addressed**
CO-1	Explain the history of developments related to the environment	R, U	PSO-1,2 PO-8
CO-2	Explain the environment in the context of ancient India	U, E	PSO-2 PO-8
CO-3	Describe the environment-related activities in Medieval and British India	U, Ap, An	PO- 1,8
CO-4	Discuss the various legal provisions and policies in independent India and describe the environmental movements	R, U	PSO-1,2,4,5 PO- 2,3
CO-5	Explain the activities and governance related to the environment in modern India and categorize activities under relevant laws, rules and policies	U, Ap	PSO-1,2,4,5 PO- 2,3

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Credits: 3:0:0 (Lecture:Tutorial: Practical)

CO No.	**CO**	**PO/PSO**	**Cognitive Level**	**Knowledge Category**	**Lecture (L)/Tutorial (T)**	**Practical (P)**
CO-1	Explain the	PSO-1,2	R, U	F, C	4	0

	history of developments related to the environment	PO-8				
CO-2	Explain the environment in the context of ancient India	PSO-2 PO-8	U, E	F, C	5	0
CO-3	Describe the environment-related activities in Medieval and British India	PO- 1,8	U, Ap, An	F, C	7	1
CO-4	Discuss the various legal provisions and policies in independent India and describe the environmental movements	PSO-1,2,4,5 PO- 2,3	R, U	F, C	11	0
CO-5	Explain the activities and governance related to the environment in modern India and categorize activities under relevant laws, rules and policies	PSO-1,2,4,5 PO- 2,3	U, Ap	F, C, P	8	

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO4	PS O5	PSO 6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	2	3	-	-	-	-	-	-	-	-	-	-
CO 2		3	-	-	-	-	-	-	-	-	-	-

CO 3	-	-	-	-	-	-	3	-	-	-	-	-
CO 4	2	2	-	3	3	-	-	3	3	-	-	-
CO 5	2	2	-	3	3	-	-	3	3	-	-	-

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Visit to any legal firm and submit a report
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓
CO 5		✓		✓
CO 6			✓	

Discipline	**ENVIRONMENTAL SCIENCES**				
Course Code	**UK1MDCENS101**				
Course Title	**ENVIRONMENTAL EDUCATION**				
Type of Course	**MDC**				
Semester	First				
Academic Level	100 - 199				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	3	3 hours	-	-	3
Pre-requisites	1. A foundational understanding of basic ecological concepts and ecosystem dynamics. 2. Familiarity with the principles of sustainable development and				

	environmental policies. 3. An interest in environmental issues, ethics, and global awareness. 4. Eagerness to engage in field-based learning and practical applications.
Course Summary	This course delves into the definition, scope, and principles of Environmental Education (EE), its historical evolution, and its role in sustainable development. It covers basic ecological concepts, environmental policy, governance, and the importance of government agencies and NGOs. Students will explore environmental ethics, justice, and cultural perspectives, and engage in debates on contemporary issues of environmental significance.

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Introduction to Environmental Education**	**8**
	1	Definition, scope, and objectives of Environmental Education	1
	2	The guiding principles and historical evolution of Environmental Education	2
	3	Role of EE in sustainable development	1
	4	Modes of imparting Environmental Education (Formal and non-formal sectors of education)	2
	5	Environmental Education in India (levels of implementation)	2
II		**Role of Environmental Education in addressing Environmental Issues and Challenges**	**10**
	6	Introduction to Environmental issues and Challenges (Climate Change and Global Warming, Pollution and Waste Management, Biodiversity and Conservation – their causes and impacts)	2
	7	Building Environmental Literacy (environmental Awareness and Knowledge, Critical Thinking and Problem-Solving	2
	8	Promoting Sustainable Practices (Behavior Changes and Responsible Choices, Education for Sustainable Development (ESD), Green Economy and Circular Practices)	2
	9	Environmental Policies and Governance (EPA, 1986, NEPA, National and international environmental policies, Role of government agencies and NGOs, Indian Constitution and Environmental Provisions)	2
	10	Environmental Education in a Global Context (Cross-cultural exchange programs, International collaborations, Addressing global environmental challenges)	2
III		**Environmental Ethics and Values**	**10**
	11	Ethical frameworks in environmental decision-making (Polluter-Pays Principle, Ability-to-Pay Principle, Equal-Per-Capita Principle, Procedural-Involvement Principle)	2
	12	Environmental justice and Cultural perspectives on nature (Key Principles of justice-equity, participation and recognition, Landscape and Narratives, Traditional Ecological Knowledge, Indigenous Wisdom, Historical and Spiritual Connection and advocacy)	2

	13	Promoting responsible citizenship and global awareness (Education for Sustainable Lifestyles, Human Rights, Gender Equality, Culture of Peace and Non-Violence, Global Citizenship, Cultural Diversity)	2
	14	Anthropocentrism vs. Ecocentrism (perspectives and implications)	2
	15	Debates on controversial environmental issues	2
IV		**Environmental Education Pedagogy**	**12**
	16	Types and levels of EE (primary, secondary, tertiary)	2
	17	Teaching methods and approaches (Innovative Model of EE integrating knowledge, values, ethics, skills, and evaluation, Seven Approaches to Environmental Education)	3
	18	Field-based learning and experiential education (purpose, benefits, and applications with case studies in EE)	2
	19	Youth engagement and environmental leadership (Empowering Future Eco-Leaders through Student-Centered Activities, Platforms for Voices, Meaningful Connections, Experiential Learning and Global Citizenship)	3
	20	Environmental organizations and agencies (International and National, Agencies and Programmes)	2
V		**Case Studies, Field Work and Practical Applications**	**8**
	21	Field visits to natural habitats, conservation areas, and pollution sites.	2
	22	Analyzing real-world environmental challenges (case studies).	2
	23	Developing practical skills in data collection and analysis-surveying and field work	2
	24	Best Practices in Environmental Sustainability Education- real world examples	2
	25	**Open Ended**	**12**

Course Outcomes

No.	**Upon completion of the course the graduate will be able to**	**Cognitive Level**	**PO/PSO addressed**
CO-1	Explore the guiding principles that underpin effective environmental education, Understand ecosystem dynamics, including interactions between biotic and abiotic components.	U, An	PO-2 PSO-1,2
CO-2	Enhance critical thinking and problem-solving skills related to environmental issues.Address global environmental challenges through education and action.	U, An, Ap	PO-1,6 PSO-1,2,4
CO 3	Explore the concept of environmental justice and its relevance to marginalized communities, Engage in informed debates on topics such as climate change, deforestation, and animal rights, thereby Developing communication skills and analyzing differing	U, Ap	PO-1,8 PSO-1,2

	viewpoints and evidence.		
CO 4	Recognize the value of field trips, nature walks, and outdoor experiences in EE, Cultivate leadership skills related to environmental advocacy and stewardship, and design field-based activities that connect classroom learning to real-world contexts.	U, An	PO-3,5 PSO-1,2
CO 5	Learn about local biodiversity, ecosystem dynamics, and environmental threats, Gain proficiency in interpreting and presenting environmental data effectively.	U, Ap	PO-3,5 PSO-2,4

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

References

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3. Singh, Sunil Kumar. 2008. Environmental Education and Ethics, Amrit Prakashan,
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5. Principles of Environmental Science, Mc Graw Hill.
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7. Karmaoui, Ahmed, Ben Salem, Abdelkrim, Anees, Mohd Talha. 2021. Handbook of Research on Environmental Education Strategies for Addressing Climate Change and Sustainability. IGI Global.

Name of the Course: Credits: 3:0:0 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)	Open Ended (OE)
CO-1	Explore the guiding principles that underpin effective environmental education, Understand ecosystem dynamics, including	PO-2 PSO-1,2	U, An	F, C	10		2

	interactions between biotic and abiotic components.						
CO-2	Enhance critical thinking and problem-solving skills related to environmental issues.Address global environmental challenges through education and action.	PO-1,6 PSO-1,2,4	U, An, Ap	P,M	10		2
CO 3	Explore the concept of environmental justice and its relevance to marginalized communities, Engage in informed debates on topics such as climate change, deforestation, and animal rights, thereby Developing communication skills and analyzing differing viewpoints and evidence.	PO-1,8 PSO-1,2	U, Ap	F,P	10		2
CO 4	Recognize the value of field trips, nature walks, and outdoor	PO-3,5 PSO-1,2	U, An	C	10		2

	experiences in EE, Cultivate leadership skills related to environmental advocacy and stewardship, and design field-based activities that connect classroom learning to real-world contexts.						
CO 5	Learn about local biodiversity, ecosystem dynamics, and environmental threats, Gain proficiency in interpreting and presenting environmental data effectively.	PO-3,5 PSO-2,4	U, Ap	p		8	4

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO4	PSO 5	PSO 6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	1	1	-	-	-	-	-	2	-	-	-	-
CO 2	1	3	-	1	-	-	2	-	-	-	-	2
CO 3	2	1	-	-	-	-	2	-	-	-	-	-
CO 4	2	3	-	-	-	-	-	-	1	-	3	-

CO 5	-	1	-	2	-	-	-	-	2	-	1	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓
CO 5		✓		✓
CO 6			✓	

SEMESTER II

Discipline	**ENVIRONMENTAL SCIENCES**
Course Code	**UK2DSCENS100**
Course Title	**NATURAL RESOURCES AND CONSERVATION**
Type of Course	**DSC**
Semester	Second
Academic Level	100-199

Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5
Pre-requisites	1. The students should have background knowledge on the different resources on earth 2. Students should have an overall idea regarding conservation strategies around the world.				
Course Summary	Natural resource conservation is about supplying what humans need while trying to minimize the impacts of this on the environment. Natural resource conservation has greatly increased the carrying capacity of the Earth for humans. Upon completion of this course, the student will be able to describe the impact of world population growth on natural resource availability and management. Students will identify the major factors depleting natural resources and will be able to develop management strategies to conserve them.				

Detailed Syllabus:

Module	**Unit**	**Content**	**Hrs**
I		**Introduction to Natural resources**	**10**
	1	Definition – Concept, classification of natural resources (Renewable and non renewable resources) Renewable resources – Land / Soil resources –	3
	2	Land as a resource, Land degradation , Causes of soil and land degradation, Conservation measures	3
	3	Soils of India	2
	4	Waste lands, desertification	2
II		**Water and Forest resources**	**20**
	5	Sources of water, hydrological cycle, Use and exploitation of surface and groundwater, conflict over water,	2
	6	Management and conservation of water resources. Watershed management: Concept, Objectives, planning and measures;	2
	7	Land use planning for watershed management; Water harvesting and recycling, role of state in water resources management	2
	8	Importance of Forest - Ecological and Economic significance	2
	9	Classification of Forest resources	1
	10	Use and over exploitation, deforestation, Timber extraction, afforestation, basic causes of deforestation,	2
	11	Management of forest resources	1
	12	Plants and animal resources – over exploitation, species extinction, control measures.	2
	13	Social forestry – multipurpose tree species (MPTs), Nitrogen fixing Tree species (NFTs) – characteristics; community participation; pattern of planting **(Field visit)**	3
	14	Eco-restoration of eroded hill slopes and degraded Jhum land	1
	15	Agroforestry - origin and definition, types	1
	16	Tree and crop management	1
III		**Non renewable and renewable Energy resources**	**10**

	17	Non renewable energy resources – Fossil fuels (Coal, Petroleum and natural gas), nuclear fuel	3
	18	Renewable energy resources (Biomass, Biofuel, Hydropower, Tidal energy, wave energy, wind energy, geothermal energy, solar energy, magneto hydrodynamic power, Hydrogen energy **(Field Visit)**	5
	19	Energy crisis , Management of energy resources	2
IV		**Mineral resources**	**12**
	20	Classification of Minerals, Minerals of India, Uses of economic importance of minerals, Management of Mineral resources	4
	21	Mineral wealth of our planet, Non renewable nature of mineral deposits, The inexhaustible nature of mineral elements	4
	22	Use and exploitation of mineral resources, Environmental effects of extracting and using mineral resources, Remedial measures	4
V		**Food resources**	**8**
	23	World food problems, changes caused by agriculture and overgrazing, effects of modern agriculture, merits of conventional agricultural system	4
	24	World food supply, food security, Sustainable agriculture, Role of an Individual in conservation of natural resources, equitable use of resources for sustainable development.	4
	25	**Open Ended**	**15**

REFERENCES

1. Singh, C. K. 2018. Geospatial Applications for Natural Resources Management, CRC Press.
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8. Daniel, D. Chiras and Reganold, John, P. (2009). Natural Resource Conservation: Management for a Sustainable future, Addison Wesley, Boston.

Course Outcomes

No.	Upon completion of the course the graduate will be	Cognitive	PO/PSO

	able to	Level	addressed
CO-1	Understand the use, management, and protection of land and natural resources and prepare for careers in environmental management	U	PO1, PSO 1, PSO 2
CO-2	Promote responsible and conscientious stewardship of soil and mineral resources and thereby the reduce the deleterious effects of mining and soil erosion	Ap	PO2, PSO 3, PSO 4
CO-3	State and promote the knowledge of preservation and management strategies of natural resources	An	PO4, 5, PSO 6, PSO 5
CO-4	Analyze and appreciate the importance of energy efficiency and energy conservation strategy for sustainable environment	E	PO6, PSO 6
CO- 5	Develop knowledge on the values and importance of water resources and thereby inculcate awareness on the detrimental effects of overuse and depletion of water resources	Ap	PO8, PSO 3, PSO 6

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Credits: 3:0:1 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)	Open Ended
1	Understand the use, management, and protection of land and natural resources and prepare for careers in environmental management	PO1, PSO 1, PSO 2	U	F	10	2	3
2	Promote responsible and conscientious stewardship of soil and mineral resources and thereby the reduce the deleterious effects of mining and soil erosion	PO2, PSO 3, PSO 4	Ap	F	10		3
3	State and promote the knowledge of preservation and management	PO4, 5, PSO 6, PSO 5	An	F,M	10	2	3

	strategies of natural resources						
4	Analyze and appreciate the importance of energy efficiency and energy conservation strategy for sustainable environment	PO6, PSO 6	E	F	10	4	3
5	Develop knowledge on the values and importance of water resources and thereby inculcate awareness on the detrimental effects of overuse and depletion of water resources	PO8, PSO 3, PSO 6	Ap	F	12		3

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO4	PSO 5	PSO 6	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	1	-	-	1	-	-	2	-	-	1	-	3	-	-
CO 2	2	3	-	-	-	-	3	2	-	-	2	-	-	-
CO 3	-	-	1	-	-	-	-	3	-	2	1	-	-	3
CO 4	1	-	2	-	-	-	-	1	1	-	-	3	1	-
CO 5	-	1	-	-	3	-	1	1	-	-	-	-	3	1

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low

2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Assignments
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓			✓
CO 3				✓
CO 4	✓	✓	✓	✓
CO 5	✓	✓	✓	✓

Discipline	**ENVIRONMENTAL SCIENCES**				
Course Code	**UK2DSCENS101**				
Course Title	**ENVIRONMENTAL GEOLOGY**				
Type of Course	**DSC**				
Semester	Second				
Academic Level	100-199				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5
Pre-requisites	1. The students should have a basic knowledge of the geo-physical components of Earth and its processes. 2. The students should be aware of the disasters related to Earth and Climate change issues				

Course Summary	The course involves a study of earth processes and natural hazards and their influences on life in ways that either affect or control man's environment. Furthermore, this is an introduction to geologic concepts as they relate to the environment we live in. Topics under discussion include earth's geologic environment, problems posed by various geologic phenomena and some of the ways that human activities have affected the planet.

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Introduction to Environmental Geology**	**10**
	1	Origin and Evolutionary history of earth- Geological Time Scale	2
	2	Origin of life, Speciation	2
	3	Evolution of human settlement	2
	4	Plate Tectonics – Seafloor spreading and continental drift	2
	5	Forces acting on the surface of the Earth – tectonic and diastrophic forces.	2
II		**Minerals and Rocks**	**15**
	6	Definition of rocks and minerals, Rock forming minerals and ore forming minerals, Physical properties of minerals	3
	7	Brief overview of formation; forms, textures, structures, classification of Igneous rocks.	3
	8	Brief overview of formation; forms, textures, structures, classification of sedimentary rocks.	3
	9	Brief overview of formation; forms, textures, structures, classification of metamorphic rocks.	3
	11	Environmental impacts of mining and mitigatory measures.	3
III		**Ecohydrology and Groundwater**	**12**
	12	Definition and Concept of Ecohydrology; hydrologic budget	1
	13	Drainage basin – definition and characteristics	1
	14	Stream classification and ordering	2
	15	Source, occurrence and movement of groundwater; Water Table	2
	16	Geologic formations as aquifers; Aquifer types	2
	17	Water Table fluctuations – environmental and anthropological influences	2
	18	Rainwater harvesting and groundwater recharging methods.	2
IV		**Geological Hazards**	**15**
	19	Earthquakes – causes, effects, distribution and prediction	3
	20	Volcanoes –distribution, products of volcanic eruptions and their environmental impacts	3
	21	Landslides – slope stability, factors affecting slope stability, causes, effects and prevention of landslides	3
	22	Tsunami – causes, characteristics, effects	3

	23	Avalanches – causes, types, effects; Cyclones - causes and effects	3
	24	Preparation of case studies in each category mentioned in this module - Participatory Action Learning (Open Ended)	**15**
V	**Maps (Practicum)**		**8**
	25	Identification of rocks and Minerals Topographic and Geologic maps in Environmental Studies- Preparation of maps (Experiential learning)	4 4

<u>Course Outcomes</u>

No.	**Upon completion of the course the graduate will be able to**	**Cognitive Level**	**PSO addressed**
CO-1	Understand the basics of Environmental Geology	U	PSO 1
CO-2	Define the basic structures and identify geological features present on earth and its composition	R	PSO 2
CO3	Understand and identify the geological hazards	U	PSO 3
CO4	Address major environmental issues such as mining and its implications on the earth's surface	Ap	PSO 5
CO5	Interpret geological history, and solve geological problems	An	PSO 6

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Credits: 4:0:0 (Lecture:Tutorial:Practical)

CO No.	**CO**	**PO/PSO**	**Cognitive Level**	**Knowledge Category**	**Lecture (L)/Tutorial (T)**	**Practical (P)**	**Open Ended**
1	Understand the basics of Environmental Geology	PSO 1	U	**U**	**10**	**1**	**3**
2	Define the basic structures and identify geological features present on earth and its composition	PSO 2	R	F, C	10	3	3

3	Understand and identify the geological hazards	PSO 3	U	U	10	2	3
4	Address major environmental issues such as mining and its implications on the earth's surface	PSO 5	Ap	Ap	10	1	3
5	Interpret geological history, and solve geological problems	PSO 6	An	An	12	1	3

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	PSO 2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	1	-	-	1	-	-	-	1	-	1	-	1	-	1
CO 2	2	2	-	-	1	-	1	-	-	-	1	-	-	-
CO 3	-	-	1	-	-	-	-	-	2	-	-	-	2	-
CO 4	-	-	2	3	-	-	2	-	1	-	2	-	1	-
CO 5	-	1	-	-	-	-	-	-	1	2	-	-	1	2

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Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓			✓
CO 4			✓	✓
CO 5		✓	✓	✓

Discipline	**ENVIRONMENTAL SCIENCES**				
Course Code	**UK2DSCENS102**				
Course Title	**ENVIRONMENTAL METEOROLOGY**				
Type of Course	**DSC**				
Semester	Second				
Academic Level	100 - 199				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 h	-	2h	5
Pre-requisites	A general concept of weather and climate and climate change				
Course Summary	This course is designed to give the learner a basic knowledge of the weather and climatic conditions. It explains the elements of weather and climate and the EMR and Energy Budget of the earth. After giving a detail on the measurement of various meteorological parameters, the course describes the world climate systems. Finally, the course intends to give an overview of the influence of the Anthropocene on weather and climate.				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Elements of Weather and Climate**	**10**
	1	Concept and elements of meteorology	2
	2	Vertical structure and composition of the atmosphere	4
	3	Change in the composition of the atmosphere (spatial and temporal)	4
II		**Solar Radiation and Energy Budget**	**8**
	4	Nature of solar radiation	1
	5	Laws of radiation	1
	6	Radiative heating and cooling, natural greenhouse effect	2
	7	Interactions of radiation with atmosphere, Terrestrial IR radiation	2
	8	Radiation and Heat Budget of Earth	2
III		**Meteorological Instruments (Practicum)**	**24**
	9	Rain measurements (Rain and types of rain gauges)	2
	10	Temperature measurements (construction and working of temperature scales, mercury thermometer, sensitivity, and accuracy, maximum and minimum thermometer, thermograph)	3
	11	Pressure measurements (construction and working of mercury barometer, aneroid barometer - construction and working, barograph)	3
	12	Wind measurements (construction and working of wind socks, wind vanes, anemometers, anemograph)	3
	13	Humidity measurements (construction and working of dry and wet bulb thermometers construction and working, psychrometric chart, hair hygrometer)	4

	14	Radiation measurements (Crooke's radiometer, Seebeck effect, thermopile, radiation pyrometer)	3
	15	State-of the art technologies (Program Logical Circuit based)	4
IV	**World Climate System**		**6**
	16	Climates of hemispheres	2
	17	Global distribution of temperatures	2
	18	Global distribution of pressure	2
V	**Influence of Anthropocene in Weather and Climate**		**12**
	19	Preliminary Concepts - Climate Change and variability	2
	20	Drivers of Climate Change	2
	21	Response of living organisms to climate change	2
	22	Biodiversity loss in the terrestrial environment due to climate change	2
	23	Biodiversity loss in the aquatic environment due to climate change	2
	24	Effect of climate change on natural resources	2
	25	Open-ended	**15**

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Course Outcomes

No.	**Upon completion of the course, the graduate will be able to**	**Cognitive Level**	**PSO addressed**
CO-1	Define and explain the elements of weather and climate	U	PSO-1,2
CO-2	Describe the electromagnetic spectrum, the rules and characteristics, and the Heat budget of the earth	R, U	PSO-1,2, 3
CO-3	Explain the various Meteorological Instruments	R	PSO 3, 9
CO-4	Describe the World Climate System	R, U	PSO 3, 4
CO-5	Analyze the possible causes of climate-related disasters	An	PSO 4, 8, 9 PO 1,2, 6

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Credits: 3:0:1 (Lecture:Tutorial: Practical)

CO No.	**CO**	**PO/PSO**	**Cognitive Level**	**Knowledge Category**	**Lecture (L)/Tutorial (T)**	**Practical (P)**
CO-1	Define and explain the elements of weather and climate	PSO-1,2	U	F, C	10	-
CO-2	Describe the electromagnetic spectrum, the rules and characteristics, and the Heat budget of the earth	PSO-1,2, 3	R, U	F, C	6	2

CO-3	Explain the various Meteorological Instruments	PSO 3, 9	R	F, C, P	20	4
CO-4	Describe the World Climate System	PSO 3, 4	R, U	F, C	6	-
CO-5	Analyze the possible causes of climate-related disasters	PSO 4, 8, 9 PO 1,2, 6	An	F, C	15	-

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	3	3	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	2	3	3	-	-	-	-	-	-	-	-	-	-	-
CO 3	-	-	3	-	-	-	3	-	-	-	-	-	-	-
CO 4	-	-	2	2	-	-	-	-	-	-	-	-	-	-
CO 5	-	-	-	2	-	2	3	3	-	-	-	3	-	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Field experiments
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓	✓	✓
CO 5		✓		✓

Discipline	**ENVIRONMENTAL SCIENCES**				
Course Code	**UK2MDCENS100**				
Course Title	**ENVIRONMENTAL ETHICS**				
Type of Course	**MDC**				
Semester	SECOND				
Academic Level	100 to 199				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	3	3 h	-	-	3
Pre-requisites	Knowledge of environmental studies and current environmental issues				
Course Summary	Environmental ethics is the study of ethical relationships between humans and other entities, primarily the environment and non-human organisms. It also includes the study of theories of value and how they apply to our moral relationships. In this course we will assess the strengths and weakness of a variety of normative ethical theories and theories of value, including theories like holism and deep ecology that have had a substantial impact in environmental ethics in particular. Ethics benefits strongly from an applied component, so a substantial portion of the course will focus on applying the theories we discuss to key debates in environmental ethics, including sustainability, animal rights, environmental justice, climate change, and rapid technological advancement.				

Detailed Syllabus:

Module	**Unit**	**Content**	**Hours**
I	**Environmental philosophy and environmental ethics**		**7**
	1	Environmental ethics- a brief history	1
	2	Understanding the meaning of value	1
	3	Environmental philosophies	1
	4	Environmental awareness – Before the Publication of Silent Spring in 1962	2

	5	Environmental Movement from 1962 to 1992	1
	6	Environmental Movement since the 1980s to the Present Day	1
II	**Basics of environmental ethics**		**7**
	7	Evolution of environmental ethics	1
	8	Concept of environmental ethics	1
	9	Philosophies of biocentrism and ecocentrism	1
	10	Application of ethics to environmental issues	2
	11	Ecofeminism	1
	12	Environmental equity and justice.	1
III	**Anthropocentrism and Non Anthropocentric conceptions**		**8**
	13	Philosophical roots of Anthropocentrism	2
	14	Animal liberation	1
	15	Deep ecology, Land ethics, Eco-interests	1
	16	Biocentricism	2
	17	Ecological animalism	2
IV	**Concept of Sustainability**		**8**
	18	Sustainable development: the conventional definition	2
	19	Viewpoints on Conservation and sustainability	2
	20	Traditional ecological knowledge and the idea of a local economy	2
	21	Achieving a sustainable economy - two ideas	2
V	**Human place in nature and Restoration of Nature**		**6**
	22	The action of man upon nature	2
	23	Getting back to nature, Human restoration of nature	2
	24	Philosophical roots of the park and forest Service	2
	25	Open Ended	**9**

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Understand different concepts of environmental ethics	U	PSO 1
CO-2	Define the concepts central to environmental ethics	R	PSO 4
CO3	Explain and define one's own ethical standpoint according to these ethical concepts	U	PSO 5
CO4	Discriminate and assess claims regarding moral considerability	Ap	PSO 5
CO5	Understand and evaluate one's own concrete interaction to the surrounding world , especially in reference to the concept of sustainability	An	PSO 3, PSO 5

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Credits: 3:0:0 (Lecture:Tutorial:Practical)

CO No.	**CO**	**PO/PSO**	**Cognitive Level**	**Knowledge Category**	**Lecture (L)/Tutorial (T)**	**Open Ended**
1	Understand different concepts of environmental ethics	PSO 1	U	F, C	10	2
2	Define the concepts central to environmental ethics	PSO 4	R	P	10	2
3	Explain and define one's own ethical standpoint according to these ethical concepts	PSO 5	U	U	10	2
4	Discriminate and assess claims regarding moral considerability	PSO 5	Ap	Ap	10	2
5	Understand and evaluate one's own concrete interaction to the surrounding world , especially in reference to the concept of sustainability	PSO 3, PSO 5	An	An	10	2

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO 1	1	-	-	1	-	-	-	1	-	1	-	1	-	1
CO 2	2	2	-	-	1	-	1	-	-	-	1	-	-	-
CO 3	-	-	1	-	-	-	-	-	2	-	-	-	2	-
CO 4	-	-	2	3	-	-	2	-	1	-	2	-	1	-

CO 5	-	1	-	-	-	-	-	-	1	2	-	-	1	2

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Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓

CO 2	✓	✓		✓
CO 3	✓			✓
CO 4			✓	✓
CO 5		✓	✓	✓

Discipline	**ENVIRONMENTAL SCIENCES**				
Course Code	**UK2MDCENS101**				
Course Title	**INTELLECTUAL PROPERTY RIGHTS**				
Type of Course	**MDC**				
Semester	Second				
Academic Level	100 to 199				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	3	3 h	-	-	3
Pre-requisites	Basic understanding of intellectual property, trade mark and copyrights				
Course Summary	IPR provide certain exclusive rights to the inventors or creators of that property, in order to enable them to reap commercial benefits from their creative efforts or reputation. There are several types of intellectual property protection like patent, copyright, trademark, etc. This course is designed to provide comprehensive knowledge to the students regarding the general principles of IPR, its concept and theories. After the course completion the students will be able to explore the various theories, approaches, view and functional mechanism of IPR across the world and legal response to the same, to examine the protection mechanism of Intellectual Property Rights and to focus upon the Trademarks, Copyright and GI, Design, Traditional Knowledge, and other IPR under various legislation.				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Introduction to Intellectual Property Rights**	**8**
	1	Meaning of property, Origin, Nature, Meaning of Intellectual Property Rights, concept of intellectual Property and the need for protection	2
	2	The world Intellectual property Organization (WIPO) Convention - Origin and functions of World Trade Organization (WTO) -	2

	3	Trade Related Intellectual Property Rights (TRIPS) Agreement of WTO and its effects on Intellectual Property law in India; Dispute Settlement Mechanism.	2
	4	Types of Intellectual property rights—Copy Right, Patent, Trade Mark, Trade Secret and trade dress, Design, Layout Design, Geographical Indication, Plant Varieties and Traditional Knowledge.	2
II		**Patent rights**	**7**
	5	Introduction to Patent, Origin	1
	6	Types, Inventions which are not patentable	1
	7	Registration Procedure	1
	8	Rights and Duties of Patentee	1
	9	Assignment and licence , Restoration of lapsed Patents,	1
	10	Surrender and Revocation of Patents, Infringement,	1
	11	Remedies & Penalties.	1
III		**Copy right**	**6**
	12	Origin, Definition &Types of Copy Right	1
	13	Registration procedure,	1
	14	Assignment & licence	1
	15	Terms of Copy Right, Piracy	1
	16	Infringement, Remedies	1
	17	Copy rights with special reference to software	1
IV		**Trade marks, Design and Geographical indications**	**10**
	18	Origin, Meaning & Nature of Trade Marks, Types, Registration of Trade Marks, offence relating to Trade Marks, Passing Off, Penalties, Domain names on cyber space	2
	19	Introduction to Design, Registration of Design, Cancellation of Registration	2
	20	International convention on design, functions of Design. Semiconductor Integrated circuits and layout design Act-2000.	2
	21	Geographical Indications of Goods (Registration and Protection) Act, 1999 - Objects and Reasons of the Act	2
	22	Registrations – Cancellation – Rectification – Correction of Register – Infringement – Offences & Penalities - Remedies.	2
V		**Protection of traditional knowledge, plant varieties and biotechnology**	**5**
	23	Meaning and Scope of traditional Knowledge – Interface between IP and traditional Knowledge – Need and Significance of protection - International instruments on Traditional Knowledge	2
	24	Protection of Plant Varieties and Farmer's rights – GM Corps – Objectives of Plant Varieties Act – registration of Plant Varieties – Duration and effect of Registration – Infringement – Offences – Remedies. Introduction - Protection of Biological Inventions – Plant Patent Protection in India – Biotech Patents in India - Research and Development in Biotechnology	3
	25	Open ended	9

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Course Outcomes

No.	**Upon completion of the course the graduate will be able to**	**Cognitive Level**	**PO/PSO addressed**
CO-1	Imbibe the knowledge of Intellectual Property and its protection through various laws	U	PO1, PSO 1,5
CO-2	Apply the knowledge of IPR for professional development	Ap	PO6, PSO 3, 4

CO-3	Develop a platform for protection and compliance of Intellectual Property Rights & knowledge	An	PO3, PSO 4, 5
CO-4	Create awareness amidst academia and industry of IPR and Copyright compliance	C	PO4,6, PSO 6
CO-5	Deliver the purpose and function of IPR and patenting	Ap	PO5,8, PSO 5,6

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Credits: 4:0:0 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)	Open ended
CO -1	Imbibe the knowledge of Intellectual Property and its protection through various laws	PO1, PSO 1,5	U	F, C	10		3
CO -2	Apply the knowledge of IPR for professional development	PO6, PSO 3, 4	Ap	P	10	2	3

CO -3	Develop a platform for protection and compliance of Intellectual Property Rights & knowledge	PO3, PSO 4, 5	An	F,M	8	2	2
CO -4	Create awareness amidst academia and industry of IPR and Copyright compliance	PO4,6, PSO 6	C	F	8	2	2
CO -5	Deliver the purpose and function of IPR and patenting	PO5,8, PSO 5,6	Ap	P	6		2

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	1	-	-	2	-	-	2	-	1	3	2	-
CO 2	2	1	-	-	3	-	3	1	-	2	-	1

CO 3	-	-	2	-	-	1	-	3	2	-	-	1
CO 4	-	-	2	3	-	-	2	-	3	1	1	3
CO 5	-	1	-	1	-	3	1	3	-	1	1	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

§ Quiz / Assignment/ Quiz/ Discussion / Seminar
§ Midterm Exam
§ Assignments
§ Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2				✓
CO 3				✓
CO 4				✓
CO 5	✓	✓		✓
CO 6	✓		✓	✓

SEMESTER III

Discipline	**ENVIRONMENTAL SCIENCES**				
Course Code	**UK3DSCENS200**				
Course Title	**ENVIRONMENTAL MICROBIOLOGY AND BIOTECHNOLOGY**				
Type of Course	**DSC**				
Semester	Third				
Academic Level	200 - 299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 h	-	2	5
Pre-requisites	Should know basics of structure of DNA, replication and transcription				
Course Summary	This course is divided into two areas; Environmental Microbiology and Environmental Biotechnology. The course is planned to give an insight to the learners about the microorganisms in the environment and the multitude of their actions in the sustenance of the environment and the environmental processes. It describes the methods for culturing and enumerating microbes from environmental samples. In the Environmental Biotechnology portion of the course, the learners are given some basics on the structure of genetic material and the various functions of those. After that, the course introduces recombinant DNA technology, Genetically Modified Organisms, and the various environmental aspects and applications of these.				

Detailed Syllabus:

Module	**Unit**	**Content**	**Hrs**
I		**Introduction to Environmental Microbiology**	**15**
	1	Significance of microorganisms in the environment	2
	2	Principles of microscopy	2
	3	Types of microorganisms	2
	4	Observation of microorganisms using microscope (practicum)	3
	5	Role of microbes in Environmental Processes - Biogeochemical Cycles	3
	6	Microbes in Environmental Processes - Bioremediation	3
II		**Tools in Microbiology**	**15**
	7	Sampling for microbial analysis (soil, water, and air) with practical	3
	8	Types of Culture Media	1
	9	Sterilization Techniques	2
	10	Culture and Preservation of Microorganisms	1
	11	Methods of isolation and enumeration of Microorganisms in Soil, Water (Practicum)	3
	12	Membrane filtration technique, MPN	2
	13	Principles and applications of autoclave, laminar air flow chamber, Hot Air Oven, Incubator	3

III		**Basics of Biotechnology**	**10**
	14	Structure of genetic material	2
	15	Replication, transcription, and translation	2
	16	Recombinant DNA technology	3
	17	GMOs and Environmental Implications	3
IV		**Scope and Applications of Environmental Biotechnology**	8
	18	GMOs in Environmental Management - Pollution control (bioremediation), restoration of degraded lands, wastewater treatment, aerobic and anaerobic digestion, biogas from wastes, reduced need for pesticides, resistance to stress, food security	5
	19	Biopesticides and biofertilizers	3
V		**Biotechnological methods for environmental Analysis**	**5**
	20	PCR	1
	21	FISH	1
	22	FAME	1
	23	SIP	1
	24	DNA Sequencing and Molecular Phylogeny	1
	25	Open Ended	15

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Course Outcomes

No.	Upon completion of the course, the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Describe the history of Environmental Microbiology and the environmental aspects of it	R, U	PSO-1,2
CO-2	Explain the various tools used in Environmental	R, U	PSO-1,3

	Microbiology		PO-2, 6
CO-3	Describe the structure and function of genetic materials	R	PSO-1,2
CO-4	Explain the scope of Environmental Biotechnology and Microbiology in environmental management	R, U	PSO-4 PO-2, 5, 8
CO-5	List out and explain the Biotechnological tools used for environmental analysis and suggest the suitable techniques which can be used for an environmental analysis	U. Ap	PSO-4,5 PO-1,2

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Credits: 3:0:1 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO-1	Describe the history of Environmental Microbiology and the environmental aspects of it	PSO-1,2	R, U	F, C, P	10	5
CO-2	Explain the various tools used in Environmental Microbiology	PSO-1,3 PO-2, 6	R, U	P	12	3
CO-3	Describe the structure and function of genetic materials	PSO-1,2	R	F	10	-
CO-4	Explain the scope of Environmental Biotechnology and Microbiology in environmental management	PSO-4 PO-2, 5, 8	R, U	C, M	6	2

CO-5	List out and explain the Biotechnological tools used for environmental analysis and suggest the suitable techniques which can be used for an environmental analysis	PSO-4,5 PO-1,2	U. Ap	F, M	5	-

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PS O5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	3	3	-	-	-	-	-	-	-	-	-	-
CO 2	2	-	3	-	-	-	-	2	-	-	-	3
CO 3	3	3	-	-	-	-	-	-	-	-	-	-
CO 4	-	-	-	3	-	-	-	3	-	-	2	-
CO 5	-	-	-	2	3	-	3	3	-	-	-	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Laboratory
- Midterm Exam
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓
CO 5		✓		✓
CO 6			✓	

Discipline	**ENVIRONMENTAL SCIENCES**
env	**UK3DSCENS201**
Course Title	**ENVIRONMENTAL POLLUTION**
Type of Course	**DSC**
Semester	Third
Academic Level	200 - 299

Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 h	-	2 h	5

Pre-requisites	1. Real world issues and solutions 2. Should have undergone major environmental issues
Course Summary	Environmental pollution is a comprehensive study of the various pollutants that degrade the quality of the environment and threaten ecosystems, human health, and biodiversity. This course explores the sources, effects, and control measures of pollution in air, water, soil, and noise. It also examines the societal, economic, and regulatory aspects of environmental pollution and discusses sustainable solutions to mitigate its impacts.

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Introduction to Environmental Pollution**	**8**
	1	Definition and scope of environmental pollution	4
	2	Types of pollution; point and nonpoint sources	4
II		**Air and Noise Pollution**	**12**
	3	Sources and types of air pollutants	1
	4	Atmospheric chemistry and formation of smog	3
	5	Health effects of air pollution	2
	6	Climate change and greenhouse gas emissions	2
	7	Noise Pollution: Effects and consequences	2
	8	Control measures for air and noise pollution	2
III		**Water Pollution and Radioactive Pollution**	**16**
	9	Types and sources of water pollutants	2
	10	Surface water contamination	3
	11	Groundwater contamination	1
	12	Eutrophication and harmful algal blooms	2
	13	Radio active Pollution types, effects and consequences	3
	14	Disposal and Management of radio aactive pollution	3
	15	Water Quality Standards	2
IV		**Soil Pollution**	**12**
	16	Sources and types of soil pollutants	2
	17	Contaminated land and brownfield sites	2
	18	Soil erosion and degradation	2

	19	Heavy metals and organic contaminants	3
	20	Soil remediation techniques	3
V		**Marine Pollution**	**12**
	21	Sources and impacts of marine pollution	3
	22	Oil spills and their ecological consequences	3
	23	Plastic pollution and marine debris	3
	24	Overfishing and habitat destruction	3
	25	Open ended	15

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Gain an understanding of the interconnectedness of natural systems and how human activities can disrupt these systems, leading to environmental pollution.	U	PSO-1,2
CO-2	Identify various types of pollutants, including air pollutants, water pollutants, soil contaminants, and noise pollution, along with their sources, characteristics, and effects on ecosystems and human health.	R, U	PSO 2,4
CO-3	Learn about strategies and technologies for mitigating pollution and remediating contaminated environments, including pollution prevention, waste management, and pollution control technologies.	Ap	PSO 4,5
CO-4	Develop critical thinking skills to analyse complex environmental issues related to pollution and formulate evidence-based solutions to address them.	E, C	PSO 4,6

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

References

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Name of the Course: Credits: 4:0:1 (Lecture: Tutorial:Practical)

CO No.	**CO**	**PO/PSO**	**Cognitive Level**	**Knowledge Category**	**Lecture (L)/Tutorial (T)**	**Practical (P)**
CO-1	Gain an understanding of the interconnectedness of natural systems and how human activities can disrupt these systems, leading to environmental pollution.	PSO -1,2	U	F, C		
CO-2	Identify various types of pollutants, including air pollutants, water pollutants, soil contaminants, and noise pollution, along with their sources, characteristics, and effects on ecosystems and human health.	PSO 2,4	R, U	P		
CO-3	Learn about strategies and technologies for mitigating pollution and remediating contaminated environments, including pollution prevention, waste management, and pollution control technologies.	PSO 4,5	Ap	P,M		
CO-4	Develop critical thinking skills	PSO	E, C	M		

	to analyse complex environmental issues related to pollution and formulate evidence-based solutions to address them.	4,6				

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	2	1	-	-			3	2	-	1	-	-
CO 2	-	2	-	1			2	-	1	-	-	3
CO 3	-	-	3	-	2		-	1	-	2	-	3
CO 4	-	-	-	3	-	2	3	2	1	-	-	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓

Discipline	**ENVIRONMENTAL SCIENCES**				
Course Code	**UK3DSCENS202**				
Course Title	**ENERGY AND ENVIRONMENT**				
Type of Course	**DSC**				
Semester	Third				
Academic Level	200 to 299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 h	-	2 h	5
Pre-requisites	• The students should have background knowledge on the different energy resources present in earth. • Students should have an overall idea regarding energy conservation and management strategies around the world.				
Course Summary	The modules under energy and environment covers areas like conventional and non-conventional energy sources and its conservation. Students also learn sustainable energy efficient practices.				

Detailed Syllabus:

Module	Unit	Content	Hrs
I	*Introduction to energy*		**10**
	1	Definition and concepts to Energy	2
	2	Classification of Energy sources	2
	3	Present status of energy consumption	2
	4	Energy Scenario – Global and Indian	2
	5	Energy Policy-India	2
II	*Conventional Sources of Energy*		**15**
	6	Non-Renewable Sources of Energy	3
	7	Advantages & Disadvantages of Non-Renewable Sources of Energy	3
	8	Fossil Fuel, Coal, Petroleum (or crude oil), Natural Gas, LNG, CNG, Hydrogen	3
	9	Refinery products of petroleum (i.e. Crude oil)	3
	10	Nuclear Energy	3
III	*Non-conventional Sources of Energy*		**15**
	11	Solar Energy - applications, advantages and limitations	2
	12	Hydro-Electric Energy (Hydro power)	1
	13	Wind Energy (Field Visit-Practicum)	2
	14	Biomass Energy (wood waste, Biofuels viz; Ethanol & Biodiesel)	2
	16	Alcohol as a source of Energy (Gasohol, Methanol & Ethanol).	1

	17	Biogas generation Technology (Field Visit-Practicum)	3
	18	Geothermal energy reservoirs & their uses	2
	19	Tidal Energy and Sea-wave Energy	2
	20	Ocean Thermal Energy Conversion (OTEC)	
IV	***Energy Management***		**10**
	21	Definitions and significance, objectives, Energy Management programs	7
	22	Energy strategy for future, Energy Audit (Practicum)	3
V	***Energy conservation***		**10**
	23	Principles of Energy economics	4
	24	Energy conservation technologies, cogeneration, Waste heat recovery, Combined cycle power generation	6
	25	Open Ended	**15**

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Understand different concepts of available energy sources	U	PSO1
CO-2	Define the basic principles of Energy efficient technologies.	R	PSO 2
CO3	Understand and identify energy management strategies	U	PSO 5
CO4	Address major issues related to conservation of energy	Ap	PSO 5
CO5	Analyse the possible alternatives for energy use and recovery for future	An	PSO 3, PSO 6

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Credits: 4:0:0 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)	Open Ended
1	CO-1	Understand different concepts of available energy sources	U	R,U	10	2	3
2	CO-2	Define the basic	R	Ap	10	2	3

		principles of Energy efficient technologies.					
3	CO3	Understand and identify energy management strategies	U	R,U	10	2	3
4	CO4	Address major issues related to conservation of energy	Ap	E	10	2	3
5	CO5	Analyse the possible alternatives for energy use and recovery for future	An	E	12		3

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	1	-	-	1	-	-	-	1	-	1	-	1
CO 2	2	2	-	-	1	-	1	-	-	-	1	-
CO 3	-	-	1	-	-	-	-	-	2	-	-	-
CO 4	-	-	2	3	-	-	2	-	1	-	2	-
CO 5	-	1	-	-	-	-	-	-	1	2	-	-

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Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓
CO 5		✓		✓
CO 6			✓	

Discipline	**ENVIRONMENTAL SCIENCES**				
Course Code	**UK3DSEENS200**				
Course Title	**WETLAND ECOLOGY**				
Type of Course	**DSE**				
Semester	Third				
Academic Level	200 - 299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	4 h	-		4
Pre-requisites	Learners should have a basic idea about wetlands and its importance				

Course Summary	The course will provide a fundamental understanding of wetland ecosystems, the flora, fauna, and the abiotic aspects of wetlands. Mangroves, Seagrass meadows, Coral reefs, marshes, and swamps will be dealt with. Specifically, the course will encompass adaptations of flora and fauna to the specific ecosystems, the species dynamics, and aspects of wetland management and restoration. The theoretical learning shall be complemented by field visits and field studies.

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Wetlands**	**10**
	1	Introduction to Wetlands, Classification, and sub-classifications of Wetlands (Inland, coastal; Natural, Man-made)	2
	2	Types (Mangroves, Seagrass meadows, Coral reefs, Marshes, Swamps),	2
	3	Salient features of wetlands, Wetlands as blue carbon ecosystems	3
	4	Significance and ecosystem services of wetlands (water storage and purification, productivity, biochemical values, geomorphologic values, biotic values, and other values)	3
II		**Hydrology of Wetlands**	**15**
	5	Wetland hydrology – the driving force of wetland formation, geomorphic position	5
	6	Wetland water level, Hydrologic Measures (relative elevation from soil level, temporal variability of water level, residence time of water movement), Monitoring water levels	5
	7	Wetland water budget (in brief)	2
	8	Wetland stressors	3
III		**Wetland Soils**	**10**
	9	Physical and chemical and biological properties	3
	10	Types of soils in wetlands (organic, mineral, hydric soils	3
	11	Redox gradients	2
	12	Nutrient contents of wetlands	2
	13	Toxins in wetlands	2
IV		**Life in Wetlands**	**8**
	14	Flora and Fauna of wetlands	4
	15	Adaptations of flora and fauna in wetlands	4
V		**Wetland: Threats, Protection and Management**	**25**
	16	Threats: (Climate Change, pollution, invasive species, urbanization, agriculture, draining, salinization)	4
	17	Global Level (Ramsar Convention, Montreux Record, World Wetland Day)	4
	18	National Level (Wetlands (Conservation and Management) Rules, 2017, Action Plan of MoEFCC	2
	19	Wetland restoration	2
	20	National Wetland Inventory and Assessment (NWIA)	1
	21	National Wetland Conservation Program (NWCP)	1

	22	India’s wetlands of international importance	1
	23	Visit to mangrove ecosystems	5
	24	Observation of flora and fauna in wetlands - field visit	5
	25	Open ended	12

References

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https://www.epa.gov/sites/default/files/documents/wetlands_20hydrology.pdf

Course Outcomes

No.	Upon completion of the course, the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Define, classify, and describe the importance and salient features of wetlands	R, U	PSO-1,2 PO-1,3
CO-2	Explain various aspects related to the hydrology of wetlands	R. An	PSO 1, 2, 3 PO-1
CO-3	Describe the properties of wetland soils at various	R, U	PSO 1, 2,

	conditions of wetlands		3 PO-1
CO-4	Explain the types of life in wetlands and their adaptations	U, An	PO-1,2,8
CO-5	List and explain the global and national initiatives for conservation and protection of wetlands	R. U	PSO-1,2 PO- 1,2

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Credits: 3:0:0 (Lecture: Tutorial: Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO-1	Define, classify, and describe the importance and salient features of wetlands	PSO-1,2 PO-1,3	R, U	F, C	7	-
CO-2	Explain various aspects related to the hydrology of wetlands	PSO 1, 2, 3 PO-1	R. An	P	12	3
CO-3	Describe the properties of wetland soils at various conditions of wetlands	PSO 1, 2, 3 PO-1	R, U	C. P	8	4
CO-4	Explain the types of life in wetlands and their adaptations	PO-1,2,8	U, An	F, C	5	1
CO-5	List and explain the global and national initiatives for	PSO-1,2 PO- 1,2	R. U	F, C. P	25	10

	conservation and protection of wetlands					

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	3	2	-	-	-	-	2	3	-	-	-	-
CO 2	2	3	3	-	-	-	2	-	-	-	-	-
CO 3	3	3	1	-	-	-	2	-	-	-	-	-
CO 4	-	-	-	-	-	-	3	3	-	-	-	-
CO 5	2	3	-	-	-	-	2	2	-	-	-	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Field observations and experiments
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓
CO 5		✓		✓
CO 6			✓	

Discipline	**ENVIRONMENTAL SCIENCE**
Course Code	**UK3DSEENS201**
Course Title	**ECOHYDROLOGY**
Type of Course	**DSE**
Semester	III
Academic Level	200 - 299

Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3	-	2	5
Pre-requisites	1. Basics of ecology 2. Basic knowledge of land and water resources				
Course Summary	The course also identifies and quantifies the critical linkages between ecological processes and the hydrological cycle. This course provides a quantitative description of fundamental ecohydrologic processes, the interactions of between water and the atmosphere, soils, and plants, as well as techniques for estimating the movement of water in the though ecosystems.				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Water resource**	**10**
	1	Hydrological cycle: Precipitation and evapotranspiration	2
	2	Introduction to surface and ground water; Water table	2
	3	Vertical distribution of water - aquifers and hydraulic potential	3
	4	Flow and connectivity of surface runoff and groundwater systems	3
II		**Water and watershed management**	**10**
	5	Demand for water (agriculture, industrial, domestic); overuse and depletion of surface and ground water resources.	3
	6	Ground water storage and recharge	3
	7	Watershed and drainage basins; importance of watershed and watershed management	2
	8	Integrated watershed management – Field study	2
III		**Fundamentals of soil science**	**15**
	9	Formation and classification of soil; soil architecture	2
	10	Physical properties of soil: soil texture, soil profile, water holding capacity, soil temperature and soil colloids	2
	12	Chemical properties of soil: soil acidity and alkalinity, soil salinity and sodicity, soil organic matter and micronutrients	2
	13	Soil biodiversity – Field study	2
	14	Toxic organic chemicals, and organic contaminants in soils	2
	15	Fertilizers and fertilizer management	2
	16	Recycling of soil nutrients	3
IV		**Introduction to Land Resource**	**15**
	17	Land as a resource - ecological and economic importance	3
	18	Land use pattern	3
	19	Forest and Agriculture – Field study	3
	20	Major Biogeographic regions in India	3
	21	Land resources and people – Dependence and Interaction	3
V		**Management of water and land degradation**	**10**
	22	The extent and cost of water land degradation	3
	23	Protect and restore ecosystems and promote sustainable use of natural resources	4

	24	Strategies and policies to reach a water-land degradation neutral world	3
	25	Open ended	**15**

Books and References:

1. Ecohydrology of Kerala River Catchments and Coastal Backwaters, 2024, Salom Gnana Thanga Vincent, Tim C. Jennerjahn, Soman Kunjupillai, Srikumar Chattopadhyay, eBook ISBN: 9780323956079
2. River Basin Ecohydrology in the Indian Sub-Continent - Sustainable Strategies and Sustenance, 2024, AL Ramanathan, Manish Kumar, Sangam Shrestha, Keisuke Kuroda, Santanu Mukherjee, eBook ISBN: 9780323915465.
3. Ecohydrology of Water-Controlled Ecosystems – Soil Moisture and Plant Dynamics" by Ignacio Rodriguez-Iturbe and Amilcare Porporato. Cambridge University Press, Cambridge, UK, 2004.
4. Ecohydrology - Darwinian Expression of Vegetation Form and Function by Peter S. Eagleson. Cambrige University Press, Cambridge, UK, 2002.
5. Eco-hydrology – Plants and water in terrestrial and aquatic environments" edited by Andrew J. Baird and Robert L. Wilby. Routledge, NY, 1999.
6. Hydroecology and ecohydrology: Past, present and future". Edited by Paul J. Wood, David M. Hannah and Jonathan P. Sadler. John Wiley and Sons, Inc., 2007.

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Students should grasp the fundamental principles governing the movement and distribution of water in the environment. Students should be familiar with various hydrological processes, including precipitation, evaporation, infiltration, runoff, groundwater flow, and streamflow generation.	U	PSO-1,2
CO-2	Students should be aware of the environmental impacts of land-use changes, climate change, and human activities on water resources and soil health. Students should acquire skills in watershed management, including watershed modeling, land-use planning, and water resources conservation.	R, U	PSO 2, 3
CO-3	Students should understand soil properties such as texture, structure, color, moisture content, and hydraulic conductivity, and their implications for water movement and storage.	Ap	PSO 3, 4, 5
CO-4	Students should be aware of various land use pattern as well as the environmental impacts of land-use changes,	An, E	PSO 3, 5

	climate change, and human activities on water resources and soil health.		
CO-5	Overall, the course aims to provide students with a holistic understanding of water and soil resources and equip them with the knowledge, skills, and attitudes needed to address complex environmental challenges related to water and soil management.	Ap, C	PSO 7, 9

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Credits: 4:0:0 (Lecture: Tutorial: Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
1	Gather information about status of water resources	PSO-1,2	U	F, C	10	2
2	Explain watershed, associated problems and mitigations	PSO 2, 3	R,U	P	10	4
3	Knowledge about status of soil and its characteristics	PSO 3, 4, 5	Ap,	C	15	3
4	Students should gather core information about land use systems	PSO 3, 5	An, E	P	15	3
5	Enable the students to addressing water and soil related issues and mitigations	PSO 7, 9	Ap, C	P, M	10	3

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	1	-	-	2	-	1	3	-	1	-	-	-
CO 2	2	3	-	-	1	-	1	-	-	2	-	3
CO 3	-	2	1	-	-	-	-	1	-	-	-	3
CO 4	-	-	2	3	-	-	1	3	-	2	-	-
CO 5	-	1	-	1	3	-	1	1	-	-	-	3
CO 6	1	-	-	2	-	1	3	-	1	-	-	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓
CO 5		✓		✓
CO 6			✓	✓

Discipline	**ENVIRONMENTAL SCIENCES**				
Course Code	**UK3DSEENS202**				
Course Title	**FOREST ECOLOGY**				
Type of Course	**DSE**				
Semester	Third				
Academic Level	200-299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 h	-	2 h	5
Pre-requisites	1. A solid foundation in biology for understanding concepts such as ecology, evolution, genetics, and physiology 2. Fundamental knowledge in ecological principles, including population				

	dynamics, community interactions, and ecosystem processes
Course Summary	In this course, students will gain a comprehensive understanding of forest ecosystems and their components. They will explore the ecological principles governing forest structure and function, including forest classification based on climate, vegetation, and soil. Additionally, students will delve into the study of major forest types examining their ecological characteristics, biodiversity patterns, and human impacts.

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Introduction to Forest Ecology**	**12**
	1	Understanding forest ecosystems and their components (the floral and faunal components and their interaction, variability and disturbance)	2
	2	Ecological principles governing forest structure and function (forest productivity, adaptations, competition, resource allocation, and succession	3
	3	Forest classification based on climate, vegetation, and soil. (Champion and Seth (1968) classification of forest types in India)	3
	4	Temporal Changes in Ecosystem Structure and Function (forest structure (e.g., tree density, canopy cover) and function (e.g., nutrient cycling, carbon sequestration))	2
	5	Ecological Observations and Measurements (sampling methods, experimental design, and data collection protocols in forest study)	2
II		**Forest Types and Biomes**	**12**
	6	Detailed study of major forest types of the world (e.g., tropical rainforests, temperate forests, boreal forests).	3
	7	Detailed study of major forest types in the Indian context (e.g., tropical evergreen, semi-evergreen, moist deciduous, littoral and swamp, grass lands etc).	3
	8	Ecological characteristics and biodiversity patterns in different forest types	2
	9	Trends and Depletion of the Forest Cover in India	2
	10	Human impacts on forest biomes.	2
III		**Forest Community Dynamics**	**12**
	11	Succession processes in forests (Community development and interaction, Structure Analysis, and Vegetation Dynamics, Ecophysiology)	2
	12	Role of disturbance in shaping forest communities (analysis of different types-fire, wind, pests, frequency, severity, and spatial patterns of disturbances.)	3
	13	Keystone species and their ecological significance (concept, significance, mechanisms of influence, maintaining balance and stability of ecosystems)	3
	14	Forest resilience and stability (species adaptations, buffering strategies, hydrologic cycle maintenance etc)	2
	15	Conservation Challenges and Opportunities (Stakeholders and Their Roles, international Conservation Bodies- IUCN, UNDP, FAO, WWF)	2

IV		**Forest Structure and Composition**	**12**
	16	Vertical and horizontal stratification in forests (vertical layers- forest floor, herb layer, shrub layer, understory, canopy. Horizontal – riparian zones, edge habitats, glades, forest patches, microhabitats, ecotones and their significance)	3
	17	Tree species diversity and dominance (Alpha, Beta, and Gamma Diversity, relative density, relative frequency, and relative dominance, invasive species)	3
	18	Forest Biodiversity and Carbon Pools (species richness, evenness, and diversity, aboveground biomass, belowground biomass, dead organic matter, and soil organic carbon)	2
	19	Forest stand dynamics (stand development, disturbance ecology, management implications)	2
	20	Forest Soils and Nutrient Cycling (nutrient cycling, biogeochemical processes, and the importance of soil health for tree growth and productivity)	2
V		**Forest Monitoring and Assessment (Practicum)**	**12**
	21	Remote sensing techniques for forest mapping.	3
	22	Biodiversity indices and monitoring protocols.	3
	23	Short/long-term ecological research in forests (temporary/permanent plots)	3
	24	Field Visit to national parks, wildlife sanctuaries, botanical gardens etc.	3
	25	**Open Ended**	**15**

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PO/PSO addressed
CO-1	Understand fundamental ecological concepts relevant to forest ecosystems, including nutrient cycling, energy flow, and trophic interactions. Identify and describe the key components, that constitute a forest ecosystem.	U, An	PO-1,2 PSO-1,2
CO-2	Compare and contrast the unique characteristics of each forest type, including climate, vegetation, and soil conditions, Exploring biodiversity patterns, to appreciate the intricate web of life in forests	U, An	PO-1,2 PSO-2, 3
CO 3	Recognize the ecological importance of disturbances in maintaining biodiversity and promoting resilience, Explore the resilience of forest ecosystems to environmental changes and disturbances	U, Ap	PO-1,3 PSO-2,3,5

CO 4	Understand how different forest strata contribute to overall ecosystem function, Understanding the role of understory vegetation in nutrient cycling, habitat provision, and wildlife support is essential.	U, An	PO-1,2 PSO-1,2
CO 5	Explore the health status of forests, including factors such as disease prevalence and pollution impacts, Learn about various remote sensing technologies used for mapping forested areas	Ap, E, C	PO-3,5 PSO-3,4,6

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

References

1. Routledge Handbook of Forest Ecology. Edited by Kelvin S.-H. Peh, Richard T. Corlett, and Yves Bergeron. Taylor & Francis, 2015 (1st edition).
2. Forest Ecosystems, David A. Perry, Ram Oren, and Stephen C. Hart. JHU Press, 2008 (1st edition).
3. Ecology of Woodlands and Forests: Description, Dynamics, and Diversity. Peter Thomas and John Packham. Cambridge, 2007 (1st edition).
4. Forest Inventory and Analysis: Principles and Practice.
5. Forest Ecology and Conservation: A Handbook of Techniques, Adrian Newton. Oxford Press, 2007 (1st edition).
6. Forest Ecology: An Evidence-Based Approach, D. Binkley. John Wiley & Sons, 2021 (1st edition)
7. Elements of Ecology, T. M. Smith and R. L. Smith, Pearson Education, India, 2015 (1st edition)
8. Forest Ecology, J. P. Kimmins. Prentice-Hall Inc., 2004 (1st edition)
9. Forest Ecology, 4th Edition, Burton V. Barnes and Donald R. Zak. Wiley, 1998.
10. Forest ecology: Recent advances in plant ecology, Arnold G. van der Valk. Springer, 2009.

Name of the Course: Credits: 3:0:1 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO addressed	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)	OE
CO-1	Understand fundamental ecological concepts relevant to forest ecosystems, including nutrient cycling, energy flow, and trophic	PO-1,2 PSO-1,2	U, An	F, C	12		2

	interactions. Identify and describe the key components, that constitute a forest ecosystem.						
CO-2	Compare and contrast the unique characteristics of each forest type, including climate, vegetation, and soil conditions, Exploring biodiversity patterns, to appreciate the intricate web of life in forests	PO-1,2 PSO-2, 3	U, An	F,C,P	12	3	2
CO 3	Recognize the ecological importance of disturbances in maintaining biodiversity and promoting resilience, Explore the resilience of forest ecosystems to environmental changes and disturbances	PO-1,3 PSO-2,3,5	U, Ap	F,C	12	3	3
CO 4	Understand how different forest strata contribute to overall ecosystem function, Understanding the role of understory vegetation in nutrient cycling, habitat provision, and wildlife support is essential.	PO-1,2 PSO-1,2	U, An	F, C	12	3	3
CO 5	Explore the health status of forests, including factors such as disease prevalence and pollution impacts, Learn about various remote sensing technologies used for mapping forested areas	PO-3,5 PSO-3,4,6	Ap, E, C	P, M		3	5

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	1	1	-	-	-	-	1	2	-	-	-	-
CO 2	-	3	2	-	-	-	2	1	-	-	-	-
CO 3	-	1	2	-	1	-	2	-	3	-	-	-
CO 4	2	3	-	-	-	-	2	2	-	-	-	-
CO 5	-	-	2	2	-	1	1	-	2	-	1	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Internal Exam
- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Project evaluation
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5		✓	✓	

Discipline	**ENVIRONMENTAL SCIENCES**				
Course Code	**UK3DSEENS203**				
Course Title	**FUNDAMENTALS OF CLIMATE CHANGE**				
Type of Course	**DSE**				
Semester	Third				
Academic Level	200 – 299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week

	4	3 h	-	2 h	5
Pre-requisites	1. knowledge in environmental science, earth science, or related disciplines with a solid foundation for understanding the Earth's climate system, atmospheric processes, and natural environmental changes. 2. Strong critical thinking skills and the ability to analyze complex scientific concepts and data are essential for comprehending the interdisciplinary nature of climate change and its implications				
Course Summary	Equip students with the knowledge, skills, and awareness necessary to understand and address one of the most pressing challenges of our time. By exploring the science, impacts, and responses to climate change, students will be empowered to contribute to efforts to mitigate greenhouse gas emissions, adapt to changing environmental conditions, and build a more sustainable and resilient future for all.				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Introduction to Climate Change**	**10**
	1	Introduction to the basics of climate change. climate, weather and the greenhouse effect.	2
	2	Drivers of climate change.	2
	3	Overview of important greenhouse gases and their main sources.	3
	4	History of climate change - pre and post industrial periods	3
II		**Impacts of Climate change**	**15**
	5	Global warming, melting of glaciers and polar ice caps, Sea level rise, forest fire, heat waves, health effects and prevalence of diseases	4
	6	Drought, Floods, Cyclones, Hurricanes and typhoons, loss of biodiversity and risk of extinction	4
	7	Food security and climate refugees	2
	8	The projected future trends and impacts of climate change on surface temperature, precipitation, ocean pH, sea-level and polar ice caps	5
III		**International Legal and Policy Framework to Address Climate Change**	**20**
	9	Intergovernmental Panel on Climate Change (IPCC)	2
	10	Brief history of international climate change negotiations key provisions of the UNFCCC	3
	11	The United Nations Framework Convention on Climate Change (UNFCCC) its organisational structure, and different Party groups under the Convention	4
	12	Natural and Anthropogenic Factors of climate change	3
	13	Instrumental Records and Climate Data Sources (Practicum)	4
	14	COP - Kyoto Protocol and its associated bodies	4
IV		**Climate Change Adaptations and mitigation**	**15**
	15	The concept of climate change adaptation, vulnerability, the expected consequences of climate change	3
	16	Framework for assessing climate vulnerability.	2

	17	Introduction to linkages between climate change adaptation and development.	2
	18	The political context to greenhouse gas emissions, the key emitters and strategies can be applied to bring down emissions to safe levels.	3
	19	Definitions of mitigation and overview of emissions levels and mitigation targets per country. Ways to integrate mitigation into development planning, through low emission development strategies.	5
V		**Technological advancement and climate change**	**15**
	20	Renewable Energy Technologies: Solar, Wind, Hydro, and Geothermal	4
	21	Energy Efficiency and Conservation Measures	4
	22	Carbon Capture and Storage (CCS) Technologies (Institution visit)	3
	23	Observing Climate Change (Practicum)	2
	24	Satellite Technology and Ground-based Measurements	3
	25	(Open ended)	15

References

1. Cambridge University (2013). Climate Change: Action, Trends and Implications for Business.
2. IISD, UNITAR & UNEP (2009). IEA Training Material: Vulnerability and Climate Change Impact Assessment for Adaptation.
3. IPCC (2013). Climate Change 2013. The Physical Science Basis - Summary for Policymakers.
4. OECD (2009): Guidance on Integrating Climate Change Adaptation into Development Co-operation.
5. Singh et al; (2021). Global Climate Change; Candice Janco, Elsevier
6. UNEP (2009). Climate Change Science Compendium UNEP (2009). Climate in Peril, a Popular Guide to the Latest IPCC Report.
7. UNEP & UNDP (2011). Mainstreaming Climate Change Adaptation into Development Planning: A Guide for Practitioners. UNFCCC. CGE Climate Change Training Materials.
8. UNFCCC (2006). UNFCCC Handbook. UNFCCC & UNEP (2002). Climate Change Information Kit.
9. UNFCCC (2008). Compendium on Methods and Tools to Evaluate Impacts of, and Vulnerability and Adaptation to, Climate Change.
10. World Bank Report (2012). Turn Down the Heat.
11. World Meteorological Organization (2012). Greenhouse Gas Bulletins.

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand the basic concepts of climate change	**U**	**C**	Instructor-created exams / Quiz

CO2	Identify key drivers of greenhouse gas emissions across various sectors	**U**		Group Discussions/ Debates
CO 3	Know the different environmental impacts of climate change	**An**	**P**	Group Discussions/ Debates
CO4	Understand the basic idea of International Legal Framework to Address environmental issues	**Ap**	**P**	Seminar Presentation / Group Tutorial Work
CO5	Design and implement climate change mitigation plans and policies	**Ap**	**P**	Presentation
CO6	Apply the knowledge to solve climate change problems	**An**	**C**	Instructor-created exams / Home Assignments

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Credits: 4:0:0 (Lecture:Tutorial:Practical)

CO No.	**CO**	**PO/PSO**	**Cognitive Level**	**Knowledge Category**	**Lecture (L)/Tutorial (T)**	**Practical (P)**
1	CO1	1		F, C	L	
2	CO2	2		C, P	L, P	
3	CO3	3,4		P, M	L	
4	CO4	5		M	L	
5	CO5	4,5	M		L	P
6	CO6	5, 6	M			P

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO 5**	**PSO6**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO 1	1	-	-	-								
CO 2	2	3	-	-								
CO 3	-	-	1	-								
CO 4	-	-	2	3								
CO 5	-	1	-	-								

CO 6	-	-	-	3								

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓
CO 5		✓		✓
CO 6			✓	

Discipline	ENIRONMENTAL SCIENCE				
Course Code	UK3DSEENS204				
Course Title	**Solid Waste Management**				
Type of Course	**DSE**				
Semester	III				
Academic Level	200 - 299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 h	-	2 h	5
Pre-requisites	1. Sources and types of wastes and their management				

Course Summary	This course is designed to provide participants with the necessary skills and knowledge to effectively manage solid waste in various contexts. Through a combination of theoretical learning and practical exercises, participants will gain insights into the principles, techniques, and best practices associated with solid waste management. Topics covered will include waste generation, collection, transportation, treatment and disposal, as well as recycling and resource recovery strategies. Emphasis will also be placed on environmental sustainability, regulatory frameworks, and community engagement in waste management initiatives.

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Introduction to Solid Waste Management**	**8**
	1	Definition and scope of solid waste	2
	2	Historical perspective and evolution of waste management practices	2
	3	Environmental and public health implications of improper waste management	4
II		**Waste generation and composition, collection and transportation**	**12**
	4	Factors influencing waste generation rates	3
	5	Classification and characteristics of solid waste streams	3
	6	Waste auditing and characterization studies	4
	7	Methods and techniques of waste collection	6
	8	Equipment and vehicles used for waste transportation	4
III		**Waste Treatment Technologies**	**20**
	9	Overview of waste treatment options: composting, incineration, anaerobic digestion, etc.	4
	10	Selection criteria for appropriate treatment methods	3
	11	Environmental considerations and regulatory requirements	1
	12	Landfill Management	2
	13	Principles of landfill design and operation	2
	14	Landfill siting and permitting processes	2
	15	Landfill gas management and leachate treatment	2
	16	Recycling and Resource Recovery	2
	17	Importance of recycling in waste management, Recycling processes and technologies	2
IV		**Sustainable Waste Management Practices**	**20**
	18	Integrated waste management approaches	2
	19	Circular economy principles in waste management	3
	20	Case studies of successful waste reduction and recycling programs	3
	21	Overview of solid waste management policies and regulations	3
	22	Role of government agencies and stakeholders in waste management	3
	23	Public awareness campaigns and education initiatives	3
	24	Role of NGOs and grassroots organizations in waste reduction efforts	3
V		Open ended	**15**

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Understand the concepts and principles of solid waste management.	U	PSO-1,2
CO-2	Identify different types of solid waste and their characteristics.	R, U	PSO-1,2
CO-3	Analyse the factors influencing waste generation rates and patterns.	An	PSO-2,3
CO-4	Evaluate the environmental, social, and economic impacts of improper waste management.	E	PSO-3,4,5
CO-5	Demonstrate proficiency in waste collection, segregation, and transportation techniques.	C	PSO-5,6,7
CO-6	Apply appropriate methods for waste treatment, including composting, incineration, and landfilling, recycling and resource recovery	Ap	PSO-6,7

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

REFERENCES

1. Agarwal,S.K. 2005. Green Management, APH Publishing corporation, New Delhi.
2. Agarwal,S.K. 2005. Wealth from waste, APH Publishing corporation, New Delhi
3. Bhatia,S.C. 2007. Solid and Hazardous Waste Management. Atlantic Publishers and Distributors, New Delhi
4. Bide,A.D. and R.R.Sundaresan. 2001. Solid Waste Management: Collection, processing and disposal. INSDOC, New Delhi
5. Government of India, "Manual on Municipal Solid Waste Management", CPHEEO, Ministry of Urban Development, New Delhi, 2000. 2. Bhide A.D. and Sundaresan, B.B. "Solid Waste Management Collection", Processing and Disposal, 2001
6. George Techobanoglous et al.1993. Integrated Solid Waste Management, McGraw-Hill, 1993
7. Khan,M.K. 2004. Hospital waste Management: Principles and guidelines, Kanishka Publishers, New Delhi
8. Liu,D.H.F. and R.G.Liptak. 2000. Hazardous waste and solid waste. Lewis
9. Manser A.G.R. and Keeling A.A.," Practical Handbook of Processing and Recycling of Municipal solid Wastes", Lewis Publishers, CRC Press, 1996

Name of the Course: Credits: 4:0:0 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO-1	Understand the concepts and principles of solid waste management.	PSO-1,2	U	F, C		
CO-2	Identify different types of solid waste and their characteristics.	PSO-1,2	R, U	P		
CO-3	Analyse the factors influencing waste generation rates and patterns.	PSO-2,3	An	P		
CO-4	Evaluate the environmental, social, and economic impacts of improper waste management.	PSO-3,4,5	E	M		
CO-5	Demonstrate proficiency in waste collection, segregation, and transportation techniques.	PSO-5,6,7	C	P,M		
CO-6	Apply appropriate methods for waste treatment, including composting, incineration, and landfilling, recycling and resource recovery	PSO-6,7	Ap	M		

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	1	-	-	-	-	-	2	-	--	-	-	-

CO 2	2	3	-	-	-	-	-	2	-	-	-	-
CO 3	-	-	1	-	-	-	-	-	2	-	-	-
CO 4	-	-	2	3	-	-	--	-	-	2	-	-
CO 5	-	1	-	-	-	-	-	-	-	-	2	-
CO 6	-	-	-	3	-	-	-	-	-	--	2	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓
CO 5		✓		✓
CO 6			✓	

Discipline	**ENVIRONMENTAL SCIENCES**				
Course Code	**UK3MDCENS200**				
Course Title	**ENVIRONMENTAL DATA ANALYTICS**				
Type of Course	**MDC**				
Semester	Third				
Academic Level	200 - 299				
Course Details	Credit	Lecture	Tutorial	Practical	Total

		per week	per week	per week	Hours/Week
	3	2 h	-	2 h	4
Pre-requisites	The learners should be interested in data analysis				
Course Summary	The course is essentially hands-on combined with theoretical learning. Learners will understand the basic statistical concepts with applications of these to the environmental disciplines. This course will help learners to extract, analyze, and manipulate data to reach conclusions. It deals with various data analytics tools and software that help in the analysis of environmental data. It includes probability and statistics, data structures and algorithms, data simulation, and data collection				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Data Structure and Algorithms**	**8**
	1	Array, iteration, and invariants; Efficiencies, and complexities	2
	2	Hash tables, Searching	2
	3	List, recursion, stacks, and queues	2
	4	Trees, Binary search trees, Sorting	2
II		**Probability and Statistics**	**10**
	5	Probability models, model checking	2
	6	Sampling Distribution and Limits	2
	7	Random variable and distribution	2
	8	Relationship among variable	2
	9	Statistical and optimal inferences	2
III		**Text Analytics (Practicum)**	**10**
	10	Natural Language basics	2
	11	Text Summarization and Classification	2
	12	Processing and understanding text	2
	13	Text Similarity and Clustering	1
	14	Semantic and Sentiment Analysis	2
IV		**Data collection and visualization (Practicum)**	**10**
	15	Survey sampling, statistical techniques	2
	16	Extracting and presenting statistics, Observational result	2
	17	Analysis of unstructured data	2
	18	Java, Customized geographic map	2
	19	CSS, Creation of Bar chart, Scatter Plot	2
V		**Top Data Analytical Skills**	**22**
	20	Python essentials	2
	21	Microsoft excel essentials	2
	22	R Programming essentials	2
	23	SQL essentials	2
	24	Machine Learning essentials	2
	25	Open-ended	12

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No.	**Upon completion of the course, the graduate will be able to**	**Cognitive Level**	**PSO addressed**
CO-1	Explain the various data structure and algorithms	R, U	PSO-3,4 PO-1,2
CO-2	Describe and practice various theories and principles of probability and statistics	U, Ap	PSO-3,6 PO-1,2,3
CO-3	Explain and use various text analytics	U, Ap	PSO-3,4,6 PO- 1,2
CO-4	Apply data visualization techniques in research	Ap, An, C	PSO-3,4,6 PO- 1,2
CO-5	Perform Data Analysis in Python	Ap, An, C	PSO-3,4,6 PO- 1,2

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Credits: 2:0:1 (Lecture:Tutorial:Practical)

CO No.	**CO**	**PO/PSO**	**Cognitive Level**	**Knowledge Category**	**Lecture (L)/Tutorial**	**Practical (P)**

					(T)	
CO-1	Explain the various data structure and algorithms	PSO-3,4 PO-1,2	R, U	F, C	10	
CO-2	Describe and practice various theories and principles of probability and statistics	PSO-3,6 PO-1,2,3	U, Ap	F, C	10	-
CO-3	Explain and use various text analytics	PSO-3,4,6 PO- 1,2	U, Ap	F, C, P	5	6
CO-4	Apply data visualization techniques in research	PSO-3,4,6 PO- 1,2	Ap, An, C	C, P, M	8	6
CO-5	Perform Data Analysis in Python	PSO-3,4,6 PO- 1,2	Ap, An, C	C, P, M	10	5

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	-	-	3	2	-	-	3	1	-	-	-	-
CO 2	-	-	3	-	-	2	3	3	2	-	-	-
CO 3	-	-	3	3	3	-	3	3	-	-	-	-
CO 4	-	-	3	3	3	-	3	3	-	-	-	-
CO 5	-	-	3	3	3	-	3	3	-	-	-	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Analytical skills
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓
CO 5		✓		✓
CO 6			✓	

Discipline	**ENVIRONMENTAL SCIENCE**				
Course Code	**UK3MDCENS201**				
Course Title	**ENVIRONMENTAL FORENSICS**				
Type of Course	**MDC**				
Semester	Third				
Academic Level	200 – 299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	3	2 hours	-	2 hours	4
Pre-requisites	1.Basic understanding of environmental science and chemistry 2.Strong critical thinking and problem-solving skills. 3.Proficiency in data analysis and interpretation				
Course Summary	The course provides students with a comprehensive understanding of the principles, techniques, and applications of environmental forensics in investigating environmental contamination and pollution incidents. The course covers various aspects of forensic science as applied to environmental problems				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Introduction to Environmental Forensics**	**10**
	1	Overview of environmental forensics principles and applications	3
	2	Historical development and evolution of environmental forensic techniques	3

	3	Regulatory framework and legal aspects of environmental forensics	2
	4	Applications of forensic science in Environmental Investigations	2
II	**Contaminant Characterization and Analysis**		**15**
	5	Sampling techniques for environmental contaminants (practicum)	4
	6	Analytical methods for contaminant identification and quantification	4
	7	Interpretation of analytical data and quality assurance/quality control (QA/QC)	3
	8	Physical Fingerprinting Methods - Application of physical properties in source attribution (particle size distribution, isotopic composition)	4
III	**Source Attribution and Fingerprinting**		**25**
	9	Chemical fingerprinting techniques for identifying contaminant sources	3
	10	Statistical methods for source apportionment and forensic analysis	3
	11	Case studies of successful source attribution investigations	3
	12	Multivariate statistical methods for data analysis	3
	13	Principal component analysis, cluster analysis	3
	14	Receptor models for source apportionment (e.g., chemical mass balance, positive matrix factorization)	3
	15	Uncertainty analysis and sensitivity testing in source attribution studies	3
	16	Introduction to source attribution concepts and objectives	2
	17	Overview of forensic approaches in environmental science	2
IV	**Chemical approaches of Fingerprinting Techniques**		**12**
	18	Chemical Fingerprinting Techniques (practicum)	3
	19	Analytical methods for chemical characterization of environmental contaminants	3
	20	Use of chromatography, spectroscopy, and mass spectrometry in fingerprinting (practicum)	2
	21	Interpretation of chemical profiles and identification of unique markers	2
	22	Development of remediation strategies based on forensic findings	2
V	**Case Studies and Practical Applications**		**13**
	23	Analysis of real-world environmental contamination incidents	4
	24	Role-playing exercises and simulations of environmental forensic investigations	5
	25	Open ended	12

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Course Outcomes

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand the basic concepts of Environmental Forensics	U	C	Instructor-created exams / Quiz
CO2	Analyse the environmental contaminants b using forensic applications	An	P	Group Discussions/ Debates
CO3	Navigate legal frame work to environmental forensics	Ap	P	Seminar Presentation / Group Tutorial Work
CO4	legal frameworks and regulations to environmental forensics	An	C	Instructor-created exams / Home Assignments

CO5	Application of forensic methodologies to address environmental challenges	An	C	Instructor-created exams / Home Assignments
CO6	Apply the results to support decision making	An	C	Instructor-created exams / Home Assignments

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Credits: 3:0:1 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
1	Lecture	1		F, C		
2	Lecture, Tutorial	2		C, P		
3	Lecture, Tutorial	3,4		P, M		
4	Tutorial, Practical	5		M		

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	1	-	-	-	-	-	3		3	3	3		3
CO 2	2	3	-	-	-	-	3	3				4	4
CO 3	-	-	1	-	-	-		4		4	3	3	4
CO 4	-	-	2	3	-	-	4		3	4	4		4
CO 5	-	1	-	-	-	-	4	4		4	4		4
CO 6	-	-	-	3	-	-		3		4	4	4	4

Correlation Levels:

Level	Correlation
1	Nil
2	Slightly / Low
3	Moderate / Medium

4	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓
CO 5		✓		✓
CO 6			✓	

Discipline	**ENVIRONMENTAL SCIENCES**				
Course Code	**UK3VACENS200**				
Course Title	**GREEN ARCHITECTURE**				
Type of Course	**VAC**				
Semester	Third				
Academic Level	200 - 299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	3	3 h	-	-	3
Pre-requisites	The learner should be able to understand the problems of built-up in the environment and appreciate the best practices in terms of building construction with suitable and sustainable infrastructure and the general well-being of the residents				
Course Summary	This course introduces the exciting field of green architecture, where design meets sustainability. Students will explore how buildings can be constructed and operated with minimal environmental impact while promoting human health and well-being. The course will cover sustainable materials, energy-efficient systems, and design strategies for creating eco-friendly structures.				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Introduction to Green Chemistry**	**7**
	1	Contribution of Buildings towards Global Warming	1
	2	Explore the environmental challenges of conventional building practices (resource depletion, pollution, energy consumption)	1
	3	Green architecture (Green buildings) – Definition - Features- Necessity – Environmental benefits	1
		Green architecture (Green buildings) - Economical benefits - Health and Social Benefits	1
	4	Core principles of green architecture (sustainability, reduced environmental impact, occupant well-being)	1
	5	Benefits of green architecture for human health, the environment	1
	6	Energy efficiency of green architecture	1
II		**Green Design Strategies**	**5**
	7	Green Design – Definition - Principles of Sustainable Development in Building Design	1
	8	Characteristics of Sustainable Buildings – Sustainably managed materials - Integrated Lifecycle design of Materials and Structures (Concepts only).	2
	9	Importance of site selection, building orientation,	1
	10	Lighting, ventilation, airflow, and landscaping in green design	1
III		**Sustainable Building Materials and Construction**	**9**
	11	Different types of materials and their availability - Stone and Laterite blocks- Burned Bricks- Concrete Blocks- Stabilized Mud Blocks- Lime Pozzolana Cement- Gypsum Board- Light Weight Beams- Fibre Reinforced Cement Components- Fibre Reinforced Polymer Composite- Bamboo	3
	12	Environmental impact of building materials throughout their life cycle (manufacturing, transportation, use, disposal)	2
	13	Environmental issues related to quarrying of building materials	2
	14	Identify and evaluate eco-friendly building materials in terms of recycled content, low embodied energy, local sourcing	2
IV		**Energy Efficiency and Renewable Energy**	**6**
	15	Importance of passive design strategies for natural heating, cooling	1
	16	Ventilation in green buildings (building orientation, window placement)	1
	17	Active building systems for energy efficiency - high-performance insulation, energy-star appliances	2
	18	Integration of renewable energy sources into buildings - solar panels, wind turbines, rainwater harvesting	2
V		**Green Composites**	**18**
	19	Concepts of Green Composites. Water Utilisation in Buildings	1
	20	Management of Sullage Water and Sewage.	1
	21	Management of Solid Wastes - waste to wealth concept	1
	22	Green design features for water conservation, wastewater treatment, solid	2

		waste management, and indoor air quality	
	23	Real-world case studies of green buildings, evaluating their design strategies	2
	24	Evaluation of performance metrics (energy use, water consumption).	2
	25	Open Ended	9

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3. Centre for Science and Environment (2021): Building Wise. CSE, New Delhi.

Web links and Video Lectures (e-Resources
https://www.youtube.com/watch?v=THgQF8zHBW8
http://www.youtube.com/watch?v=DRO_rIkywxQ

Course Outcomes

No.	Upon completion of the course, the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Explain the benefits of Green Architecture	U, An	PSO-1,2, 3
CO-2	Describe the various strategies for green design	Un, An	PSO-3,4,6
CO-3	Explain the selection of building materials for green architecture	U, Ap, An	PSO-3,4,6
CO-4	Describe the strategies for making green architecture energy-efficient and sustainable	An	PSO-9,10
CO-5	Evaluate the performance of green buildings	E	PSO-8,9

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create
Note: 1 or 2 COs/module
Name of the Course: Credits: 3:0:0 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO-1	Explain the benefits of Green Architecture	PSO-1,2, 3	U, An	F, C	7	0
CO-2	Describe the various	PSO-3,4,6	Un, An	F, C, P	5	1

	strategies for green design					
CO-3	Explain the selection of building materials for green architecture	PSO-3,4,6	U, Ap, An	P, M	7	2
CO-4	Describe the strategies for making green architecture energy-efficient and sustainable	PSO-9,10	An	C, P, M	4	2
CO-5	Evaluate the performance of green buildings	PSO-8,9	E	C, M	5	4

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	2	1	3	-	-	-	-	-	-	-	-	-
CO 2			3	3	-	3	-	-	-	-	-	-
CO 3	-	-	3	3	-	3	-	-	-	-	-	-
CO 4	-	-	-	-	-	-	-	-	3	3	-	-
CO 5	-	-	-	-	-	-	-	3	3	-	-	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Field observations and experiments
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓
CO 5		✓		✓
CO 6			✓	

Discipline	**ENVIRONMENTAL SCIENCES**				
Course Code	**UK3VACENS201**				
Course Title	**ENVIRONMENTAL HEALTH AND SAFETY**				
Type of Course	**VAC**				
Semester	Third				
Academic Level	200 - 299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	3	2 hours	-	2	4
Pre-requisites	The learner should have undergone the course Fundamentals of Environmental Science				
Course Summary	This course provides an overview of various environmental pollutants that pollute air, water, and land. The learners of the course shall understand the health problems due to various pollutants in these spheres. The health problems created by an emerging concern, the spread of antibiotic resistance with far-reaching consequences are also included in this course. From the awareness and knowledge created, the learners shall be able to develop skills to manage and mitigate environmental and occupational hazards, both to humans and to the environment.				

Detailed Syllabus:

Module	Unit	Content	Hrs
I	**Introduction to Environmental Pollutants and Health Effects of Air Pollution**		**17**
	1	Definition of pollution and pollutants	1

	2	Types of environmental pollution	2
	3	Ambient air quality and standards	1
	4	Air Quality Index of India	1
	5	Primary and Secondary air pollutants	1
	6	Health impacts of air pollutants (oxides of C, oxides of N, oxides of sulphur, PM, VOCs, and hydrocarbons)	3
	7	Indoor air pollutants (combustion products, tobacco, VOCs from new furniture, carpets, cleaning and maintenance products, personal care products, heating/cooling systems, humidity, and moisture), Short-term and long-term effects	3
	8	Noise pollution, permissible ambient noise levels, health effects of excessive noise	2
	9	Radioactive pollution, sources of radioactive pollutants, Health effects of radioactive pollution	2
	10	Light pollution, sources of light pollution, and health effects of light pollution	1
II		**Health Effects of Water Pollution**	**8**
	11	Water quality parameters and standards (Practicum)	1
	12	Water pollutants (domestic wastes, pesticides, industrial wastes, food processing wastes, wastes from livestock management, VOCs, chemicals, organic pollutants, microorganisms, heavy metals)	3
	13	Effects of water pollutants on human health (nitrate, flouride, arsenic, chlorine, cadmium, mercury, lead, zinc, microplastics)	2
	14	Waterborne diseases (Bacterial, viral, parasitic), water-related diseases	2
III		**Health Effects of Land/Soil Pollution**	**10**
	15	Indicators of soil quality and Soil Quality Index (SQI)	1
	16	Sources of pollutants in soil (industrial wastes, fertilizers, pesticides, manures, landfills, construction wastes, urban activities, heavy metals, e-wastes, radioactive wastes) and factory visit (practicum)	5
	17	Short-term health problems of soil pollutants with causative agents (dermatitis, allergies)	2
	18	Long-term health impacts of soil pollution with causative agents (cancer, liver, and kidney damage, impacts on the Central Nervous System)	2
IV		**Antibiotic Resistance**	**5**
	19	Soil-borne diseases (anthrax, plague, tetanus), Antibiotic resistance, occurrence and spread, associated health risk	5
V		**Safety Aspects (practicum)**	20
	20	Introduction to Environmental Health and Safety (EHS), Environmental Monitoring	2
	21	Safety management in industries; Occupational safety	1
	22	Safety in solid, liquid, hazardous and biomedical waste management	2

	23	Clinical safety	1
	24	Health, Safety and Environment (HSE) Management System	2
	25	Open-ended	12

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Course Outcomes

No.	Upon completion of the course, the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Define and explain environmental pollution and environmental pollutants; Identify various air pollutants and relate the health problems created to various sources of air pollution	R, U	PSO-1,2 PO- 2,5

CO-2	List out water quality standards and parameters, identify various water pollutants, and describe the health problems caused by various pollutants	R, An	PSO-1,3,6 PO-1,2
CO-3	Explain and estimate the Soil Quality Index (SQI) and describe the short-term and long-term health problems of soil pollution	U, Ap	PSO-1,3 PO-1,2
CO-4	Identify and list the factors affecting human exposure to pollution, describe soil-borne diseases, and explain the problems associated with antibiotic resistance	U, E	PSO-1,2 PO- 1,2,4
CO-5	Explain and practice various aspects of EHS	Ap, E	PSO-1, 3, 4 PO- 1,2,6

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Credits: 2:0:1 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO-1	Define and explain environmental pollution and environmental pollutants	PSO-1,2 PO- 2,5	R, U	F, C	11	-
CO-2	Identify various air pollutants and relate the health problems created to various sources of air pollution	PSO-1,3,6 PO-1,2	U, An	P	14	-
CO-3	List out water quality standards and parameters, identify various water pollutants, and describe the health problems caused by various pollutants	PSO-1,3 PO-1,2	R, An	F,C.P	7	1
CO-4	Explain and estimate the Soil Quality Index (SQI) and describe the short-term and long-term health problems of soil pollution	PSO-1,2 PO- 1,2,4	U, Ap	C,P,M	6	4

CO-5	Identify and list the factors affecting human exposure to pollution, describe soil-borne diseases, and explain the problems associated with antibiotic resistance	PSO-1, 3, 4 PO- 1,2,6	U, E	C,P,M	5	12

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	2	3	-	-	-	2	-	2	-	-	3	-
CO 2	2	-	3	-	-	3	3	3	-	-	-	-
CO 3	-	-	2	3	-	-	3	3	-	-	-	-
CO 4	3	3	-	-	-	-	3	3	-	1	-	-
CO 5	2	-	3	2	-	-	3	3	-	-	-	3

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Laboratory experiments
- Field visit and field report
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓
CO 5		✓		✓
CO 6			✓	

Semester IV

Discipline	**ENVIRONMENTAL SCIENCES**				
Course Code	**UK4DSCENS200**				
Course Title	**BIODIVERSITY AND CONSERVATION**				
Type of Course	**DSC**				
Semester	IV				
Academic Level	200 - 299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	1	4
Pre-requisites	A basic understanding on Biodiversity and its importance				
Course Summary	This course is designed to understand the intricate connection of life on earth and its importance. The contents of the course are designed in such a way that the learner shall get the concept of biodiversity, the types, the methods for measurement of biodiversity, and the threats faced by the biodiversity of the earth. The course also encompasses the conservation measures to ensure the sustenance of biodiversity and various national and international governance to protect biodiversity. The course will help the learner to appreciate this rich natural resource of the earth.				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Concepts of Biodiversity**	**5**
	1	Definition, Levels of Biodiversity	1
	2	Biodiversity and its measurement	1
	3	Ecological values of biodiversity and Ecosystem services of biodiversity	1
	4	Economic values of biodiversity	1
	5	Threats to Biodiversity and factors causing Biodiversity loss	1
II		**Biodiversity of the Indian subcontinent and Conservation**	**24**
	6	Biodiversity hotspots, Megadiversity countries	2
	7	Biogeographical regions in India	1
	8	India as a mega diversity nation	1
	9	Biodiversity of India - past and present	1
	10	Biodiversity conservation - National, State and Local levels	3
	11	Traditional Conservation Practices and documentation of local biodiversity along with field study	2
	12	In situ conservation (Biosphere Reserves, National Parks, Wildlife Sanctuaries, Community Reserves, Sacred Habitats)	4

	13	Ex situ Conservation (Botanical Gardens, Zoological parks, seed banks, gene banks, seedling collections, tissue culture, pollen culture, butterfly parks, Ecoparks)	4
	14	Documentation of traditional knowledge along with field study (practicum)	6
III		**Biodiversity Conservation Policies - National and International**	**5**
	15	Indian Wildlife (Protection) Act, 1972	1
	16	Indian Biodiversity Act 2002	1
	17	IUCN Red List of Threatened Species	1
	18	The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), CBD	1
	19	Role of WWF, WCU and TRAFFIC in Biodiversity Conservation	1
IV		**Biodiversity Conservation Action Plans in India**	6
	20	National Biodiversity Action Plan of India	1
	21	Biodiversity hotspots in India	1
	22	Conservation Projects in India (Tiger, Rhino, Lion, Crocodiles, Birds)	1
	23	Biodiversity interactions: Man-animal conflict, co-existence, wildlife crimes	3
V		**Observation and Survey Techniques (Practicum)**	**35**
	24	Species sampling method (Quadrat, Line Transect, Belt Transect, Pitfall, Mark-Recapture technique, Radio-telemetry etc.) along with field	20
	25	Open Ended	15

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Course Outcomes

No.	Upon completion of the course, the graduate will be able to	Cognitive Level	PSO addressed

CO-1	Define biodiversity and explain its concepts	R, U	PSO-1,2 PO-4,6
CO-2	Identify and explain the values of biodiversity and the factors affecting biodiversity	U, E	PSO-2,3,4 PO- 8
CO-3	Identify biodiversity hotspots and document local biodiversity	U, Ap, An	PSO-1,2 PO- 1,2,8
CO-4	Explain various conservation techniques for biodiversity	R, U	PSO-6 PO- 2,8
CO-5	Perform survey techniques to assess biodiversity	C	PSO-3,4 PO- 2,3

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create
Note: 1 or 2 COs/module

Name of the Course: Credits: 3:0:1 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO-1	Define biodiversity and explain its concepts	PSO-1,2 PO-4,6	R, U	F, C	4	1
CO-2	Identify and explain the values of biodiversity and the factors affecting biodiversity	PSO-2,3,4 PO- 8	U, E	P	14	10
CO-3	Identify biodiversity hotspots and document local biodiversity	PSO-1,2 PO-1,2,8	U, Ap, An	C. P	5	0
CO-4	Explain various conservation techniques for biodiversity	PSO-6 PO- 2,8	R, U	C	5	1
CO-5	Perform survey techniques to	PSO-3,4 PO- 2,3	C	P, M	4	4

	assess biodiversity					

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PS O5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	3	3	-	-	-	-	-	-	-	3	-	3
CO 2	-	3	3	2	-	-	-	-	-	-	-	-
CO 3	3	3	-	-	-	-	2	2	-	-	-	-
CO 4	-	-	-	-	-	3	-	3	-	-	-	-
CO 5	-	-	3	3	-	-	-	3	3	-	--	-

Correlation Levels:-

-Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Field observations and experiments
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓
CO 5		✓		✓
CO 6			✓	

Discipline	**ENVIRONMENTAL SCIENCE**				
Course Code	**UK4DSCENS201**				
Course Title	**CURRENT ENVIRONMENTAL ISSUES**				
Type of Course	**DSC**				
Semester	IV				
Academic Level	200 – 299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5
Pre-requisites	Basic knowledge of ecological concepts, such as ecosystems, biodiversity, and natural resource management Familiarity with environmental issues and challenges facing society				
Course Summary	Empower students with the knowledge, skills, and motivation to address the complex environmental challenges confronting the world today. By exploring the science, policy, and social dimensions of global environmental issues, students will be equipped to contribute to efforts to promote sustainability, resilience, and environmental justice on a global scale				

Detailed Syllabus:

Module	Unit	Content	Hrs
I	**Introduction to Environmental Issues**		**10**
	1	Fundamentals, causes, effects and mitigation strategies of – Global Warming, Depletion of Stratospheric Ozone Layer depletion and Acid Rain	3
	2	Climate change - adaptability, energy security, food security and sustainability. Environmental Pollution; Air, Water, Soil pollution (in brief); waste disposal	3
	3	water scarcity, epidemiological issues-water, air and vector borne diseases. Plastic pollution, Impacts of Microplastics in ocean and food chain.	2
	4	Natural resource depletion; Causes and consequences of biodiversity loss, conservation of biodiversity; Deforestation, wildlife depletion.	2
II	**Environmental Issues - Indian Context**		**15**
	5	Deforestation, wildlife depletion, Man animal conflict, desertification, changing land-use pattern, loss of Biodiversity and species extinction, population explosion and rapid urbanization, waste management and handling.	3
	6	El-Nino and La Nina, Acid rain.	2
	7	Environmental issues related to water resource projects - Issues related to Kerala - Flood, Drought, saltwater intrusion, Coastal erosion, loss of wetlands.	7

		Issues related toIndia - Narmada dam, Tehri dam, Almatti dam, Kaveri and Mahanadi, Hydro-power projects in Jammu & Kashmir, Himachal and North-Eastern States.	
	8	Harmful algal blooms and Eutrophication	3
III	**Types and causes of recent Environmental problems**		**20**
	9	Degradation, conversions and encroachment of wetlands	2
	10	Depletion of water resources	2
	11	Global water crisis	2
	12	Flood and drought with case studies (practicum)	2
	13	Transboundary water disputes.	2
	14	Ocean acidification, ocean oil spill	2
	15	Threats to mangrove	2
	16	Extinction of species; Types and causes of extinction, Anthropogenic causes of extinction.	4
	17	Exotic and invasive species	2
IV	**Environmental problems and urban environment**		**15**
	18	Soil erosion and Depletion of Soil fertility, soil degradation.	3
	19	Construction of Dam, roads, railways	3
	20	Exploitation of natural resources, ground water, quarrying, sand mining (field visit)	3
	21	London smog, photochemical Smog, Los Angeles Smog	3
	22	Flash flood, Urban flooding	3
V	**Urbanisation - present and future global crisis**		**15**
	23	Urban encroachment, urban heat island, global energy crisis	5
	24	Desertification, Food and Water Insecurity, reduction of agricultural land, overuse of chemical fertilizers.	10
	25	Open ended	15

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Course Outcomes :

S No.	Course Outcome No.	Course Outcome	Taxonomic Level
1	CO 1	Understand the basic concepts of current environmental issues	Un
2	CO 2	Know the different environmental problems and its impacts	Un
3	CO 3	Understand the basic idea of national and global environmental issues	Un
4	CO 4	Apply the knowledge to solve environmental problems	Ap
5.	CO 5	Describe the impacts of current environmental problems	Ap
6.	CO6	Generate solutions for the problems related to Environment	Un Re, Un, Ap

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Credits: 3:0:1 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
1	**Lecture**	1		F, C		
2	**Lecture, Tutorial**	2		C, P		
3	**Lecture, Tutorial**	3,4		P, M		
4	**Tutorial, Practical**	5		M		
5	**Tutorial, Practical**	5, 6		M		
6	**Tutorial, Practical**	6		M		

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO 5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	1	-	-	-	-	-	-	-	2	--	2	2
CO 2	2	3	-	-	-	-	-	3	-	3	3	4
CO 3	-	-	1	-	-	-	-	-	-	4	4	3
CO 4	-	-	2	3	-	-	-	3	3	4	-	-
CO 5	-	1	-	-	-	-	-	2	-	2	3	4
CO 6	-	-	-	3	-	-	2	-	3	-	3	4

Correlation Levels

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar

- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓
CO 5		✓		✓
CO 6			✓	

Discipline	**ENVIRONMENTAL SCIENCES**				
Course Code	**UK4DSEENS200**				
Course Title	**NATURAL AND INTEGRATED FARMING**				
Type of Course	**DSE**				
Semester	IV				
Academic Level	200-299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3	-	2	5
Pre-requisites	Should have a basic knowledge about different aspects of agricultural farming, including crop cultivation, livestock management, soil characteristics and about the basics of integrated farming techniques.				
Course Summary	Agriculture is the science, art, or practice of cultivating the soil, producing crops and raising livestock and in varying degrees the preparation and marketing of the resulting products in congruence with the laws of nature. Today, conventional farming is a common method of farming using external inputs and use of chemicals and fertilizers giving more emphasis on yield maximization rather than yield optimization leading to soil fatigue, high cost of production, declining factor productivity and causing imbalance in the ecosystem and lead				

	to high dependency of the farmers on the market forces. Natural farming is emerging as an alternative farming focusing on optimum utilization of native local resources according to principles of agroecology. Integrated farming is a farming system with simultaneous activities involving crops and animals. Essentially, the crop residues serve as feed to the livestock and fish, and in turn, the wastes from the livestock and fish serve as fertilizer to the crops. This course studies the concept of systems and interactions between subsystems in farming systems, studies various kinds of integrated farming systems, and analyzes sustainable integrated farming systems.

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Natural Farming**	**12**
	1	Introduction to Natural farming	2
	2	Ecosystem services and Natural Farming	2
	3	Soil Health and Nutrient Management	2
	4	Bio inputs	2
	5	Elements, Characteristics and Design of Natural Farming Systems	4
II		**Pest and Disease Management in Natural Farming**	**13**
	6	Pest identification	2
	7	Causes of outbreaks of pests	2
	8	Insect Ecology	2
	9	Pest management in natural farming	3
	10	Plant based concoctions and decoctions for pest and disease management	2
	11	Management of Non-Insect Pests	2
III		**Water and soil management**	**15**
	12	Importance of irrigation –Methods of irrigation –surface, subsurface and overhead irrigation- Micro irrigation methods – Sprinkler and drip irrigation- localized irrigation	2
	13	Irrigation management in different soil types. Water conveyance structures- Irrigation of principal crops	2
	14	Water logging and drainage -quality of irrigation water	2
	15	Watershed – Concepts, approaches, objectives, delineation, resource appraisal – Planning watershed development	2
	16	Watershed development plan – PLA techniques – Implementation of watershed development programmes- soil and water conservation **(Case study)**	4

	17	Terracing- water harvesting and recycling- Ground water recharge- Roof water harvesting	3
IV		**Integrated Farming Systems**	**20**
	18	Goals, components and advantages	2
	19	Integration of components – livestock, poultry, rabbitry, apiculture, aquaculture, sericulture, mushroom culture, etc. Integration of Horticulture Crops under Natural Farming	4
	20	Contribution of components in IFS – economic contribution, resource recycling and employment generation	2
	21	Regional adaptation of various farming systems in India	1
	22	Regional adaptation of various farming systems in Kerala	1
	23	Crops and animal waste utilization	1
	24	Modern techniques – Biogas plant- installation, working and maintenance **(Field Visit)**	4
V		**Open Ended**	**15**
	25	Open ended	15

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Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	To evolve a teaching-learning ecosystem for a comprehensive knowledge and skills of ecofriendly agricultural practices in its totality as a science, a set of practice and a social movement.	U	PSO 1, PSO 2
CO-2	To develop a mechanism for teaching and study of a transdisciplinary science, combining different scientific disciplines to seek solutions to real world problems in agriculture at landscape-scale level, encompassing landscape ecology and, more recently, social science and political ecology related to the development of equitable and sustainable food systems	U	PSO 3, 7, 10
CO-3	To focus on a system approach embracing management of interactions among components, rather than focusing only on specific technologies in agriculture	U, R	PSO 6, PSO 7
CO-4	To create a knowledge, innovation and entrepreneurship support system for nature- based farming through a collaborative community of different stakeholders in the society	E, C	PSO 7,8,10
CO-5	To focus on technology upgradation and capacity building of youth and stakeholders in natural farming	U, An	PSO 7, PSO 9

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: Credits: 4:0:0 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)	Open Ended

1	To evolve a teaching-learning ecosystem for a comprehensive knowledge and skills of ecofriendly agricultural practices in its totality as a science, a set of practice and a social movement.	PSO 1, PSO 2	U	F, C	10	2	3
2	To develop a mechanism for teaching and study of a transdisciplinary science, combining different scientific disciplines to seek solutions to real world problems in agriculture at landscape-scale level, encompassing landscape ecology and, more recently, social science and political ecology related to the development of equitable and sustainable food systems	PSO 3, 7, 10	U	P	10	2	3

3	To focus on a system approach embracing management of interactions among components, rather than focusing only on specific technologies in agriculture	PSO 6, PSO 7	U, R		12	2	3
4	To create a knowledge, innovation and entrepreneurship support system for nature- based farming through a collaborative community of different stakeholders in the society	PSO 7,8,10	E, C		10		3
5	To focus on technology upgradation and capacity building of youth and stakeholders in natural farming	PSO 7, PSO 9	U, An		10	2	3

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	1	-	-	2	-	-						
CO 2	2	2	-	-	3	-						

CO 3	-	-	1	-	-	-						
CO 4	-	-	2	2	-	-						
CO 5	-	1	-	-	2	-						

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2				✓
CO 3	✓			✓
CO 4			✓	✓
CO 5	✓	✓	✓	✓

Discipline	**ENVIRONMENTAL SCIENCES**				
env	**UK4DSEENS201**				
Course Title	**WASTEWATER TREATMENT METHODS**				
Type of Course	**DSC**				
Semester	IV				
Academic Level	200 - 299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5
Pre-requisites	Knowledge on sources of water and their contamination				
Course Summary	The course on wastewater treatment systems provides an in-depth exploration of the principles, technologies, and processes involved in the treatment of wastewater. It covers various aspects of wastewater				

	treatment, including physical, chemical, and biological methods, as well as the design, operation, and maintenance of treatment systems.

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Introduction to Wastewater Treatment**	**10**
	1	Different types of waste water	2
	2	Overview of wastewater management	2
	3	Wastewater composition and characteristics	3
	4	Environmental impacts of untreated wastewater	3
II		**Wastewater Treatment Processes**	**15**
	5	Preliminary, Primary, Secondary and Tertiary treatments	4
	6	Physical treatment methods (screening, sedimentation)	4
	7	Chemical treatment methods (coagulation, flocculation)	4
	8	Biological treatment methods (activated sludge, trickling filters)	3
III		**Advanced Treatment Technologies**	**15**
	9	Membrane processes (reverse osmosis, ultrafiltration)	1
	10	Nutrient removal (phosphorus and nitrogen removal)	2
	11	Disinfection methods (chlorination, UV irradiation)	2
	12	Sludge treatment and disposal	2
	13	Domestic waste water treatment	2
	14	Industrial waste water treatment	3
	15	Muncipal waste water treatment	3
IV		**Wastewater Treatment Plant Operation and Maintenance**	**10**
	16	Plant layout and equipment, Operation procedures and protocols	2
	17	Maintenance strategies and troubleshooting	2
	18	Regulatory Framework	2
	19	Overview of environmental regulations	2
	20	Emerging trends and challenges in wastewater management	2
V			**25**
	21	Wastewater Treatment Plant Design: Principles and methodologies for designing treatment facilities considering factors like flow rate, pollutant load, and site conditions.	5
	22	Compliance requirements related to wastewater treatment.	2
	23	Quality standards	1
	24	Case studies with respect to industrial waste water treatment Field visit to water treatment plant	2
	25	Open ended	15

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Understand the characteristics of wastewater and its	U	PSO-1,2

	impact on the environment.		
CO-2	Identify and describe the various components of wastewater treatment systems.	R, U	PSO-1,2,3
CO-3	Analyze and apply design principles for wastewater treatment processes.	Ap	PSO-2,3,4
CO-4	Evaluate the efficiency and effectiveness of different treatment methods.	E, C	PSO-4,5,6
CO-5	Interpret environmental regulations related to wastewater treatment.	Ap	PSO-6,7,8

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

REFERENCES

1. APHA (American Public Health Association) Handbook,1998
2. Soil, Plant and Water Analysis - P. C. Jaiswal
3. Chemical and Biological Analysis of Water - Dr. R. K. Trivedy and P. K. Goel.
4. "Wastewater Engineering: Treatment and Reuse" by Metcalf & Eddy
5. "Biological Wastewater Treatment" by Grady, Daigger, & Lim
6. Environmental Protection Agency (EPA) guidelines and publications
7. "Principles of Wastewater Treatment" Author: Smith, J. & Johnson, A. Publisher: ABC Publishing

Name of the Course: Credits: 4:0:0 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO-1	Understand the characteristics of wastewater and its impact on the environment.	PSO-1,2	U	F, C		
CO-2	Identify and describe the various components of wastewater treatment systems.	PSO-1,2,3	R, U	P		

CO-3	Analyze and apply design principles for wastewater treatment processes.	PSO-2,3,4	Ap	P,M		
CO-4	Evaluate the efficiency and effectiveness of different treatment methods.	PSO-4,5,6	E, C	M		
CO-5	Interpret environmental regulations related to wastewater treatment.	PSO-6,7,8	Ap	M		

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	2	1	-	-	-	-	3	-	-	-	-	-
CO 2	1	2	-	-	-	-	-	2	--	-	-	-
CO 3	-	2	3	--	-	-	-	-	2	-	-	-
CO 4	-	-	-	2	3	-	-	-	-	2	3	-
CO 5	-	-	-	-	-	2	-	-	-	-	-	2
CO 6												

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓
CO 5		✓		✓
CO 6			✓	

Discipline	**ENVIRONMENTAL SCIENCES**				
Course Code	**UK4DSEENS202**				
Course Title	**URBAN ECOLOGY**				
Type of Course	**DSE**				
Semester	IV				
Academic Level	200-299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5
Pre-requisites	1. Basic understanding of ecology and environmental science 2. Familiarity with urban studies or geography				
Course Summary	This course explores the ecological dynamics of urban environments, focusing on the interactions between human activities and natural ecosystems in urban settings. Students will examine the ecological processes, patterns, and challenges unique to urban areas, as well as strategies for promoting sustainable urban development and enhancing urban biodiversity. Through lectures, discussions, fieldwork, and case studies, students will gain insights into the complexities of urban				

	ecosystems and develop the analytical skills necessary to address urban environmental issues.

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Introduction to Urban Ecology**	**5**
	1	Definition of urban ecology	1
	2	Historical perspectives on urbanization and ecological studies	1
	3	Urban ecosystems: characteristics and components	1
	4	Urbanization and Its Ecological Impacts, Drivers of urbanization	2
II		**Urban Biodiversity and Ecosystem Services**	**15**
	5	Biodiversity patterns in urban environments	2
	6	Factors influencing urban biodiversity	2
	7	Conservation of urban biodiversity	2
	8	Ecosystem services provided by urban environments	2
	9	Valuation of urban ecosystem services	2
	10	Importance of green spaces in cities	2
III		**Green Infrastructure. Urban Design and Urban Pollution**	**15**
	12	Role of green infrastructure in urban ecology	1
	13	Sustainable urban design principles	2
	14	Case studies of green infrastructure projects	3
	15	Sources and impacts of pollution in urban areas	2
	16	Air quality, water quality, and soil contamination	3
	17	Strategies for pollution control and environmental health management	1
IV		**Urban Agriculture and Food Systems**	**5**
	18	Urban agriculture: types and benefits	1
	19	Challenges and opportunities for urban food systems	2
	20	Community gardening and urban farming initiatives	1
V		**Social-Ecological Dynamics in Urban Areas**	**20**
	21	Human-nature interactions in urban environments	2
	22	Socioeconomic factors influencing urban ecology; Equity and justice in urban environmental management	3
	25	Open ended	15

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Understand the principles of urban ecology and apply ecological concepts to urban environments.	U	PSO-1,2
CO-2	Describe the structure and function of urban ecosystems and their interactions with human society.	R, U	PSO-1,2,3
CO-3	Analyze the drivers of urbanization and their impacts on biodiversity, ecosystem services, and	An	PSO-2,3

	environmental quality.		
CO-4	Evaluate strategies for sustainable urban planning, design, and management to enhance urban ecological resilience.	E	PSO-3,4,5
CO-5	Apply quantitative methods and spatial analysis techniques to study urban ecology patterns and processes.	Ap	PSO-5,6

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

REFERENCES:

1. McDonnell, M. J., & Hahs, A. K. (Eds.). (2015). The Routledge Handbook of Urban Ecology. Routledge.
2. Grimm, N. B., et al. (2008). Global Change and the Ecology of Cities. Science, 319(5864), 756-760.
3. Marzluff, J. M., et al. (Eds.). (2008). Urban Ecology: An International Perspective on the Interaction Between Humans and Nature. Springer.
4. Pickett, S. T. A., et al. (2011). Urban Ecological Systems: Scientific Foundations and a Decade of Progress. Journal of Environmental Management, 92(3), 331-362.
5. Gandy, M. (2013). The Fabric of Space: Water, Modernity, and the Urban Imagination. MIT Press.
6. McPhearson, T., et al. (2016). Advancing Urban Ecology Toward a Science of Cities. BioScience, 66(3), 198-212.
7. Kowarik, I. (2011). Novel Urban Ecosystems, Biodiversity, and Conservation. Environmental Pollution, 159(8-9), 1974-1983.
8. United Nations. (2018). World Urbanization Prospects: The 2018 Revision. Department of Economic and Social Affairs, Population Division.

Name of the Course: Credits: 4:0:0 (Lecture: Tutorial: Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO-1	Understand the principles of urban ecology and apply ecological concepts to urban environments.	PSO-1,2	U	F, C		

CO-2	Describe the structure and function of urban ecosystems and their interactions with human society.	PSO-1,2,3	R, U	C,P		
CO-3	Analyze the drivers of urbanization and their impacts on biodiversity, ecosystem services, and environmental quality.	PSO-2,3	An	P,M		
CO-4	Evaluate strategies for sustainable urban planning, design, and management to enhance urban ecological resilience.	PSO-3,4,5	E	M		
CO-5	Apply quantitative methods and spatial analysis techniques to study urban ecology patterns and processes.	PSO-5,6	Ap	P,M		

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	1	-	-	-	-	-	-	2	-	-	-	--

CO 2	2	3	-	-	-	-	-	-	3	-	-	-
CO 3	-	2	2	-	-	-	-	2	-	-	-	-
CO 4	-	-	2	3	3	-	-	-	-	4	-	-
CO 5	-	-	-	3	3	-	-	-	2	-	-	-
CO 6												

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓
CO 5		✓		✓
CO 6			✓	

Discipline	**ENVIRONMENTAL SCIENCES**				
Course Code	**UK4DSEENS203**				
Course Title	**Marine Ecology**				
Type of Course	**DSE**				
Semester	**IV**				
Academic Level	200-299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5
Pre-requisites	Basic understanding of oceanographic features, Problems faced by marine ecosystem and Need for conservation of marine ecosystems				
Course Summary	Marine ecology is the study of the relationships between marine organisms and their ocean environment. Ocean environment presents many unique challenges for marine communities and the organisms that live there. Students in Marine Ecology course will (1) explore the relationships of marine animals to the marine environment, (2) understand the relationships of organismal form, function, ecology, and evolution, and (3) engage in discussions about the impact of humans and climate change on the sustainability of the planet (4) explore the multi-dimensional challenges of the physical, chemical and biological processes that influence the structure of marine communities, (5) synthesize alterative solutions to the greatest challenges our oceans face today including overharvesting, habitat destruction, and global climate change, and (6) effectively communicate the complex conservation strategies essential for the preservation of our oceans.				

Detailed Syllabus:

Module	Unit	Content	Hrs
I	**PHYSICAL OCEANOGRAPHY**		**10**
	1	Major divisions of marine environment;	2
	2	Physical properties of seawater	2
	3	Thermal properties of seawater	1
	4	Properties of Waves: Types of waves and properties of ocean waves	1
	5	Tides - Origin of the tides	2
	6	Wind and Ocean circulation – Types of currents	2
II	**MARINE ECOLOGY AND POLLUTION**		**10**
	7	Community ecology	1
	8	Intertidal ecology - Benthic, pelagic and deep sea ecology	2
	9	Food Chain and food web	1
	10	Food pyramid	1
	11	Animal association in the marine environment	2
	12	Types of marine pollution, source and their biological effects **(Practicum/Field visit to relevant sites)**	3

III	**MARINE BIODIVERSITY AND CONSERVATION**		**15**
	13	Threats to marine biodiversity	3
	14	Need for marine biodiversity conservation	2
	15	Ecological impact of pollutants on marine environments	2
	16	IUCN categorization	2
	17	Need for conservation and conservation strategies – germplasm banks, cryopreservation, marine protected areas, sea ranching, mesh size regulation, TED, fishing holidays	3
	18	Coastal and Ocean Resource Management-endangered coastal biota, Marine biosphere reserves and marine parks.	3
IV	**MARINE MICROBIOLOGY**		**15**
	19	Marine microbial environment – Benthic & littoral zone	3
	20	Mangroves and estuarine microbes **(Practicum)**	5
	21	Microbial loop in ocean food webs	2
	22	Marine microbial community - Bacteria, Fungi, Protozoa	3
	23	Marine Extremophiles	2
V	**OCEAN POLICIES AND MANAGEMENT**		**10**
	24	Role of National and International agencies and organizations in ocean management , Intellectual Property Right (IPR) and Ocean policy (India)	10
	25	Open Ended	**15**

Course Outcomes

No.	**Upon completion of the course the graduate will be able to**	**Cognitive Level**	**PSO addressed**
CO-1	Acquire knowledge on the basic and recent development in the field of Marine Biology.	U	PSO1, PSO2
CO-2	Acquire skill on theoretical and experimental protocols in understanding the marine environment.	Ap	PSO 4
CO3	Possess knowledge for independent thinking, in writing scientific proposal, and its presentation.	An	PSO 6
CO4	Man power development for becoming successful researchers and academicians	C	PSO 3
CO5	Understand the overview structure and function of life in the marine environment	E	PSO 6

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Credits: 3:0:1 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)	Open Ended
1	Acquire knowledge on the basic and recent development in the field of Marine Biology.	PSO1, PSO2	U	R,U	12	4	3
2	Acquire skill on theoretical and experimental protocols in understanding the marine environment.	PSO 4	Ap	U	10	4	3
3	Possess knowledge for independent thinking, in writing scientific proposal, and its presentation.	PSO 6	An	Ap	10		3
4	Man power development for becoming successful researchers and academicians	PSO 3	C	E	10		3
5	Understand the overview structure and	PSO 6	E	C	10		3

	function of life in the marine environment						

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	1	-	-	1	-	-	-	1	-	1	-	1
CO 2	2	2	-	-	1	-	1	-	-	-	1	-
CO 3	-	-	1	-	-	-	-	-	2	-	-	-
CO 4	-	-	2	3	-	-	2	-	1	-	2	-
CO 5	-	1	-	-	-	-	-	-	1	2	-	-

REFERENCES

1. Levinton, J.S., 2000. Marine ecology, Biodiversity and function. Oxford University Press.
2. Bertness, M.D, Gaines, S.D. and Hay, M.K., 2000. Marine Community Ecology Sinauer Associates.
3. Gage. J.D. and Tyler, P.A. 1991. Deep Sea Biology, Cambridge University Press, Cambridge.
4. William, C., 1991. Seashore life between the tides. Dover Publication.

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓			✓
CO 4			✓	✓
CO 5		✓	✓	✓

Discipline	**ENVIRONMENTAL SCIENCE**				
Course Code	**UK4DSEENS204**				
Course Title	**GLOBAL CLIMATE CHANGE**				
Type of Course	**DSC**				
Semester	**IV**				
Academic Level	200-299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	4 hours	-	-	4
Pre-requisites	1. Students should have a basic knowledge about weather and climate.				
Course Summary	By the end of this course, students will be able to: Understand the scientific principles underlying global climate change, identify the drivers and causes of climate change, including natural and human-induced factors. To understand the environmental, social, and economic impacts of climate change on local and global scales, Analyze strategies for mitigating greenhouse gas emissions and reducing the effects of climate change. Evaluate adaptation measures to address the impacts of climate change on ecosystems, communities, and economies. Examine the ethical, social, and political dimensions of climate change and the challenges of global cooperation. Develop communication and advocacy skills to engage in informed discussions and actions on climate change.				

Detailed Syllabus:

Module	**Unit**	**Content**	**Hrs**
I		**Introduction to Climate Change**	**10**
	1	Definition of weather and climate, meterology and climatology,	2
	2	Components of the climate system: Atmosphere: Composition, circulation patterns, and climate zones, Hydrosphere: Oceans, sea level rise, and ocean acidification, Cryosphere: Ice sheets, glaciers, and permafrost,	4
	3	Biosphere: Ecosystems, biodiversity, and carbon cycle.	2

	4	Earth's climate zones and circulation patterns, Earth's energy balance	2
II	**Science of Climate Change**		**10**
	5	Drivers of climate change-natural Vs. anthropogenic	2
	6	Aerosols-reflective and black,feed back process in climate system	2
	7	Role of human activities, including fossil fuel combustion, deforestation, and agriculture	3
	8	Greenhouse gases and its sources, Enhanced greenhouse gas effect, Global warming and its impacts, Global Warming Potential (GWP)	3
III	**Impacts of Climate Change and Mitigation**		**20**
	9	Environmental impacts: melting ice caps, rising sea levels, shifts in ecosystems	2
	10	Major impacts of climate change on forest and agriculture	2
	11	Health impacts: heat waves, vector-borne diseases, air pollution issues	2
	12	Social and economic impacts: food security, water scarcity, displacement of populations	3
	13	Mitigation Strategies- Renewable energy sources: solar, wind, hydroelectric, geothermal	3
	14	Improved energy efficiency, fuel substitution, hydropower, carbon capture and sequestration, land based carbon sinks	3
	15	Policy instruments: carbon pricing, emissions trading, renewable energy incentives, Carbon neutral society, Net zero emmissions	2
	16	Energy efficiency and conservation measures	2
	17	Management option to tackle climate change.	1
IV	**International Climate Policy and Governance:**		**15**
	18	United Nations Framework Convention on Climate Change (UNFCCC), Kyoto Protocol and Paris Agreement	3
	19	Nationally Determined Contributions (NDCs), Global Climate Funds: Green Climate Fund (GCF) and the Global Environment Facility (GEF)	5
	20	Conference of the Parties (COP), and climate action plans	3
	21	Equity considerations in climate policy and decision-making	2
	22	Public perceptions of climate change	2
V	**Climate change awareness**		**20**
	23	Effective communication strategies for engaging diverse audiences, Climate literacy and education initiatives	3
	24	**Case studies**: successful adaptation and mitigation efforts at local, regional, and national levels	**2**
	25	**Open Ended**	**15**

References

1. Arya S. Pal (1998). Introduction to Micrometeorology, Academic Press.
2. Arya, S. Pal (1999). Air Pollution Meteorology and Dispersion, Oxford University Press, London
3. Barry R. G. and R. J. Chorley (2009) Atmosphere, Weather and Climate. Routledge.

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5. Bryers H. R. (1974) General Meteorology, Mc Graw – Hill.
6. Finlayson – Pitts (1986). Atmospheric Chemistry: Fundamental and Experimental Techniques, John Wiley and Sons, New Delhi.
7. Hess S. L. (1959). Introduction to Theoretical Meteorology, Holt Renehart and Winston, New York.
8. Menon P.A. and C.K. Rajan (1989). Climates of Kerala, Classic Printers, Cochin.
9. Sachs, J.D. (2015). The Age of Sustainable Development
10. O'Neill, S. & Nicholson-Cole, S. (2009). "Fear Won't Do It": Promoting Positive Engagement with Climate Change Through Visual and Iconic Representation.
11.Betsill, M.M. & Bulkeley, H. (2006). Cities and the Multilevel Governance of Global Climate Change.
12.Adger, W.N. et al. (2007). Assessment of adaptation practices, options, constraints and capacity.
13.Smit, B. (2000). Adaptation to Climate Change in the Context of Sustainable Development and Equity
14.Savinder Singh (2002).Climatology. Pravalika Publication.
15.IPCC Special Report on Global Warming of 1.5°C
16.Intergovernmental Panel on Climate Change (IPCC). (2014). Climate Change 2014: Synthesis Report.

Course Outcome

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PO/PSO addressed
CO-1	Explain the components of climate system and earths energy balance system	U,R	PO 1,2 PSO-1,2
CO-2	Describe the drivers of climate change	R, U	PO 1 PSO 1,2,3
CO-3	Explain the impacts of climate change and mitigation	R,U	PO 1,2 PSO-1,6,5
C0 -4	To explain the international climate policy and governance	R,U,A	PO 2,3 PSO 1,5
CO -5	To explain the climate change awareness and case studies	U,Ap,An	PO 1,2 PSO -1,5,3

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Credits: 3:0:1 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial	Practical (P)	Open Ended

					(T)		
CO-1	Explain the components of climate system and earths energy balance system	PO 1,2 PSO-1,2	U,R	F	10		3
CO-2	Describe the drivers of climate change	PO 1 PSO 1,2,3	R, U	F	12		3
CO-3	Explain the impacts of climate change and mitigation	PO 1,2 PSO-1,6,5	R,U	F,C	18		3
C0 -4	To explain the international climate policy and governance	PO 2,3 PSO 1,5	R,U,A	F,M	10		3
CO - 5	To explain the climate change awareness and case studies	PO 1,2 PSO - 1,5,3	U,Ap,An	F,C	2	8	3

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	PSO 2	PSO3	PSO4	PSO5	PSO6	PO 1	PO2	PO 3	PO4	PO5	PO6
CO 1	1	-	-	1	-	-	1	-	-	-	-	-
CO 2	1	2	-	-	-	-	-	1	-	-	-	-
CO 3	-	-	1	-	-	2	-	-	2	1	-	1
CO 4	1	-	2	1	-	-	-	-	-	1	-	-
CO 5	-	1	2	-	1	-	-	-	2	-	-	-

Correlation Levels:

Level	Correlation
-	Nil

1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1				✓
CO 2	✓			✓
CO 3	✓			✓
CO 4	✓	✓		✓
CO 5		✓		✓

<table>
<tr><td>Discipline</td><td colspan="5">ENVIRONMENTAL SCIENCES</td></tr>
<tr><td>Course Code</td><td colspan="5">UK4SECENS200</td></tr>
<tr><td>Course Title</td><td colspan="5">Fundamentals of Geospatial Technology</td></tr>
<tr><td>Type of Course</td><td colspan="5">SEC</td></tr>
<tr><td>Semester</td><td colspan="5">IV</td></tr>
<tr><td>Academic Level</td><td colspan="5">200 - 299</td></tr>
<tr><td rowspan="2">Course Details</td><td>Credit</td><td>Lecture per week</td><td>Tutorial per week</td><td>Practical per week</td><td>Total Hours/Week</td></tr>
<tr><td>3</td><td>2 hours</td><td>-</td><td>2 hours</td><td>4</td></tr>
<tr><td>Pre-requisites</td><td colspan="5">1. Basic map reading and interpretation skills
2. Basic understanding of physical and geographical concepts involved in geospatial technology</td></tr>
<tr><td>Course Summary</td><td colspan="5">This is a comprehensive course that introduces both majors and non-majors to the fascinating world of geographic technologies. In this course, students explore a wide range of tools and concepts used by geographers today. Each module covers key principles and includes practical lab activities, allowing students to gain hands-on experience with relevant software. Topics covered include geospatial data acquisition, spatial analysis techniques, Global Navigation Satellite Systems (GNSS), and ethical considerations. Whether the student is interested in environmental</td></tr>
</table>

	science, urban planning, or disaster management, this course provides a solid foundation for understanding and utilizing geospatial technology.

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Introduction to Geospatial Technology**	**8**
	1	Introduction to geospatial technology (Definition, scope, and components)	1
	2	Geospatial Data Acquisition and Sources (data sources, collection methods, accuracy and precision, spatial data infrastructure)	2
	3	Digital Representations of the Real World (raster, vector, co-ordinates, GCS, PCS)	2
	4	Conceptualizations of Geographic Attributes (attributes, spatial relationships, metadata)	2
	5	Industry trends and advancements in geospatial technology	1
II		**Remote Sensing Technology**	**12**
	6	Basic principles of remote sensing (Electromagnetic Spectrum and Its Characteristics, Interaction of EMR with Atmosphere and Earth’s Surface: Absorption, Reflectance and Scattering, Spectral Signature, atmospheric window,	3
	7	Remote sensing platforms (Types- Ground-based, airborne, and spaceborne, Orbits-polar, geostationary, Sensors-active, passive, MSS, Radar, Lidar, Resolution - Spatial, spectral, temporal, and radiometric).	3
	8	Aerial photography (Conceptual understanding, photogrammetry basics, Aerial Cameras and Sensors, image interpretation and geometric concepts)	3
	9	Basics of Digital Image Processing (Basics of image rectification and registration, Enhancement techniques (contrast adjustment, sharpening, etc.), Image classification methods (supervised, unsupervised) Accuracy assessment of classified images)	3
	10	Recent trends and applications in RS technology (high resolution sensors-optical and radar, real-time data, DEMs, AI-ML techniques)	2
III		**Geographical Information System**	**10**
	11	Basic principles of GIS (Components of GIS, Data Element and Data Structure, Fundamentals of Database concepts, Spatial vs. non-spatial data, Spatial data models – Raster and Vector, generic GIS workflow)	2
	12	Data input and geo-correction (Data Acquisition Through Scanners and Digitizers, Co-ordinate systems and map projections, Attribute data linking and topology, Spatial Data Quality: Accuracy, Precision, Error and Uncertainty)	2
	13	Database management system (Advantage of DBMS in context of GIS, RDBMS: Concepts and specific features, Basic Concepts of Geodatabase, Linkage between spatial and non-spatial data)	2
	14	Spatial data analysis and visualization (Raster Data Analysis Techniques – Local, Focal, Global and Zonal, Vector Data Analysis- Buffering, Overlay Analysis, Distance Measurements, Vector and Raster Data Query: Logical Expressions, Map layout & Geographic Visualization)	2

	15	Recent trends and applications in GIS technology (Web-GIS, Enterprise GIS, Mobile GIS, 3-D Visualization, Open GIS, AI-ML integration)	2
IV		**Global Navigation Satellite System (GNSS)**:	**10**
	16	Introduction to GNSS (Principles segments and Geopositioning - Basic Concepts, Pseudo Range Measurement, Phase Difference Measurement)	2
	17	GNSS constellations (GPS, GLONASS, Galileo, IRNSS- signals, segments and services).	2
	18	GNSS signals and errors (satellite orbits and clocks, tropospheric and ionospheric effects, multipath error, relativity and timing delay)	2
	19	Positioning Augmentation (Differential positioning, Real-time kinematic (RTK) positioning, SBAS)	2
	20	Recent trends and applications in GPS technology (AI-ML integration, wearable technology, 5G, Augmented Reality etc.)	2
V		**Capstone Project and Practical Applications (Practicum)**	**8**
	21	Students will work on a geospatial project integrating concepts from all modules.	2
	22	Hands-on exercises using Open source software like QGIS, Maptitude etc.	2
	23	Presentations and discussions on real-world geospatial challenges.	2
	24	Field visits and guest lectures by industry professionals	2
	25	**Open Ended**	**12**

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PO/PSO addressed
CO-1	Understand the Scope and Applications of Geospatial Technology, Demonstrate awareness of fundamental remote sensing and spatial analysis techniques	U, An	PO-1 PSO-1,2
CO-2	Interpret satellite imagery for land cover classification, change detection, and environmental monitoring.	U, An	PO-1 PSO-3,4
CO 3	Use geospatial tools to extract relevant information based on spatial relationships. Explore network datasets and understand their significance in geospatial analysis	U, Ap	PO-1,2 PSO-3,4
CO 4	Demonstrate proficiency in using Global Positioning System (GPS) devices for accurate location data collection and its utility in real world problem solving	U, An	PO-1,2 PSO-4,5
CO 5	Apply knowledge and skills acquired throughout the	U, Ap	PO-1,3

	course to address real-world spatial challenges. Gain insights into practical applications, industry trends, and career opportunities in geospatial technology		PSO-3,5,6

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

REFERENCES

1. Geographic Information Science and Systems by Paul A. Longley, Michael F. Goodchild, David J. Maguire, and David W. Rhind. John Wiley & Sons, 2015 (4th edition).
2. GIS and Spatial Analysis for the Social Sciences: Coding, Mapping, and Modeling by Robert Nash Parker and Emily K. Asencio. Routledge, 2019 (1st edition).
3. Remote Sensing and Image Interpretation by Thomas Lillesand, Ralph W. Kiefer, and Jonathan Chipman. John Wiley & Sons, 2015 (7th edition).
4. GIS for Environmental Management by Xuan Zhu. Routledge, 2019 (1st edition).
5. Understanding GPS: Principles and Applications" by Elliott D. Kaplan and Christopher J. Hegarty. IEEE Explore, 2006 (1st edition).
6. Introduction to Geospatial Technology, Bradley A. Shellito. Macmillan Learning, 2023, (6th edition).
7. Geospatial Technologies for Resources Planning and Management. Springer Nature, 2022.

Name of the Course: Credits: 4:0:0 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO addressed	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)	OE
CO-1	Understand the Scope and Applications of Geospatial Technology, Demonstrate awareness of fundamental remote sensing and spatial analysis techniques	PO-1 PSO-1,2	U, An	F, C	12	-	1
CO-2	Interpret satellite imagery for land cover classification, change detection, and environmental	PO-1 PSO-3,4	U, An	C, P	12	4	3

	monitoring.						
CO 3	Use geospatial tools to extract relevant information based on spatial relationships. Explore network datasets and understand their significance in geospatial analysis	PO-1,2 PSO-3,4	U, Ap	C, P	12	4	3
CO 4	Demonstrate proficiency in using Global Positioning System (GPS) devices for accurate location data collection and its utility in real world problem solving	PO-1,2 PSO-4,5	U, An	P, M	12	4	3
CO 5	Apply knowledge and skills acquired throughout the course to address real-world spatial challenges. Gain insights into practical applications, industry trends, and career opportunities in geospatial technology	PO-1,3 PSO-3,5,6	U, Ap	P, M	-	4	5

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	1	1	-	-	-	-	1	-	-	-	-	-
CO 2	-	-	2	2	-	-	2	-	-	-	-	-
CO 3	-	-	2	1	-	-	2	3	-	-	-	-
CO 4	-	-	-	2	1	-	2	2	-	-	-	-
CO 5	-	-	2	-	1	1	1	-	2	-	-	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Internal Exam
- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Project evaluation
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5		✓	✓	

Discipline	**ENVIRONMENTAL SCIENCE**				
Course Code	**UK4SECENS201**				
Course Title	**WATER QUALITY MONITORING**				
Type of Course	**SEC**				
Semester	IV				
Academic Level	200 - 299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	3	2 hours	-	2 hours	4
Pre-requisites	1. Basics of Water quality 2. Basics of water pollution				
Course Summary	The course intends to prepare a student in acquiring skills on the art of water monitoring and quantitative analysis of critical water quality parameters. It also brings in those aspects of chemistry which are important for water quality management and pollution control. The course typically aims to equip participants with the necessary knowledge and				

	skills to effectively assess and manage water quality. The course may include practical field exercises, laboratory sessions, case studies, and/or internships to provide students with hands-on experience in water quality monitoring and management practices.

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Introduction to Hydrology**	**6**
	1	Water resource in India and Global Scenario	2
	2	Hydrological Cycle	1
	3	Precipitation- causes, variation, and measurement (practicum)	2
	4	Evapotranspiration, measurement of evaporation and evapotranspiration	1
II		**Fresh Water Ecosystem and Marine Ecosystem**	**6**
	5	Characteristic of Fresh water and marine ecosystem	1
	6	Chemistry of lakes, rivers, ponds, streams, lagoons, estuaries and oceans	1
	7	Biological methods of Zonation- Microbial load and Aquatic biota	2
	8	Chemistry - Zonation in marine ecosystem - marine biota	2
III		**Sampling of water and waste water**	**12**
	9	Sample collection, Selection of sample containers,	2
	10	Selection of sample containers (Grab, Composite, Integrated sampling)	2
	12	Selection of type of filling the container (In – situ measurements)	2
	13	Sampling techniques - basic concept of quantitative techniques	2
	14	Instrument methods of analysis	2
	15	Standard solutions	1
	16	Water quality standards for different applications	1
IV		**Water quality and testing and analysis(Practicum)**	**14**
	17	Types and methods of analysis	2
	18	Physical parameters of water quality (Turbidity, Temperature, colour and taste, Electrical Conductivity)	3
	19	Chemical Parameters (pH, Acidity, Alkalinity, Chloride, Sulphate, Fluoride, Hardness, Dissolved Oxygen, BOD and COD)	3
	20	Analysis of Nutrients and Heavy Metals	3
	21	Biological Parameters - Indicator Organisms, Coliforms and MPN	3
V		**Water Conservation Programmes**	**10**
	22	**National Water Conservation Initiatives: Jal Shakti Abhiyan, Atal Bhujal Yojana and National Water Mission**	3
	23	**International Water Conservation Initiatives: World Wildlife Fund (WWF) Water Conservation Campaigns and United Nations (UN) Water Conservation Initiatives**	4
	24	The Water (Prevention and Control of Pollution) Act, 1974	3
	25	Open ended	**12**

Books and References:

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2. Alley ER. Water Quality Control Handbook. Vol. 2. New York: McGraw-Hill; 2007

3. Shah C. Which Physical, Chemical and Biological Parameters of Water Determine Its Quality?; 2017
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7. Spellman FR. The Drinking Water Handbook. 3rd ed. Boca Raton: CRC Press; 2017
8. APHA. Standard Methods for the Examination of Water and Wastewater. 21st ed. Washington, DC: American Public Health Association; 2005
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11. World Health Organization Guidelines for drinking-water quality. 4th ed. Geneva: WHO; 2011
12. McGhee TJ, Steel EW. Water Supply and Sewerage. New York: McGraw-Hill; 1991
13. Dojlido J, Best GA. Chemistry of Water and Water Pollution. Chichester: Ellis Horwood Limited; 1993
14. Mara D, Horan NJ. Handbook of Water and Wastewater Microbiology. London: Elsevier; 2003

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Students should learn about key ecological processes such as nutrient cycling, energy flow, primary production, decomposition, and succession within aquatic ecosystems, and how these processes contribute to ecosystem functioning and resilience. Students should be well-equipped to contribute to efforts aimed at protecting and improving water quality in various settings, whether in the context of environmental research, regulatory compliance, water resource management, or community engagement.	U	PSO-1,2
CO-2	Students should understand the importance of aquatic ecosystems in providing essential ecosystem services, such as water purification, flood regulation, fisheries, recreational opportunities, cultural values, and climate regulation, and recognize the consequences of ecosystem degradation for human well-being Participants should be able to describe the diversity of organisms inhabiting aquatic ecosystems, including	R, U	PSO 2, 3

	plants, animals, microbes, and algae, and understand the ecological interactions among species, such as competition, predation, symbiosis, and mutualism.		
CO-3	Students should be proficient in various methods for collecting water samples from different sources, such as rivers, lakes, groundwater, and wastewater treatment plants, while ensuring sample integrity and representativeness. Students should be able to effectively communicate water quality sampling and monitoring findings to diverse stakeholders, including policymakers, community members, industry representatives, and other relevant audiences, through written reports, presentations, and other forms of outreach.	Ap	PSO 3, 4, 5
CO-4	Students should learn about key physical, chemical, and biological parameters used to assess water quality, including temperature, pH, dissolved oxygen, turbidity, nutrients, metals, pathogens, and others Students should gain practical experience in laboratory and field-based techniques for analyzing water samples, including spectrophotometry, titration, chromatography, microbiological assays, and sensor technologies.	An, E	PSO 3, 5
CO-5	Students should learn to engage with diverse stakeholders, including government agencies, non-profit organizations, community groups, and the public, to foster collaboration, partnerships, and collective action towards water conservation goals. Students should understand how water quality monitoring data can inform decision-making processes related to environmental protection, resource management, urban planning, and public health.	Ap, C	PSO 7, 9

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Credits: 2:0:1 (Lecture: Tutorial: Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
1	Gather information about Total Budget particularly in India and world as whole	PSO-1,2	U	F, C	8	2

2	Explain diversity and interaction in marine and fresh water ecosystems	PSO 2, 3	R,U	P	6	4
3	Knowledge about water sampling methods for various physical Chemical and Biological analysis	PSO 3, 4, 5	Ap,	C	20	4
4	Students should well be equipped with hands on practical experience in laboratory and field-based techniques	PSO 3, 5	An, E	P	6	4
5	Enable the students to addressing water challenges in the face of increasing population growth, urbanization, climate change, and resource constraints.	PSO 7, 9	Ap, C	P, M	15	4

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	3	2	-	-	-	-	2	3	-	-	-	-
CO 2	2	3	3	-	-	-	2	-	-	-	-	-
CO 3	3	3	1	-	-	-	2	-	-	-	-	-
CO 4	-	-	-	-	-	-	3	3	-	-	-	-
CO 5	2	3	-	-	-	-	2	2	-	-	2	-
CO 6	3	2	-	-	-	-	2	3	-	-	-	-

Correlation Levels:

Level	Correlation
-	Nil

1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓
CO 5		✓		✓
CO 6			✓	✓

Discipline	**ENVIRONMENTAL SCIENCE**				
Course Code	**UK4VACENS200**				
Course Title	**WATER CONSERVATION METHODS**				
Type of Course	**VAC**				
Semester	IV				
Academic Level	200-299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	3	2 hours	-	2 hours	4
Pre-requisites	1. Students should have the basic knowledge about the local water resources and their availability. 2. Basic knowledge about different conservation methods.				
Course Summary	This course provides an overview of various water conservation methods and techniques aimed at sustainable water management. Students will learn about the importance of water conservation, explore different strategies for reducing water consumption, and examine case studies of successful water conservation initiatives.				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Introduction to Water Conservation**	**10**
	1	Importance of water conservation	2
	2	Global water challenges and trends	2
	3	The role of water conservation in sustainable development	2
	4	Behavioural approaches to water conservation	2
	5	Overview of water resources management	2
II		**Water Use Efficiency, Pattern and Trends**	**10**
	6	Water use efficiency concepts and measures	2
	7	Technologies for improving water use efficiency (e.g., low-flow fixtures, drip irrigation)	2
	8	Assessment of water use patterns	2
	9	Factors influencing water consumption	2
	10	Scientific and nature based approaches to promoting water conservation	2
III		**Watershed management, Rainwater Harvesting and Greywater Recycling**	**10**
	11	Sustainable Watershed Approach & Watershed Management Practices	3
	12	Principles and techniques of rainwater harvesting	3
	13	Grey water recycling systems and applications	2
	14	Case studies of successful rainwater harvesting and greywater recycling projects	2
IV		**Sustainable Agriculture and Irrigation Practices**	5
	15	Water-efficient irrigation techniques (e.g., drip irrigation, sprinkler irrigation)	1
	16	Soil moisture management and crop water requirements	1
	17	Integrated approaches to sustainable agriculture and water conservation	2
	18	Crop selection and rotation for water conservation	1
V		**Urban, Industrial and Commercial Water Conservation**	13
	19	Urban water demand management strategies, Economic incentives for promoting water conservation in the industrial and commercial sectors	2

	20	Water-efficient landscaping and urban design	1
	21	Policy and Regulations for Water Conservation	2
	22	Water conservation practices in industries and commercial establishments **(Field Visit)**	4
	23	Water reuse and recycling technologies **(Field Visit)**	**4**
	24	Open Ended	12

References

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Course Outcomes

No.	**Upon completion of the course the graduate will be able to**	**Cognitive Level**	**PO/PSO addressed**
CO-1	Explain the importance of water conservation	U	PO1,2 PSO-1,2,5
CO-2	Describe the water use efficiency and technologies and factors influencing water consumption	R, U	PO1 PSO-1,2,6
CO-3	Explain the watershed management and water harvesting techniques.	R,U,Ap	PO 1,2 PSO-1,2,3,5,3

CO-4	Explain the sustainable agriculture and irrigation practices	R,U,Ap	PO2 PSO-5,3
CO-5	Describe the urban and industrial and commercial water conservation	R,U,Ap	PO 1,2 PSO-3,4,5

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Credits: 2:0:1 (Lecture:Tutorial:Practical)

CO No.	**CO**	PO/PSO	**Cognitive Level**	**Knowledge Category**	**Lecture (L)/Tutorial (T)**	**Practical (P)**	**Open Ended**
CO-1	Explain the importance of water conservation	PO1,2 PSO-1,2,5	U	C	10		3
CO-2	Describe the water use efficiency and technologies and factors influencing water consumption	PO1 PSO-1,2,6	R, U	C	10		3
CO-3	Explain the watershed management and water harvesting techniques.	PO 1,2 PSO-1,2,3,5,3	R,U,Ap	C	12		3
CO-4	Explain the sustainable agriculture and irrigation practices	PO2 PSO-5,3	R,U,Ap	F	12		3

CO -5	Describe the urban and industrial and commercial water conservation	PO 1,2 PSO-3,4,5	R,U,Ap	P	8	8	3

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	1	-	-	-	1	-	-	1	-	-	-	2
CO 2	2	1	-	-	1	-	-	1	1	-	-	
CO 3	-	-	1	-	2	-	2	1	-	-	-	1
CO 4	-	-	-	1	-	-	1	-	1	-	1	-
CO 5	-	1	-	1	-	-	2	-	-	-	1	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓

CO 2	✓			✓
CO 3	✓			✓
CO 4	✓	✓		✓
CO 5	✓	✓	✓	✓

Discipline	**ENVIRONMENTAL SCIENCE**				
Course Code	**UK4VACENS201**				
Course Title	**GREEN CHEMISTRY**				
Type of Course	**VAC**				
Semester	IV				
Academic Level	200 - 299.				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	3	2 hours	-	2 hours	4
Pre-requisites	Students should know about the basic environment friendly products				
Course Summary	In this course students will understand the importance of green chemistry in promoting sustainable and environment friendly chemical processes. They will also learn the 12 principles that guide the practice of green chemistry, aiming to reduce or eliminate the use or generation of hazardous substances. This course will also explore the methods for synthesizing chemicals that minimising the environmental impact including the use of green solvents. The students will also understand the clean technology sustainable development.				

Detailed Syllabus:

Module	**Unit**	**Content**	**Hrs**
I		**Introduction to Green Chemistry**	8
	1	Definition, history of the development of Green Chemistry	2
	2	Objectives of Green Chemistry and need for Green Chemistry	2
	3	Framework of green chemistry	2
	4	Limitations/ Obstacles in the pursuit of the goals of Green Chemistry	2
II		**Principles of Green Chemistry**	6
	5	12 Principles of green chemistry	1
	6	Concept of atom economy.	1

	7	Tools of green chemistry	1
	8	Green catalysts: Phase Biocatalysts. Energy requirements for reactions – alternative sources of energy: use of microwaves and ultrasonic energy	2
	9	Zero waste technology	1
III		**Green Chemistry in Agriculture and Environment**	**14**
	10	Alternative feed stocks- Alternative feed stocks starting material, Alternative Reagents, Advantages of alternative catalyst.	2
	11	Agrochemicals- Introduction, Biocides: types and applications, Organic Insecticides – Fungicides- Insecticides	2
	12	Types Plant origin Insecticides – Neem, Nicotine, Pyrethrum & rotenone Inorganic Insecticides – Arsenic	2
	13	Pest Management- Pest Management, Cultural methods, Field sanitation, Crops rotation	
	14	Trap crops, secondary Crops, Sowing time, Tillage practices	2
	15	Areas of green chemistry, Evaluation for Chemical Reaction Efficiency	2
	16	Green Solvents/ reaction Media, Catalysis and Bio catalysis. Microwave oven as a reactor, Theory of Microwave Heating.	2
IV		**Clean Development Technology**	**6**
	17	Clean development mechanisms	1
	18	role of industry; reuse, reduce and recycle	1
	19	Raw material substitution; wealth from waste;	1
	20	carbon credits, carbon trading, carbon sequestration, eco labelling.	1
	21	Oxidation technology for- Cavitation, Fenton chemistry, photo catalysis and hybrid processes.	2
V		**Design of Green Synthesis**	**26**
	22	Designing a Green Synthesis using green chemistry principles, Selecting non-toxic reagents, Minimizing waste, Energy efficiency,	4
	23	Use of renewable feed stocks, real time analysis for pollution prevention.	2
	24	Case studies and field visit (practicum)	**8**
	25	Open Ended	**12**

References

1. Ahluwalia,V.K.(2015).Green Chemistry. Ane Books Pvt .Ltd.
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Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Understand the definition, history and goals of green chemistry.	U	PO 1 PSO-1,2
CO-2	Explain the principles of green Chemistry	R, U,Ap	PO 1,2 PSO-5,3
CO-3	Explain the importance and applications of green chemistry in agriculture and environment.	R,U,Ap,An	PO 1,3 PSO -5,3
CO-4	Explain the clean development technology	R,U,Ap	PO 1 PSO-2,5,6
CO-5	Understand the green designing using green chemistry principles	R,U,Ap,An	PO 1,2 PSO-2,6,3,6

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Credits: 4:0:0 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)	Open Ended
CO-1	Understand the definition, history and goals of green chemistry.	PO 1 PSO-1,2	U	F	10		3

CO -2	Explain the principles of green Chemistry	PO 1,2 PSO-5,3	R, U,Ap	C	12		3
CO -3	Explain the importance and applications of green chemistry in agriculture and environment .	PO 1,3 PSO - 5,3	R,U,Ap,A n	C	14		3
CO -4	Explain the green clean technology	PO 1 PSO- 2,5,6	R,U,Ap	F,C	10		3
CO -5	Understand the green designing using green chemistry principles	PO 1,2 PSO- 2,6,3,6	R,U,Ap,A n	F	6	8	3

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	2	2	-	-	-	1	-	-	-	-	-	1
CO 2			1	-	2	2	-	-	1	-	-	-
CO 3	-	-	2	-	2		-	-	-	-	-	-
CO 4	-	2	-	-	1	2	-	-	-	1	-	-
CO 5	-	2	1	-	-	2	2	-	1	2	-	1

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1				✓
CO 2	✓			✓
CO 3	✓			✓
CO 4	✓	✓		✓
CO 5	✓			✓

Discipline	**ENVIRONMENTAL SCIENCE**				
Course Code	**UK4VACENS203**				
Course Title	**ENVIRONMENTAL GOVERNANCE**				
Type of Course	**VAC**				
Semester	**IV**				
Academic Level	200-299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	3	3 hours	-	-	3
Pre-requisites	1. Basic knowledge on environmental laws and policies				
Course Summary	Environmental Governance addresses some of the key environmental challenges of our time, exploring the connections between environmental governance and policies and the production, distribution and consumption of resources. The course is ideal for pursuing a career in environmental				

	regulation and management, those wishing to conduct further research on these topics, and environmental professionals wishing to deepen their knowledge. In this course we examine local, national and international environmental governance issues, with a focus on ethical principles, theories and frameworks that may be used to address a wide range of problems relating to environment and development issues.

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Environmental Policy in India**	**8**
	1	Environmental Legislation Protection Laws in India – Ancient and Pre-Independence	2
	2	Environmental Legislation in Post – Independence Period,	2
	3	Constitutional and Legislative Provisions in India. Fundamental principle; 42nd Amendment Act; Direct Principles Fundamental Rights	2
	4	Environmental Legislations	2
II		**Environmental Laws in India**	**8**
	5	Legal, administrative and constitutional provisions for environmental protection in India	2
	6	Constitutional and Statutory laws in India	2
	7	Statutory protection of human environment–Factories actof1948, MotorVehicleAct, the mines and minerals act of 1957, Hazardous Waste Legislation for pollution abatement	2
	8	Anti Pollution Acts – The Water Act, 1974, The Air Act 1981, The Environment Protection Act, 1986, The national environment appellate authority act of 1997	2
III		**Forest and Wild Life Protection Act and Rules**	**7**
	9	Forest policies and Legislation in Pre – independence Period	1
	10	Wildlife and Biodiversity: IFA, 1927; WLPA, 1972; FCA, 1980; Biological Diversity Act, 2002; Forest Rights Act, 2006.	3
	11	Strategies for conservation–Project Tiger, Elephant, Rhino etc.	2
	12	International Organisation	1
IV		**Environmental Movements in India**	**5**
	13	Chipko movement	1
	14	Narmada Bachao Andolan	1
	15	Appiko movement	1
	16	Tehri Dam, Almetti Dam	1
	17	Silent Valley movement	1
V		**International Environmental Conventions and Treaties**	**17**
	18	Stockholm Conference, 1972; Nairobi Declaration, 1982; Rio Conference, 1992; Rio +5; Rio +10	2
	19	Montreal Protocol, 1987; Kyoto protocol 1997	1
	20	Vienna Convention for the protection of ozone layer, 1985	1
	21	Conference of Parties	1
	22	Basel Convention, 1989	1
	23	Convention on Biological Diversity	1

	24	Convention on Climate Change - UNFCC	1
	25	Open ended	9

REFERENCES

1. Divan, Sand Rosencranz.A. 2001. Environmental Law and Policy in India. Oxford University Press, NewDelhi
2. Gurdeep Singh. 2005. Environmental Law in India. Mc Millan, NewDelhi
3. Shyam Divan and Armin Rosencranz 2002. Environmental Law and Policy in India. 2nd Edn. Oxford University Press, New Delhi
4. Upadhyay S. and Upadhyay V. (2002) Hand Book on Environmental Law- Forest Laws, Wildlife Laws and the Environment; Vols. I, II and III, Lexis Nexis-Butterworths-India, New Delhi
5. Kamala S. and Singh U.K. (eds.) (2008) Towards Legal Literacy: An Introduction to Law in India, Oxford, New Delhi
6. Birnie P. (2009) et al., International Law and the Environment, 3rd ed., Oxford
7. Guha R. (2000) Environmentalism: A Global History, Oxford, New Delhi
8. Philippe Sands and Jacqueline Peel, Principles of International Environmental Law (4th ed., 2018).
9. Shibani Ghosh ed., Indian Environmental Law: Key Concepts and Principles (2019).
10. P. Leelakrishnan, Environmental Law in India (5th ed., 2019)

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	To make students aware of various policies and regulations available for environmental protection.	U	
CO-2	To show students the various environmental protection movements in the past.	R	
CO-3	To make students aware of the translational environmental policies	U	
CO-4	Get a thorough and in-depth understanding of Environmental Laws and policies	U	
CO-5	Analyze the environmental protection movements and environment related legal regulatory framework in India.	An	

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Credits: 3:0:0 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
1	To make students aware of various policies and regulations available for environmental protection.			F, C		
2	To show students the various environmental protection movements in the past.			P		
3	To make students aware of the translational environmental policies					
4	Get a thorough and in-depth understanding of Environmental Laws and policies					

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	1	-	-	-	-	-	2	--	3	-	3	4
CO 2	2	3	-	-	-	-	-	-	3	-	-	4
CO 3	-	-	1	-	-	-	-	3	-	-	3	-

CO 4	-	-	2	3	-	-	-	-	3	-	-	4
CO 5	-	1	-	-	-	-	-	3	-	-	-	-
CO 6	-	-	-	3	-	-	-	3	-	-	-	4

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓
CO 5		✓		✓
CO 6			✓	

SEMESTER V

Discipline	**ENVIRONMENTAL SCIENCES**
Course Code	**UK5DSCENS300**
Course Title	**ENVIRONMENTAL IMPACT ASSESSMENT**
Type of Course	**DSC** / DSE / MDC / SEC / VAC / AEC
Semester	**V**
Academic Level	**300 - 399**

Course Details	**Credit**	**Lecture per week**	**Tutorial per week**	**Practical per week**	**Total Hours/Week**
	4	**4 hours**	**-**		**4**

Pre-requisites	The learner should have a basic understanding of the environmental issues caused by developmental activities
Course Summary	The course is intended to give learners an understanding of the impacts of activities on the environment and the mechanisms to measure the significance of those. This gives an idea of the process of EIA and the various stages of this. It explains what a standard Terms of Reference of a developmental activity is and the processes of Environmental Clearance. The course is structured in a way to make the learner competent to get a job in the State Environment Impact Assessment Authority and in various projects.

Detailed Syllabus:

Module	**Unit**	**Content**	**Hrs**
I		**Introduction to Environmental Impact Assessment (EIA)**	**13**
	1	Development and associated Environmental Degradation	2
	2	History of EIA and EIA notification	2
	3	Stages of EIA (Pre-study period: Screening, scoping, assessment, Study period: preparation of EIS. Post-study period: review, decision making, and monitoring)	3
	4	Types of EIA (preliminary, rapid, comprehensive)	2
	5	Participants of EIA	2
	6	Environmental Impact characteristics (types and nature, magnitude, and significance, extent, duration, uncertainty, reversibility)	2
II		**Process of EIA**	**15**

	7	Description of project and project alternatives by the project proponent	2
	8	Environment Attributes: air, water, noise, land and soil	2
	9	Baseline Data collection	2
	10	Screening, initial environmental examination,	2
	11	Scoping	1
	12	Draft Environmental Impact Statement, public participation, Final EIS	2
	13	Reviewing and decision-making	2
	14	Monitoring, impact management, EIA audit, and evaluation	2
III		**Environmental Impacts**	**8**
	15	Impact identification and methods of impact identification (ad hoc, checklist, matrix, network, overlay)	2
	16	Impact prediction and predictive methodologies (professional judgment, system models, physical models, empirical models, mathematical models	2
	17	Impact evaluation (assessment), Impact mitigation	2
	18	Social Impact Assessment, Health Impact Assessment, Strategic Impact Assessment (SIA)	2
IV		**Terms of Reference (TOR) and EMP**	**6**
	19	The general format of TOR as per MoEF&CC	3
	20	Environmental Management Plan	3
V		**Developmental Projects and Case Studies**	**18**
	21	Categories of projects	1
	22	Environmental Clearance in India	1
	23	Environmental Appraisal Committee (EAC)	2
	24	Functions of State Environment Impact Assessment Committee and Post Environmental Clearance Monitoring, Transferability of clearance	2
	25	Open-ended	**12**

References

1. Anji Reddy Mareddy, Butterworth-Heinemann, 2017. Environmental Impact Assessment.
2. Assessment. IK International Publishing House Pvt. Ltd.
3. Bregman, J.I. and Mackenthum, K.M. 1992. Environmental impact statements. Chelsia Michigan: Lewis.
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6. Glasson J, Taylor and Francis, 2019. Introduction To Environmental Impact Assessment 5Ed.
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10. Morris, P and Therivel, R. 1995. Methods of environmental impact assessment. London. UCL press.
11. Munn, R.E.1979. Environmental impact assessment: principles and procedures, 2nd Edn. New York: Wiley.
12. Sabu Joseph and Arunkumar K S. 2022. Environmental Impact Assessment of Developmental Projects

Course Outcomes

No.	**Upon completion of the course, the graduate will be able to**	**Cognitive Level**	**PSO addressed**
CO-1	Describe the history of EIA, explain the various types, stages, and characteristics of EIA	R, U	PSO-1,2 PO-1
CO-2	Explain the concept of project and project alternatives, and environmental attributes, and will be able to describe the process of Environmental Impact Assessment.	R, U	PSO-1,2,3,4 PO-1,2
CO-3	Identify, predict, and evaluate impacts	Ap	PSO-2,3,4 PO-1,3,6
CO-4	List various categories of project and identify which of those need an EIA	Ap	PSO-3,4 PO-2,3,6
CO-5	Describe the functions of the State Environment Impact Assessment Committee, Environmental Clearance in India and the functions of Environmental Appraisal Committee	R, Un	PSO-1,2,5 PO- 1,6,8

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Credits: 4:0:0 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO-1	Describe the history of EIA, explain the various types, stages, and characteristics of EIA	PSO-1,2 PO-1	R, U	**F, C**	**10**	**3**
CO-2	Explain the concept of project and project alternatives, and environmental attributes, and will be able to describe the process of Environmental Impact Assessment.	PSO-1,2,3,4 PO-1,2	R, U	**F,C**	**12**	**3**
CO-3	Identify, predict, and evaluate impacts	PSO-2,3,4 PO-1,3,6	Ap	**C,P,M**	**8**	**0**
CO-4	List various categories of project and identify which of those need an EIA	PSO-3,4 PO-2,3,6	Ap	**C,P,M**	**4**	**2**
CO-5	Describe the functions of the State Environment Impact Assessment Committee, Environmental Clearance in India and the functions of Environmental	PSO-1,2,5 PO- 1,6,8	R, Un	**F,C**	**6**	**-**

	Appraisal Committee					

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	3	3	-	-	-	-	3	-	-	-	-	-
CO 2	2	3	2	2	-	-	3	3	-	-	-	-
CO 3	-	2	2	3	-	-	3	-	3	-	-	3
CO 4	-	-	3	3	-	-		3	3	-	-	2
CO 5	2	2	-	-	1	-		3	3	-	-	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Field Report
- Final Exam

Mapping of COs to Assessment Rubrics

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓

CO 4		✓		✓
CO 5		✓		✓
CO 6			✓	

Discipline	**ENVIRONMENTAL SCIENCE**				
Course Code	**UK5DSCENS301**				
Course Title	**SUSTAINABLE DEVELOPMENT**				
Type of Course	**DSC**				
Semester	V				
Academic Level	300 - 399.				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	4 hours	-	-	4
Pre-requisites	Preliminary knowledge on environmental policies				
Course Summary	The course aims to provide students with a comprehensive understanding of the complex interconnections between environmental, social, and economic systems, and to equip them with the knowledge and skills needed to address sustainability challenges effectively. This course details the various aspects of sustainability. Topic comes to be associated with several normative principles that now guide environmental management practices and international law but increasingly stretch to other issue areas.				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Introduction to Sustainable Development**	**8**
	1	Definition and need for Sustainable Development	2
	2	History of Sustainable Development (Brundtland, Rio, Millennium Development Goals, Sustainable Development Goals,)	2
	3	Concept of carrying capacity and public participation for sustainability	2
	4	Dimensions of sustainability	2
II		**Sustainable livelihood**	**10**
	5	Inequities in quality of life (pollution, poverty and hunger)	2
	6	Sustainable livelihood framework (health, education and empowerment of women, children and indigenous people)	2
	7	Measuring sustainability (Indicators of sustainability)	2
	8	Sustainable agriculture: Food security and nutrition	2
	9	Sustainable forestry and fisheries	2
III		**Socio-economic sustainability**	**10**

	10	Biodiversity and sustainability (Ecotourism and ecosystem integrity)	2
	11	Urbanization and sustainability (sustainable habitats, green buildings, sustainable transportation)	2
	12	Sustainable consumption and production	1
	13	Sustainable energy	1
	14	Sustainable climate (climate change adaptation and mitigation)	2
	15	Sustainable income and labour	2
IV	**Sustainable Development Models**		**10**
	16	Three Pillar Basic Models	2
	17	Alternative Prism Models of Sustainability	2
	18	The Egg of Sustainability Model	2
	19	Atkisson's Pyramid Model	2
	20	Amoeba Model	2
V	**Future in Sustainable Development**		**12**
	21	Strategies and current practices of sustainability in global, regional and national context	3
	22	Sustainability and Corporate Social/ Environmental Responsibility with a case study (Industrial Visit) - Practicum	3
	23	Approaches in measuring sustainability, their pros and cons (ecological footprint, Human Development Index, Human Development Report)	3
	24	International and National efforts for SDGs	3
	25	Open ended	**12**

Books and References:

1. Bharucha, E. 2021. Text Book of Environmental Studies. University Press (India) Pvt. Ltd.,
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8. Katar Singh and Anil Shishodia 2007, Environmental Economics; Theory and Application, Sage Publication.
9. Arvindari Upadhyay, 2021, Environmental Impact and Risk Assessment, Academic Aspirations, New Delhi.

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed

CO-1	The module provides a Broad-based approach that supports sustainable development in terms of integration and coordination, ecosystem-based management, environmental protection, carrying capacity and sustainable livelihood	U	PSO-1,2
CO-2	Our students need to conserve the vital resources of air, land and water. We want to reduce our negative environmental impacts, and work in collaboration with partners and local communities to enhance the natural resources we all rely on.	R, U	PSO 3,4. 5
CO-3	Operational strategies of the module create an effective governance framework, including: policy and institutional reforms, multi stakeholder participation, functional partnerships and networking, capacity development, information and knowledge management, coastal strategy development and monitoring and evaluation.	U, E	PSO 3,4, 6
CO-4	Study of sustainable development models endeavour to create comprehensive solutions at all levels, ranging from local to global. Their planning should take into account the coexistence and interaction of the three capitals: Economic, social and environmental.	R, U, An	PSO 3, 6. 7, 8
CO-5	Provide an understanding of the ethical responsibility, towards present and future generations. An understanding of the social responsibility as a future professional and as a citizen. Knowledge of global trends that impact the life quality of present and future generations	A, An	PSO 6, 8, 9

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Credits: 4:0:0 (Lecture: Tutorial: Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
1	Understanding the history and evolution of Sustainable development	PSO 1,2		F, C	10	-
2	Analyse interdisciplinary perspectives of sustainable livelihood	PSO 3,4. 5		P	6	-

3	Develop skills in systems thinking to understand the interconnectedness of social, economic, and environmental systems for intervention towards sustainability.	PSO 3,4, 6			12	-
4	Equipped to contribute to sustainable development efforts in various professional roles.	PSO 3, 6. 7, 8			6	-
5	Explore strategies for achieving economic sustainability through green growth, circular economy approaches, sustainable business practices, and technology transfer, balancing economic development with environmental protection and social well-being	PSO 6, 8, 9			12	-

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	3	3	-	-	-	-						
CO 2	3	3	-	-	-	-						
CO 3	-	-	3	-	2	2						
CO 4	3	3	-	2	-	-		2				
CO 5	-	1	-	-	-	-		3	3			

CO 6	3	3	-	-	-	-						

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓			✓
CO 3	✓	✓		✓
CO 4				✓
CO 5		✓		✓

Discipline	**ENVIRONMENTAL SCIENCES**				
Course Code	**UK5DSCENS302**				
Course Title	**ENVIRONMENTAL HAZARDS AND RISK MANAGEMENT**				
Type of Course	**DSC**				
Semester	V				
Academic Level	300-399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5

Pre-requisites	1. Basic knowledge of physical, biological, chemical, and geological concepts related to the environment. 2. An understanding of the ethical considerations related to environmental hazard issues and awareness of environmental policies and regulations
Course Summary	In this course, the students will explore the concept of environmental hazards, including their causes, impacts, and interconnectedness. They will analyze significant environmental disasters from the past by assessing and quantifying risks associated with them. They will also learn about strategies to mitigate and manage these risks effectively.

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Introduction to Environmental Hazards**:	**12**
	1	Understanding the concept of environmental hazards (overview, definition and historical examples)	2
	2	Types of environmental hazards (classification-natural and anthropogenic, geological, biological, meteorological, climatological, technological).	3
	3	Risk assessment and management strategies (Risk analysis and assessment methods, Strategies for hazard mitigation and prevention)	2
	4	Role of government agencies and policies (International and national - UNDRR and The Sendai framework, Disaster Management Authorities at the central and state levels, DM Act, 2005)	3
	5	Case studies of significant environmental hazards	2
II		**Climatological and Meteorological Hazards**	**12**
	6	Droughts, sea level fluctuations and extreme temperatures- their causes, effects and mitigation strategies	3
	7	Floods, Cyclones and Cloud bursts - their causes, effects and mitigation strategies	3
	8	Climate change as a global environmental hazard.	2
	9	Ozone depletion and its consequences	2
	10	Risk and vulnerability assessment for climatological and meteorological hazards	2
III		**Geological and Technological Hazards**	**12**
	11	Earthquakes, landslides, and volcanic eruptions- their causes, effects and mitigation strategies	3
	12	Industrial accidents, fire and chemical hazards- their causes, effects and mitigation strategies	3
	13	Hazardous waste management and disposal.	2
	14	Urban planning for hazard resilience.	2
	15	Risk and vulnerability assessment for geological and technological hazards	2
IV		**Biological Hazards**	**12**

	16	Infectious diseases and their environmental origins in the context of global pandemics. (types, routes of exposure and mitigation strategies)	3
	17	Zoonotic diseases and their impact on human populations, in the context of global pandemics. (types, routes of exposure and mitigation strategies)	3
	18	Bioterrorism and biosecurity measures. (bioterrorism-types and motivation, biosafety levels, laboratory practices)	2
	19	Ecological factors influencing disease transmission.	2
	20	Risk and vulnerability assessment for biological hazards	2
V		**Practicum**	**12**
	21	Field Surveys and Hazard Mapping in their locality using citizen science apps	3
	22	Analyze historical data and interview local residents to understand hazard patterns	3
	23	Case study preparation on different types of hazards	3
	24	Expert sessions from industries and governmental/legal agencies	3
	25	**Open Ended**	**15**

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PO/PSO addressed
CO-1	Conceptual Understanding of Environmental Hazards, Identify and describe various types of environmental hazards, Analyze real-world examples of environmental disasters	U, An	PO-1 PSO-1,2,3
CO-2	Understanding Air Pollution and Its Impact, Comprehend the science behind climate change, Explore the role of greenhouse gases in altering the Earth's climate	R, U, An	PO-1 PSO-1,2
CO 3	Explore the underlying processes that lead to different geological and technical hazards, Understand regulations and best practices for handling hazardous wastes, Integrate hazard mapping, land-use zoning, and building codes to reduce vulnerability	U, Ap	PO-1,2 PSO-1,2,5
CO 4	Investigate the role of environmental factors in disease transmission, Explore biosecurity protocols to prevent unauthorized access to dangerous pathogens, and Practically apply the knowledge to local-level real-life situations to evaluate the risk factors involved.	Ev, Cr	PO-3,8 PSO-3,4,3

CO 5	Learn about field surveys, their importance, and how they contribute to hazard mapping, Explore community-based resilience measures and Develop policy recommendations based on survey results and expert insights	Un, An, Cr	PO-1,3 PSO-3,4,3

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

References

11. Environmental Hazards: Assessing Risk and Reducing Disaster, Prof. Keith Smith, Routledge. 2013 (2nd edition).
12. Biological and Environmental Hazards, Risks, and Disasters, Ramesh Sivanpillai, Elsevier. 2018 (1st edition).
13. Environmental Health - Theory and Practice. Volume 1: Basic Sciences and their Relations to the Environment. Ramesha Chandrappa , Diganta Bhusan Das. Springer Link. 2019 (1st edition).
14. Environmental Hazards and Disasters: Contexts, Perspectives, and Management, Bimal Kanti Paul, John Wiley & Sons. 2016 (1st edition).
15. Routledge Handbook of Environmental Hazards and Society, Edited By Tara K. McGee, Edmund C. Penning-Rowsell. Taylor & Francis, 2022 (1st edition).
16. Natural Disasters, Patrick Leon Abbott, McGraw-Hill Education. 2014 (1st edition).
17. Natural Hazards and Disasters, Donald Hyndman and David Hyndman, Brooks/Cole, 2017(1st edition).
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19. Environmental Risk Assessment: A Toxicological Approach by Ted Simon, CRC Press, 2008 (1st edition).
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Name of the Course: Credits: 4:0:0 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)	Open Ended
1	Conceptual Understanding of Environmental Hazards, Identify and describe various types of environmental hazards, Analyze real-world examples of environmental disasters	PO-1 PSO-1,2,3	U, An	F, C	13	2	2

2	Understanding Air Pollution and Its Impact, Comprehend the science behind climate change, Explore the role of greenhouse gases in altering the Earth's climate	PO-1 PSO-1,2	R, U, An	F,C	13	2	3
3	Explore the underlying processes that lead to different geological and technical hazards, Understand regulations and best practices for handling hazardous wastes, Integrate hazard mapping, land-use zoning, and building codes to reduce vulnerability	PO-1,2 PSO-1,2,5	U, Ap	F,C	13	2	5
4	Investigate the role of environmental factors in disease transmission, Explore biosecurity protocols to prevent unauthorized access to dangerous pathogens, and Practically apply the knowledge to local-level real-life situations to evaluate the risk factors involved.	PO-3,8 PSO-3,4,3	Ev, Cr	C,P	13	2	5
5	Learn about field surveys, their importance, and how they contribute to hazard mapping, Explore community-based resilience measures and Develop policy recommendations based on survey results and expert insights	PO-1,3 PSO-3,4	Un, An, Cr	P,M		4	

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	1	1	2	-	-	-	1	-	-	-	-	-
CO 2	1	2	-	-	-	-	2	-	-	-	-	-
CO 3	2	2	-	-	2	-	2	2	-	-	-	-
CO 4	-	-	2	3	-	-	-	-	3	-	-	-
CO 5	-	-	2	3	-	-	1	-	2	-	-	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Internal Exam
- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Project evaluation
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5			✓	

Discipline	**ENVIRONMENTAL SCIENCES**				
Course Code	**UK5DSCENS303**				
Course Title	**ENVIRONMENTAL PLANNING**				
Type of Course	**DSC**				
Semester	V				
Academic Level	300-399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5
Pre-requisites	• Basic understanding of ecological concepts • Background information related to the basics of urban and land use planning				
Course Summary	The course covers concepts of ecology and ecosystem and includes resource analysis for various ecosystems. Course also covers the environmental issues we face today and development imperatives attached to it. It also deals with the environmental design as applicable to build environment and landscape development. Special area included to address urban climatology and effects of climate change on city Planning.				

Detailed Syllabus:

Module	Unit	Content	Hrs
I	**Concepts of Environmental Planning**		**10**
	1	History of Environmental Planning	2
	2	Development of habitat patterns	2
	3	settlement structure and form in response to environmental challenges;	2
	4	Concepts of Ecology and Ecosystem	2
	5	Urban Ecosystem	2
II	**Resource Analysis and Conservation**		**10**
	6	Resource analysis for various ecosystems and development imperatives	2
	7	Land, geology, soil, climate, water and vegetation characteristics	2
	8	Over exploitation of resources	2
	9	Causative factors for degradation	2
	10	Analytical techniques	2
III	**Environmental Zones**		**15**
	11	Environmental Zones- Hill, coastal, arid - characteristics	1
	12	Resources, settlements pattern, problems and potentials	2
	13	Regulating mechanisms for development	2
	14	Conservation aspects of built-up areas	3
	15	Environmental approaches to design and planning of rural settlements	3

	16	Use of alternate technology in design of human settlements (Case studies/Practicum)	4
IV	**Urban Climatology, Acoustics and Climate Change**		**15**
	17	Urban climatology	1
	18	Effects of thermal pollution,	2
	19	Factors causing heat sink effects-direct radiation	2
	20	Climatic effects on Urban areas and control techniques	2
	21	Urban acoustics:- source of noise, methods of control, design techniques..	2
	22	Climate Change and City Planning, Application of Energy code	2
	23	Clean Development Mechanism (Case Studies-Practicum)	4
V	**Environmental Policies, Significant Conventions, Conferences**		**10**
	24	Environmental Policies and initiatives, Policies, strategies, protocols, treaties and agreements.	10
	25	Open Ended	**15**

Course Outcomes

No.	**Upon completion of the course the graduate will be able to**	**Cognitive Level**	**PSO addressed**
CO-1	Understand different concepts of available resources	U	PSO 1
CO-2	Define the basic principles of environmental planning	R	PSO 4
CO3	Understand and identify resource analysis and conservation	U	PSO 5
CO4	Address major issues related to conservation of environmental zones	Ap	PSO 5
CO5	Analyse the possible alternatives to reduce urban heat	An	PSO 3, PSO 5

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Credits: 4:0:0 (Lecture:Tutorial:Practical)

CO No.	**CO**	**PO/PSO**	**Cognitive Level**	**Knowledge Category**	**Lecture (L)/Tutorial (T)**	**Practical (P)**	**Open Ended**
1	Understand different concepts of available resources	PSO 1	U	R,U	10		3
2	Define the basic principles of environmental planning	PSO 4	R	Ap	10		3

3	Understand and identify resource analysis and conservation	PSO 5	U	An	12	4	3
4	Address major issues related to conservation of environmental zones	PSO 5	Ap	An	10	4	3
5	Analyse the possible alternatives to reduce urban heat	PSO 3, PSO 5	An	Ap	10		3

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	1	-	-	1	-	-	-	1	-	1	-	1
CO 2	2	2	-	-	1	-	1	-	-	-	1	-
CO 3	-	-	1	-	-	-	-	-	2	-	-	-
CO 4	-	-	2	3	-	-	2	-	1	-	2	-
CO 5	-	1	-	-	-	-	-	-	1	2	-	-

REFERENCES

1. Andrews, Goudie, The Human Impact on the Natural Environment – Past, Present and Future, 2006, Wiley Publishers
2. James K. Lein, Integrated Environmental Planning, 2002, Wiley Publishers
3. V.H. Dale, Mary R.English, Tools to Aid Environmental Decision Making, 2020, Swinger
4. William Fox, EnslinVan Rooyen (eds.), The Quest for Sustainable Development,2004, Juta & Co. Ltd., Cape Town.
5. Fabio Giudice, Guido La Rosa, Fabio Giudice, Guido La Rosa, Antonino Risitano, Product Design for the Environment: A Life Cycle Approach, 2006 , Taylor and Francis Group
6. Amos Rapoport, Meaning of the Built Environment: A Non-Verbal Communication Approach, 1990, Sage Publications, USA

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓			✓
CO 4			✓	✓
CO 5		✓	✓	✓

Discipline	**ENVIRONMENTAL SCIENCES**				
Course Code	**UK5DSEENS300**				
Course Title	**RENEWABLE ENERGY**				
Type of Course	**DSE**				
Semester	**V**				
Academic Level	**300-399**				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	3	3 hours	-	2 hours	5
Pre-requisites	The students should have a basic knowledge about different energy sources.				
Course Summary	Energy has become an important and one of the basic infrastructures for the economic development of the country. It is imperative for the sustained growth of the economy. This course envisages the new and renewable source of energy, available in nature and to expose the students on sources of energy crisis and the alternates available, also stress up on the application of non-conventional energy technologies. Students pursuing renewable energy courses will equip themselves with a comprehensive understanding of all the natural resources. Students will also learn about the various applications of renewable energy and technologies used for extracting natural resources. Renewable energy courses give knowledge about various topics such as extracting natural				

	resources, environmental studies, sustainable energy, and renewable energy management.

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Fundamentals of Sustainable Energy**	**10**
	1	Introduction to Renewable energy	2
	2	Need of switching to Renewable Energy sources	2
	3	Difference between Renewable & Non-renewable source	2
	4	Main sources – solar, wind, tidal, biomass, geothermal, Applications	2
	5	Advantages & Disadvantages of Renewable Energy	2
II		**Renewable energy resources**	**15**
	5	Major renewable energy sources- Biomass, wind, hydroelectric, ocean, geothermal; Secondary energy resources - electricity, hydrogen	2
	6	Alternate energy resources; Renewable energy usage, limitations and scope	2
	7	Modern techniques for energy resource recovery using microbes,	2
	8	Solar collectors, photovoltaics, solar ponds	2
	9	Nuclear-fission and fusion	4
	10	MagnetoHydrodynamic Power (MHD)	2
	11	Biomas gasification	1
III		**Solar Energy and Thermo-electric power**	**12**
	12	Technique for harvesting solar energy, direct utilization of solar energy by thermal conversion thermo-mechanical conversion	2
	13	Helio-electric conversion, Photo-voltaic conversion	2
	14	Indirect utilization through water power- Ocean Thermal Energy Conversion (OTEC), Solar ponds	2
	15	Thermo - Electric power- Basic Principles-Thermoelectric power generator-Thermionic Generation **(Practicum/Field visit to Thermal power plant)**	4
	16	Introduction-Thermionic emission & work function-Basic Thermionic generator-Chemical Energy Sources	1
	17	Introduction-Fuel cells – Principles of operation, classification & Types-Applications of fuel cells.	1
IV		**Wind, Geothermal and Tidal resources**	**15**
	18	Basic Principles of Wind energy conversion-The nature of wind-The power in the wind	4
	19	Wind power stations, wind turbines – types, efficiency: Betz limit**(Field visit to sites of relevance)**	4
	20	Geothermal energy sources, status, geo -thermal systems and their characteristics	2
	21	Tidal energy and Ocean waves	2

	22	Tidal Energy-Basic Principles of Tidal Power-Components of Tidal Power Plants- Schematic Layout of Tidal Power house-Advantages & Limitations of Tidal power.	3
V	**Biomass energy**		**8**
	23	Biomass based energy, Environmental impacts of renewable resources	4
	24	Biogas systems, petro-plants, dendrothermal energy, urban waste to energy conversion-MSW incineration plant	4
	25	**Open Ended**	**15**

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11. Falmer, P., Elliot, D. (2003), Energy, Society and Environment, Technology for a Sustainable Future, Rutledge, USA.
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Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PO/PSO addressed
CO-1	Able to understand the renewable energy sources available at present.	U	PO1, PSO 1
CO-2	Able to understand the solar energy operation and its characteristics.	U	PO1, PSO 3
CO-3	To educate the wind energy operation and its types.	R	PO1, PSO 2, PSO 3
CO-4	To educate the tidal and geothermal energy principles and its operation.	U	PO1, PSO 6
CO-5	Understand the need of energy conversion and the various methods of energy storage	R, U, An	PO7,8, PSO 3, PSO 4

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Credits: 4:0:0 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)	Open Ended
1	Able to understand the renewable energy sources available at present.	PO1, PSO 1	U	F, C	10	2	3
2	Able to understand the solar energy operation and its characteristics.	PO1, PSO 3	U	P	10	4	3
3	To educate the wind energy operation and its types.	PO1, PSO 2, PSO 3	R	F, C	12	2	3

4	To educate the tidal and geothermal energy principles and its operation.	PO1, PSO 6	U	F, M	10		3
5	Understand the need of energy conversion and the various methods of energy storage	PO7,8, PSO 3, PSO 4	R,U,An	F, P	10		3

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO 4	PSO 5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	1	-	-	1	-	3	1	-	3	-	-	2
CO 2	2	2	-	-	1	-	-	2	-	2	-	-
CO 3	-	-	1	-	-	2	1	-	-	3	2	1
CO 4	-	-	2	3	-	1	2	3	1	-	-	1
CO 5	-	1	-	-	3	-	1	3	-	2	-	1

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar

- Midterm Exam
- Assignments
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓		✓	✓
CO 3	✓			✓
CO 4		✓		✓
CO 5		✓	✓	✓

Discipline	**ENVIRONMENTAL SCIENCE**				
Course Code	**UK5DSEENS301**				
Course Title	**WATER RESOURCE MANAGEMENT**				
Type of Course	**DSE**				
Semester	V				
Academic Level	300 – 399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5
Pre-requisites	1. Basic understanding of hydrology, ecology, and environmental policy.				
Course Summary	comprehensive understanding of water resource management, covering various aspects such as hydrological processes				

Detailed Syllabus:

Module	**Unit**	**Content**	**Hrs**
I		**Introduction to Water Resource Management**	**5**
	1	Water Cycle and Hydrological Processes	1
	2	Water Quality Assessment	1
	3	Water Demand and Supply Management, Irrigation Systems and Practices	2
	4	Urban Water Management, Agricultural Water Management Industrial Water	1
II		**Climate and water resources**	**8**

	5	Climate Change and Water Resources	2
	6	Water Policy and Legislation	2
	7	Water Governance and Institutions	2
	8	Mitigation measures to reduce greenhouse gas emissions in the water sector	2
III		**Water Governance**	**17**
	9	Water Economics, water governance structures at local, national, and international levels	3
	10	Social and Cultural Aspects of Water	2
	11	Environmental Impact Assessment in Water Projects,	1
	12	Water Ethics and Equity	1
	13	Case Studies in Water Resource Management	3
	14	Emerging Trends in Water	1
	15	Irrigation techniques and efficiency, Sustainable agriculture practices to conserve water and reduce environmental impacts.	1
	16	Water recycling and treatment technologies.	2
	17	Vulnerability assessment and adaptation strategies for water resources management	3
IV		**Water Resource Management**	**15**
	18	Groundwater Management, Surface Water Management Flood Management and Control, Drought Management and Mitigation	4
	19	Landscape Water Conservation	3
	20	Strategies for reducing outdoor water use through xeriscaping, native plant selection, soil improvement, mulching, and irrigation efficiency.	4
	21	Integrated Water Resource Management (IWRM)	2
	22	Case studies illustrating successful implementation of IWRM principles.	2
V		**Water Conservation Techniques (Practicum)**	**30**
	23	Rainwater Harvesting: Overview of rainwater harvesting, historical perspectives, and importance in water conservation	5
	24	Rainwater Collection Systems: Types of rainwater collection systems including rooftop harvesting, surface runoff collection, and stormwater management	10
	25	Open ended	15

References

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Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	significance in water resource management	U	PSO-1,2
CO-2	Assess water quality parameters and implement measures for water quality improvement	R, U	PSO-3
CO-3	Analyse water supply and demand dynamics and propose strategies for sustainable water management.	An, E	PSO-4
CO-4	Apply integrated approaches to water resource management in diverse contexts.	Ap, C	PSO-5
CO-5	Apply Water Resource Management	Ap, C	PSO-4
CO-5	Apply Water Conservation Techniques	Ap, C	PSO-5

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: Credits: 4:0:0 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
1	**Lecture**	1		F, C		
2	**Lecture, Tutorial**	2		C, P		

3	**Lecture, Tutorial**	3,4		P, M		
4	**Tutorial, Practical**	5		M		

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	1	-	-	-	-	-		3	3	3		3
CO 2	2	3	-	-	-	-	3				4	4
CO 3	-	-	1	-	-	-	4		4	3	3	4
CO 4	-	-	2	3	-	-		3	4	4		4
CO 5	-	1	-	-	-	-	4		4	4		4
CO 6	-	-	-	3	-	-	3		4	4	4	4

Correlation Levels:

Level	**Correlation**
1	Nil
2	Slightly / Low
3	Moderate / Medium
4	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓

CO 5		✓		✓
CO 6			✓	

Discipline	ENVIRONMENTAL SCIENCES				
Course Code	UK5DSEENS302				
Course Title	Bioremediation				
Type of Course	DSC / **DSE** / MDC / SEC / VAC / AEC				
Semester	V				
Academic Level	300-399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	4 hours	-		4
Pre-requisites	The learners should have an understanding of environmental pollution and remediation				
Course Summary	This course includes an overview of the bioremediation process; describes the typical bioremediation strategies for contaminated environments; and explores bioremediation technologies' applications.				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Introduction to bioremediation**	**2**
	1	Definition and types of bioremediation	1
	2	Role and importance of bioremediation in environmental restoration	1
II		**Microbial strategies and concerns of bioremediation**	**6**
	3	Strategies of microbial degradation and bioremediation	2
	4	Biodegradation, biotransformation, Mineralisation	2
	5	Constraints of bioremediation	2
III		**Factors affecting bioremediation**	**6**
	6	Requirements for bioremediation	1
	7	Biotransformation of chemicals	1
	8	Environmental effects on microbial degradation	2
	9	Kinetics of biodegradation	2
IV		**Types of bioremediation**	**30**
	10	Bioremediation of organic and inorganic pollutants	2
	11	Biotransformation of pesticides and hydrocarbons	2
	12	Bioremediation techniques for heavy metal removal	2
	13	Insitu Bioremediation: Biostimulation and Bioaugmentation; Bioventing and Biosparging	2
	14	Ex-situ Bioremediation: Landfarming, biopiles, bioreactors, composting	2
	15	Phytoremediation: Types: Advantages and Disadvantages	2
	16	Microbial-assisted phytoremediation, endosymbiotic relationships (plant-bacteria) – plant growth promotion (metabolites)	2

	17	Methods used in phytoremediation: Rhizoremediation	2
	18	Genetically modified organisms used in bioremediation: Pros and Cons	2
	19	Application of bioremediation technologies	2
	20	Bioremediation of industrial wastes	2
	21	Bioconversion of organic wastes: composting	2
	22	Bioremediation of gaseous pollutants	2
	23	Biosensors and their applications	2
V		**Biofilms**	**16**
	24	Biofilms and their applications	4
	25	Open-ended	12

References

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Course Outcomes

No.	Upon completion of the course, the graduate will be able to	Cognitive Level	PSO addressed

CO-1	Explain the nature and importance of bioremediation	R, U	PSO- 3,4 PO- 2,3,6
CO-2	Evaluate the impacts of contaminant characteristics to the bioremediation process	R, U, An	PSO-1,2,3,4 PO- 1,2,8
CO-3	Elaborate the use of bioremediation in real-world applications	Ap	PSO-3,4,6 PO-1,2,5,8
CO-4	Apply the principles of bioremediation	Ap	PSO-3,4,6 PO-1,2,5,8

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Credits: 4:0:0 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO-1	Explain the nature and importance of bioremediation	PSO- 3,4 PO-2,3,6	U, Ap	F, C, P	14	-
CO-2	Evaluate the impacts of contaminant characteristics to the bioremediation process	PSO-1,2,3,4 PO-1,2,8	An, Ap	C, P, M	30	
CO-3	Elaborate the use of bioremediation in real-world applications	PSO-3,4,6 PO-1,2,5,8	Ap	F, C, P	16	
CO-4	Apply the principles of biormediation					

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6

CO 1	-	-	3	3	-	-	-	3	2	3	-	-
CO 2	3	3	3	3	-	-	3	3	-	-	-	-
CO 3	-	-	3	3	-	3	3	3	-	-	3	-
CO4	-	-	3	3	-	3	3	3	-	-	3	-

Mapping of COs with PSOs and POs:

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Analytical skills
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓		✓	✓
CO 2	✓		✓	✓
CO 3	✓			✓
CO4	✓			✓

Discipline	**ENVIRONMENTAL SCIENCE**
Course Code	**UK5SECENS300**
Course Title	**ENVIRONMENTAL AUDITING**
Type of Course	**SEC**
Semester	**V**

Academic Level	300 – 399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5
Pre-requisites	1. Students should know the basic environmental laws and regulations. 2.Students should aware about the basic environmental pollution				
Course Summary	Auditing helps the students to understand the environmental impact of human activities, industries, and policies. By learning auditing techniques, students can evaluate and quantify the environmental consequences of various actions. Auditing in environmental science equips students with the knowledge and skills to assess compliance with environmental regulations and standards. This is crucial for ensuring that organizations and industries adhere to laws aimed at protecting the environment. Auditing teaches students how to identify potential environmental risks and hazards associated with different processes, products, and practices. This enables proactive measures to mitigate or eliminate these risks. By conducting environmental audits, students learn to analyze resource consumption patterns and identify opportunities for resource conservation and efficiency improvements. This fosters sustainable resource management practices.				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Environment Audit**	**10**
	1	Environmental Audit- Definition, Origin, Objectives, Scope of audit	1
	2	Types of Environmental audit- General audit methodology and audit process, basic steps for environmental audit.	3
	3	Reporting Environmental Audit Findings - Importance of Environmental Audit Report to industry, public and the governments.	3
	4	Approaches for environmental auditing, benefits of environmental auditing	3
		Environment Audit Methodologies	**17**
	5	Types of environmental audits (compliance audit, management systems audit, performance audit)	2
	6	Audit planning process, preparation and resource allocation	2

II	7	Data collection techniques: Data collection tools, sampling methods, Fieldwork	2
	8	Audit data analysis methods and interpretation of audit findings	2
	9	Risk assessment and prioritization	2
	10	Reporting: Preparation of audit reports	2
	11	Communicating findings and recommendations	2
	12	Documentation: documentation standards and requirements	2
	13	Structure and Content of Environment Audit Report	1
III		**Green Auditing**	**10**
	14	Introduction, Necessity, procedure	1
	15	Environmental Management System- ISO 14000 series of standards	2
	16	Green Entrepreneurship- Green Consumerism, Green Technology	3
	17	Certification Process – Different Phases of Audit, Certification Audit. Various Certifying Agencies in Operation	4
IV		**Environmental Impact Assessment and Sustainability**	**10**
	18	Introduction to Environmental Impact Assessment (EIA)	1
	19	EIA process and requirements	2
	20	Role of auditing in EIA	1
	21	Sustainable development concepts	2
	22	Auditing for sustainability, Green auditing practices	4
V		**Case Studies and Real-world Examples**	**5**
	23	Emerging Trends in Environmental Auditing: Technology in Environmental Auditing, Lessons learned and best practices	5
	24	Analysis of environmental audit case studies-water, energy, waste, green audit, biodiversity audit(case study)	**8**
	25	Open Ended	**15**

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1. Anjaneyalu, Y. and Valli Manickam. 2014. Environmental Impact Assessment Methodologies. BS Publications, Hyderabad.
2. Barton, H., & Bruder, N. (2014). A guide to local environmental auditing. Routledge.
3. Internal Audit Standards Board. (2012).Guide on Environment Audit. Published by Institute of Chartered Accountants of India.
4. Jones, B. W. (1996). Environmental Auditing: A Guide to Best Practice in the UK and Europe.
5. Nelson, D. D. (1998). International environmental auditing. Government Institutes.
6. Rao, P. S. B. and Rao, P. M. (Eds). 2001. Environment Management and Audit. Deep and Deep Publications Pvt. Ltd.
7. Schneider, J. P. (2002). Environmental Auditing: Theory and Applications
8. Shrivastva, A.K.(2003).Environment Audit. A.P.H Publishing Corporation, New Delhi

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Explain the types, needs and benefits of environmental auditing.	U,R	PO 1 PSO-1,2
CO-2	Understand the methodologies in environmental auditing.	R, U, Ap	PO 1,2 PSO-3,4,3
CO-3	Explain the green auditing and its certification process.	U, An, Ap	PO 1,2 PSO-1,2
CO-4	Describe the environmental impact assessment and role of auditing in EIA.	U, Ap	PO 2 PSO-1,2,3,3
CO-5	Analyse the case studies and technology in environmental auditing.	U, Ap ,An, E	PO 1,2 PSO-3,6,3

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create*Note: 1 or 2 COs/module*

Name of the Course: Credits: 4:0:0 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)	Open Ended
CO-1	Explain the types, needs and benefits of environmental auditing.	PO 1 PSO-1,2	U,R	F	10		3
CO-2	Understand the methodologies in environmental auditing.	PO 1,2 PSO-3,4,3	R, U, Ap	F,P	17		3

CO -3	Explain the green auditing and its certification process.	PO 1,2 PSO-1,2	U, An, Ap	F	10		3
CO -4	Describe the environmental impact assessment and role of auditing in EIA.	PO 2 PSO-1,2,3,3	U, Ap	F,P	10		3
CO -5	Analyse the case studies and technology in environmental auditing.	PO 1,2 PSO-3,6,3	U, Ap ,An, E	C,P	5	8	3

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO 6	PO 7	PO 8
CO 1	2	1	-	-	-	-	2	-	-	-	-	-	-	-
CO 2	2	1	2	1	-	-	1	2	-	-	-	-	-	-
CO 3	2	1	1	-	-	-	2	1	1	-	-	-	-	-
CO 4	2	2	1	1	-	-	2	2	1	-.	-	-	-	-
CO 5	-	1	-	-	-	-	2	1	1	1	-	-	-	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

§ Quiz / Assignment/ Quiz/ Discussion / Seminar
§ Midterm Exam

§ Programming Assignments
§ Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4	✓	✓		✓
CO 5	✓	✓		✓
CO 6			✓	✓

Discipline	**ENVIRONMENTAL SCIENCE**				
Course Code	**UK5SECENS301**				
Course Title	**ENVIRONMENT AND GREEN MARKETING**				
Type of Course	**SEC**				
Semester	**V**				
Academic Level	300 - 399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	3	3 hours	-		3
Pre-requisites	1. Prose and cones of current marketing systems 2. Consequence of hazardous waste 3. Harmful effects of E-waste				
Course Summary	The course is designed to understand the importance of Green Marketing on consumer satisfaction and environmental safety. Green revolution, going green, environment protection, and sustainable development have become the buzz words today. Consumers are gradually becoming conscious buying eco-friendly products. This course aims at understanding the concept of Green Products and Marketing. This course also revisits the factors that affect consumers' purchase decision in general.				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Fundamentals of Green Marketing**	**5**
	1	Marketing Vs Green Marketing	1
	2	Concept & Evolution of Green Marketing	1
	3	Adoption and status of green products	1
	4	Benefits of green marketing: Environmental, Commercial and Social	2

II		**Environmental Concerns of Green Marketing**	**5**
	5	Green design, green positioning, green pricing, green logistics, green disposal	2
	6	Segments of green marketing: Green Spinning, Green Selling, Green Harvesting, Green washing	3
	7	Climate Performance, Leadership Index and Promotional Channels of Green Marketing.	3
	8	3Ps of green marketing: Passion, Purpose, and Precision	2
III		**Green Marketing Policies**	**10**
	9	Introduction to green marketing policy & process	2
	10	Utilising sustainable resources	2
	12	Making sustainable products	2
	13	Implementing eco-friendly energy practices	1
	14	Using shipping methods that are conscious of emissions	1
	15	Green firm's initiatives and green management policies	1
	16	Status of ecofriendly electronic products	1
IV		**Environmental Consciousness**	**10**
	17	Introduction and types of Environmental Consciousness	2
	18	Environmental movement and Importance of environmentalism	2
	19	Benefits of green environment to the society	2
	20	E-waste exchange: Guidelines for collection, storage transport and disposal	2
	21	Environmentally Sound Recycling of E-Waste.	2
V		**Environmental, Technological and Legal aspects of green marketing**	**15**
	22	Opportunities of green marketing	2
	23	Green Protocol of marketing: Certification, Green packing, and Ecolabelling	2
	24	Limitations and future directions	2
	25	Open ended	**9**

Books and References:

1. Green Marketing Management by Robert Dahlstrom, Cengage Learning India. Latest Edition.
2. Green Marketing - Concepts, Literatures and Examples. M. Meera. Evincepub Publishing. Latest Edition.
3. Green Marketing and Environmental Responsibility in Modern Corporations, Esakki and Thangasamy, IGI Global, 2017. Latest Edition.
4. Green Marketing: Challenges and Opportunities for the New Marketing Age, Jacquelyn A. Ottman, NTC Business Books, 1993. Latest Edition.
5. The New Rules of Green Marketing, Jacquelyn A. Ottman, Berrett-Koehler Publishers, 2011. Latest Edition.
6. Belz F., Peattie K. (2009): Sustainability Marketing: A Global Perspective. John Wiley & Sons

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Students should gain a deep understanding of sustainable development principles and how they relate to marketing practices. This includes learning about environmental, social, and economic dimensions of sustainability.	U R	PSO-1,2
CO-2	Students should learn how to design, develop, and market environmentally sustainable products and services. This includes considerations such as eco-friendly materials, energy efficiency, recyclability, and product lifecycle analysis.	R, Ap, C	PSO 4
CO-3	Students should analyse real-world examples of successful green marketing campaigns and initiatives across various industries, learning from both the successes and failures of companies in integrating sustainability into their marketing strategies	An, Ap	PSO 6, 7
CO-4	Topic equips students with the knowledge, skills, and mindset needed to develop and implement environmentally sustainable marketing strategies that contribute to both business success and environmental stewardship. It also fosters an understanding of the ethical implications of green marketing, including issues such as greenwashing, transparency, and corporate accountability	U, An, Ap	PSO 8
CO-5	The topic should cover strategies for building and promoting green brands, including green messaging, eco-labeling, green advertising, and corporate social responsibility initiatives.	An, E, C	PSO 9, 10

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Credits: 4:0:0 (Lecture: Tutorial: Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
1	Explain green marketing and its importance to the	PSO-1,2	U R	F, C	10	

	environment from the perspective of consumers and businesses					
2	Describe the current state of the environment resulting from the past and present practices of the human consumption.	PSO 4	R, Ap, C	P	6	
3	Demonstrate evidence of emerging green consumer segments and how marketers are addressing those needs	PSO 6, 7	An, Ap	F, P	20	
4	Strategic approach and awareness about environmental problems and mitigation related to green marketing.	PSO 8	U, An, Ap	P, M	6	
5	Understand the opportunities, challenges, and issues in designing and implementing green marketing strategies.	PSO 9, 10	An, E, C	P, M	15	

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6

CO 1	1	-	-	2	-	1	3	-	1	-	-	-
CO 2	2	3	-	-	1	-	1	-	-	2	-	3
CO 3	-	2	1	-	-	-	-	1	-	-	-	3
CO 4	-	-	2	3	-	-	1	3	-	2	-	-
CO 5	-	1	-	1	3	-	1	1	-	-	-	3
CO 6	1	-	-	2	-	1	3	-	1	-	-	-

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓
CO 5		✓		✓
CO 6			✓	✓

Semester VI

Discipline	**ENVIRONMENTAL SCIENCE**				
Course Code	**UK6DSCENS300**				
Course Title	**ENVIRONMENTAL TOXICOLOGY**				
Type of Course	**DSC**				
Semester	**VI**				
Academic Level	300-399.				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total hours per week
	4	3 hours	-	2 hours	5
Pre-requisites	Students should know the basic knowledge about the toxic substance in the environment.				
Course Summary	In this course the students will understand the basic principles and scope of environmental toxicology, including the history. The students will learn the biochemical effects and mechanisms by which pollutants cause toxicity. They also learn how the toxicants move through and impact the environment. This also includes an overview of the rules and regulation of food contamination .The students can also learn the methods for toxicity testing.				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Introduction to Environmental Toxicology**	**10**
	1	Definition, history, scope and principles of Environmental Toxicology	1
	2	Concept of toxins, toxicity and toxicology; types of toxic substances	2
	3	Systemic toxic effects: acute toxicity, sub chronic toxicity, chronic toxicity.	3
	4	Classification of toxicant-, natural toxins - animal toxins, plant toxins; food toxins, genetic poisons and chemical toxins;	3
	5	Factors affecting toxicity	1
II		**Metabolism of Toxicants**	**10**
	6	Biotransformation, biomagnification, bioaccumulation, bioconcentration, bio activation	3
	7	Routes of toxicants to human body	2
	8	ADME (Absorption, distribution, metabolism and excretion)	5
III		**Environmental toxicants and their mode of action**	**16**
	9	Toxic chemicals in the environment - air, water, soil and their effects	2

	10	Sources and entry route of toxicants in the environment	2
	11	Biochemical effects of arsenic, cadmium, lead mercury	2
	12	Biochemical effects of carbon monoxide, ozone and PAN pesticide	2
	13	Fate and transport of toxicants in air, water and soil	2
	14	Trans boundary pollutants and its effects	1
	15	Teratogens	2
	16	Mutagens	2
	17	Carcinogens	1
IV		**Dose-response relationship**	**10**
	18	Introduction of dose and response	2
	19	Selection of doses	2
	20	Duration and types of exposure	2
	21	Types of dose-response relationship-Quantitative and Quantum	2
	22	Cumulative response and therapeutic index	2
V		**Effects and Evaluation of Toxicity**	**6**
	23	Classification, Methods of assessment, Types of Bioassay, bioassay test, Threshold Limit Value (TLV), Toxicity testing: acute, sub - acute and chronic tests	6
	24	Lethal Concentration (LC_{50}, Lethal Dose LD_{50}, Median Lethal Dose, Maximum Acceptable Toxicant Concentration (MATC) **(Practicum)**	**8**
	25	Open Ended	**15**

References

1. Balram Pani. (2019).Text Book of Ecotoxicology. Dram tech Press, New Delhi.
2. Calow P.(1994) Handbook of Ecotoxicology. Blackwell Scientific publications, London.
3. Donald G.Crosby(1998).Environmental Toxicology and Chemistry.Oxford University Press.
4. Gupta P.K (2010).Modern Toxicology, Pharmamed Press/BSP Books,Hyderabad
5. Jacobson-Kram, D. (2006).Toxicological testing Handbook; Principles, Application and Data Interpretation, Taylor and Francis New York.
6. John H,D.,Howard G.J.W(2006).Fundamental Toxicology.RSC Publishing.
7. Soumitro Ghose.(2005).Toxicology.Dominant Publishers and Distributors,New Delhi
8. Wayne G.L., Sofield,M.S.,Ming,Ho.Yu. (2011).Environmental Toxicology. CRC Press

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PO/PSO addressed

CO-1	Introduce the basic concepts, history and principles of toxicology	U	PO 1 PSO-3
CO-2	To understand the biological concepts and the xenobiotics transport and its mechanism in the human body	R, U	PO 1,2 PSO-1
CO-3	Provide fundamental knowledge on the environment's fate and transport of toxicants and how these processes affect their toxicity	R,U	PO 1,2 PSO 1
C0 - 4	Explain the dose-response relationship and its types	R,U,A	PO 1,2 PSO-3,4,6
CO - 5	To apply the knowledge acquired for evaluating toxicity	U,Ap,An	PO 1,2 PSO-3,3

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Credits: 4:0:0 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)	Open Ended
CO-1	Introduce the basic concepts, history and principles of toxicology	PO 1 PSO-3	U	F	10	-	3
CO-2	To understand the biological concepts and the xenobiotics transport and its mechanism in the human body	PO 1,2 PSO-1	R, U	F	10	-	3
CO-3	Provide fundamental knowledge on the environment's fate and transport of toxicants and how these processes affect their toxicity	PO 1,2 PSO 1	R,U	P	16	-	3

C0 -4	Explain the dose-response relationship and its types	PO 1,2 PSO- 3,4,6	R,U,A	F,C	10	-	3
CO -5	To apply the knowledge acquired for evaluating toxici ty	PO 1,2 PSO- 3,3	U,Ap,An	P	6	8	3

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO 1	PO2	PO3	PO4	PO 5	PO6	PO7	PO8
CO 1	1	-	2	-	-	-	2	-	-	1	-	-	-	-
CO 2	2	1	-	-	-	-	2	1	-	-	-	-	-	-
CO 3	2	-	1	-	-	-	3	2	-	1	-	1	-	-
CO 4	-	-	1	3	3	1	3	1	-	1	-	-	-	-
CO 5	-	-	2	2	-	-	2	2	-	-	-	-	-	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1				✓
CO 2	✓	✓		✓
CO 3	✓			✓
CO 4		✓		✓
CO 5		✓		✓
CO 6			✓	

Discipline	**ENVIRONMENTAL SCIENCES**				
Course Code	**UK6DSCENS301**				
Course Title	**RESEARCH METHODS IN ENVIRONMENTAL SCIENCES**				
Type of Course	**DSC**				
Semester	**VI**				
Academic Level	300 - 399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	4 hours	-		4
Pre-requisites	The learners should have an aptitude in research				
Course Summary	This course is destined to give learners the basics of pursuing research. It discusses the purpose of doing research, the types of data to be collected for research, and methods of data analysis. The course also deals with design of experiments and ethics in research.				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Research Basics**	**22**
	1	Definition, purpose, and types; Significance of research in applied sciences; Objectives and Dimensions of Research problem, Research questions, Research design; Tools of Research: Library, Field, Laboratory; Methods of research: Qualitative and Quantitative	3
	2	Data Types (primary and secondary data), collection methods; presentation (Graphical and diagrammatic)	3
	3	Data Processing: checking, editing, coding, transcriptions, classification, and tabulation	3
	4	Data analysis: meaning and methods; quantitative and qualitative analysis; Bivariate Data Analysis using Correlation and Regression analysis	3
	5	Analysis of time series, Interpolation, and Extrapolation misuse of various tools like mean, median, mode, dispersion, correlation, technical errors	3

	6	Theoretical distribution: Normal, Poisson, Binomial with application in various areas/ disciplines	3
	7	Sampling types, steps; sampling errors, sampling of attributes (including Chi-square test), sampling of small and large sample variables (including ANOVA); Hypothesis Testing	4
II		**Environmental Sampling and Analysis (Practicum)**	**12**
	8	Environmental sampling: Finite-population sampling, stratified random sampling, composite sampling, ranked set sampling, capture-recapture methods	2
	9	Time series analysis	4
	10	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 (Practicum)	6
III		**Laboratory Safety**	**7**
	11	Laboratory safety measures	1
	12	Disposal of Hazardous/Poisonous/chemical and biological agents	2
	13	Laboratory waste disposal with field study	3
	14	Dealing with electrical and fire hazards	1
IV		**Experimental Design (Practicum)**	**12**
	15	Randomization, replication, and local control	2
	16	Completely Randomized Design (CRD)	2
	17	Randomized Block Design (RBD)	2
	18	Latin Square Design (LSD)	2
	19	Factorial designs	2
	20	Split Plot and Strip Plot designs	2
V		**Research Ethics**	**22**
	21	Definition, moral philosophy, nature of moral judgments and Intellectual honesty and research integrity	1
	22	Scientific misconducts: falsification, fabrication, and Plagiarism (FFP)	1
	23	Redundant publication: duplicate, overlapping, salami slicing, Violation of publication ethics, authorship and contributorship	3
	24	Predatory publishers and journals	2
	25	Open ended	15

References

1. Bhattacharyya, D. K. (2006). *Research methodology*. Excel Books India.
2. Chawla, D., & Sodhi, N. (2011). *Research methodology: Concepts and cases*. Vikas Publishing House.
3. Davidavičienė, V. (2018). Research methodology: An introduction. *Modernizing the academic teaching and research environment: Methodologies and cases in business research*, 1-23.

4. Graf, C., Wager, E., Bowman, A., Fiack, S., Scott-Lichter, D., & Robinson, A. (2007). Best practice guidelines on publication ethics: a publisher's perspective. *International journal of clinical practice*, *61*, 1-26.
5. Introductory Biological Statistics, Raymond Hampton, John Havel, and Scott Meiners, 4th Edition. Waveland Press, ISBN: 9781478638186
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7. PANNEERSELVAM, R. (2014). *Research methodology*. PHI Learning Pvt. Ltd..
8. Sengupta, S., & Honavar, S. G. (2017). Publication ethics. *Indian journal of ophthalmology*, *65*(6), 429-432.
9. Singhal, S., & Kalra, B. S. (2021). Publication ethics: Role and responsibility of authors. *Indian Journal of Gastroenterology*, *40*, 65-71.
10. Watts, Simon, and Lyndsay Halliwell. 1996. Essential Environmental Science: Methods and Techniques. Routledge, London, England.

Course Outcomes

No.	Upon completion of the course, the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Describe the basics of research such as data types, data processing, and data analysis	R, U	PSO-3,4 PO-1,2,6
CO-2	Explain environmental sampling, time series analysis, and perform statistical analysis of the data	U, Ap	PSO-3,4 PO-1,2,7
CO-3	Describe and practice lab safety practices	U, Ap	PSO-3 PO-1,2
CO-4	Describe and select the proper experimental design	U, Ap	PSO-3,4 PO-1,3
CO-5	Apply the principles of ethics in research	U, An	PO-8

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Credits: 4:0:0 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO-1	Describe the basics of research such as data types, data processing, and data analysis	PSO-3,4 PO-1,2,6	R, U	F, C, P		

CO-2	Explain environmental sampling, time series analysis, and perform statistical analysis of the data	PSO-3,4 PO-1,2,7	U, Ap	C, P, M		
CO-3	Describe and practice lab safety practices	PSO-3 PO-1,2	U, Ap	C. P, M		
CO-4	Describe and select the proper experimental design	PSO-3,4 PO-1,3	U, Ap	C, P, M		
CO-5	Apply the principles of ethics in research	PO-8	U, An	C, P		

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	-	-	3	3	-	-	3	3	-	-	-	3
CO 2	-	-	3	3	-	-	3	3	-	-	-	-
CO 3	-	-	3	-	-	-	2	2	-	-	-	-
CO 4	-	-	2	3	-	-	2	-	2	-	-	-
CO 5	-	-	-	-	-	-	-	-	-	-	-	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Perform data analysis using statistical packages
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓

CO 3	✓			✓
CO 4		✓		✓
CO 5		✓		✓
CO 6			✓	

Discipline	**ENVIRONMENTAL SCIENCES**				
Course code	**UK6DSCENS302**				
Course Title	**TECHNIQUES IN ENVIRONMENTAL SCIENCES**				
Type of Course	**DSC**				
Semester	VI				
Academic Level	300 - 399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5
Pre-requisites	1. Basic knowledge regarding environmental contaminants 2. Recall what are the environmental samples				
Course Summary	The course provides students with fundamental skills and knowledge necessary for understanding and analysing environmental issues. Through a combination of theoretical lectures and practical exercises, students will gain proficiency in various techniques used in environmental science research and analysis. Topics covered include sampling methods, data analysis, laboratory techniques, and fieldwork methodologies. Emphasis is placed on hands-on learning experiences to develop critical thinking and problem-solving skills in the context of environmental science.				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Introduction to Environmental Monitoring**	**10**
	1	Environmental monitoring - Definition and concepts	2
	2	Types of environmental monitoring (air quality monitoring, water quality monitoring)	3
	3	Types of environmental monitoring (biodiversity monitoring)	3
	4	Case studies illustrating the importance of monitoring for environmental management	2
II		**Sampling Methods**	**10**
	5	Sampling methods - air and water	2
	6	Sampling methods - soil and sediment	2

	7	Sampling devices - principles and working of water samplers, sediment corers and air samplers	4
	8	Sample preparation and handling techniques	2
III		**Laboratory Techniques**	**15**
	9	Safety protocols in the laboratory environment, MSDS	2
	10	Microscopy	3
	11	Introduction to laboratory analysis methods (Physical, Chemical and biological)	4
	12	Instrumentation techniques used in Environmental Analysis	4
	13	Flora and fauna	1
	14	Phytoplanktons and Zooplanktons	1
	15	Biodiversity indices	1
	16	Hands-on demonstrations of basic laboratory techniques by using various instruments (e.g, pH meters, spectrophotometry, chromatography, microbiological analysis)	3
	17	Online environmental monitoring	1
IV		**Data Analysis and Interpretation**	**15**
	18	Basics of data analysis using statistical tools	4
	19	Interpretation of environmental data	4
	20	Integration of field and laboratory data for environmental assessment	6
	21	Data handling by using Excel through graphical representations, mean, SD, correlation, Regression	5
	22	Designing effective presentations on scientific findings	1
V		**Environmental Management for Air, Water and Soil**	**10**
	23	Concepts of Environmental management	4
	24	Case studies illustrating the importance of monitoring for environmental management	6
	25	Open ended	**15**

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Understand the principles and importance of environmental monitoring.	U	PSO-1,2
CO-2	Familiarize the essential field and laboratory techniques commonly used in Environmental Science.	R, U	PSO-1,2,3
CO-3	Enable students to apply basic techniques for sampling, analysis, and interpretation of environmental data.	Ap	PSO-3,4,6
CO-4	Develop critical thinking skills regarding environmental issues and solutions.	E	PSO 4,5

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

References

1. APHA (2012). Standard Method for the Examination of Water and Waste water, Washington, D.C.
2. Bard, A.J. and Faulkner, L.R. (2001) Electrochemical Methods, 2nd Ed., John Wiley Sons.
3. Christian G.D. (2000), Analytical Chemistry, 6thed, John Wiley & Sons.
4. De, A.K. (1994). Environmental Chemistry. New Age International Ltd. New Delhi.
5. Eving, G.W. (1985). Instrumental Methods of Chemical Analysis, 5th Ed.,,Mc-Graw Hill Book Company.
6. Radojecic, M. and Bashkin, V.N. (2007). Practical Environmental Analysis. RSC Publishing, Cambridge.
7. Skoog, D.A., Holler F.J. and Nieman (2003). Principles of Instrumental Methods, 5th Ed., Thomson Asia Pvt. Ltd., Singapore.
8. Vogel A.I. (1999). Textbook of Quantitative Chemical Analysis, 5th Ed., Addison Wesley Longman Singaporepte Ltd.
9. Willard, Merritt, Dean and Settle (1986). Instrumental Methods of Analysis, 7th Ed., C B S Publishers & Distributors

Name of the Course: Credits: 4:0:0 (Lecture: Tutorial: Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO-1	Understand the principles and importance of environmental monitoring.	PSO-1,2	U	F, C		
CO-2	Familiarize the essential field and laboratory techniques commonly used in Environmental Science.	PSO-1,2,3	R, U	P		

CO-3	Enable students to apply basic techniques for sampling, analysis, and interpretation of environmental data.	PSO-3,4,6	Ap	P,M		
CO-4	Develop critical thinking skills regarding environmental issues and solutions.	PSO 4,5	E	M		

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	1	-	-	-	-	-	3	2	1	-	-	-
CO 2	-	-	2	-	-	-	-	-	-	-	2	3
CO 3	3	2	-	-	-	-	1	-	-	3	-	-
CO 4	2	-	-	-	3		3	-	2	-	-	1

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar

- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓

Discipline	**ENVIRONMENTAL SCIENCE**				
Course Code	**UK6DSCENS303**				
Course Title	**WILDLIFE PROTECTION AND MANAGEMENT**				
Type of Course	**DSC**				
Semester	VI				
Academic Level	300 – 399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5
Pre-requisites	1. Familiarity with environmental ethics, conservation principles, and wildlife policy issues can provide a valuable background for studying wildlife protection and management 2. A genuine interest in wildlife conservation and a passion for protecting biodiversity				
Course Summary	Wildlife Protection and Management course aims to equip students with the knowledge, skills, and perspectives needed to address the complex challenges facing wildlife conservation and management in the 21st century. By fostering an interdisciplinary approach and promoting collaboration among stakeholders, the course seeks to empower students to become effective leaders and advocates for wildlife protection and sustainable management.				

Detailed Syllabus:

Module	**Unit**	**Content**	**Hrs**
I		**Introduction to Wildlife Protection and Management**	**15**
	1	Overview of Wildlife Conservation History of Wildlife Management	3
	2	Legal Frameworks for Wildlife Protection, Wildlife Policies and Governance	3
	3	Wildlife Ecology and Behaviour, Principles of Wildlife Ecology Population Dynamics and Demography	5

	4	Habitat Selection and Use, Animal Behaviour and Communication, Protected areas, RET species, IUCN, WWF, Major protected species in India	4
II		**Wildlife Conservation Genetics**	**10**
	5	Genetic Diversity and Conservation	2
	6	Molecular Tools in Wildlife Conservation	3
	7	Population Genetics Techniques	3
	8	Conservation Genomics	2
III		**Wildlife Habitat Management**	**20**
	9	Habitat Assessment and Mapping Habitat Restoration and Enhancement,	3
	10	Landscape Ecology and Connectivity Urban Wildlife Management	3
	11	Wildlife Health and Disease Management	3
	12	Wildlife Disease Ecology Emerging Infectious Diseases in Wildlife	3
	13	Wildlife Health Assessment Techniques	3
	14	Human-Wildlife Conflict Management	2
	15	Understanding Human-Wildlife Interactions	2
	16	Conflict Resolution Strategies Human Dimensions of Wildlife Management	3
	17	Livelihoods and Conservation	1
IV		**Conservation Policy and Planning**	**15**
	18	Conservation Planning Principles, Conservation strategies, Protected Areas Management	3
	19	Wildlife Economics and Sustainable Development	3
	20	Sustainable Use and Wildlife Trade, Economic Valuation of Wildlife Resources	3
	21	Ecotourism and Wildlife-based Enterprises, Integrating Conservation into Development Planning	3
	22	International Conservation Agreements	3
V		**Wildlife Education**	**15**
	23	Public Engagement in Conservation	4
	24	Environmental Education Strategies Communication and Advocacy Skills Community-based Conservation Initiatives, Field study to protected areas to create a model conservation strategy for wildlife	11
	25	Open ended	15

References

1. Duffus, D. A. (Ed.). (2017). *Wildlife and Society: The Science of Human Dimensions.* Island Press.
2. Sinclair, A. R. E., & Arcese, P. (Eds.). (1995). *Serengeti II: Dynamics, Management, and Conservation of an Ecosystem.* University of Chicago Press.
3. Groom, M. J., Meffe, G. K., & Carroll, C. R. (2006). *Principles of Conservation Biology.* Sinauer Associates.
4. Primack, R. B. (2014). *Essential of Conservation Biology.* Sinauer Associates.
5. Caughley, G., & Sinclair, A. R. E. (1994). *Wildlife Ecology and Management.* John Wiley & Sons.

6. Conover, M. R. (2002). *Resolving Human-Wildlife Conflicts: The Science of Wildlife Damage Management.* CRC Press.
7. Redford, K. H., & Taber, A. (2000). *Wildlife Conservation Society Birds of Brazil.* University of California Press.
8. Knight, R. L., & Gutzwiller, K. J. (Eds.). (1995). *Wildlife and Recreationists: Coexistence through Management and Research.* Island Press.
9. Dickman, A. J., Macdonald, E. A., & Macdonald, D. W. (Eds.). (2011). *Human-Wildlife Conflicts: The Challenges of Shared Spaces.* Cambridge University Press.
10. Western, D., Wright, R. M., & Strum, S. C. (Eds.). (1994). *Natural Connections: Perspectives in Community-based Conservation.* Island Press.
11. Conover, M. R. (2001). *Human dimensions of wildlife management in North America.* Wildlife Society.
12. Knight, R. L., & Gutzwiller, K. J. (Eds.). (1995). *Wildlife and Recreationists: Coexistence through Management and Research.* Island Press.
13. Hoare, R. E., & Du Toit, J. T. (Eds.). (1999). *Coevolution of Humans and Large Herbivores in Africa.* John Wiley & Sons.
14. Western, D., Wright, R. M., & Strum, S. C. (Eds.). (1994). *Natural Connections: Perspectives in Community-based Conservation.* Island Press.
15. Terborgh, J., & Van Schaik, C. (Eds.). (2002). *Making parks work: Strategies for preserving tropical nature.* Island Press.

Course Outcomes

No.	**Upon completion of the course the graduate will be able to**	**Cognitive Level**	**PSO addressed**
CO-1	comprehensive understanding of the principles, practices, and challenges associated with conserving wildlife	U	PSO-1,2
CO-2	Evaluate and apply tools for managing wildlife populations and habitats	R, U	PSO-2,3
CO3	Address complex issues related to wildlife conservation and sustainable management.	Ap	PSO-3,4
CO4	Integrates ecological, social, economic, and policy perspectives	An, Ap, C	PSO- 5
CO5	Analyze strategies and techniques for wildlife management	An, Ap,	
CO6	Apply field research methods and monitoring techniques	Ap, C	

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Credits: 4:0:0 (Lecture:Tutorial:Practical)

CO No.	**CO**	**PO/PSO**	**Cognitive Level**	**Knowledge Category**	**Lecture (L)/Tutorial**	**Practical (P)**

					(T)	
1	**Lecture**	1		F, C		
2	**Lecture, Tutorial**	2		C, P		
3	**Lecture, Tutorial**	3,4		P, M		
4	**Tutorial, Practical**	5		M		

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	1	-	-	-	-	-	-	-	5	-	-	3
CO 2	2	3	-	-	-	-	-	-	2	-	3	-
CO 3	-	-	1	-	-	-	-	-	-	2	-	3
CO 4	-	-	2	3	-	-	-	-	-	2	3	4
CO 5	-	1	-	-	-	-	-	-	3	--	-	4
CO 6	-	-	-	3	-	-	-	-	-	3	3	4

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓
CO 5		✓		✓
CO 6			✓	

Discipline	**ENVIRONMENTAL SCIENCE**				
Course Code	**UK6DSEENS300**				
Course Title	**SUSTAINABLE AGRICULTURE**				
Type of Course	**DSE**				
Semester	**VI**				
Academic Level	300 - 399**.**				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2	5
Pre-requisites	1. Basics of Agronomy 2. Basics of agricultural and farming practices 3. Pros and cons of Agrochemicals				
Course Summary	Course provides an introduction about sustainable agriculture and also covers other topics like soil health and nutrient management, water resource management and modern technologies in sustainable agriculture in order to provide better understanding of these topics to the scholar. The course develops hands-on skills through fieldwork, internships, or laboratory work, including soil testing, crop monitoring, pest identification, and sustainable farming techniques.				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Introduction to Sustainable Agriculture**	**10**
	1	Principles of Agronomy	1
	2	Overview of sustainable agriculture - definitions and goals, background, importance and need of sustainable agriculture	3
	3	Sustainable water and soil management	3
	4	Sustainable disease and pest management	3

II		**Principles and process of Sustainable Agriculture**	**10**
	5	Economics of sustainable agriculture	2
	6	National Mission for Sustainable Agriculture (NMSA)	2
	7	Climate change and sustainable agriculture	2
	8	Biopesticides and bioherbicides – role, importance and commercialization	2
	9	Green manures and biocontrol agents	2
III		**Soil health and Nutrient Management**	**15**
	10	Soil fertility, micro and macro nutrients	2
	11	Organic matter, soil pH, soil moisture and aeration	2
	12	Role of organic manures in soil health	3
	13	Integrated nutrient management	2
	14	Crop rotation systems	3
	15	Soil conservation systems	3
IV		**Water Resource Management**	**10**
	16	Effect of water quality on soil and plants	2
	17	Water harvesting techniques and Watershed management	2
	18	Irrigation and Drainage systems	2
	19	Environmental concerns and sustainable water management practices in agriculture	4
V		**Emerging trends in sustainable agriculture**	**15**
	20	Application of biotechnological tools in sustainable agriculture	3
	21	Remote sensing and GIS in land use planning	
	22	Sustainable Farming practices: Vertical farming, farm automation, rainfed farming, live stock farming, precision agriculture, flood-based farming system, drought proof farming system, Chemigation, Fertigation (practicum)	5
	23	Innovative farm integrations: Agriculture-Aquaculture-Animal husbandry integrations	5
	24	Artificial intelligence and nanotechnology in agriculture	2
	25	Open ended	**15**

Books and References:

1. Chatterjee, A., & Clay, D. (2016). Soil fertility management in agroecosystems, Madison, USA: American Society of Agronomy.
2. Coleman, D.C., Crossley, Jr. D.A., & Hendrix, P.F. (2004). Fundamentals of soil ecology (2nded.). Burlington, MA: Elsevier Academic Press.
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4. Gugino, B. K., Idowu, O.J., Schindelbeck, R.R., van Es, H.M., Moebius-Clune, B.N., Wolfe, D.W., Thies, J.E., & Abawi, G.S. (2009). Cornell soil health assessment training manual (2nd ed.). Ithaca: Cornell University.

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7. Magdoff F., &Es, H.V. (2009). Building soils for better crops: Sustainable soil management (3rd ed.). Bretwood, California: SARE Outreach Publications.
8. Poonia, R.C., Gao, X-Z., Raja, L., Sharma, S., & Vyas, S. (2019). Smart farming technologies for sustainable agricultural development, Hershey, USA: IGI Global.
9. Reicosky, D. (2018). Managing soil health for sustainable agriculture: Monitoring and management, Cambridge, UK: Burleigh Dodds Science Publishing.
10. M.A Khan and M.Y Zargar (2004), Agriculture and Environment, APH Publishing Corporation, New Delhi.
11. Edwards, C.A. et al. (ed.) 1990. Sustainable agricultural systems. Soil and Water Conservation Society. Akeny, IA.

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Understand the various aspects of sustainable agriculture, their role and importance in the present scenario The student will be able to explain in general the relationships among culture, economics, politics, science, and agricultural development. Students will develop a deep comprehension of the principles and concepts of sustainable agriculture, including its ecological, economic, and social dimensions.	U	PSO-1,2
CO-2	The student will be able to explain the major aspects of agricultural practices in terms of sustainable water and soil management and traditions through time and throughout the world. Understand the policy frameworks and regulations relevant to sustainable agriculture, including government incentives, certification programs, and environmental regulations.	R, U	PSO-3,5
CO-3	Gain knowledge of ecological processes and how they apply to agricultural systems, including soil health, nutrient cycling, water management, and biodiversity conservation. Learn techniques for soil conservation, soil fertility management, erosion control, and the importance of soil health for sustainable agriculture.	U, E	PSO 7

CO-4	Learn sustainable water use practices, including irrigation efficiency, rainwater harvesting, and water conservation strategies.	R, U, An	PSO 2,3
CO-5	A solid understanding of the cross-cultural interactions and exchange that linked the world's people and facilitated agricultural development is also expected in addition to analyse the importance of advanced technologies in agriculture. Enhance critical thinking skills to analyse complex agricultural problems and develop innovative solutions that balance environmental, social, and economic considerations. Develop hands-on skills through fieldwork, internships, or laboratory work, including soil testing, crop monitoring, pest identification, and sustainable farming techniques	A, An	PSO 8,9

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Credits: 4:0:0 (Lecture: Tutorial: Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
1	Understanding the overview of Sustainable agriculture	PSO-1,2	U	F, C	10	
2	Understand the policy document and the upcoming vision of Sustainable agriculture		R,U	C, P	10	5
3	Learn and analyse the soil management practices and understand the soil conservation systems.	PSO-3,5	U, E	C	15	4
4	Learn sustainable water management practices in terms of agricultural sustainability.	PSO 2,3	R, U, An	C	10	2
5	Apply value added agricultural integration and its implementation of the faming integration for public services.	PSO 8,9	A, An	P	15	4

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	1	-	-	1	-	3	1	-	3	-	-	
CO 2	2	2	-	-	1	-	-	2	-	2	-	1
CO 3	-	-	1	-	-	2	1	-	-	3	2	
CO 4	-	-	2	3	-	1	2	3	1	-	-	3
CO 5	-	1	-	-	3	-	1	3	-	2	-	1
CO 6	1	-	-	1	-	3	1	-	3	-	-	1

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓
CO 5		✓		✓
CO 6			✓	✓

Discipline	**ENVIRONMENTAL SCIENCE**
Course Code	**UK6DSEENS301**
Course Title	**GREEN PRODUCTS AND ENTREPRENEURSHIP**
Type of Course	**DSE**
Semester	VII
Academic Level	300 – 399

<table>
<tr><td rowspan="2">Course Details</td><td>Credit</td><td>Lecture per week</td><td>Tutorial per week</td><td>Practical per week</td><td>Total Hours/Week</td></tr>
<tr><td>4</td><td>3 hours</td><td>-</td><td>2 hours</td><td>5</td></tr>
<tr><td>Pre-requisites</td><td colspan="5">1. Basic understanding of entrepreneurship principles.
2. Familiarity with sustainability concepts.
3. Knowledge of business models and market analysis.
4. Understanding of environmental science and its relevance to product development.</td></tr>
<tr><td>Course Summary</td><td colspan="5">Understand the principles of sustainability and their application to entrepreneurship, including the triple bottom line approach (economic, environmental, and social). Evaluate green product development strategies, considering factors such as lifecycle assessment, eco-design principles, and sustainable sourcing practices. Analyze the market demand for green products, identifying consumer trends, market niches, and opportunities for innovation. Develop a business plan for a green venture, integrating concepts of sustainability into all aspects of business strategy, including product development, marketing, operations, and finance.</td></tr>
</table>

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Introduction to Green Products and Entrepreneurship**	**10**
	1	Understanding Green Products - Definition and characteristics of green products, Importance of sustainability in product design and development.	3
	2	Market Trends and Opportunities - Analysis of consumer preferences towards sustainable products, Identification of market niches and opportunities for green entrepreneurs	3
	3	Principles of Sustainable Design - Eco-design principles and life cycle thinking, Integration of sustainability criteria into product development processes	2
	4	Sustainable Materials and Manufacturing - Selection of eco-friendly materials and production processes, Strategies for reducing environmental impacts in manufacturing. Sustainable Packaging and Distribution - Eco-friendly packaging options and alternatives.	2
II		**Green Product Development (practicum)**	**15**
	5	Ideation and Conceptualization - Generating ideas for green products, Concept development and feasibility analysis	4

	6	Design Thinking for Sustainability - Human-centered design approaches, Prototyping and testing green product concepts	4
	7	Sustainable Product Engineering - Design for disassembly, recycling, and reuse, Incorporating renewable energy and resource efficiency into product design	3
	8	Life Cycle Assessment (LCA) - Methodologies for assessing environmental impacts throughout a product's life cycle, Case studies and applications of LCA in green product development. Certification and Standards. Overview of eco-labels, certifications, and environmental standards, Compliance requirements and benefits for green products	4
III	**Sustainable Business Models**		**25**
	9	Circular Economy Principles - Understanding the principles of the circular economy, Implementing circular business models and strategies	3
	10	Product-Service Systems (PSS) - Concept and benefits of PSS for sustainability, - Examples of successful PSS implementations	3
	11	Collaborative Consumption and Sharing Economy - Role of collaborative consumption in promoting sustainability, Business opportunities and challenges in the sharing economy	3
	12	Cradle-to-Cradle (C2C) Approach - Principles of C2C design and manufacturing, Case studies of companies adopting C2C principles	3
	13	Social Entrepreneurship and Impact Investing - Using entrepreneurship for social and environmental impact, Financing options and support networks for green entrepreneurs	3
	14	Marketing and Branding Green Products - Green Marketing Strategies, Communicating sustainability attributes to consumers, Ethical marketing practices and greenwashing avoidance	3
	15	Building Sustainable Brands - Branding strategies for green products and companies, - Creating brand value through environmental and social responsibility	3
	16	Consumer Behavior and Psychology - Understanding consumer motivations and barriers towards sustainable consumption, - Behavior change strategies and marketing interventions	2
	17	Green Product Promotion and Distribution - Strategies for promoting green products through various channels, - Sustainable retailing and online marketing tactics	2
IV	**Scaling Up and Impact Measurement**		**10**
	18	Scaling Green Ventures - Strategies for scaling up green businesses, Challenges and opportunities in expanding market reach	2
	19	Access to Finance and Investment - Financing options for green entrepreneurs, - Impact investment and venture capital for sustainability ventures	2
	20	Supply Chain Management and Transparency - Ensuring sustainability throughout the supply chain, - Supply chain transparency and traceability for green products	2

	21	Impact Assessment and Reporting - Methods for measuring and reporting environmental and social impact, Communicating impact to stakeholders and investors	2
	22	Stakeholder Engagement and Partnerships - Building relationships with stakeholders and influencers, Collaborating with NGOs, governments, and other organizations to promote green products	2
V	**Case Studies and Practical Applications – Open ended**		**15**
		: Case Studies and Best Practices - Analysis of successful green product ventures and entrepreneurs, Lessons learned and best practices for aspiring green entrepreneurs	

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Course Outcomes

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understanding of Green Products	**U**	**C**	**Instructor-created exams / Quiz**
CO2	Entrepreneurial Mindset	**An**	**P**	**Group Discussions/ Debates**
CO3	Market Analysis and Opportunity Identification	**Ap**	**P**	**Seminar Presentation / Group Tutorial Work**
CO4	Product Development and Design	**An**	**C**	**Instructor-created exams / Home Assignments**
CO5	Business Model Innovation	**An**	**C**	**Instructor-created exams / Home Assignments**
CO6	Supply Chain Management	**An**	**C**	**Instructor-created exams / Home Assignments**

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Credits: 4:0:0 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
1	**Lecture**	1		F, C		
2	**Lecture, Tutorial**	2		C, P		
3	**Lecture, Tutorial**	3,4		P, M		
4	**Tutorial, Practical**	5		M		

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6

CO 1	1	-	-	-	-	-		3	3	3		3
CO 2	2	3	-	-	-	-	3				4	4
CO 3	-	-	1	-	-	-	4		4	3	3	4
CO 4	-	-	2	3	-	-		3	4	4		4
CO 5	-	1	-	-	-	-	4		4	4		4
CO 6	-	-	-	3	-	-	3		4	4	4	4

Correlation Levels:

Level	Correlation
1	Nil
2	Slightly / Low
3	Moderate / Medium
4	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓
CO 5		✓		✓
CO 6			✓	

Discipline	**ENVIRONMENTAL SCIENCES**				
Course Code	**UK6DSEENS302**				
Course Title	**RESTORATION ECOLOGY**				
Type of Course	**DSC**				
Semester	VI				
Academic Level	300-399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5
Pre-requisites	1. Need basic understanding to developing your own restoration plan or policy, with an outline of all the foundational concepts 2. Have a basic knowledge to review tools, strategies, and principles behind consultation, planning, implementation, monitoring, and reporting for restoration work.				
Course Summary	The United Nations General Assembly declared 2021-2030 as the UN Decade on Ecosystem Restoration. The UN Decade is a universal call for the protection and revival of ecosystems around the world, for the benefit of people and nature. It calls for commitment of the global community to restoring degraded ecosystems through clear, measurable goals and targets to address the dangerous loss of biodiversity and safeguarding ecosystem services and functionality, and lead the way to achieving the CBD 2050 Vision of "Living in Harmony with Nature". So, a course loke this detailing all aspects of ecosystem restoration will help build experts in the field to raise awareness and reverse the trend of biodiversity decline in our surroundings.				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Basics of Restoration Ecology**	**10**
	1	Restoration Ecology-Definition and Concept	2
	2	History of Restoration Ecology and Impacts on Ecosystems	2
	3	Goals of Restoration Ecology	1
	4	Principles of Restoration Ecology	1
	5	Examples of ecological restoration (National and International)-**Field Visit to Sites of Importance**	4
II		**Types of Ecological Restoration**	**10**
	6	Passive restoration	3
	7	Active restoration	3
	8	Rehabilitation	2
	9	Reclamation	2
III		**Concepts Underpinning Restoration**	**15**
	10	Disturbance	3
	11	Genetics	3

	12	Succession	3
	13	Community Assembly Theory	3
	14	Landscape Ecology	3
IV		**Approaches to Ecological Restoration**	**15**
	15	Importance of Ecological Restoration	2
	16	Assessing the site	1
	17	Formulating project goals	1
	18	Removing sources of disturbance	1
	19	Restoring processes/disturbance cycles	1
	20	Rehabilitating substrates	2
	21	Restoring vegetation- **Field Visit/Practicum**	4
	22	Monitoring and maintenance	2
V		**Challenges and Solutions**	**10**
	23	Climate Change Impacts	5
	24	Solutions - Collaborative and adaptive approaches	5
	25	Open ended	**15**

Course Outcomes

No.	**Upon completion of the course the graduate will be able to**	**Cognitive Level**	**PSO addressed**
CO-1	Understand the basics of ecological restoration	U	PSO 1
CO-2	Define the goals and principles involved with valid proof	R	PSO 2
CO3	Understand the different steps involved in the restoration process	U	PSO 6
CO4	Address the major challenges involved in the restoration process and come up with possible solutions to solve the problem	E	PSO 4
CO5	Recognize the importance of environmental changes, demonstrate an understanding of theoretical and practical environmental issues	An	PSO 6, PSO 10

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Credits: 4:0:0 (Lecture:Tutorial:Practical)

CO No.	**CO**	**PO/PSO**	**Cognitive Level**	**Knowledge Category**	**Lecture (L)/Tutorial (T)**	**Practical (P)**	**Open Ended**

1	Understand the basics of ecological restoration	PSO 1	U	F, C	10		3
2	Define the goals and principles involved with valid proof	PSO 2	R	P, C	10		3
3	Understand the different steps involved in the restoration process	PSO 6	U	M	12	4	3
4	Address the major challenges involved in the restoration process and come up with possible solutions to solve the problem	PSO 4	E	M	10	4	3
5	Recognize the importance of environmenta l changes, demonstrate an understandin g of theoretical and practical environmenta l issues	PSO 6, PSO 10	An	P	10		3

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO10	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	1	-	1	-	-	-	1	-	1	-	1	-	1
CO 2	2	3	-	-	-	-	-	1	-	-	-	1	-
CO 3	-	-	1	-	-	2	-	-	-	2	-	-	-
CO 4	-	-	2	3	-	-	-	2	-	1	-	2	-
CO 5	-	1	-	-	-	3	1	-	-	1	2	-	-

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Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓
CO 5		✓		✓
CO 6			✓	

Discipline	**ENVIRONMENTAL SCIENCES**				
Course Code	**UK6DSEENS303**				
Course Title	**SOIL CONSERVATION**				
Type of Course	**DSE**				
Semester	**VI**				
Academic Level	300-399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5
Pre-requisites	1. Basic knowledge of environmental science or biology 2. Understanding of ecological principles 3. Familiarity with agricultural practices				
Course Summary	This course provides an in-depth exploration of the principles and practices of land management and soil conservation. Students will learn about the importance of sustainable land use, soil properties and classification, erosion control techniques, water management, and the role of policy and regulations in land conservation. Through theoretical discussions, case studies, fieldwork, and practical exercises, students will gain the necessary knowledge and skills to address challenges related to land degradation and implement effective soil conservation strategies.				

Detailed Syllabus:

Module	**Unit**	**Content**	**Hrs**
I		**Introduction to Land Management and Soil Conservation**	**8**

	1	Definition of land management and soil conservation	2
	2	Importance of sustainable land management	3
	3	Historical perspectives and development of soil conservation practices	3
II	**Soil Properties and Classification**		**8**
	4	Soil formation processes	2
	5	Soil texture, structure, and composition	3
	6	Soil classification systems (e.g., USDA soil taxonomy)	3
III	**Erosion Control and Soil Conservation Practices**		**15**
	7	Types of soil erosion (water, wind, tillage)	2
	8	Erosion control practices (e.g., contour ploughing, terracing, windbreaks)	3
	9	Soil erosion modelling and prediction	2
	10	Conservation tillage methods (e.g., no-till, reduced tillage)	2
	11	Cover cropping and crop rotation	1
	12	Conservation buffer zones	2
	13	Soil amendments and organic matter management	3
IV	**Land Use Planning and Sustainable Agriculture**		**7**
	14	Principles of sustainable land use planning	1
	15	Integrated land management approaches	2
	16	Agroforestry and silvopastoral systems	3
	17	Urban land management and green infrastructure	1
V	**Soil Degradation and Remediation**		**7**
	18	Soil degradation: causes and consequences	1
	19	Soil pollution and contamination	2
	20	Soil remediation techniques (e.g., phytoremediation, bioremediation)	2
	21	Land rehabilitation and restoration strategies	2

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Understand the importance of sustainable land management practices for environmental conservation and food security.	U	PSO-1,2
CO-2	Identify different types of soil erosion and apply appropriate erosion control techniques.	R, U	PSO-2,3
CO-3	Implement conservation tillage methods and sustainable agricultural practices to reduce soil erosion and improve soil health.	Ap	PSO-3,4
CO-4	Evaluate water management strategies and their	E	PSO-2,3.4

	impact on soil conservation.		
CO-5	Analyze the role of land use planning and policy frameworks in promoting sustainable land management.	An	PSO-4,5

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

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Note: 1 or 2 COs/module

Name of the Course: Credits: 4:0:0 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO-1	Understand the importance of sustainable land management practices for environmental conservation and food security.	PSO-1,2	U	F, C		
CO-2	Identify different types of soil erosion and apply appropriate erosion control techniques.	PSO-2,3	R, U	C,P		
CO-3	Implement conservation tillage methods and sustainable agricultural practices to	PSO-3,4	Ap	P,M		

	reduce soil erosion and improve soil health.					
CO-4	Evaluate water management strategies and their impact on soil conservation.	PSO-2,3.4	E	M		
CO-5	Analyze the role of land use planning and policy frameworks in promoting sustainable land management.	PSO-4,5	An	P,M		

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	2	1	-	-	-	-	2	-	-	-	-	-
CO 2	-	2	3	-	-	-	-	-	-	-	-	-
CO 3	--	-	2	1	-	-	-	2	-	-	-	-
CO 4	-	1	2	3	-	-	-	-	2	--	--	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar

- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓
CO 5		✓		✓
CO 6			✓	

Discipline	**ENVIRONMENTAL SCIENCES**				
Course Code	**UK6DSEENS304**				
Course Title	**WASTE TO ENERGY**				
Type of Course	**DSE**				
Semester	**VI**				
Academic Level	300-399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	4 hours	-		4
Pre-requisites	The learners should have an understanding of environmental problems created by various kinds of waste. The learner also should have a basic idea of the problems associated with the availability of energy and alternative sources of energy.				
Course Summary	This course provides the learner with the details of the different waste-to-energy systems and the techniques of waste conversion				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Introduction to waste management**	**2**
	1	Principles of waste management and waste utilization	1
	2	Waste management hierarchy: 3R Principle	1
II		**Classification of wastes**	**4**
	3	Waste production in different sectors: domestic, industrial, agriculture; International and National scenario	2
	4	Classification of wastes: biodegradable/ non-biodegradable; hazardous and non-hazardous	2
		Waste Conversions	**12**
	5	Technologies for waste to energy: biochemical conversion	2

III	6	Anaerobic digestion and fermentation; biogas production	2
	7	Biogas plant technology: Design and construction features	2
	8	Types of biogas plants - applications	2
	9	Thermochemical conversion; combustion	2
	10	Incineration and pyrolysis	2
IV		**Energy from wastes**	**26**
	11	Gasification, Plasma Arc Technology	2
	12	Landfill gas: collection and recovery	2
	13	Conversion of wastes to fuel resources	2
	14	Plastic wastes and energy recovery	2
	15	Biomass extraction and valorization	2
	16	Hydrogen production: Pyrolysis of biomass; gasification	2
	17	Bioethanol production from biomass wastes	2
	18	Biodiesel production from biomass waste and vegetable oil	2
	19	Transesterification of triglycerides	2
	20	Biodiesel from spent oil	2
	21	Determination of biodiesel viscosity and flammability point	2
	22	Alcohol production from biomass	2
	23	Bioconversion of organic wastes: composting	2
V		**Biomass energy program**	**16**
	24	Urban wastes to energy conversion and biomass energy program in India	4
	25	Open-ended	12

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Course Outcomes

No.	Upon completion of the course, the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Analyze the various aspects of waste-to-energy systems	R, U	PSO- 1,2,3 PO- 1,2
CO-2	Illustrate the classification of waste and its conversions to different types of fuels	R, U	PSO- 1,2,3 PO- 3,4
CO-3	Explain the concept of waste to energy	U	PSO-1,2,3 PO-1.2
CO-4	Explain different types of biomass combustion techniques	An	PSO-3,4 PO-2,7
CO-5	Link legal, technical and management principles for the production of energy from waste	An, Ap	PSO- 3,4,5 PO- 1,2,6,8

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create
Note: 1 or 2 COs/module
Name of the Course: Credits: 4:0:0 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO-1	Analyze the various aspects of waste-to-energy systems	PSO-1,2,3 PO- 1,2	R, U	F, C	2	-
CO-2	Illustrate the classification of waste and its conversions to different types of fuels	PSO-1,2,3 PO- 3,4	R, U	F, C	4	-
CO-3	Explain the concept of waste to energy	PSO-1,2,3 PO-1.2	U	F, C	12	-

CO-4	Explain different types of biomass combustion techniques	PSO-3,4 PO-2,7	An	F, C, M	26	
CO-5	Link legal, technical and management principles for the production of energy from waste	PSO-3,4,5 PO-1,2,6,8	An, Ap	F, C	4	

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	3	3	3	-	-	-	3	3	-	-	-	-
CO 2	3	3	3	-	-	-	-	-	3	3	-	-
CO 3	-	-	3	3	-	-	3	3	2	-	-	-
CO 4	3	3	3	-	-	-	2	2	-	-	-	-
CO 5	-	-	3	-	-	2	-	-	3	2	-	3

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Analytical skills
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations

CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓
CO 5		✓		✓
CO 6			✓	

Discipline	**ENVIRONMENTAL SCIENCES**				
Course Code	**UK6SECENS301**				
Course Title	**REMOTE SENSING AND DIGITAL IMAGE PROCESSING**				
Type of Course	**SEC**				
Semester	**VI**				
Academic Level	300 - 399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5
Pre-requisites	1. Basic map reading and interpretation skills 2. Basic understanding of physical and geographical concepts involved in geospatial technology				
Course Summary	This course covers the interdisciplinary field of geoinformatics, exploring its definition, components, and role in development and administration. The students will acquire practical skills in remote sensing and GIS, familiarity with ArcGIS software, and applications in natural hazard assessment, urban planning, biodiversity conservation, and climate change analysis.				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Introduction to Remote Sensing**	**10**
	1	Basic Principles of Remote Sensing (Physics of remote sensing, Characteristics of electro-magnetic radiation; Interactions between matter and electro-magnetic radiation; energy interaction in the atmosphere; energy interactions with the earth's surface, spectral reflectance curves)	2
	2	Types of remote sensing (Ground-based, airborne, and spaceborne, Orbits-polar, geostationary, Sensors-active, passive, MSS, Radar, Lidar, Resolution - Spatial, spectral, temporal, and radiometric).	2
	3	Scanners and sensors(imaging sensors, Thermal sensors; Atmospheric sensors; Sonar; Laser, radar, hyperspectral sensors, Panchromatic, Multispectral-whisk broom & push broom, stereo images, Products from scanner data, Image data characteristics	2
	4	Data products and softwares (Digital data products and their characteristics. Digital Image Formats-BSQ, BIL, BIP, licensed and	2

		opensource softwares for geodata processing)	
	5	Data visualisation (Image layer stacking, Colour image generation, Initial data statistics, Histogram and Scatter plot, Mosacing)	2
II		**Digital image processing I – Pre processing**	**10**
	6	Image Rectification (Atmospheric, Geometric corrections, radiometric correction, noise removal)	2
	7	Image registration (image to map, image to image)	2
	8	Spatial Filtering- Low Frequency, High Frequency,	2
	9	Band ratioing and Band Combination	2
	10	Image Enhancement (Contrast manipulation, Spatial feature manipulation, Multi-image manipulation)	2
III		**Digital image processing II – Image classification**	**10**
	11	Unsupervised classification techniques (generating clusters, assigning classes)	2
	12	Supervised classification techniques	2
	13	Training site creation and signature editing	2
	14	Classifiers: Maximum Likelihood, Euclidian Distance, Mahalanobis Distance, Paralellopiped.	2
	15	Classification. Accuracy Assessment and Error Matrix (Kappa statistics)	2
IV		**Recent trends and applications in digital image processing**	**10**
	16	High-Resolution Sensors (optical and radar)	2
	17	Real-Time Data Acquisition	2
	18	Digital Elevation Models (DEMs)	2
	19	Artificial Intelligence and Machine Learning Techniques	2
	20	Geo-spatial Modelling and TimeSeries Analysis	2
V		**Project and Practical Applications**	**8**
	21	Hands-on experience with Google Earth Engine and open source softwares	2
	22	Mapping land use and land cover changes.	2
	23	Project-based Field visits	2
	24	Guest lectures by industry professionals	2
	25	**Open Ended**	12

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PO/PSO addressed
CO-1	Explore the characteristics of electromagnetic radiation, Learn about products derived from scanner data and image data charact	U, R	PO-2 PSO-1,2
CO-2	Understand the impact of atmospheric effects on remotely sensed imagery and Learn techniques to correct for atmospheric distortions. Understand	U, R	PO-1 PSO-1,2

	contrast stretching techniques		
CO 3	Understand the concept of unsupervised and supervised classification, Learn about the confusion matrix and its components, Calculate Kappa statistics to assess overall classification accuracy	U, Ap, An	PO-3,7 PSO-1,2
CO 4	Understand relevant aspects of digital image representation and their practical implications, Apply artificial intelligence and machine learning techniques to geospatial data	U, Ap	PO-3,7 PSO-1,3
CO 5	Explore open-source software platforms (such as QGIS, GRASS GIS, or R) for spatial data processing and analysis, Apply theoretical knowledge to practical scenarios and gain insights into the challenges faced in the field.	An, Ap	PO-5,7 PSO-3,4,6

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

References

1. Understanding Earth Observation,The Electromagnetic Foundation of Remote Sensing, Domenico Solimini. Springerlink, 2016.
2. Digital Image Processing, Rafael C. Gonzalez, Richard Eugene Woods. Prentice Hall, 2008.
3. Digital Image Processing, Rafael C. Gonzalez. Pearson Education India, 2009.
4. Remote Sensing and Image Interpretation by Thomas Lillesand, Ralph W. Kiefer, and Jonathan Chipman. John Wiley & Sons.
5. Remote Sensing and Digital Image Processing with R, Marcelo de Carvalho Alves, Luciana Sanches. 2023 (1st Edition).
6. Math Physics Foundation of Advanced Remote Sensing Digital Image Processing, Lei Yan , Hongying Zhao , Yi Lin , Yanbiao Sun. Springerlink, 2023.
7. Image Processing and GIS for Remote Sensing Techniques and applications, Jian Guo Liu and Philippa J. Mason. Wiley Blackwell, 2016 (2nd edition).
8. Introductory Digital Image Processing - A Remote Sensing Perspective, John R Jensen. Pearson, 2017(Fourth Edition).

Name of the Course: Credits: 4:0:0 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)	Open Ended (OE)

CO 1	1	PO-2 PSO-1,2	U, R	F, C	10		2
CO 2	2	PO-1 PSO-1,2	U, R	F, C	10		2
CO 3	3	PO-3,7 PSO-1,2	U, Ap, An	C, P	10		2
CO 4	4	PO-3,7 PSO-1,3	U, Ap	C, P	10		2
CO 5	5	PO-5,7 PSO-3,4,6	An, Ap	P, M		8	4

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO 1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO 1	1	1	-	-	-	-	-	2	-	-	-	-
CO 2	1	3	-	-	-	-	2	-	-	-	-	-
CO 3	2	1	-	-	-	-	-	-	3	-	-	-
CO 4	2	-	1	-	-	-	-	-	1	-	-	-
CO 5	-	-	2	2	-	1	-	-	-	-	1	-

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Internal Exam
- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Project evaluation
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5			✓	

Discipline	**ENVIRONMENTAL SCIENCES**				
Course Code	**UK6SECENS302**				
Course Title	**APPLICATIONS OF ENVIRONMENTAL IMPACT ASSESSMENT**				
Type of Course	**SEC**				
Semester	**VI**				
Academic Level	300 - 399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	4 hours	-		4
Pre-requisites	The learner should have a basic understanding of the environmental issues caused by developmental activities				
Course Summary	The course is intended to give learners, an understanding of the impacts of activities on the environment and the mechanisms to measure the significance of those. This gives an idea of the process of EIA and the various stages of this. It explains what a standard Terms of Reference of a developmental activity is and the processes of Environmental Clearance. The course is structured in a way to makes the learner competent to get a job in the State Environment Impact Assessment Authority and various projects. Finally, the learner is expected to execute an EIA study of a selected project				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Introduction to Environmental Impact Assessment (EIA)**	**17**
	1	Stages of EIA (Pre-study period: Screening, scoping, assessment, Study period: preparation of EIA. Post-study period: review, decision making, and monitoring), Types of EIA (preliminary, rapid, comprehensive)	4
	2	EIA as an integral part of planning	1
	3	Description of project and project alternatives by the project proponent	1

	4	Environment Attributes: air, water, noise, land and soil	2
	5	Baseline Data collection	1
	6	Screening, initial environmental examination, scoping	2
	7	Scoping	1
	8	Draft Environmental Impact Statement, public participation, Final EIS	2
	9	Reviewing and decision-making	1
	10	Monitoring, impact management, EIA audit, and evaluation	2
II		**EIA of Highrise Buildings and Construction Projects**	**6**
	11	Introduction	1
	12	Categorization of Building Projects	1
	13	Guidelines for EIA study	1
	14	Standard TOR	2
	15	Case Study (Practicum)	1
III		**EIA of Highway Projects**	**6**
	16	Introduction, Guidelines for EIA Study	1
	17	Generic Structure of Highway Projects	1
	18	Validity and Transferability of Environmental Clearance	1
	19	Post-environmental Clearance Monitoring	1
	20	Case Study (Practicum)	2
IV		**EIA of Rock Quarrying**	**4**
	21	Introduction, Generic Structure of EIA document	1
	22	Validity and Transferability of Environmental Clearance	1
	23	Case Study (Practicum)	2
V		**EIA of Mining**	**12**
	24	Introduction, Categorisation of Mining Projects, Generic Structure of EIA with Case Study (Practicum)	3
	25	Open-ended	9

References

1. Anji Reddy Mareddy, Butterworth-Heinemann, 2017. Environmental Impact Assessment.
2. Assessment. IK International publishing house Pvt. Ltd.
3. Bregman, J.I. and Mackenthum, K.M. 1992. Environmental impact statements. Chelsia Michigan: Lewis.
4. Canter, W. Larry. 1996. Environmental impact assessment. McGraw-Hill International editions. 660p.
5. Fortlage, C. 1990. Environmental assessment: a practical guide.Aldershot: Gower
6. Glasson J, Taylor and Francis, 2019. Introduction To Environmental Impact Assessment 5Ed.
7. Glasson, J; Therivel, R and Chadwick, Al. 1999. Introduction to environmental impact assessment. UCL Press. 496p.
8. Glasson, J., & Therivel, R. (2013). *Introduction to environmental impact assessment*. Routledge.
9. Khandeshwar, S.R., Raman, N.s., Gajbhiye, A.R (2019). Environmental Impact

10. Morris, P and Therivel, R. 1995. Methods of environmental impact assessment. London. UCL press.
11. Munn, R.E.1979. Environmental impact assessment: principles and procedures, 2nd Edn. New York: Wiley.
12. Sabu Joseph and Arunkumar K S. 2022. Environmental Impact Assessment of Developmental Projects

Course Outcomes

No.	Upon completion of the course, the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Describe the history of EIA, explain the various types, stages, and characteristics of EIA	R, U	PSO-1,2,6 PO- 1,2
CO-2	Explain the concept of project and project alternatives, and environmental attributes, and will be able to describe the process of Environmental Impact Assessment.	R, U	PSO-1,2,6 PO- 1,6,7
CO-3	Identify, predict, and evaluate impacts	Ap	PSO-2,3,4,6 PO- 1,2,5
CO-4	List various categories of projects and identify which of those need an EIA	Ap	PSO-6 PO- 2
CO-5	Describe the functions of the State Environment Impact Assessment Committee, Environmental Clearance in India, and the functions of the Environmental Appraisal Committee	R, Un	PSO-1,2,6 PO- 1,2

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create
Note: 1 or 2 COs/module
Name of the Course: Credits: 4:0:0 (Lecture: Tutorial: Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO-1	Describe the history of EIA, explain the various types, stages, and characteristics of EIA	PSO-1,2,6	1	F, C	7	0
CO-2	Explain the	PSO-	R, U	F, C	5	1

	concept of project and project alternatives, and environmental attributes, and will be able to describe the process of Environmental Impact Assessment.	1,2,6				
CO-3	Identify, predict, and evaluate impacts	PSO-2,3,4,6	Ap	F, C, P	4	2
CO-4	List various categories of projects and identify which of those need an EIA	PSO-6,9	Ap	C, P, M	2	2
CO-5	Describe the functions of the State Environment Impact Assessment Committee, Environmental Clearance in India, and the functions of the Environmental Appraisal Committee	PSO-1,2,6,9	R, Un	C. P	1	2

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	2	2	-	-	-	3	3	3	-	-	-	-

CO 2	2	2	-	-	-	3	3	-	-	-	-	3
CO 3	-	3	3	-	-	3	3	3	-	-	2	-
CO 4	-	-	-	-	-	3	-	3	-	-	-	-
CO 5	3	3	-	-	-	3	3	3	-	-	-	-

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Case Studies
- Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓
CO 5		✓		✓
CO 6			✓	

Discipline	**ENVIRONMENTAL SCIENCES**
Course Code	**UK6SECENS303**
Course Title	**ECOTOURISM**
Type of Course	**SEC**
Semester	**VI**
Academic Level	300 - 399

Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	3	2 hours	-	1 hours	3
Pre-requisites	1. A basic understanding on the ecological and social concepts 2. A genuine interest in ecotourism and sustainability				
Course Summary	This course delves into the principles of sustainable tourism, emphasizing the engagement of local communities and assessing the ecological impacts of tourism, including carrying capacity and ecological limits. Community engagement and empowerment are central to the course, highlighting the role of local communities in ecotourism, community-based tourism initiatives, and the socioeconomic benefits and challenges they face. The course is enriched with field visits to ecotourism sites and guest lectures from industry experts, providing practical insights and real-world applications.				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Ecotourism-Introduction & Ecological Foundations**	**10**
	1	Definition, historical context, and evolution of ecotourism	2
	2	Principles of sustainable tourism & engagement of local communities	2
	3	Concepts, characteristics and attributes of ecotourism (the six characters (Chesworth, 1995), species and ecosystem conservation, livelihood for local communities)	2
	4	Ecological impacts of tourism (positive and negative, balancing economic benefits with ecological consequences)	2
	5	Types of eco-tourists (hardcore, dedicated, mainstream, casual)	2
II		**Natural Resource Management**	**10**
	6	Aims in accordance with sustainable use of natural resources	2
	7	Forests, wetlands, marine environments (potentials and challenges of each with examples)	2
	8	Ecological restoration and habitat enhancement (methods and benefits)	2
	9	Ecotourism standards (protection of the cosystem, maintenance of physico-chemical conditions, conservation of local culture, sustainability)	2
	10	Case studies of successful wildlife tourism projects	2
III		**Economic Aspects and Tourism Marketing**	**10**
	11	Economic impact assessments (CBA, Economic IO, revenue generation assessment in the context of ecotourism projects)	2
	12	Pricing strategies for ecotourism products (product quality, distribution and accessibility, cost structure and profit marginality)	2
	13	Marketing strategies and campaigns (Partenship creation, awareness campaigns, highlighting sustainability patterns, educational contents, leveraging digital platforms etc)	2
	14	Target audiences and Responsible advertising (targeting adventure seekers, nature lovers, and conservationists through showcasing sustainability, educating tourists, digital marketing and collaborating with stakeholders)	2
	15	Carrying capacity and ecological limits (methods of assessment and	2

		factors under consideration)	
IV	**Tourism Policies and Regulations**		**10**
	16	National and international policies (Wildlife (Protection) Act, 1972, State Policies, UN-declared International Year of Ecotourism (IYE) 2002, UNWTO (United Nations World Tourism Organization)	2
	17	Certification programs (e.g., Green Globe, Rainforest Alliance)	2
	18	Legal frameworks for ecotourism development	2
	19	Ecotourism performance indicators (Key Performance Indicators (KPIs)- carbon footprint reductio, community engagement, waste management and recycling, education and awareness, sustainable resource management, local economic development)	2
	20	Benefits/advantages of ecotourism	2
V	**Community Engagement and Empowerment (Practicum)**		**8**
	21	Role of local communities in ecotourism- field-based experience generation	2
	22	Ecological Surveys: Students learn to assess biodiversity, habitat quality, and ecosystem health.	2
	23	Field visits to ecotourism sites and Guest lectures from industry experts	2
	24	Development of basic planning strategies for ecotourism development	2
	25	**Open Ended**	**12**

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PO/PSO addressed
CO-1	Understand the historical development and evolution of ecotourism as a concept. recognize the critical role of local communities in ecotourism development and management, evaluate the ecological limits of specific ecosystems and their implications for sustainable tourism practices	U, R	PO-1 PSO-1,2
CO-2	Understand the principles of sustainable resource utilization in ecotourism, explore techniques for enhancing habitats to support biodiversity and ecotourism activities, and examine real-world examples of wildlife tourism initiatives that have achieved a balance between conservation and visitor experience	U, An, Ap	PO-2,3 PSO-1,2,4
CO 3	Understand how tourism activities influence local economies, employment, and revenue generation, determine appropriate pricing for ecotourism experiences while considering sustainability and	U, Ap	PO-3, 6 PSO-1,2,7

	affordability, explore digital marketing, content creation, and promotional techniques tailored to ecotourism.		
CO 4	Explore legal frameworks related to tourism at both global and national levels, understand the role of certification in promoting sustainable practices within the tourism industry, and evaluate the success and effectiveness of ecotourism initiatives.	U, An	PO-3.7 PSO-1,2,5
CO 5	Recognize the pivotal role local communities play in ecotourism development, critically examine community challenges, such as capacity building, resource management, and balancing economic gains with cultural preservation, and gain practical insights through field visits to ecotourism destinations, observing community involvement and sustainable practices.	U, Ap, An	PO-2,3 PSO-4, 5,6

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-CreatePO-

Note: 1 or 2 COs/module

References

1. Ecotourism, David A. Fennell. Routledge, 2020 (5th edition).
2. The Encyclopedia of Ecotourism, David Weaver. CABI, 2001.
3. Ecotourism Policy and Planning, David A. Fennell CABI, 2003.
4. Culture, Ecology, and Sustainable Development, Sukanta K. Chaudhury. Mittal Publications, 2006 (1st edition).
5. Environment Impacts of Ecotourism, Ralf Buckley. CABI, 2004.
6. Ecotourism: Environment, Health, and Education, Wei-Ta Fang , Arba'at Hassan , Max Horng. Springer, 2024.

Name of the Course: Credits: 2:0:1 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO addressed	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)	OE
CO-1	Understand the historical development and evolution of ecotourism as a concept. recognize the critical role of local communities in ecotourism development and management, evaluate the ecological limits of	PO-1 PSO-1,2	U, R	F, C	12		2

	specific ecosystems and their implications for sustainable tourism practices						
CO-2	Understand the principles of sustainable resource utilization in ecotourism, explore techniques for enhancing habitats to support biodiversity and ecotourism activities, and examine real-world examples of wildlife tourism initiatives that have achieved a balance between conservation and visitor experience	PO-2,3 PSO-1,2,4	U, An, Ap	C, P	12	3	2
CO 3	Understand how tourism activities influence local economies, employment, and revenue generation, determine appropriate pricing for ecotourism experiences while considering sustainability and affordability, explore digital marketing, content creation, and promotional techniques tailored to ecotourism.	PO-3, 6 PSO-1,2,6	U, Ap	P, M	12	3	3
CO 4	Explore legal frameworks related to tourism at both global and national levels, understand the role of certification in promoting sustainable practices within the	PO-3.7 PSO-1,2,5	U, An	P, M	12	3	3

	tourism industry, and evaluate the success and effectiveness of ecotourism initiatives.						
CO 5	Recognize the pivotal role local communities play in ecotourism development, critically examine community challenges, such as capacity building, resource management, and balancing economic gains with cultural preservation, and gain practical insights through field visits to ecotourism destinations, observing community involvement and sustainable practices.	PO-2,3 PSO-4, 5,6	U, Ap, An	P, M		3	5

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	1	1	-	-	-	-	1	-	-	-	-	-
CO 2	1	3	-	2	-	-	-	1	2	-	-	-
CO 3	2	1	-	-	-	1	-	-	3	-	-	2
CO 4	2	3	-	-	1	-	-	-	2	-	-	-
CO 5	-	-	-	2	1	1	-	2	2	-	-	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Internal Exam
- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Project evaluation
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5			✓	

Discipline	**ENVIRONMENTAL SCIENCES**				
Course Code	**UK6VACENS300**				
Course Title	**ENVIRONMENTAL MANAGEMENT SYSTEMS AND ISO 14001**				
Type of Course	**VAC**				
Semester	**VI**				
Academic Level	300 - 399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	3	2 hours	-	1 hours	3
Pre-requisites	1. Basic understanding of environmental issues, sustainability, and the importance of minimizing environmental impact. 2. Basic knowledge of environmental laws, regulations, and compliance requirements.				
Course Summary	This course provides a comprehensive introduction to environmental management systems (EMS) and ISO 14001. Students will explore the evolution of EMS, understand ISO 14001:2015 requirements, and learn about key elements such as legal compliance, risk assessment, and environmental impact assessment. The course emphasizes stakeholder engagement, document control, and performance evaluation. By the end of the course, students will be equipped with the knowledge and tools to promote sustainable environmental practices within organizations.				

Detailed Syllabus:

Module	Unit	Content	Hrs
I	**Introduction to Environmental Management Systems (EMS) and ISO 14001**		**10**
	1	Environmental Quality: Understanding environmental quality parameters (air, water, soil, noise).	2

		Measurement techniques and standards for environmental quality.	
	2	History of EMS: Evolution of environmental management systems. Milestones and key developments in EMS implementation. Definition, aims and key principles	2
	3	2015 Standards (ISO 14001:2015): Overview of ISO 14001:2015 requirements. High-level structure and core elements. Transition from ISO 14001:2004 to ISO 14001:2015.	2
	4	Intended Parties and Stakeholders: Identifying interested parties (internal and external). Understanding their roles and expectations in EMS implementation.	2
	5	Legal and regulatory framework: Environmental compliance	2
II		**Environmental issues, risks and opportunities**	**10**
	6	Internal Issues: Organizational context and culture. Internal factors influencing EMS effectiveness.	2
	7	External Issues: Legal, regulatory, and industry-specific requirements. Social, economic, and technological trends affecting environmental management.	2
	8	Environmental Risks and Opportunities: Risk assessment methodologies. Identifying environmental risks and opportunities. Mitigation strategies and preventive measures.	2
	9	Environmental Impact Assessment (EIA): EIA process and its role in EMS. Conducting environmental impact assessments for projects.	2
	10	Emergency Preparedness and Response: Developing emergency plans and procedures. Training personnel for effective emergency response.	2
III		**Document Control and Environmental Performance Evaluation**	**10**
	11	Document Control: Establishing document control procedures. Managing EMS documentation (policies, procedures, records).	2
	12	Environmental Performance Evaluation: Monitoring environmental indicators. Assessing performance against objectives and targets. Reporting on environmental performance.	2
	13	Internal Audit: Planning and conducting EMS audits. Evaluating compliance and effectiveness. Corrective actions based on audit findings.	2
	14	Management Review: Reviewing EMS performance with top management. Decision-making for continual improvement. Ensuring alignment with organizational goals.	2
	15	Environmental operational control procedures	2

IV		**Current and Innovative Approaches in EMS**	**10**
	16	Technology integration, eco-design, and circular economy in the context of EMS	2
	17	Mutual exchange programs and water budgeting	2
	18	Life cycle approaches and extended producer's responsibility (EPR)	2
	19	Online monitoring system for quality parameters Continual improvement for meeting quality standards	2
	20	Environmental Sustainability in EMS: Waste reduction strategies. Carbon footprint reduction initiatives.	2
V		**Case Studies and Practical Applications (Practicum)**	**8**
	21	Real-world Case Studies: Analyzing successful EMS implementations.	2
	22	Practical Applications: Developing an EMS implementation plan. Applying ISO 14001 principles to specific industries (manufacturing, services, construction)	2
	23	Learning from challenges and best practices.	2
	24	Sessions from industrial experts	2
	25	**Open Ended**	**12**

Course Outcomes

No.	**Upon completion of the course the graduate will be able to**	**Cognitive Level**	**PO/PSO addressed**
CO-1	Understand parameters related to environmental quality and address environmental issues, risks, and opportunities.	U, An	PO-2 PSO-1,2
CO-2	Understand internal factors and external issues that influence the effectiveness of environmental management systems (EMS), Learn risk assessment methodologies and develop skills in identifying environmental risks and opportunities.	U, An, Ap	PO-2,6 PSO-1,3,4
CO 3	Develop skills in assessing performance against objectives and targets, Explore management review processes, including decision-making for continual improvement and alignment with organizational goals.	U,E,C	PO-2,5- PSO-4,5
CO 4	Understanding mutual exchange programs, water budgeting, and extended producer's responsibility (EPR) and Addressing environmental sustainability	An, Ap, C	PO-1,8 PSO-5,6

	through waste reduction strategies and carbon footprint reduction initiatives.		
CO 5	Demonstrate a comprehensive understanding of ISO 14001 principles and requirements. Apply knowledge to practical scenarios and case studies.	U, Ap	PO-2,3 PSO-1,3,5

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create
Note: 1 or 2 COs/module
References

1. Environmental Science: Toward A Sustainable Future, Dorothy F. Bourse and Richard T. Wright
2. Social Learning in Environmental Management: Towards a Sustainable Future, Meg Keen, Valerie A. Brown, and Rob Dyball
3. Principles of Environmental Science, William P. Cunningham and Mary Ann Cunningham
4. Visualizing Environmental Science, Linda R. Berg, Mary Catherine Hager, and David M. Hassenzahl.
5. Textbook of Environment and Ecology, Springer Singapore, 2024.
6. Environmental Management Handbook, Second Edition – Six Volume Set, Sven Erik Jorgensen and Brian D. Fath. CRC Press, 2022.
7. ISO 14001:2015 (en), Environmental Management Systems - Requirements with Guidance for Use. International Organization for Standardization (ISO), 2015.

Name of the Course: Credits: 2:0:1 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)	Open Ended (OE)
CO-1	Understand parameters related to environmental quality and address environmental issues, risks, and opportunities.	PO-2 PSO-1,2	U, An	F, C	12		2
CO-2	Understand internal factors and external issues that influence the effectiveness of environmental management systems (EMS), Learn risk assessment methodologies and develop skills in identifying environmental risks and opportunities.	PO-2,6 PSO-1,3,4	U, An, Ap	C, P	12		2

CO 3	Develop skills in assessing performance against objectives and targets, Explore management review processes, including decision-making for continual improvement and alignment with organizational goals.	PO-2,5-PSO-4,5	U,E,C	C, P, M	12		3
CO 4	Understanding mutual exchange programs, water budgeting, and extended producer's responsibility (EPR) and Addressing environmental sustainability through waste reduction strategies and carbon footprint reduction initiatives.	PO-1,8 PSO-5,6	An, Ap, C	P, M	12		3
CO 5	Demonstrate a comprehensive understanding of ISO 14001 principles and requirements. Apply knowledge to practical scenarios and case studies.	PO-2,3 PSO-1,3,5	U, Ap	F, P		12	5

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	1	1	-	-	-	-	-	2	-	-	-	-
CO 2	2	-	2	1	-	-	-	1	-	-	-	1
CO 3	-	-	-	1	1	-	-	2	-	-	2	-
CO 4	-	-	-	-	2	1	2	-	-	-	-	-
CO 5	3	-	2	-	2	-	-	1	2	-	-	-

Correlation Levels:

Level	Correlation

-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Internal Exam
- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Project evaluation
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5		✓	✓	

Semester VII

<table>
<tr><td>Discipline</td><td colspan="5">ENVIRONMENTAL SCIENCES</td></tr>
<tr><td>Course Code</td><td colspan="5">UK7DSCENS400</td></tr>
<tr><td>Course Title</td><td colspan="5">ECOLOGICAL MODELLING</td></tr>
<tr><td>Type of Course</td><td colspan="5">DSC</td></tr>
<tr><td>Semester</td><td colspan="5">VII</td></tr>
<tr><td>Academic Level</td><td colspan="5">400 - 499</td></tr>
<tr><td rowspan="2">Course Details</td><td>Credit</td><td>Lecture per week</td><td>Tutorial per week</td><td>Practical per week</td><td>Total Hours/Week</td></tr>
<tr><td>4</td><td>4 hours</td><td>-</td><td></td><td>4</td></tr>
<tr><td>Pre-requisites</td><td colspan="5">Students should be familiar with basic statistical tools; matrix notation and basic vector/matrix operations (i.e., linear algebra).</td></tr>
<tr><td>Course Summary</td><td colspan="5">Process based models are widely used in Environmental Science as a management tool to support decision-making processes. This course comprise of fundamental theory of environmental/ ecological modelling that will provide a comprehensive overview of various model types and their applications. Students will be familiarised with most of the basic equations used to represent ecological processes in the physical, chemical and biological processes of ecosystems.</td></tr>
</table>

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Ecosystem Modelling**	**15**
	1	Concept and need for Ecosystem Modelling	
	2	Classification of models; Deterministic models, Stochastic models, steady state and dynamic models	
	3	Ecological Models: compartment model; matrix model; statistical and mathematical models	
	4	Ecoinformatics: Definition and scope in environmental analysis	
II		**Modelling Population Dynamics**	**15**
	5	Growth models in population dynamics: Single population growth model	
	6	Interaction between populations:	
	7	Interspecific competition, Prey-Predator models: Lotka-Voltera model	
	8	Consumer-resource models; dynamics	
	9	Dynamics and spread of invasive species	
III		**Modelling physical, chemical and biological processes**	**7**
	10	Physical processes: Mass transport	
	11	Physical processes: Advection, diffusion & turbulent diffusion	
	12	Aquatic ecosystems : eutrophication modelling	
	13	Basics of Bayesian models	
	14	Models for animal movement	
	15	Determinate and Stochastic density independent models	
	16	Food-web model	
IV		**Pollution Modelling**	8
	17	Water quality modelling: Surface and groundwater pollution models	
	18	Air quality modelling: Box model	
	19	Gaussian plume model; Gaussian Puff model	
V		**Models in Ecology**	**15**
	20	Regression models	
	21	Generalised Linear models	
	22	Introduction to MATLAB	
	23	Nutrient uptake models	
	24	Food Web Model : Ecopath with Ecosim (EwE)	
	25	Marine Ecosystem model: Atlantis	

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Course Outcomes

No.	Upon completion of the course, the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Define and explain the need for Environmental Modelling	Un,Re	PSO1,2
CO-2	Describe the interaction between populations and create models of population interactions	An	PSO2
CO-3	Develop models for physical, chemical and biological processes in the ecosystem	An,Cr	PSO3,4
CO-4	Create models for air and water quality	An,Cr	PSO3,4
CO-5	Apply the models for ecosystem processes	Ap	PSO3,4

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Credits: 4:0:0 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial	Practical (P)

					(T)	
CO-1	Define and explain the need for Environmental Modelling	PSO1,2	R, U	F, C, P	11	
CO-2	Describe the interaction between populations and create models of population interactions	PSO2	U, Ap, E	F, C, P	7	
CO-3	Develop models for physical, chemical and biological processes in the ecosystem	PSO3,4	U, Ap, An	C, P, M	8	
CO-4	Create models for air and water quality	PSO3,4				
CO-5	Apply the models for ecosystem processes	PSO3,4				

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO 5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	3	-			-	-	3	3	-	-	3	-
CO 2	3	-			-	-	3	3	-	-	3	-
CO 3	3	3	3	3	-	-	3	-				-
CO 4	3	3	3	3	-	-	3	-				-
CO 5	3	3	3	3	-	-	3	-				-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓
CO 5		✓		✓
CO 6			✓	

Discipline	**ENVIRONMENTAL SCIENCES**				
env	**UK7DSCENS401**				
Course Title	**POLLUTION MANAGEMENT AND CONTROL**				
Type of Course	**DSC**				
Semester	**VII**				
Academic Level	300 - 399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5

Pre-requisites	1. Fundamental knowledge regarding causes and consequences of environmental issues 2. Environmental pollution
Course Summary	Pollution Management and Control is an interdisciplinary course designed to provide students with a comprehensive understanding of the causes, effects, and mitigation strategies related to environmental pollution. The course covers various types of pollution, including air, water, soil, and noise pollution, along with their impacts on human health and ecosystems. Additionally, students explore regulatory frameworks, technological solutions, and policy measures aimed at preventing and controlling pollution.

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Introduction to Pollution**	**10**
	1	Overview of pollution	2
	2	Types of pollution (air, water, soil, noise, etc.)	2
	3	Sources of pollution	3
	4	Impacts of pollution on the environment and human health	3
II		**Air Pollution Control Measures**	**15**
	5	Air pollutants-Gaseous and particulate	4
	6	Air quality monitoring and assessment	5
	7	Air quality standards	4
	8	Control technologies and strategies for reducing air pollution	2
III		**Water Pollution Control Measures**	**15**
	9	Sources and Types of water pollution	5
	10	Water quality standards	4
	11	Water quality assessment and monitoring	4
	12	Treatment technologies and management practices for water pollution control	2
IV		**Soil Pollution Management**	**15**
	13	Sources and types of soil pollution	2
	14	Different types of soil pollutants-organic and ionrganic	3
	15	Effects of soil pollution on agriculture and ecosystems	3
	16	Soil contamination assessment and remediation techniques	4
	17	Soil conservation and pollution prevention measures	3
V		**Waste Management**	**20**
	18	Types and sources of waste	2
	19	Waste generation, collection, and disposal practices	2
	20	Recycling and waste minimization strategies	3
	21	Waste hierarchy and Pay Polluter Principle	5
	22	Hazardous waste management and regulations	3
	23	International treaties and agreements related to pollution control,	2
	24	Innovative technologies for pollution control	2

	25	Case studies and examples of successful pollution management initiatives	1

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Identify different types of pollution and their sources.	U	PSO-1,2
CO-2	Recognize the environmental and human health impacts of pollution.	R, U	PSO-1,2,3
CO-3	Apply various pollution management and control strategies to real-world scenarios.	Ap	PSO-2,3,4
CO-4	Analyse legal and regulatory frameworks related to pollution control.	An	PSO-4,5,6
CO-5	Recommend appropriate technologies and best practices for mitigating pollution.	Ap	PSO-7,8

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

References

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Name of the Course: Credits: 4:0:0 (Lecture:Tutorial:Practical)

CO No.	**CO**	**PO/PSO**	**Cognitive Level**	**Knowledge Category**	**Lecture (L)/Tutorial (T)**	**Practical (P)**
CO-1	Identify different types of pollution and their sources.	PSO-1,2	U	F, C		
CO-2	Recognize the environmental and human health impacts of pollution.	PSO-1,2,3	R, U	C,P		
CO-3	Apply various pollution management and control strategies to real-world scenarios.	PSO-2,3,4	Ap	P,M		
CO-4	Analyse legal and regulatory frameworks related to pollution control.	PSO-4,5,6	An	C,P,M		
CO-5	Recommend appropriate technologies and best practices for mitigating pollution.	PSO-7,8	Ap	M		

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	3	2	-	-	-	-	1	2	-	-	-	-
CO 2	3	2	1	-	-	-	-	2	-	-	-	-
CO 3	-	3	2	-	-	-	-	-	2	-	-	-
CO 4	-	-	-	2	1	3	-	-	-	-	-	-
CO 5	-	-	-	-	-	2	-	-	-	-	-	1
CO 6	3	2	-	-	-	-						

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓
CO 5		✓		✓
CO 6			✓	

Discipline	**ENVIRONMENTAL SCIENCES**				
Course Code	**UK7DSCENS402**				
Course Title	**ARTIFICIAL INTELLIGENCE IN ENVIRONMENTAL MANAGEMENT**				
Type of Course	**DSC**				
Semester	**VII**				
Academic Level	400 - 499				
Course Details	Credit	Lecture	Tutorial	Practical	Total

		per week	per week	per week	Hours/Week
	4	4 hours	-		4
Pre-requisites	Prior knowledge of AI				
Course Summary	AI based technological solutions can enhance the sector's resource efficiency by reducing the use of land, water, fertilizers, and pesticides while also enhancing output quality. This course introduces the use and applications of AI for environmental sustainability, energy efficiency, sustainable agriculture, waste management and climate change and disaster management.				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**AI for Environmental Sustainability**	**11**
	1	Artificial Intelligence: Definition and Concept, Evolution of AI in Environmental Management	2
	2	Digital Transformation and Sustainability Transformation	2
	3	The role of AI in attaining SDGs	1
	4	Data Mining	2
	5	Wildlife poaching	1
	6	Deep Learning, Land Cover, and Poverty	2
	7	Social Networks to Aid Shelters	1
II		**AI for Energy Efficiency**	**7**
	8	Predicting and Contextualizing Building Energy	2
	9	Improving Power Storage	1
	10	Prediction of supply and demand	1
	11	Optimization of yield	1
	12	Smart grid management	2
	13	Increased and improved use of renewable Energy	1
III		**AI for Sustainable Agriculture**	**8**
	14	Mathematical Programming for Biodiversity Conservation	2
	15	AI-powered precision agriculture	2
	16	Optimal irrigation, and fertilization application based on real-time data	2
	17	Crop harvesting robots, AI-enhanced drones, Robotic weed control, Robotic application of herbicides	2
IV		**AI for Waste Management**	12
	18	Real-time waste monitoring	2
	19	Waste sorting and processing	2
	20	Smart Sensors	2
	21	Route Optimization	2
	22	Data-driven decision making	2
	23	Recycling of mixed wastes	2
V		**Climate Change, Disaster Management and AI**	**22**
	24	Disaster Prediction, Disaster Resilience, directing relief operations, optimal evacuations, delivery of supplies, damage analysis, Use of AI in Weather prediction, Pollution identification, iceberg tracking, and Deforestation Mapping. Ocean clean-ups	10

	25	Open Ended	12

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https://2030.builders/8-ways-ai-can-contribute-to-environmental-conservation/

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Course Outcomes

No.	Upon completion of the course, the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Explain the role of AI in developing sustainability	R, U	PO-1,2,5,7 PSO-1,3,4,5
CO-2	Describe the role of AI in attaining energy efficiency and practicing it	U, Ap, E	PO-1,2,5 PSO-1,3,4
CO-3	Explain the use of AI in sustainable agriculture and identify the situations of application of AI	U, Ap, An	PO-1,3,4,5 PSO-1,2,3,4
CO-4	Explain the applications of AI in waste management and undertake the applications in real-life situations	U, Ap, An	PO-1,3,4,5 PSO-1,2,3,4
CO-5	Describe the use of AI in disaster relief, weather prediction, and pollution	U, Ap, An	PO-1,3,4,5 PSO-

			1,2,3,4

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Credits: 4:0:0 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO-1	Explain the role of AI in developing sustainability	PO-1,2,5,7 PSO-1,3,4,5	R, U	F, C, P	11	-
CO-2	Describe the role of AI in attaining energy efficiency and practicing it	PO-1,2,5 PSO-1,3,4	U, Ap, E	F, C, P	7	-
CO-3	Explain the use of AI in sustainable agriculture and identify the situations of application of AI	PO-1,3,4,5 PSO-1,2,3,4	U, Ap, An	C, P, M	8	-
CO-4	Explain the applications of AI in waste management and undertake the applications in real-life situations	PO-1,3,4,5 PSO-1,2,3,4	U, Ap, An	C, P, M	12	-
CO-5	Describe the use of AI in disaster relief, weather prediction, and pollution	PO-1,3,4,5 PSO-1,2,3,4	U, Ap, An	C, P, M	10	

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	3	-	3	3	-	-	3	3	-	-	3	-
CO 2	3	-	3	3	-	-	3	3	-	-	3	-
CO 3	3	3	3	3	-	-	3	-	3	3	3	-
CO 4	3	3	3	3	-	-	3	-	3	3	3	-
CO 5	3	3	3	3	-	-	3	-	3	3	3	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Field observations and experiments
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓
CO 5		✓		✓
CO 6			✓	

Discipline	**ENVIRONMENTAL SCIENCE**				
Course Code	**UK7DSCENS403**				
Course Title	**WASTE MANAGEMENT TECHNIQUES**				
Type of Course	**DSC**				
Semester	VII				
Academic Level	400-499				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5
Pre-requisites	1. Basic knowledge on type and nature of wastes				
Course Summary	The course provides basic idea regarding pollution control strategies employed in various sectors including air, water, wastewater and solid waste treatment in conventional unit operations including the scientific engineering principles on which they are based. It also deals with advanced techniques available in the treatment of potable water and also incorporates a general learning on hazardous waste management strategies. Policies and laws pertaining to the management of aforesaid areas are also dealt within. After completing this course the students will get a clear idea regarding treatment of wastes and management of pollution and they should be able to practise it in real life situations.				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Wastes and Management**	**10**
	1	Wastes and Management: Definition, concept.	4
	2	The changing nature, quantity, composition in urban and rural areas of India and World	6
II		**Waste water and its treatment methods**	**15**
	3	Waste water: Nature and types; sources and characteristics	3
	4	Waste water generation in India	3
	5	Treatment methods – physical, chemical, biological and advanced treatment methods	3
	6	Natural treatment systems-constructed wetlands, wastewater reclamation and reuse	3
	7	Selection of suitable treatment methods for municipal and industrial waste water	3
III		**Solid wastes and management (practicum)**	**20**
	8	Solid wastes: types of wastes; Residential and Commercial, Municipal wastes	3
	9	Solid waste Management: Source and types of municipal solid wastes – factors affecting generation, characteristics	3
	10	Methods of sampling. Storage methods, Collection and transfer	3
	11	MSW management – processing: mechanical volume reduction – necessary equipments	3

	12	MSW treatment methods: composting, vermi- composting, biomethanation,	3
	13	Landfilling : sanitary landfill- methods of operation –	3
	14	Advantages and disadvantages of sanitary land fill - site selection – gas and leachate movement and control	2
IV		**Hazardous wastes and management**	**10**
	15	Hazardous wastes: Definition, source and characteristics	2
	16	Management of medical and hospital wastes	2
	17	Nuclear and radioactive wastes – classification, sources and disposal	2
	18	Industrial wastes- sources and impacts	1
	19	Industrial waste management practices	1
	20	E-waste- types and sources	1
	21	Management of e- waste	1
V		**Waste management policies**	**20**
	22	Waste management policies, polluter pays principle;	2
	23	Wealth from waste -compost, single cell protein; waste to energy – ethanol, biogas, hydrogen	2
	24	Waste audit; waste management economics	1
	25	Open ended	15

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1. Freeman, H. M. (1998), Standard Book of Hazardous Waste Treatment and Disposal, McGraw Hill, New York.
2. Robert, U., Ayres, Leslie, A. (2002), A Handbook of Industrial Ecology, Edward Elgar Publishing Limited, Cheltenham, UK
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10. Waste Water Treatment Plant design. (1997), A Manual of Practice. Water Pollution Control Federation.

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PO/PSO addressed
CO-1	Identify the different types of solid wastes	R	PO6, PSO 1
CO-2	To make physical and chemical analysis of municipal solid wastes and apply them for a management system that will be set up.	R	PO1, PSO 1, PSO 2
CO- 3	Compare the various waste water treatment methods	An	PO8, PSO 3, PSO 4
CO- 4	Explain the source, characteristics and management of hospital wastes	U	PO2, 7, PSO 3, PSO 6
CO-5	Explain the methods of converting wastes to useful products	U	PO4, PSO 3, PSO 6

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Credits: 4:0:0 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)	Open Ended
1	Identify the different types of solid wastes	PO6, PSO 1	R	F	10	2	3
2	To make physical and chemical analysis of municipal solid wastes and apply them for a management system that will be set up.	PO1, PSO 1, PSO 2	R	p	10	4	3

3	Compare the various waste water treatment methods	PO8, PSO 3, PSO 4	An	F	10	2	3
4	Explain the source, characteristics and management of hospital wastes	PO2, 7, PSO 3, PSO 6	U	F, C	10		3
5	Explain the methods of converting wastes to useful products	PO4, PSO 3, PSO 6	U	M	12		3

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Assignments
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓	✓	✓

CO 5		✓	✓	✓

Discipline	**ENVIRONMENTAL SCIENCE**				
Course Code	**UK7DSCENS404**				
Course Title	**ENVIRONMENTAL ECONOMICS**				
Type of Course	**DSC**				
Semester	**VII**				
Academic Level	400 - 499				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5
Pre-requisites	1. Basics of Environment and Economics 2. Fundamental concepts of Environment and Economics, definition and scope of Environmental Economics.				
Course Summary	This course provides students with a comprehensive understanding of the complex interactions between the environment, economics, and development, equipping them with the knowledge and tools necessary to address contemporary environmental challenges in a sustainable manner.				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Overview of Environmental Economics**	**10**
	1	The evolution and growth of Environmental Economics.	2
	2	Environmental economics vs. traditional economics, Tracing Environmental inputs into the Economy.	3
	3	Environment and Economic Growth	2
	4	Environment and Development	3
II		**Basic Concepts and theories**	**15**
	5	Characters of environmental goods	3
	6	Consumption and Demand	2
	7	Production and supply	2
	8	Markets and Market Failures	4
	9	Government intervention and public policy Failure	4

III	**Environmental Valuation, Accounting and Management (practicum)**		**20**
	10	Meaning and types of environmental values	2
	11	Valuation of intangible benefits of the environment	4
	12	Historical development of National accounts on India	3
	13	Genesis of environmental accounting	3
	14	Forest resource accounting: A case study	4
	15	Concept of environmental management	2
	16	An action system for environmental management	2
IV	**Human Environment and Economy**		**10**
	17	Land and environment: land degradation and restoration	2
	18	Water and environment: Water related problems and mitigation	2
	19	Forest and environment: Deforestation and Reforestation	2
	20	Biodiversity and conservation	2
	21	Climate change and environment	2
V	**Environment Impact Assessment (practicum)**		**5**
	22	EIA: Concept and History	2
	23	Basic Principles of EIA	2
	24	EIA: A Case Study	1
	25	Open ended	**15**

Books and References:

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2. Chiras, D.D. (2009). Environmental science. Jones & Bartlett Publishers.
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6. Mahua Basu and Xavier Savarimuthu SJ, 2017, Cambridge University Press
7. Purnima Das and Chubanaro Aier, 2023, Environmental Studies: for BA, B. Com and BSc. 1st semester of Nagaland university, Global net Publications
8. Katar Singh and Anil Shishodia 2007, Environmental Economics; Theory and Application, Sage Publication.
9. Arvindari Upadhyay, 2021, Environmental Impact and Risk Assessment, Academic Aspirationns, New Delhi

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed

CO-1	Develop awareness of the sub-discipline of environmental economics dealing with interrelationship and interaction between environment and economic activities	U	PSO-1,2
CO-2	Gain a solid understanding of basic economic concepts and principles, such as supply and demand, market equilibrium, externalities, market failure, cost-benefit analysis, discounting, and welfare economics, as they relate to environmental issues. Students should become familiar with various methods used to value environmental goods and services, including contingent valuation, hedonic pricing, travel cost method, production function approach, and stated preference methods, and understand their strengths, limitations, and applications.	R, U, An	PSO-1,2,7
CO-3	It enhances the knowledge and skills of the students enable them to comprehend and apply the tools and techniques of environmental valuation, environmental auditing and environmental management.	R, U	PSO-4,6,7
CO-4	Students should understand the economic principles governing the management of renewable and non-renewable natural resources, such as fisheries, forests, water resources, minerals, and energy, including concepts of resource depletion, rent extraction, optimal extraction paths, and sustainable resource management. Topic enhances the knowledge and skill of students to identify and analyse the economic problems related to land, water, forest and other resources and suggest how the problems could be addressed using tool and techniques of Environmental economics	R, U, Ap	PSO-6,7,8

CO-5	It enhances the students to evaluate EIA systems within the framework of environmental and economic sustainability, it also enhances students of environmental science to study action plan in terms of mitigation of impacts, it makes major and minor project purely ecofriendly.	Ap, An, E, C	PSO-8,10

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create
Note: 1 or 2 COs/module
Name of the Course: Credits: 3:0:1 (Lecture: Tutorial: Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
1	Understand the history and evolution of Environmental Economics	PSO-1,2	U	F, C	10	
2	Understand the basic concept of Fundamentals of Environmental Economics	PSO-1,2,7	R, U, An	P	15	
3	Understanding about tools and techniques of Environmental valuation, Accounting and management	PSO-4,6,7	R, U		15	
4	Learning about environmental management in terms of water, air, land and forest environment	PSO-6,7,8	R, U, Ap		15	
5	Analyse and understand the challenges in Environmental Impact Assessment and its cost benefit analysis.	PSO-8,10	Ap, An, E, C		10	

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive
Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	1	-	-	2	-	1	3	-	1	-	-	-
CO 2	2	3	-	-	1	-	1	-	-	2	-	3
CO 3	-	2	1	-	-	-	-	1	-	-	-	3
CO 4	-	-	2	3	-	-	1	3	-	2	-	-
CO 5	-	1	-	1	3	-	1	1	-	-	-	3
CO 6	1	-	-	2	-	1	3	-	1	-	-	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓
CO 5		✓		✓
CO 6			✓	✓

Discipline	**ENVIRONMENTAL SCIENCE**				
Course Code	**UK7DSCENS405**				
Course Title	**CLIMATE CHANGE: MITIGATION AND ADAPTATION**				
Type of Course	**DSC**				
Semester	VIII				
Academic Level	400 – 499				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5
Pre-requisites	1. The concept of different climate related environmental problems 2. The preliminary concept of recent environmental issues				
Course Summary	This course details the various aspects of Climate Change				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Introduction to Global Climate**	**10**
	1	Global air circulation and climate, ocean current and climate	2
	2	Seasonal winds and monsoon	2
	3	Climate of India; Indian monsoon, EL Nino	3
	4	Tropical cyclones, Western disturbance, Weather modification anthropogenic climate change and its causes	3
II		**Climate change Mitigation**	**15**
	5	Introduction to mitigation of GHGs and stabilization scenario; characteristics of mitigation in regional and national context; long term and short-term mitigation options of climate change.	4
	6	Methodologies for regional GHG inventories	3
	7	IPCC good practice guidelines for National greenhouse gas inventories.	4
	8	Mitigation from a cross-sector perspective such as transport, power, agriculture, municipal waste, specific industries, and buildings.	4
III		**Climate policy instruments and framework**	**20**
	9	The causes of global warming, emission trends, fossil fuel emissions and deforestation.	3
	10	The technological options to reduce emissions, climate policy tools, their theoretical merits and practical experiences climate mitigation	4
	11	The cost and benefits of mitigation	2
	12	Trade offs, potentials, and limitations of climate change mitigation	2
	13	Quantification of climate change impacts and mitigation benefits	2

	14	Ethics and politics of Climate change	1
	15	Agriculture and Land Use Mitigation Strategies	2
	16	Policy and Governance Frameworks for Climate Change Mitigation	2
	17	Technological Innovations for Carbon Capture and Removal	2
IV	**National Action Plan on Climate Change**		**15**
	18	Missions of NAPCC - National Solar Mission, National Mission for Enhanced Energy Efficiency, National Action Plan on Climate Change (mitigation specific missions); alternate energy programmes	4
	19	National Mission on Sustainable Habitat	1
	20	National Water Mission, National Mission for Sustaining the Himalayan Ecosystem	4
	21	National Mission for a Green India, National Mission for Sustainable Agriculture, National Mission on Strategic Knowledge for Climate Change.	3
	22	Alternate energy crops programmes and afforestation; other flexible mechanism and voluntary mechanisms such as REC and PAT program, Micro level policy initiatives	3
V	**International organisations for climate justice**		**15**
	23	2001-Bonn Agreement, Doha Declaration, 2002- World summit on Sustainable development- Johannesburg. 2003 – United nations decade of Education for sustainable development. 2005 -Millennium ecosystem Assessment. Montreal Protocol.; 2007 – United Nations Climate change conference Bali; 2009 -G20 Fossil fuel subsidies, Pittsburgh Summit, 2009- CoP 15 Copenhagen. 2016 – CoP16 Cancun, Mexico, 2010 – Nagoya Protocol, Japan. 2011 – Durban Climate conference S. Africa. 2012 – UN Conference on sustainable development Rio de Janeiro, 2012- Dhoha Climate Conference. 2013 CoP 19 Warsaw Poland.2015 – Paris Agreement. Kigali Amendment. 2018 – CoP 24. 2019-UN Chief plans climate action summit. 2019 – CoP25 Madrid, Spain. 2021 – CoP 26 Glasgow. 2022 – The UN Climate change conference in Sharm el-Sheikh, Egypt, COP 27.2023- COP 28 UNFCCC, Dubai. Intergovernmental Panel on Climate Change (IPCC)	12
	24	SDG -13 - Climate Action	3
	25	Open ended	15

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1. Banerjee K.K. (1995) Global Warming Database Technology Options in Power and End-use Sectors Using Fossil Fuels, New Delhi.
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5. *EIA Directive (85/337/EEC):https://ec.europa.eu/environment/eia-legalcontext.html*
6. *EIA Training resource manual, UNEP 2002, https://wedocs.unep.org/bitstream/handle/20.500.11822/26503/EIA_Training_resource manual.pdf.*
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15. Nakicenovic N. (Eds) (1993) Integrative Assessment of Mitigation, Impacts and Adaptation to Climate Change, Austria.
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18. Thomas S. (2003) Policy Instruments for Environment and Natural Resource Management, RFF Publication, Washington DC.
19. Tiwari G.N. (2003) Greenhouse Technology for Controlled Environment, New Delhi
20. *UN Convention on Climate Change and Biological Diversity (1992) EIA as a implementing mechanism: https://www.cbd.int/doc/legal/cbd-en.pdf*
21. United Nations Environment Programme 2021, "A continuation of the effort implied by the latest unconditional NDCs and announced pledges is at present estimated to result in warming of about 2.7 °C (range: 2.2–3.2 °C) with a 66 per cent chance."

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Course Outcomes

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO 1	Understand the Global climatic conditions	**U**	**C**	**Instructor-created exams / Quiz**

CO 2	Know the different policy frame work of climate change	**An**	**P**	**Group Discussions/ Debates**
CO 3	Understand the basic idea of national and International efforts to mitigate environmental issues	**Ap**	**P**	**Seminar Presentation / Group Tutorial Work**
CO 4	Demonstrate the ability to integrate climate change considerations into various sectors and decision-making processes			
CO 5	Apply the knowledge to solve climate change problems	**An**	**C**	**Instructor-created exams / Home Assignments**
CO 6	Capable of decision-making and policy development	**Ap**	**C**	**Assignments**

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Credits: 4:0:0 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
1	**Lecture**	1		F, C		
2	**Lecture, Tutorial**	2		C, P		
3	**Lecture, Tutorial**	3,4		P, M		
4	**Tutorial, Practical**	5		M		
5	**Tutorial, Practical**			P, M		
6	**Tutorial, Practical**			M		

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	1	-	-	-	-	-	-	-	-	4	4	4
CO 2	2	3	-	-	-	-	2	-	-	-	-	4
CO 3	-	-	1	-	-	-	-	3	4	-	-	4
CO 4	-	-	2	3	-	-	-	-	-	4	-	-
CO 5	-	1	-	-	-	-	-	4	-	-	-	4
CO 6	-	-	-	3	-	-	-	-	4	-	4	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓
CO 5		✓		✓
CO 6			✓	

Discipline	**ENVIRONMENTAL SCIENCE**
Course Code	**UK7DSCENS406**
Course Title	**ECOSYSTEM SERVICES**
Type of Course	**DSC**
Semester	**VIII**
Academic Level	400 – 499

<table>
<tr><td rowspan="2">Course Details</td><td>Credit</td><td>Lecture per week</td><td>Tutorial per week</td><td>Practical per week</td><td>Total Hours/Week</td></tr>
<tr><td>4</td><td>3 hours</td><td>-</td><td>2 hours</td><td>5</td></tr>
<tr><td>Pre-requisites</td><td colspan="5">1.Basic understanding of ecology, environmental science, or related fields
2.Familiarity with ecological concepts such as biodiversity, ecosystem functioning, and ecological interactions would also be helpful</td></tr>
<tr><td>Course Summary</td><td colspan="5">Students will have gained a deep understanding of the importance of ecosystem services, their valuation, and the implications for human well-being and environmental management. They will be equipped with the knowledge and tools to contribute to the sustainable use and conservation of ecosystems and the services they provide.</td></tr>
</table>

Detailed Syllabus:

Module	**Unit**	**Content**	**Hrs**
I		**Introduction to ecosystem service**	**15**
	1	Ecosystem service fundamentals, the products/raw materials or energy outputs like food, water, medicines and other resources from ecosystems.,	3
	2	Ecosystems the source of food, water, medicines, wood, biofuels	3
	3	Types of ecosystem service; Provisioning services, Regulating Services, Supporting services, Cultural services.	6
	4	The Millenium Ecosystem Assessment	3
II		**Threats to ecosystem services**	**15**
	5	Direct threats - land use change, deforestation, loss of biodiversity,	4
	6	overfishing, over hunting, invasive species	2
	7	over exploitation, alteration of biogeochemical cycles, climate change	6
	8	Indirect drivers- Socioeconomic, demographic, technological	3
III		**The Quantification of ecosystem services**	**15**
	9	Measuring Ecosystem Services, Biophysical assessments (e.g. calculating meteorological variables and carbon sequestration etc.),	2
	10	Case Studies in Ecosystem Service Valuation (Practicum)	1
	11	Numerical Models and GIS	1
	12	Social Scientific Assessments utilising expert interviews, focus groups, and literature reviews.	2

	13	Valuing forest ecosystem services.	2
	14	Quantifying ecosystem services, hedonic pricing	2
	15	Benefits of ecosystems - clean water, air purification, climate regulation, pollination, and recreational opportunities	2
	16	Quantification of ecosystem services- Market-based Valuation, Cost-based Valuation, Revealed Preference Methods, Stated Preference Methods	2
	17	Integrated Assessment Models, Composite Indices	1
IV		**Importance of ecosystem services**	**15**
	18	Human Survival, Economic Value, Natural Resource Management	3
	19	Climate Regulation, Biodiversity Conservation	3
	20	Human Health and Well-being, Cultural and Spiritual Values	3
	21	Social Equity and Justice	3
	22	Carbon sequestration, carbon footprint.	3
V		**Ecosystem Services and Human Well-being**	**15**
	23	Linkages Between Ecosystem Services and Human Well-being	4
	24	Ecosystem Services and Livelihoods, Ecosystem Services and Cultural Values	11
	25	Open ended	15

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6. Costanza, R., d'Arge, R., Groot, R., Farber, S., Grasso, M., Hannon, B., ... & van den Belt, M. (1997). The value of ecosystem services: Putting the issues in perspective. *Ecological Economics*, 25(1), 67-72.
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Course Outcomes

At the end of the course, the student will be able to:

S No.	Course Outcome No.	Course Outcome	Taxonomic Level
1	CO 1	Understand the basic concepts of ecosystem service	Un
2	CO 2	Know the different types of ecosystem service	Un
3	CO 3	Apply the knowledge of ecosystem service to economic development	Ap
4	CO 4	Quantification of ecosystem services	Re, Un, Ap
5	CO5	Apply principles of ecosystem-based management and conservation	Ap
6	CO6	Communicate ecosystem services concepts, values, and management strategies to stakeholders	C

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Credits: 4:0:0 (Lecture:Tutorial:Practical)

CO No.	**CO**	**PO/PSO**	**Cognitive Level**	**Knowledge Category**	**Lecture (L)/Tutorial (T)**	**Practical (P)**
1	Understand the basic concepts of ecosystem service	1		F, C	L	
2	Know the different types of ecosystem service	2		C, P	L, T	
3	Apply the knowledge of ecosystem service to economic development	3,4		P, M		
4	Quantification of ecosystem services	5		M		
5	Application of principles of ecosystem management					P
6	Communicate with stakeholders part of decision making					

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO 5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	1	-	-	-	-	-	-	2	-	3	4	-
CO 2	2	3	-	-	-	-	2	-	-	3	-	4
CO 3	-	-	1	-	-	-	2	3	-	3	-	4
CO 4	-	-	2	3	-	-	-	2	-	-	4	-
CO 5	-	1	-	-	-	-	-	2	2	3	3	4
CO 6	-	-	-	3	-	-	-	-	2	-	3	4

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓
CO 5		✓		✓
CO 6				

Discipline	**ENVIRONMENTAL SCIENCE**				
Course Code	**UK7DSEENS400**				
Course Title	**CLIMATE RISK AND VULNERABILITY**				
Type of Course	**DSE**				
Semester	VIII				
Academic Level	400 – 499				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5
Pre-requisites	1. The concept of different climate related environmental problems 2. Understanding of basic concepts in climatology, environmental impact assessment, and risk analysis.				
Course Summary	The course integrates theoretical knowledge with practical applications, preparing students to address real-world climate risk and vulnerability issues in various sectors and contexts.				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Climate Change Strategies**	**10**
	1	Analysis of national and international policies, frameworks, and Institutions for climate risk management	2
	2	Role of adaptation planning and disaster risk reduction.	2
	3	Strategies for integrating climate risk considerations into decision-making processes across sectors like land use planning, infrastructure development, and emergency management	4
	4	Ethical considerations and equity issues in climate risk assessment and adaptation	2
II		**Mitigation of Climate change**	**10**
	5	Introduction to mitigation of GHGs and stabilization scenario; characteristics of mitigation in regional and national context; long term and short-term mitigation options of climate change.	3
	6	Risk Assessment Methods: Examination of quantitative and qualitative methods for assessing climate-related risks,	3
	7	Probabilistic modeling, scenario analysis, and vulnerability mapping	2
	8	Mitigation from cross sector perspective such as transport, power, agriculture, municipal waste, specific industries, and buildings.	2
III		**Climate policy instruments and framework**	**15**
	9	Vulnerability Assessment Frameworks: Analysis of vulnerability assessment frameworks	3
	10	Metrics for evaluating societal, environmental, and economic vulnerability to climate change	3
	11	The technological options to reduce emissions, climate policy tools, their theoretical merits and practical experiences climate mitigation	3

	12	The cost and benefits of mitigation	1
	13	Quantify climate change impacts and mitigation benefits through appropriate metrics.	1
	14	climate change with respect to ethics and international politics.	1
	15	Agriculture and Land Use Mitigation Strategies	1
	16	Policy and Governance Frameworks for Climate Change Mitigation	1
	17	Technological Innovations for Carbon Capture and Removal	1
IV	**Action Plan on Climate Change**		**15**
	18	National Solar Mission, National Mission for Enhanced Energy Efficiency, National Action Plan on Climate Change (mitigation specific missions); alternate energy programmes; National Mission on Sustainable Habitat	3
	19	National Water Mission, National Mission for Sustaining the Himalayan Ecosystem	2
	20	National Mission for a Green India, National Mission for Sustainable Agriculture, National Mission on Strategic Knowledge for Climate Change.	3
	21	Alternate energy crops programmes and afforestation; other flexible mechanism and voluntary mechanisms such as REC and PAT program, Micro level policy initiatives	3
	22	Case Studies in Climate Risk Management: Examination of case studies from different regions and sectors, highlighting successful and unsuccessful approaches to climate risk management and adaptation (practicum)	4
V	**Adaptation Strategies and Measures**		**10**
	23	Exploration of adaptation strategies and measures to reduce climate risks and enhance resilience, including engineering solutions, ecosystem-based approaches, and policy interventions.	5
	24	Climate Risk Communication: Effective communication of climate risks and vulnerabilities to stakeholders, decision-makers, and the public, including strategies for fostering awareness, understanding, and action.	5
	25	Open ended	15

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Course Outcomes

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand the scientific principles underlying climate change and its impacts.	**U**	**C**	**Instructor-created exams / Quiz**
CO2	Know the policy frame work of climate change	**An**	**P**	**Group Discussions/ Debates**
CO3	Apply risk assessment methodologies to evaluate climate-related risks and vulnerabilities	**Ap**	**P**	**Seminar Presentation / Group Tutorial Work**
CO4	Critically assess case studies to draw lessons for climate risk management practice.	**An**	**C**	**Instructor-created exams / Home Assignments**

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Credits: 4:0:0 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
1	**Lecture**	1		F, C		
2	**Lecture, Tutorial**	2		C, P		
3	**Lecture, Tutorial**	3,4		P, M		
4	**Tutorial, Practical**	5		M		

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	1	-	-	-	-	-	-	-	-	4	4	4
CO 2	2	3	-	-	-	-	2	-	-	-	-	4
CO 3	-	-	1	-	-	-	-	3	4	-	-	4
CO 4	-	-	2	3	-	-	-	-	-	4	-	-

CO 5	-	1	-	-	-	-	-	4	--	-	-	4
CO 6	-	-	-	3	-	-	-	-	4	-	4	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓
CO 5		✓		✓
CO 6			✓	

Discipline	**ENVIRONMENTAL SCIENCES**				
Course Code	**UK7DSEENS401**				
Course Title	**NANOTECHNOLOGY FOR ENVIRONMENTAL REMEDIATION**				
Type of Course	**DSE**				
Semester	**VIII**				
Academic Level	400 - 499				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2	5
Pre-requisites	The learners should have an understanding of environmental pollution and remediation				
Course Summary	This course provides the learner with the details of nanomaterials, the techniques of synthesis of nanomaterials, and the use of nanomaterials for remediation of various environmental spheres				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Introduction to Nanotechnology**	**7**
	1	Definition of nanotechnology and nanomaterials	1
	2	Types of nanomaterials (Carbon-based materials – tubes, fullerenes, Metals, and metal oxides – TiO_2, Fe-oxides, magnetic fluids, Q-dots, Polymeric nanowires-dendrimers and conductive polymers, Surface modification)	6
II		**Synthesis of nanomaterials (Practicum)**	**9**
	3	Nanomaterials synthesis – Top-down (Chemical Synthesis, Self-assembly, and positional assembly)	3
	4	Nanomaterials synthesis – Bottom-up methods (Lithography, cutting, edging and grounding)	3
	5	Biosynthesis of nanoparticles (plants, microorganisms, algae, enzymes and biomolecules, industrial and agricultural wastes), the advantages of biosynthesized nanomaterials	3
III		**Nano bioremediation (Practicum)**	**12**
	6	Nanotechnology in soil remediation	3
	7	Nanotechnology in water treatment	3
	8	Nanotechnology in pollution remediation	2
	9	Nanotechnology in air pollution remediation	2
	10	Nanomaterials infiltration	2
IV		**Specific nanomaterials for bioremediation**	**26**
	11	Nano adsorbents for environmental remediation	2
	12	Iron nanoparticles for environmental remediation	2
	13	Metal oxide nanoparticles for environmental remediation	2
	14	Biopolymeric nanoparticles for environmental remediation	2
	15	Functionalized nanoparticles for environmental remediation	2
	16	Nanocrystals for environmental remediation	2

	17	Carbon nanotubes for environmental remediation	2
	18	Enzyme nanoparticles for environmental remediation	2
	19	Nanofibers and nanocomposites for environmental remediation	2
	20	Nanocatalysts in environmental applications	2
	21	Aerogels for environmental remediation	2
	22	Nanomaterials-based environmental sensors	2
	23	Intelligent nanomaterials for environmental remediation	2
V		**Nanomaterials and Environment**	**21**
	24	Environmental Toxicology of Nanomaterials: Challenges, Societal impact of nanomaterials, LCA of nanomaterials for bioremediation	6
	25	Open-ended	15

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Course Outcomes

No.	Upon completion of the course, the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Explain the types of nanomaterials	R, U	PSO- 6 PO- 1,2
CO-2	Describe the various methods of synthesis of nanomaterials	R, U	PSO- 6 PO- 1,2
CO-3	Explain the applications of nanomaterials in environmental remediation	Ap	PSO-1,3 PO-2,3
CO-4	Describe the various types of nanomaterials used for bioremediation	An, E	PSO-3,4 PO-2,7

CO-5	Explain the environmental and social aspects of nanotechnology	U, An	PSO- 4,5 PO- 1,2,6

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Credits: 4:0:0 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO-1	Explain the types of nanomaterials	PSO- 6 PO- 1,2	R, U	F, C	7	-
CO-2	Describe the various methods of synthesis of nanomaterials	PSO- 6 PO- 1,2	R, U	F, C	5	4
CO-3	Explain the applications of nanomaterials in environmental remediation	PSO-1,3 PO-2,3	Ap	F, C, P	8	4
CO-4	Describe the various types of nanomaterials used for bioremediation	PSO-3,4 PO-2,7	An, E	F, C	20	6
CO-5	Explain the environmental and social aspects of nanotechnology	PSO- 4,5 PO- 1,2,6	U, An	F, C, M	6	

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

	PSO1	PSO2	PSO3	PSO4	PSO 5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	-	-	-	-	-	3	3	3	-	-	-	-
CO 2	-	-	-	-	-	3	3	3	-	-	-	-

CO 3	3	-	3	-	-	-	-	2	2	-	-	-
CO 4	-	-	3	3	-	-	-	2	-	-	-	-
CO 5	3	3	-	-	-	2	-		-	-	-	-

Mapping of COs with PSOs and POs:

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Analytical skills
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓
CO 5		✓		✓
CO 6			✓	

Discipline	**ENVIRONMENTAL SCIENCES**				
Course Code	**UK7DSEENS402**				
Course Title	**ENVIRONMENTAL AND GEOSPATIAL DATA ANALYTICS**				
Type of Course	**DSE**				
Semester	**VIII**				
Academic Level	400 - 499				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5
Pre-requisites	1. A basic understanding of the environmental, ecological, and social concepts and theories. 2. A genuine interest in quantitative methods in the subject				
Course Summary	This course is aimed at the application of analytics including optimization, simulation, regression, and time series analysis, to problems in environmental sciences to support environmental decision-making and communication of results with emphasis placed on learning skills directly applicable to conducting environmental research and problem-solving in a variety of settings.				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Introduction to Environmental Data Analytics**	**9**
	1	Overview of environmental data analysis	
	2	Probabilistic and statistical methods – introduction (Descriptive and inferential statistics, ecological modelling, data plots and sampling techniques, spatial statistics)	
	3	Data management and reproducibility (quality control, metadata creation, standard data formats and data transformation in data management and version control, structured documentation, licensing and archiving in reproducibility)	
	4	Contemporary software tools (R, R Studio, Python, GitHub)- introduction, data manipulation and general workflow	
	5	**Hands-On Lab:** Setting Up R or Python Environment **(Practicum)** Installing R and R Studio Basic R syntax Loading data into R Creating your first R script	**4**
II		**Exploratory Data Analysis**	**9**
	6	Data visualization techniques (univariate, bivariate, multivariate and time-series visualizations)	
	7	Descriptive statistics (frequency distribution, measures of central tendency, measures of dispersion, percentiles and quartiles)	
	8	Distribution analysis (missing values, removing data duplication, normalizing and scaling)	
	9	Outlier detection (understanding and detecting outliers using visual, statistical and ML techniques)	

	10	**Hands-On Lab:** Exploring Environmental Data **(Practicum)** Visualizing environmental variables Detecting outliers Summary statistics in R	**4**
III		**Regression Analysis**	**9**
	11	Linear regression (fundamental concepts of linear regression, relationship between independent variable (predictor) and dependent variable (response), estimating the regression coefficients (slope and intercept) using least squares, model fitting.	
	12	Multiple regression (multiple independent variables, collinearity, model significance and variable contributions)	
	13	Model selection (assess model performance using metrics like R-squared, adjusted R-squared, and root mean squared error (RMSE).	
	14	Assumptions and diagnostics (Diagnose potential issues (e.g., outliers, influential points) using residual plots)	
	15	**Hands-On Lab:** Building Regression Models in R **(Practicum)** Fitting linear regression models Assessing model assumptions Interpreting regression output	**4**
IV		**Spatial and Temporal Data Analysis**	**9**
	16	Geospatial data handling (data models and types, data acquisition and pre-processing, basic data queries, analysis and data visualization/layout)	
	17	Spatial interpolation (introduction and different techniques- IDW, NN)	
	18	Time series analysis (importance of time series analysis in geospatial research, Components: trend, seasonality, cyclic behaviour, noise)	
	19	Accuracy assessment (Kappa Statistics-Accuracy Metrics and Measures)	
	20	**Hands-On Lab:** Mapping Environmental Variables using any open-source GIS softwares like QGIS, GRASS GIS, Maptitude etc. **(Practicum)** Creating spatial maps Interpolating data points Forecasting future values/ change detection	**4**
V		**Introduction to advanced topics in Environmental Data Analytics**	**8**
	21	Machine learning for environmental data	
	22	Big data analytics	
	23	AI and IoT	
	24	Case studies and applications	
	25	**Open Ended**	**15**

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PO/PSO addressed
CO-1	Understand: Gain insights into the significance of data analysis in environmental sciences.	U, R	PO-1,7 PSO-1,2,3

	Learn: Acquire knowledge of probabilistic and statistical methods. Explore: Dive into data management practices and reproducibility. Familiarize: Get acquainted with contemporary software tools like R, R Studio, Python, Shiny, and GitHub. Practice: Set up the R environment and create basic scripts.		
CO-2	Visualize: Create scatter plots, histograms, and other visualizations. Calculate: Compute descriptive statistics (mean, median, variance). Analyze: Investigate distribution patterns. Detect: Identify outliers. Apply: Explore environmental data using R.	U, An, Ap	PO-2,7 PSO-1,2,4
CO 3	Model: Build linear regression models. Extend: Progress to multiple regression. Select: Choose appropriate models. Assess: Validate assumptions and diagnose model performance. Implement: Construct regression models in R.	U, Ap	PO-3,7 PSO-2,3,4
CO 4	Handle: Work with geospatial data. Interpolate: Estimate values spatially. Analyze: Explore time series data. Evaluate: Assess uncertainty. Map: Create spatial visualizations using R.	U, An	PO-3,7 PSO-2,3,4
CO 5	Explore: Delve into machine learning for environmental data. Tackle: Address big data challenges. Consider: Reflect on ethical implications. Apply: Investigate case studies and real-world applications. Customize: Explore specialized topics based on interest	U, Ap, An	PO-2,7 PSO-1,2,6

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

References

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4. Introduction to Environmental Data Science, Jerry Davis. Chapman and Hall/CRC Press, 2023 (1st edition).
5. Environmental Data Analysis with MatLab or Python - Principles, Applications, and Prospects, William Menke. Elsevier, 2022 (3rd Edition).

Name of the Course: Credits: 4:0:0 (Lecture:Tutorial:Practical)

CO No.	**CO**	**PO/PSO**	**Cognitive Level**	**Knowledge Category**	**Lecture (L)/Tutorial (T)**	**Practical (P)**	**OE**
CO-1	Understand: Gain insights into the significance of data analysis in environmental sciences. Learn: Acquire knowledge of probabilistic and statistical methods. Explore: Dive into data management practices and reproducibility. Familiarize: Get acquainted with contemporary software tools like R, R Studio, Python, Shiny, and GitHub. Practice: Set up the R environment and create basic scripts.	PO-1,7 PSO-1,2,3	U, R	F, C	12	3	2
CO-2	Visualize: Create scatter plots, histograms, and other visualizations. Calculate: Compute descriptive statistics (mean, median, variance). Analyze: Investigate distribution patterns. Detect: Identify	PO-2,7 PSO-1,2,4	U, An, Ap	C, P	12	3	2

	outliers. Apply: Explore environmental data using R.						
CO 3	Model: Build linear regression models. Extend: Progress to multiple regression. Select: Choose appropriate models. Assess: Validate assumptions and diagnose model performance. Implement: Construct regression models in R.	PO-3,7 PSO-2,3,4	U, Ap	P, M	12	3	3
CO 4	Handle: Work with geospatial data. Interpolate: Estimate values spatially. Analyze: Explore time series data. Evaluate: Assess uncertainty. Map: Create spatial visualizations using R.	PO-3,7 PSO-2,3,4	U, An	P, M	12	3	3
CO 5	Explore: Delve into machine learning for environmental data. Tackle: Address big data challenges. Consider: Reflect on ethical implications. Apply: Investigate case studies and real-world applications. Customize: Explore specialized topics based on interest	PO-2,7 PSO-1,2,6	U, Ap, An	P, M			5

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6

CO 1	1	2	2	-	-	-	1	-	-	-	-	-
CO 2	1	3	-	2	-	-	-	1	-	-	-	-
CO 3	-	1	2	1	-	-	-	-	3	-	-	-
CO 4	-	3	2	1	-	-	-	-	2	-	-	-
CO 5	2	1	-	-	-	1	-	-	2	-	-	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Internal Exam
- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Project evaluation
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5		✓	✓	