Department of Environmental Science and Engineering

M.Sc. Environmental Science
Curriculum and Syllabus
(Applicable to the students admitted from AY 2024-26)

School of Engineering and Sciences
SRM University-AP, Andhra Pradesh

SRM University – AP, Andhra Pradesh
Neerukonda, Mangalagiri Mandal
Guntur District, Mangalagiri, Andhra Pradesh 522240

Department Vision

To enhance societal welfare by developing skilled and committed professionals to address pressing environmental issues using sustainable strategies.

Department Mission

Statement 1	Provide rigorous education by employing innovative and interdisciplinary approaches to effectively confront current and emerging environmental challenges.
Statement 2	Equip future leaders with essential skills to develop sustainable solutions for pressing environmental, societal, and climatic issues.
Statement 3	Cultivate a new generation of environmental educators and researchers capable of effectively tackling complex environmental challenges.

Program Educational Objectives (PEO)

PEO 1: To create awareness and knowledge about sustainability.
PEO 2: To produce confident, technical, creative and employable postgraduates.
PEO 3: To create awareness and innovation to deal with environmental issues.

Mission of the Department to Program Educational Objectives (PEO) Mapping

	PEO 1	PEO 2	PEO 3
Mission Statement 1	3	2	3
Mission Statement 2	3	3	3
Mission Statement 3	3	3	3

Program Specific Outcomes (PSO)

PSO 1: Identify the solution for complex environmental problems.
PSO 2: Analyse environmental issues and design necessary modules to arrive at optimized solutions.
PSO 3: Design/recommend sustainable solutions for efficient use of natural resources to meet sustainable development goals (SDGs).

Mapping Program Educational Objectives (PEO) to Program Learning Outcomes (PLO)

PEOs	Program Learning Outcomes (PLO)	
	POs	PSOs

	Scientific and Disciplinary	Analytical Reasoning and	Critical and Reflective Thinking	Scientific Reasoning and Design	Research Related Skills	Modern Tools and ICT Usage	Environment and Sustainability	Moral, Multicultural and Ethical	Individual and Teamwork Skills	Communication Skills	Leadership Readiness Skills	Self-Directed and Lifelong Learning	**PSO 1**	**PSO 2**	**PSO 3**
PEO 1	1	1	1	1	2	1	3	2	1	3	2	1	1	1	3
PEO 2	2	2	3	3	2	2	3	2	2	1	1	2	2	2	3
PEO 3	3	1	1	1	3	2	3	2	3	1	3	3	3	3	3

Category Wise Credit Distribution

Course Sub-category	**Subcategory Credits**	**Category Credits**	**Learning hours**
Ability Enhancement Courses (AEC)		Sum of (A + B)	(2 + 1) X 30 = 90
University AEC	2	3	
School AEC	1		
Value Added Courses (VAC)		Sum of (C + D)	(4 + D) X 30 = 120
University VAC	4	4	
School VAC	-		
Skill Enhancement Courses (SEC)		Sum of (E + F + G)	(6 + F + G) X 30 = 180
School SEC	6	6	
Department SEC	-		
SEC Elective	-		
Foundation/ Interdisciplinary courses (FIC)		Sum of (H + I)	(9 + I) X 30 = 270
School FIC	9	9	
Department FIC	-		
Core + Core Elective including Specialization (CC)		Sum of (J + K)	(30 + 15) X 30 = 1350
Core	30	45	
Core Elective (Inc Specialization)	15		
Minor (MC) + Open Elective (OE)	L Credits	Sum of (L)	(L) X 30
Research / Design / Internship/ Project (RDIP)		Sum of (M + N)	(3 + 14) X 30 = 510
Internship / Design Project / Startup / NGO	3	17	
Internship / Research / Thesis	14		
Total		**Sum of (A to N) = 84**	**Sum of (A to N) = 2520**

Semester wise Course Credit Distribution Under Various Categories

Category	Semester									
	I	II	III	IV	V	VI	VII	VIII	Total	%
Ability Enhancement Courses - AEC	1	1	1	-	-	-	-	-	3	
Value Added Courses - VAC	2	2	-	-	-	-	-	-	4	
Skill Enhancement Courses - SEC	3	3	-	-	-	-	-	-	6	
Foundation / Interdisciplinary Courses - FIC	3	3	3	-	-	-	-	-	9	
CC / SE / CE / TE / DE / HSS	13	14	18	-	-	-	-	-	45	
Minor / Open Elective - OE	-	-	-	-	-	-	-	-	-	
(Research/ Design/ Industrial Practice/Project/Thesis/Internship) -RDIP	-	-	3	14	-	-	-	-	14	
Grand Total	**22**	**23**	**25**	**14**	-	-	-	-	**84**	

Note: L-T/D-P/Pr and the class allocation is as follows (15 weeks in a semester).

a) One contact hour of Lecture/Tutorial per week of 60 minutes each is equivalent to 1 credit.
b) Two contact hours of Discussion per week of 60 minutes each is equivalent to 1 credit.
c) Two contact hours of Practical per week of 60 minutes each is equivalent to 1 credit.
d) Two contact hours of Project work per week of 60 minutes each is equivalent to 1 credit. (timetable not required)

S. No.	Semester	Credits
1	I	22
2	II	23
3	III	25
4	IV	14
Total		**84**

SEMESTER - I								
S. No	**Category**	**Sub-Category**	**Course Code**	**Course Title**	**L**	**T/D**	**P/Pr**	**C**
1	AEC1	University AEC	VAC 104	Community Engagement and Social responsibility	0	0	0	1*
2	VAC1	University VAC	AEC 501	Effective communication for impactful interviews	2	0	0	2
3	SEC1	School SEC	SEC 501	Introduction to R and Python	1	1	1	3
4	CC	Department	EVS 501	Environmental issues, Climate Change, and sustainable development	3	1	0	4
5	CC	Department	EVS 502	Earth and Planetary processes	2	1	0	3
6	CC	Department	EVS 503	Environmental Pollution	2	1	0	3
7	CC	Department	EVS 504	Environmental Laboratory – I	0	0	**3**	3
8	FIC	School	FIC 501	Data Science for Beginners	3	0	0	3
				Semester Total	**13**	**4**	**4**	**22**

SEMESTER - II								
S. No	**Category**	**Sub-Category**	**Course Code**	**Course Title**	**L**	**T/D**	**P/Pr**	**C**
1	AEC2	University AEC	VAC 502	Community Engagement and Social responsibility	0	0	0	1*
2	VAC2	University VAC	VAC 503	Entrepreneurial mindset	2	0	0	2
3	SEC2	School SEC	SEC 105	Research Design and Methods	2	1	0	3
4	CE	Department	EVS 550/EVS 551/EVS 552/EVS 553	Freshwater Resources / Introduction to Limnology & Oceanography / Solid Waste Management / Wastewater Treatment / Water contaminants: Sources, Transport and Remediation strategies /Carbon Sequestration	2	1	0	3
5	CC	Department	EVS 505	Environmental Chemistry & Microbiology	3	1	0	4
6	CC	Department	EVS 506	Ecology & Biodiversity	3	1	0	4
7	CC	Department	EVS 507	Environmental Laboratory – II	0	0	**3**	3
8	FIC	University	FIC 108	Design Thinking	3	0	0	3
				Semester Total	**15**	**4**	**3**	**23**

Summer Internship

S. No	Category	Sub-Category	Course Code	Course Title	L	T/D	P/Pr	C
1	RDIP	Department		Summer Internship	0	0	3	3
		Total			**0**	**0**	**3**	**3**

SEMESTER - III

S. No	Category	Sub-Category	Course Code	Course Title	L	T/D	P/Pr	C
1	AEC3	School AEC		Research Seminar	0	0		1*
2	CC	Department	EVS 508	Environmental Impact Assessment and Audits	2	1	0	3
3	CC	Department	EVS 509	Geospatial Technologies for Environmental Applications	2	1	0	3
4	CE	Department	EVS 554/EVS 555/EVS 556/EVS 557	Hydroinformatics / Aquatic Microbial Ecology & Biogeochemistry / Applied Hydrogeology / Urban Mining and Sustainability	2	1	0	3
5	CE	Department	EVS 560	Energy and Environment / Process Design and Systems Analysis / Soil Pollution and Remediation Measures	2	1	0	3
6	CE	Department	EVS 562/EVS 563	Environmental Entrepreneurship and planning / Biomass Energy / Agriculture, food security and climate change	2	1	0	3
7	CE	Department	EVS 565/	Bioeconomy / Membrane Technology for Industrial Water Treatment / Ecosystem Restoration	2	1	0	3
8	FIC	School		Open Elective	3	0	0	3
				Semester Total	**15**	**6**	**0**	**22**

SEMESTER - IV								
S. No	**Category**	**Sub- Category**	**Course Code**	**Course Title**	**L**	**T/D**	**P/Pr**	**C**
1	RDIP	Internship/Research/Thesis		Project Work	0	0	14	14
				Semester Total	**0**	**0**	**14**	**14**

Specializations / Core Electives / Open Electives / Minor

S. No	Category	Sub-Category	Course Code	Course Title	L	T/D	P/Pr	C
Water Security and Under Water Life Stream								
	Elective	Department	EVS 550	Freshwater Resources	2	1	0	3
			EVS 551	Introduction to Limnology & Oceanography	2	1	0	3
			EVS 554	Hydroinformatics	2	1	0	3
			EVS 556	Applied Hydrogeology	2	1	0	3
			EVS 555	Aquatic Microbial Ecology & Biogeochemistry	2	1	0	3
Waste and Resource Management Stream								
	Elective	Department	EVS 552	Solid Waste Management	2	1	0	3
			EVS 555	Wastewater Treatment	2	1	0	3
			EVS 557	Urban Mining and Sustainability	2	1	0	3
			EVS 560	Soil Pollution and Remediation Measures	3	0	0	3
			ENV 120	Water contaminants: Sources, Transport and Remediation strategies	2	1	0	3
			-	Membrane Technology for Industrial Water Treatment	2	1	0	3
			EVS 563	Agriculture, food security and climate change	2	1	0	3
			OEC 104	Carbon Sequestration	2	1	0	3
			-	Ecosystem Restoration	2	1	0	3

Energy Stream								
	Elective	Department	EVS 561	Environmental Entrepreneurship and planning	2	1	0	3
			EVS 562	Biomass Energy	2	1	0	3
			EVS 564	Bioeconomy	2	1	0	3
			EVS 559	Process Design and Systems Analysis	2	1	0	3
			EVS 558	Energy and Environment	2	1	0	3

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Effective Communication for Impactful Interviews

Course Code	AEC 501	Course Category	AEC	L-T/D-P/Pr-C	2	0	0	2
Total Contact Hours		45	Total Learning Hours		60			
Pre-Requisite Course(s)	None	Co-Requisite Course(s)	None	Progressive Course(s)				
Course Offering Department	**Literature & Languages**	Professional / Licensing Standards						

Course Objectives:

This course equips the learners for successful job hunting by fostering a comprehensive understanding and application of the KASB Model in professional communication, enhancing verbal communication skills to excel in interviews, mastering non-verbal communication for a positive first impression, and guiding them in customizing application materials to stand out from the crowd.

Course Outcomes (COs)

	At the end of the course the learner will be able to	**Bloom's Level**	**Expected Proficiency Percentage**	**Expected Attainment Percentage**
CO 1	Identify key components of verbal and non-verbal communication and their significance in the interview process.	1	50%	50%
CO 2	Develop the skill to articulate thoughts clearly and concisely, using effective interview responses.	2	65%	60%
CO 3	Exhibit proficiency in the art of storytelling as a communication tool in interviews.	2	65%	60%
CO 4	Create personalized and tailored resumes, cover letters, and SOPs to align with specific job or educational opportunities.	3	70%	60%

Learning Assessment (Macro)

Bloom's Level of Cognitive Task		**Continuous Learning Assessments (60%)**			
		CLA-1 (15%)	**CLA-2 (15%)**	**CLA-3 (15%)**	**Interview Handling Process (40%)**
Level 1	Remember	100%	30%	50%	20%
	Understand				
Level 2	Apply		70%	50%	50%
	Analyse				
Level 3	Evaluate				30%
	Create				
Total		**100%**	**100%**	**100%**	**100%**

Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)

CLOs	Program Learning Outcomes (PLO)														
	Scientific and Disciplinary Knowledge	Analytical Reasoning and Problem Solving	Critical and Reflective Thinking	Scientific Reasoning and Design Thinking	Research Related Skills	Modern Tools and ICT Usage	Environment and Sustainability	Moral, Multicultural and Ethical Awareness	Individual and Teamwork Skills	Communication Skills	Leadership Readiness Skills	Self-Directed and Life Long Learning	PSO 1	PSO 2	PSO 3
Outcome 1	2	1	1	1	3	1		3	2	3	2	3			
Outcome 2	2	3	3	1	3	1		3	2	3	3	3			
Outcome 3	2	1	3	2	3	2		3	2	3	3	3			
Outcome 4	2	3	3	2	3	3		3	2	3	3	3			
Course Average	**2**	**2**	**2.5**	**1.5**	**3**	**1.75**		**3**	**2**	**3**	**2.75**	**3**			

Course Unitization Plan

Unit No.	Unit Name	Required Contact Hours	CLOs Addressed	References Used
Unit 1	**Introduction: An Overview**	**9**		
	Types of interview	2	1	4
	Communication as a strategy	3	1	4,5
	The KASB Model	4	1	4
Unit 2	**Articulation Skills**	**8**		
	The 3 Vs of Communication	2	1	1,4
	Tone, Pitch and Modulation	4	2	4,5
	Practice session	4	2	
Unit 3	**Story Telling**	**6**		
	The Importance of story telling	2	3	6
	Creating stories around' Tell Me About Yourself'	2	3	6,7
	Group Discussion	2	3	8
Unit 4	**Written Strategy**	**10**		
	Resume	4	4	2,4
	Cover Letter	4	4	2,4
	SOP	2	4	2,4
Unit 5	Mock Interview Sessions	**12**		
			1,2,3.4	
	Total Hours	**45**		

Recommended Resources

1. Cialdini, R. B. (2021). Influence: The psychology of persuasion (Revised edition). Harper Perennial Modern Classics.
2. Dipboye, R. L., & Cole, C. H. (2019). Secrets of a hiring manager: How to land any job and win over any boss. HarperBusiness.
3. LaFare, M. (2013). Veritas: A game of lies. Penguin Books.
4. Mock, P., & Turner, L. (2019). The interview for dummies (6th edition). John Wiley & Sons.

5. Stone, D. D., Patton, B., & Heen, S. (2000). Difficult conversations: How to discuss what matters most (2nd edition). Viking.

6. Dolan, G. (2019). Storytelling for job interviews: How to use stories, nail an interview and land your dream job. BookBaby.

7. Pink, S. (2014). To sell is human: The science of persuasion. Penguin Books.

8. Lewis, V. J. (2018). Group discussion: A practical guide (7th edition). Kogan Page

Course Designers

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Introduction to R and Python

Course Code	SEC 501	**Course Category**		**L-T-P-C**	2	0	2	3
Pre-Requisite Course(s)		**Co-Requisite Course(s)**		**Progressive Course(s)**				
Course Offering Department	Mathematics	**Professional / Licensing Standards**						

Course Objectives

1. In Python, identify and describe essential elements such as syntax, keywords, variables, indentation, data types, lists, tuples, sets, dictionaries, operators, control statements, and loops.
2. Understand the significance of built-in functions, user input-output, matrix computations, linear equations, and graphing curves and surfaces using Matplotlib and file handling in Python.
3. Implement R programming fundamentals, including objects, vectors, matrices, arrays, data manipulation techniques (subsetting, filtering, merging), and data frames, and create visualisations using ggplot2 in R.
4. Synthesise knowledge from Python and R to perform comprehensive data analysis and create reports that include descriptive statistics, linear regression, hypothesis testing, and time series forecasting.

Course Outcome (COs)

CO's	At the end of the course the learner will be able to	Bloom's Level	Expected Proficiency Percentage	Expected Attainment Percentage
1	Demonstrate an understanding of Python programming fundamentals, including syntax, keywords, variables, data types, lists, tuples, sets, dictionaries, operators, and control statements.	2	80	70
2	Grasp core programming concepts by comprehending the role of built-in functions, user input-output, file handling and graphing curves and surfaces using Matplotlib in Python.	3	75	70
3	Apply programming skills in R by effectively using objects, vectors, matrices, arrays, and data frames, and will demonstrate the practical application of data manipulation techniques, including sub-setting, filtering, and merging, and create visualizations using ggplot2 in R.	4	75	70
4	Integrate Python and R knowledge to perform sophisticated data analysis that incorporates descriptive statistics, linear regression, hypothesis testing, and time series forecasting, showcasing a synthesis of programming skills across both languages.	4	75	70
5	Demonstrate an understanding of Python programming fundamentals, including syntax, keywords, variables, data types, lists, tuples, sets, dictionaries, operators, and control statements.	2	80	70

Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)

CLOs	Program Learning Outcomes (PLO)														
	Scientific and Disciplinary Knowledge	Analytical Reasoning and Problem Solving	Critical and Reflective Thinking	Scientific Reasoning and Design Thinking	Research Related Skills	Modern Tools and ICT Usage	Environment and Sustainability	Moral, Multicultural and Ethical Awareness	Individual and Teamwork Skills	Communication Skills	Leadership Readiness Skills	Self-Directed and Life Long Learning	PSO 1	PSO 2	PSO 3
Outcome 1	3	3	3	3					1			2	3	1	2
Outcome 2	3	3	3	2	1				2			2	3	2	2
Outcome 3	3	3	3	3	1				2			2	3	2	2
Outcome 4	3	3	3	3	3				3			2	3	2	2
Outcome 5	3	2	3	3	3				2			3	2	2	2
Course Average	**3**	**3**	**3**	**3**	**2**				**2**			**2**	**3**	**2**	**2**

Course Unitization Plan - Theory

Unit No.	Unit Name	Required Contact Hours	CLOs Addressed	References Used
Unit No. 1		**6**		
	Introduction to data and its different types of scales.	3	1,2	1
	Summarising data, different types of descriptive statistics	3	1,2	1
Unit No. 2		**9**		
	Introduction to Vectors, matrices	3	2,3	1
	Recursive functions, Matrix computations and linear equations	3	2,3	1
	Solving system of Linear Equations. Consistency, transpose, determinants, inverses, trace,	3	2,3	1
Unit No. 3		**15**		
	Basic principles of probability, Random variables.	2	3,4	2
	The Binomial, Normal and other popular distributions.	2	3,4	2
	Inference for one or two samples means using the t-distribution, statistical power for comparing two groups	2	3,4	2
	Introduction to Correlation Analysis, Correlation coefficient for Categorical and Continuous data.	2	4	2
	Introduction to the logistics regression.	4	4	2
Total Contact Hours		**30**		

Course Unitization Plan - Lab

No.	Experiment Name	Required Contact Hours	CLOs Addressed	References Used
1	Write a program to demonstrate the use of Python syntax, keywords, and variables.	2	1	1
2	Create a program that uses indentation and comments to improve code readability.	2	1	1
3	Implement a program that showcases different data types in Python (int, float, string, Boolean).	2	1	1
4	Write a program that manipulates lists (e.g., sorting, appending, slicing).	2	1	1
5	Create a program that demonstrates using tuples and sets in Python.	2	2	1
6	Implement a dictionary to store and retrieve information.		2	1
7	Write a program that uses different operators in Python (+, -, *, /, //, %, **).	2	2	1
8	Create a program that includes control statements (if-else, nested if-else, switch-case) and loops (for, while).	2	2	1
9	Write a program to create and manipulate objects in R.	2	3	2
10	Implement a program that demonstrates using vectors and matrices in R.	2	3	2
11	Create a program that works with arrays and lists in R.	2	3	2
12	Write a program to handle missing data in a data frame.	2	3	2
13	Implement a program that reads and writes data to CSV or text files.	2	4	2
14	Create a program that performs data manipulation tasks (subsetting, filtering, merging) on a data frame.	2	4	2
15	Write a program that uses ggplot2 to create a plot in R.	2	3,4	2
Total Contact Hours		**30**		

Learning Assessment

Bloom's Level of Cognitive Task		Continuous Learning Assessments (60%)								End Semester Exam (40%)	
		CLA-1 (20%)		CLA-2 (10%)		CLA-3 (10%)		Mid Term (20%)			
		Th	Prac	Th	Prac	Th	Prac	Th	Prac	Th	Prac
Level 1	Remember	35%	40%	30%	15%	25%		20%	20%	20%	15%
	Understand	35%	40%	30%	15%	25%		20%	20%	20%	15%
Level 2	Apply	15%	10%	20%	20%	25%		20%	20%	25%	25%
	Analyse	15%	10%	20%	20%	25%		20%	20%	25%	25%
Level 3	Evaluate				15			10%	10%	5%	10%
	Create				15			10%	10%	5%	10%
Total		**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Recommended Resources

1. Guido van Rossum and the Python development team Python Tutorial Release 3.7.0.

2. W. N. Venables, D. M. Smith and the R Core Team, An Introduction to R
3. R in Action, Robert L. Kabacoff, Second Edition, Paperback, Dreamtech Press
4. A Beginner's Guide to R, Alain F. Zuur, Elena N. Ieno, Erik H. W. G. Meesters, Springer New York.
5. The Absolute Beginner's Guide to Python Programming, A Step-by-Step Guide with Examples and Lab Exercises, Kevin Wilson, Apress Berkeley, CA
6. Python Programming Fundamentals, Kent D. Lee, Springer London

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Environmental Issues, Climate Change and Sustainable Development

Course Code	EVS 501	**Course Category**	CC	**L-T-P-C**	3	1	0	4
Pre-Requisite Course(s)	-	**Co-Requisite Course(s)**	-	**Progressive Course(s)**				
Course Offering Department	Environmental Science and Engineering	**Professional / Licensing Standards**	-					

Course Objectives

1. To understand the basic concepts, principles, and background of major environmental issues.
2. To understand the basic concepts, principles, and physical science basis of climatic change.
3. To provide a strong background, principles, and practices on the concept of sustainability.

Course Outcome (COs)

CO's	At the end of the course the learner will be able to	Bloom's Level	Expected Proficiency Percentage	Expected Attainment Percentage
1	Acquire knowledge on various Environmental issues	1	80%	70%
2	Explain different aspects climate change and its impacts on environment, solutions, and the way ahead.	2	80%	70%
3	Illustrate the role of various ecosystems in climate change adaptation and mitigation.	3	80%	70%
4	Explore concepts, principles and practice of sustainable development.	3	80%	70%

Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)

CLOs	**Program Learning Outcomes (PLO)**														
	Engineering Knowledge	**Problem Analysis**	**Design and Development**	**Analysis, Design and Research**	**Modern Tool and ICT Usage**	**Society and Multicultural**	**Environment and Sustainability**	**Moral, and Ethical Awareness**	**Individual and Teamwork Skills**	**Communication Skills**	**Project Management and**	**Self-Directed and Life Long**	**PSO 1**	**PSO 2**	**PSO 3**
Outcome 1	-	**1**	**1**	**2**	**1**	**1**	3	2	**1**	**-**	**1**	3	1	2	2
Outcome 2	-	1	**1**	**2**	**1**	**1**	3	**2**	**1**	**-**	**1**	3	1	2	2
Outcome 3	-	**1**	**1**	**2**	**1**	**1**	3	**2**	**1**	**-**	**1**	3	1	2	2
Outcome 4	-	1	**1**	**2**	**1**	**1**	3	**2**	**1**	**-**	**1**	3	1	2	2
Course Average	**-**	**1**	**1**	**2**	**1**	**1**	**3**	**2**	**1**	**-**	**1**	**3**	1	2	2

Course Unitization Plan

Unit No.	Syllabus Topics	Required Contact Hours	CLOs Addressed	References Used
Unit No. 1	**Fundamentals of Environment**	**12**	**1**	**1, 2, 11**
	Concept, ideas, and types and components of environment; objectives	**3**	**1**	**1, 2, 11**
	Man, society and environment relationships	**3**	**1**	**1, 2, 11**
	Moral and aesthetic nature of environmental science	**3**	**1**	**1, 2, 11**
	Sustainability and carrying capacity	**2**	**1**	**1, 2, 11**
	Environmental awareness	**2**	**1**	**1, 2, 11**
	Global Environmental change	**2**	**1**	**1, 2, 11**
Unit No. 2	**Climate Change and Policy**	**15**	**1,2**	**3, 4, 5**
	Conventions on climate change: national and international initiatives	**2**	**1,2**	**3, 4, 5**
	National Action Plan, State Action Plan	**2**	**1,2**	**3, 4, 5**
	Environmental policy debate; international agreements	**2**	**1,2**	**3, 4, 5**
	Montreal Protocol 1987; Kyoto Protocol 1997	**2**	**1,2**	**3, 4, 5**
	United Nations Climate Change conferences	**2**	**1,2**	**3, 4, 5**
	Paris Agreement, IPCC	**1**	**1,2**	**3, 4, 5**
	Global Scenario – Indian Scenario – Observed changes and projected changes of IPCC - carbon credit and carbon trading;	**3**	**1,2**	**3, 4, 5**
	Clean Development Mechanism	**1**	**1,2**	**3, 4, 5**
Unit No. 3	**Impacts, Adaptation and Mitigation Strategies**	**12**	**2**	**6, 7, 8**
	Impacts of climate change on forest ecosystems, agriculture, livestock, terrestrial and aquatic ecosystems	**2**	**2**	**6, 7, 8**
	Impacts of climate change on terrestrial and aquatic ecosystems	**1**	**2**	**6, 7, 8**
	Introduction and concept of Mitigation and Adaptation, agriculture, forestry and other land use change and management	**3**	**2**	**6, 7, 8**
	Introduction and concept of human health, afforestation and reforestation	**2**	**2**	**6, 7, 8**
	Implications for policy and sustainable development	**2**	**2**	**6, 7, 8**
	Carbon capture and sequestration	**2**	**2**	**6, 7, 8**
Unit No. 4	**Sustainable Development**	**11**	**3**	**9, 10**
	Concept of sustainable development	**1**	**3**	**9, 10**
	Sustainable Development Goals	**2**	**3**	**9, 10**
	Triple bottom line of sustainable development	**2**	**3**	**9, 10**
	Principles of sustainable development, Leopold's land ethics	**2**	**3**	**9, 10**

	Instituting sustainable development – Brundtland commission report	**2**	**3**	**9, 10**
	Earth summit, World summit on sustainable development; Rio+20 and beyond	**2**	**3**	**9, 10**
Unit No. 5	**Individualising Responsibility**	**10**	**4**	**9, 10**
	Consumerism; Consumption and its environmental impact – mobile phones and fashion	**2**	**4**	**9, 10**
	Sustainable consumption – global initiatives; Private sector and civil society initiatives;	**3**	**4**	**9, 10**
	Carbon neutrality; Eco-labelling; Limits of individualizing responsibility;	**3**	**4**	**9, 10**
	Resistance – unsustainable agricultural practice.	**2**	**4**	**9, 10**
Total Hours		**60**		

Learning Assessment

Bloom's Level of Cognitive Task		**Continuous Learning Assessments (50%)**								**End Semester Exam (50%)**	
		CLA-1 (10%)		**CLA-2 (10%)**		**CLA-3 (15%)**		**Mid Term (15%)**			
		Th	**Prac**	**Th**	**Prac**	**Th**	**Prac**	**Th**	**Prac**	**Th**	**Prac**
Level 1	Remember	40%	-	30%	-	20%	-	50%	-	50%	-
	Understand		-		-		-		-		-
Level 2	Apply	60%	-	70%	-	80%	-	50%	-	50%	-
	Analyse		-		-		-		-		-
Level 3	Evaluate		-		-		-		-		-
	Create		-		-		-		-		-
Total		**100%**	**-**	**100%**	**-**	**100%**	**-**	**100%**	**-**	**100%**	**-**

Recommended Resources

1. Environmental Science: A Study of Interrelationship; Enger & Smith. 16th Edition, McGraw Hill.
2. Environmental Science: A Global Concern; Cunningham & Saigo WCB. 16th Edition McGraw Hill.
3. Global Environmental Politics Problems, Policy and Practice. Cambridge University Press. Hayley S. (2018). ISBN: 978-1-107-12183-6
4. Humanity's Footprint: Momentum, Impact, and Our Global Environment. Columbia University Press. Walter K. D. (2018).
5. Global Environmental Issues – 2nd Edition. John Wiley & Sons. Frances Harris (2012). ISBN: 1119952085, 9781119952084
6. Environmental Issues - Daya Publishing House. Malik S. S. (2020). ISBN: 9789388982962
7. Climate Change: Causes, Effects and Solutions for Global Warming. David S.K.T., Jaqueline A.S. Candice Janco (2021).

8. Climate and Global Environmental Change (Understanding Global Environmental Change) 1st Edition Prentice Hall. (2018).
9. Climate Change: A Very Short Introduction. Maslin M. (2014). Oxford Publications.
10. Climate Change: The Science of Global Warming and our Energy Future. Mathez, E.A. Simerdon J.E. (2018). 2nd Edition. Columbia University Press.
11. Environmental Science – 9th Edition. Jones & Bartlet publishers. Daniel D.C. (2012). ISBN: 978-93-80853-60-4

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Earth and Planetary processes

Course Code	EVS 502	**Course Category**	CC	L-T-P-C	2	1	0	3
Pre-Requisite Course(s)	-	**Co-Requisite Course(s)**	-	Progressive Course(s)	-			
Course Offering Department	Environmental Science and Engineering	**Professional / Licensing Standards**	-					

Course Objectives

1. Aims to provide an overview of various processes shaped our planet from global to local scale.
2. To understand structure of our plant, its place in the solar system, and reasons behind some of the natural calamities such as volcanic eruption, earthquakes.

Course Outcome (COs)

Outcomes	**At the end of the course, the learner will be able to**	Bloom's Level	Expected Proficiency Percentage	Expected Attainment Percentage
Outcome 1	Explain how earth came to be what it now, understand how it works, and current variability due to anthropogenic activities	2	80%	70%
Outcome 2	Classify different types of rock formation, mountain, and landscape building processes	2	80%	70%
Outcome 3	Articulate the structure of the Earth's interior and tectonic movements	3	80%	70%
Outcome 4	Assess reasons behind the natural calamities such as earthquakes volcanic eruption and the relation with the climate change vis-a-vis	3	80%	70%

Course Articulation Matrix (CO) to Program Learning Outcomes (PO)

COs	**Program Learning Outcomes (PO)**														
	Engineering Knowledge	**Problem Analysis**	**Design and Development**	**Analysis, Design and Research**	**Modern Tool and ICT Usage**	**Society and Multicultural Skills**	**Environment and Sustainability**	**Moral, and Ethical Awareness**	**Individual and Teamwork**	**Communication Skills**	**Project Management and Finance**	**Self-Directed and Life Long Learning**	**PSO 1**	**PSO 2**	**PSO 3**
Outcome 1	-	1	-	1	1	1	3	-	1	-	1	1	0	0	0

Outcome 2	-	1	-	1	1	1	3	-	1	-	1	1	0	0	0
Outcome 3	-	2	2	2	1	1	3	1	1	1	1	2	0	0	0
Outcome 4	-	3	3	3	3	2	3	2	1	1	2	3	0	0	0
Course Average	-	1.75	2.5	1.75	1.5	1.25	3	1.5	1	1	1.25	1.75	0	0	0

Course Unitization Plan

Unit No.	Unit Name	Required Contact Hours	COs Addressed	References Used
Unit 1	**Origin of Earth and its position in the solar system**	9	1	1, 2
	Origin of solar system; Early earth; Exploring solar system and beyond	3	1	1, 2
	Geological timescale; and evolution of life	3	1	1, 2
	Earth systems (atmosphere, hydrosphere, lithosphere, and biosphere) and their interactions	3	1	1, 2
Unit 2	**Structure of Earth's interior and tectonic plates**	8	3	1, 2
	The layered Earth - Crust, Mantle, and Core	2	3	1, 2
	Chemical composition of Earth's major layers	3	3	1, 2
	Tectonic plates; Rates and history of tectonic plate movements	3	3	1, 2
Unit 3	**Rocks, Minerals, sedimentation, and weathering**	8	2	1, 2
	Minerals: Formation, properties, and structure; Properties and types of rocks	2	2	1, 2
	Sedimentation and burial, from sediments to rocks	2	2	1, 2
	Alteration of rocks by temperature and pressure	2	2	1, 2
	Geological history from rocks, weathering, erosion, and mass wasting.	2	2	1, 2
Unit 4	**Volcanoes, Earthquakes, and landscape development**	10	3,4	1, 2
	What are volcanoes; Volcanic deposits, eruptions and landforms; Interaction with volcanoes and other geosystem	2	3,4	1, 2
	Global patterns and human affairs of volcanism	2	3,4	1, 2

	What are earthquakes; understanding earthquakes; prediction, hazards, and risks of earthquakes	2	3,4	1, 2
	Topography, Elevation, and Relief;	2	3,4	1, 2
	Landforms: Features Sculpted by Erosion, and Sedimentation; Models of landscape development	2	3,4	1, 2
Unit 5	**Climate systems and human impacts on Earth's processes**	10	3,4	1,3
	Components of climate systems – Atmosphere, Hydrosphere, Lithosphere, Cryosphere and Biosphere	2	3,4	1,3
	Greenhouse gas effect; Climate variation – regional to global scale; Long-term global variation	1	3,4	1,3
	Carbon cycle; Anthropogenic effects on climate change	2	3,4	1,3
	Carbon economy	1	3,4	1,3
	Global energy consumption	2	3,4	1,3
	Fossil fuels – global warming – consequences	2	3,4	1,3
	Total Hours	45		

Learning Assessment

Bloom's Level of Cognitive Task		**Continuous Learning Assessments (50%)**				**End Semester Exam (50%)**
		CLA-1 (10%)	**CLA-2 (15%)**	**CLA-3 (10%)**	**Mid-1 (15%)**	
Level 1	Remember	30%	50%	30%	50%	25%
	Understand					
Level 2	Apply	70%	50%	70%	50%	75%
	Analyse	-	-	-	-	-
Level 3	Evaluate	-	-	-	-	-
	Create					
Total		**100%**	**100%**	**100%**	**100%**	**100%**

Recommended Resources

1. Carlson, D.H., Plummer, C.C., Hammersley, L. (2015) Physical Geology (15th edition), Mac Graw Hill.
2. Faure, G., and Mensing, T.M. (2017) Introduction to Planetary Science - The Geological Perspective. Springer Publishers. ISBN-13 978-1-4020-5233-0 (HB)
3. Cowie, J. (2002) Climate change: Biological and Human Aspects (2nd Edition), Cambridge University Press

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Environmental Pollution

Course Code	EVS 503	**Course Category**		L-T-P-C	2	1	0	3
Pre-Requisite Course(s)	-	**Co-Requisite Course(s)**	-	Progressive Course(s)	-			
Course Offering Department	Environmental Science and Engineering	**Professional / Licensing Standards**	-					

Course Objectives / Course Learning Rationales (CLRs)

1. Aims to provide fundamentals of air pollution and its chemistry.
2. To understand different air pollutants, environmental conditions, and monitoring techniques.

Course Outcomes / Course Learning Outcomes (CLOs)

Outcomes	At the end of the course, the learner will be able to	Bloom's Level	Expected Proficiency Percentage	Expected Attainment Percentage
Outcome 1	Identify different types of environmental pollution and health impacts.	1	80%	70%
Outcome 2	Explain air pollution and its control measures.	2	80%	70%
Outcome 3	Determine water and soil pollutants and treatment processes.	3	80%	70%
Outcome 4	Examine noise and radiation pollution and appropriate control measures.	3	80%	70%

CLOs	**Program Learning Outcomes (PLO)**														
	Engineering Knowledge	Problem Analysis	Design and Development	Analysis, Design and Research	Modern Tool and ICT Usage	Society and Multicultural Skills	Environment and Sustainability	Moral, and Ethical Awareness	Individual and Teamwork Skills	Communication Skills	Project Management and Finance	Self-Directed and Life Long Learning	PSO1	PSO2	PSO3
Outcome 1	1	-	-	1	-	-	3	-	1	-	-	1	3	3	3
Outcome 2	1	-	-	1	1	-	3	-	1	-	-	1	3	3	3
Outcome 3	1	-	-	1	1	-	3	-	1	-	-	1	3	3	3
Outcome 4	1	-	-	1	-	-	3	-	1	-	-	1	3	3	3
Course Average	1	-	-	1	1	-	3	-	1	-	-	1	3	3	3

Course Unitization Plan

Unit No.	Unit Name	Required Contact Hours	CLOs Addressed	References Used
Unit 1	**Pollution and Its impacts**	5	1	1, 2
	Definitions of Pollution and contaminants,	1	1	1, 2
	Types of pollution, environmental effects and health impacts	1	1	1, 2
	Walkthrough analysis of different types of pollution in surrounding environment	3	1	1, 2
Unit 2	**Air Pollution and Controls**	10	1,2,3	1,3
	Sources of air pollution	1	1,2,3	1,3
	Classification of air pollutants,	1	1,2,3	1,3
	Environmental and health effects due to air pollutants	1	1,2,3	1,3
	Air pollution control measures	1	1,2,3	1,3
	Air pollution control using Scrubber, Bag filter, ESP	1	1,2,3	1,3
	Air pollution control using Bag filter	1	1,2,3	1,3
	Air pollution control measures using ESP	1	1,2,3	1,3
	Case studies of Air pollution: Bhopal Gas Tragedy & London Smog	1	1,2,3	1,3
	Case studies of Air pollution: Donora Episode, Malaysian Haze Episode	1	1,2,3	1,3
Unit 3	**Water Pollution and Controls**	10	1,2	2,4
	Sources of water pollution	1	1,2	2,4
	Types of water pollution,	1	1,2	2,4
	Water standards, water quality index,	1	1,2	2,4
	Water treatment process	1	1,2	2,4
	Case studies on water and waste pollutions	3	1,2	2,4
	Analyze the water parameter from the case study	3	1,2	2,4
Unit 4	**Soil Pollution and Controls**	10	1,3	3
	Source of soil pollution	1	1,3	3
	Soil pollution and their harmful effects soil quality	1	1,3	3

	Soil remediations; physical and chemical remediation	1	1,3	3
	Phytoremediation	1	1,3	3
	Bioremediation	1	1,3	3
	Case studies on soil pollution and remediation	3	1,3	3
	Handson experience on soil parameter	2	1,3	3
Unit 5	**Noise and Radiation Pollution and its Controls**	10	1,4	1,2,4
	Noise and Sound levels	1	1,4	1,2,4
	Noise detector, noise standards, and control measures	1	1,4	1,2,4
	Radiation, classification of radiation hazards, control measures	1	1,4	1,2,4
	Radiation control measures	1	1,4	1,2,4
	Case study on Chernobyl, National Highways, etc.	3	1,4	1,2,4
	Analyse different locations with sound meter	3	1,4	1,2,4
	Total hours	**45**		

Recommended Resources

1. Environmental Pollution Control Engineering. CS Rao (2021), New Age International Publisher.
2. Wastewater Engineering: Treatment, disposal, Reuse (4th ed.). Metcalf & Eddy Inc. Tata McGraw-Hill, New Delhi, 2004.
3. Soil Pollution: From Monitoring to Remediation, 1st Edition. Armando Duarte, Anabela Cachada, Teresa Rocha-Santos (2018), Elsevier.
4. Environmental Engineering. HS Peavy, RR Donald, and G Tchobanoglous (2017). McGraw-Hill Int. Singapore.

Learning Assessment

Bloom's Level of Cognitive Task		**Continuous Learning Assessments (50%)**								**End Semester Exam (50%)**	
		CLA-1 (10%)		**Mid-1 (15%)**		**CLA-2 (10%)**		**Mid-2 (15%)**			
		Th	**Prac**	**Th**	**Prac**	**Th**	**Prac**	**Th**	**Prac**	**Th**	**Prac**
Level 1	Remember	60%	-	40%	-	20%	-	40%	-	40%	-
	Understand										
Level 2	Apply	40%	-	40%	-	60%	-	40%	-	40%	
	Analyse										
Level 3	Evaluate										
	Create	-	-	-	-		-	-	-		
Total		100%		100%		100%		100%		100%	

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Environmental Laboratory – I

Course Code	EVS 504	**Course Category**	CC	**L-T-P-C**	3	0	0	3
Pre-Requisite Course(s)		**Co-Requisite Course(s)**		**Progressive Course(s)**				
Course Offering Department	Environmental Science and Engineering	**Professional / Licensing Standards**						

Course Objectives

1. Develop the field-based knowledge and skills for a wider exposure of students, which is prerequisite for understanding the structural and functional aspects of ecosystems.
2. Provide field knowledge, sampling skills, field sample collection, labelling, carrying procedures from field to laboratory
3. Provide students with a clear understanding on lab analysis, data interpretation and report preparation.

Course Outcome (COs)

CO's	At the end of the course the learner will be able to	Bloom's Level	Expected Proficiency Percentage	Expected Attainment Percentage
1	Describe the basics of the structural and functional aspects of ecosystems.	1	70%	70%
2	Discuss practical and analytical techniques for test size, structure & population dynamics in ecosystems	2	80%	70%
3	Discover fieldwork components and acquire a wider exposure of the field conditions.	3	80%	70%
4	Demonstrate a wider understanding of both field and lab components.	3	80%	70%

Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)

CLOs	**Program Learning Outcomes (PLO)**														
	Engineering Knowledge	**Problem Analysis**	**Design and Development**	**Analysis, Design and Research**	**Modern Tool and ICT Usage**	**Society and Multicultural**	**Environment and Sustainability**	**Moral, and Ethical Awareness**	**Individual and Teamwork Skills**	**Communication Skills**	**Project Management and**	**Self-Directed and Life Long**	**PSO 1**	**PSO 2**	**PSO 3**
Outcome 1	1	1	-	1	-	-	3	2	1	2	-	1	1	1	1
Outcome 2	1	1	-	1	-	-	3	2	1	2	-	1	1	1	1
Outcome 3	1	1	-	1	1	-	3	2	1	2	-	1	1	1	1
Outcome 4	-	1	-	-	-	-	-	2	-	2	-	1	1	1	1
Course Average	1	1	-	1	1	-	3	2	1	2	-	1	1	1	1

Course Unitization Plan

List of Practical's				
Exp. No.	**Experiment Name**	**Required Contact Hours**	**CLOs Addressed**	**References Used**
1	Estimation of population size by quadrat method.	2	1	
2	To determine the density, basal area of forest/grassland ecosystems.	2	2,3	
3	To study the plant diversity of Andhra Pradesh and other southern states.	2	1	
4	To study the plant population structure in a forest/grassland stand.	2	3	
5	To analyze the plant functional traits: leaf area index, wood density, height etc.	2	1	
6	Estimation of belowground fine root biomass and carbon in forest/grassland ecosystems.	2	3	
7	Assessment of disturbance in different ecosystems.	2	2	
8	To determine the litter accumulation and collection of samples in a forest stand.	2	1	
9	Estimation of biomass and carbon stocks of forest/grassland stands by allometric model.	2	3	
10	To determine the growth of trees through increment model.	2	2	
11	Estimation of primary, secondary, and net primary productivity (NPP) of different ecosystems.	3	3	
12	Invasive species and their distribution in various ecosystems	3	1	
13	A study on the microbial diversity in soils of forest/grassland/aquatic ecosystems	3	1	
14	Techniques and methods for the collection of soil samples by soil core sampler	3	3	
15	To determine the colour, bulk density, porosity, and texture of soil	4	2	
16	To determine the pH, C, N, P & K in soil samples	3	3	
17	Field trip to protected (National parks, Biosphere reserves, sanctuary etc.) and un-protected areas and waterbodies for data collection and report preparation.	6	3	
	Total Hours	**45**		

Learning Assessment

Bloom's Level of Cognitive Task		Continuous Learning Assessments (50%)								End Semester Exam (50%)	
		CLA-1 (10%)		CLA-2 (10%)		Mid Term 1 (15%)		CLA 3 (15%)			
		Th	Prac	Th	Prac	Th	Prac	Th	Prac	Th	Prac
Level 1	Remember	-	20%	-	30%	-	20%	-	20%	-	40%
	Understand	-	30%	-	30%	-	50%	-	40%	-	30%
Level 2	Apply	-	50%	-	40%	-	50%	-	40%	-	30%
	Analyse	-	-	-	-	-	-	-	-	-	
Level 3	Evaluate	-		-	-	-	-	-	-	-	
	Create	-		-	-	-	-	-	-	-	
Total		**-**	100%	**-**	100%	**-**	100%	**-**	**-**	**-**	100%

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Data Science for Beginners

Course Code	FIC501	**Course Category**	FIC	**L-T-P-C**	3	0	0	3
Pre-Requisite Course(s)		**Co-Requisite Course(s)**		**Progressive Course(s)**				
Course Offering Department	Mathematics	**Professional / Licensing Standards**						

Course Objectives

1. After completing this course, students will fully grasp different data types and representations. Also, they have a basic understanding of descriptive statistics for the given datasets.

2. Students will understand linear algebra concepts well, enabling them to manipulate vectors and matrices and solve linear systems efficiently.

3. Upon completing the course, students will be proficient in applying probability principles and conducting statistical inference, including point estimation, confidence intervals, and hypothesis testing for various scenarios.

4. Equip the Students with the knowledge and skills necessary to apply regression techniques for modelling numerical outcomes and logistic regression for classification tasks, both for numerical and categorical data

Course Outcome (COs)

CO's	At the end of the course the learner will be able to	Bloom's Level	Expected Proficiency Percentage	Expected Attainment Percentage
1	Explain the different types of data and graphical representation of data.	2	70%	65%
2	Compute descriptive statistics for any given dataset, such as different measures of central tendency and variation in the data.	3	70%	65%
3	Interpret different definitions of probability and the different types of random variables. Illustrate the application of the central limit theorem. Draw inferences about the population parameters.	3	70%	65%

4	Describe regression analysis using the concept of matrices and the solution of the system of equations.	2	70%	65%

Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)

CLOs	Program Learning Outcomes (PLO)														
	Scientific and Disciplinary Knowledge	Analytical Reasoning and [illegible]	Critical and Reflective Thinking	Scientific Reasoning and Design Thinking	Research Related Skills	Modern Tools and ICT Usage	Environment and Sustainability	Moral, Multicultural and Ethical Awareness	Individual and Teamwork Skills	Communication Skills	Leadership Readiness Skills	Self-Directed and Life Long Learning	PSO 1	PSO 2	PSO 3
Outcome 1	2	3	2	2	1	-	-	-	-	-	-	-	-	-	-
Outcome 2	1	2	2	2	1	-	-	-	-	-	-	-	-	-	-
Outcome 3	2	2	1	1	1	-	-	-	-	-	-	-	-	-	-
Outcome 4	2	2	2	1	2	-	-	-	-	-	-	-	-	-	-
Course Average	**2**	**2**	**2**	**1**	**1**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	-	-	-

Course Unitization Plan

Unit No.	Syllabus Topics	Required Contact Hours	CLOs Addressed	References Used
Unit No. 1	Introduction to data, data structures	1	1	1,3
	Variables and Basic data collection techniques	1	1	1,3
	Summarizing data, Descriptive Statistics	2	1,2	1,3
	Graphics, Histograms, and Popular database software.	2	1,2	1,3
	A glimpse inside the mind of a data scientist	1	1	1,3
	Discussion and Tutorial	2	1	1,3
Unit No. 2	Introduction to Vectors, matrices and linear systems,	1	4	1,2
	Solving systems of Linear Equations. Consistency, transpose, determinants, inverses, trace,	1	4	2
	Vector space, subspaces,	1	4	2
	Independence of vectors, basis and dimension, dot product, inner product, Eigenvalues and Eigenvectors.	2	4	1,2

	Dot product, inner product and its application	2	4	2
	Eigenvalues and Eigenvectors.	1	4	2
	Discussion on Practical applications of vector spaces and Matrices.	2	2,4	1,2,4
Unit No. 3	Basic principles of probability, Different approaches for defining the probability.	1	3	1,3
	Random variables, Types of random Variables and their distribution.	1	3	1,3
	The Binomial, Normal and other popular distributions.	1	3	1,3
	Foundations for Statistical inference, Point and Interval Estimates.	1	3	1,3
	Discussion and Tutorial	1		1,3
	General ideas for statistical inference in estimating the population proportion, Central Limit theorem and its application.	2	3	1,3
	Inference for proportions and tables using the normal and chi-square distributions.	1	3	1,3
	Inference for categorical data,	1	3	1,3
	Inference for one or two samples means using the t-distribution, statistical power for comparing two groups	2	3	1,3
	Tutorial	1	3	1,3,4
Unit No. 4	Introduction to Correlation Analysis, Correlation coefficient for Categorical and Continuous data.	2	4	**1,4**
	Introduction to linear regression, Scatter Plot.	1	4	1,4
	Regression for a numerical outcome with one predictor Variable,	2	4	1,4
	Brief Discussion about Model Adequacy, accuracy, and validation.	2	4	1,3,4
	Regression for numerical and categorical data using many Predictors,	1	4	1,4

	Logistic regression for classification,	2	4	1,4
	Tutorial and Doubt Clearing Session	1	4	1,4
Unit No. 5	Practical applications of Regression and Classification in prediction and forecasting	2	4	1,4
	Tutorial	1	4	1,4

Learning Assessment

Bloom's Level of Cognitive Task		**Continuous Learning Assessments (50%)**								**End Semester Exam (50%)**	
		CLA-1 (10%)		**Mid-term (20%)**		**CLA-2 (10%)**		**CLA-3 (10%)**			
		Th	**Prac**	**Th**	**Prac**	**Th**	**Prac**	**Th**	**Prac**	**Th**	**Prac**
Level 1	Remember	30%		25%		30%		20%		20%	
	Understand	30%		25%		30%		20%		30%	
Level 2	Apply	20%		25%		20%		30%		25%	
	Analyse	20%		25%		20%		30%		25%	
Level 3	Evaluate										
	Create										
Total		**100%**		**100%**		**100%**		**100%**		**100%**	

Recommended Resources:

1. Openintro Statistics (4th edition), Diez David M Christopher D Barr and Çetinkaya, 2019.
2. Linear Algebra and its Applications, Gilbert Strang, Publisher Cengage India Private Limited, 2005.
3. First Course in Probability (11th Edition), Sheldon Ross, Academic Press, 2014.

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Guntur District, Mangalagiri, Andhra Pradesh 522240

Name of the Course

Course Code	SEC105	**Course Category**	Foundation Course (FC)	**L-T-P-C**	3	0	0	3
Pre-Requisite Course(s)	Nil	**Co-Requisite Course(s)**	Nil	**Progressive Course(s)**				
Course Offering Department		**Professional / Licensing Standards**						

Course Objectives

1. **Provide a comprehensive overview of the significance, purpose, and types of research, both basic and applied.**
2. **Instruct students on the steps involved in conducting a literature survey and designing a robust research methodology.**
3. **Emphasize the importance of key ethical principles in research, including honesty, integrity, and transparency.**

Course Outcome (COs)

CO's	At the end of the course, the learner will be able to	Bloom's Level	Expected Proficiency Percentage	Expected Attainment Percentage
1	Remember **the basic concepts of research design and methods, including the definition, significance, purpose, and types of research**	**2**	**85%**	**80%**
2	Explain **the process of developing clear and focused research questions and hypotheses**	**3**	**80%**	**75%**
3	Utilize **reference management tools and bibliographic techniques to organize research sources effectively.**	**4**	**80%**	**75%**
4	Apply **knowledge of research methodology and ethical principles to conduct literature surveys, and design research studies.**	**4**	**75%**	**70%**

Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)

CLOs	**Program Learning Outcomes (PLO)**														
	Engineering Knowledge	**Problem Analysis**	**Design and Development**	**Analysis, Design and Research**	**Modern Tool and ICT Usage**	**Society and Multicultural**	**Environment and Sustainability**	**Moral, and Ethical Awareness**	**Individual and Teamwork Skills**	**Communication Skills**	**Project Management and**	**Self-Directed and Life Long**	**PSO 1**	**PSO 2**	**PSO 3**
Outcome 1	3	2	3	2	3		3	2	3	3	3		2	1	3
Outcome 2	2	1	2	2	1		2	2	1	2	3		3	2	2
Outcome 3	3	3	3	3	2		2	1	2	2	1		1	3	1
Outcome 4	3	3	3	3	2		2	1	2	2	1		1	3	1
Course Average	**3**	**2**	**3**	**2**	**2**		**2**	**2**	**2**	**2**	**2**		2	2	2

Course Unitization Plan

Unit No.	Syllabus Topics	Required Contact Hours	CLOs Addressed	References Used
Unit No. 1	**Introduction to Research Design and Methods**	**10**	**1**	**1,2**
	Overview of research: Definition, significance, purpose, and types.	4		
	Types of Research: Basic and applied research.	4		
	Google scholar, ResearchGate, Citations, h-index, i10 index Bibliography, Reference manager	2		
Unit No. 2	**Formulating Research Questions and Hypotheses**	**10**	**2**	**1,3**
	Developing clear and focused research questions	2		
	Literature survey, various sources of research information	2		
	Methodology of research	2		
	Importance of research design	2		
	Steps in conducting research	2		
Unit No. 3	**Introduction to scientific ethics**	**10**	3	**1,2,3**
	Key ethical principles: Honesty, integrity, transparency.	4		
	The role of ethics in experimental design	2		
	Ethical considerations in data collection and analysis.	2		
	Human and animal research ethics.	2		
Unit No. 4	**Report your findings**	**10**	3	**1,2,3**
	Writing reports, Structuring reports	2		
	Writing journal articles,	3		
	Writing research proposals	3		
	Producing oral presentations	2		
Total Contact Hours		**45**		

Learning Assessment

Bloom's Level of Cognitive Task		Continuous Learning Assessments (50%)								End Semester Exam (50%)	
		CLA-1 (10%)		CLA-2 (10%)		CLA-3 (15%)		Mid Term (15%)			
		Th	Prac	Th	Prac	Th	Prac	Th	Prac	Th	Prac
Level 1	Remember	20%		20%		20%		20%		20%	
	Understand	20%		20%		20%		20%		20%	
Level 2	Apply	40%		40%		40%		40%		40%	
	Analyse	10%		10%		10%		10%		10%	
Level 3	Evaluate	10%		10%		10%		10%		10%	
	Create										
Total		**100%**		**100%**		**100%**		**100%**		**100%**	

Recommended Resources

1. **Bordens K.S. and Abbott, B.b.: Research Design and Methods, Mc Graw Hill, 2008.**
2. **John W. Creswell and J. David Creswell Research Design: Qualitative, Quantitative, and Mixed Methods Approaches" SAGE Publications, 2017**
3. **Wayne C. Booth, Gregory G. Colomb, Joseph M. Williams, Joseph Bizup and William T. FitzGerald, The Craft of Research, Fourth Edition, University of Chicago Press, 2016**

SRM University – AP, Andhra Pradesh
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Introduction to Limnology and Oceanography

Course Code	EVS 551	**Course Category**	CE	**L-T-P-C**	2	1	0	3
Pre-Requisite Course(s)		**Co-Requisite Course(s)**		**Progressive Course(s)**				
Course Offering Department	Environmental Science and Engineering	**Professional / Licensing Standards**						

Course Objectives

1. Provide fundamental understanding on the distribution and physical, chemical, and biological characteristics of freshwater aquatic systems.
2. To understand consequences of climate change and anthropogenic perturbations on carbon and nutrient dynamics of freshwater aquatic systems.
3. Provide fundamental understanding on physical, chemical, and biological characteristics of marine environment.
4. To understand consequences of climate change and anthropogenic perturbations on oceanic environments.

Course Outcome (COs)

CO's	At the end of the course the learner will be able to	Bloom's Level	Expected Proficiency Percentage	Expected Attainment Percentage
1	Summarise the global distribution and functioning and various chemical constituents of freshwater ecosystems.	1	80%	70%
2	Explain the origin and physical, chemical, and biological characteristics of ocean and its significance in maintaining the earth's climate.	2	80%	70%
3	Analyse the importance of biogeochemistry of freshwater systems and potential impacts of human perturbations on carbon and nutrient cycling.	3	80%	70%
4	Examine the ongoing environmental and climatic changes and their consequence in global ocean.	3	80%	70%

Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)

CLOs	Program Learning Outcomes (PLO)														
	Engineering Knowledge	**Problem Analysis**	**Design and Development**	**Analysis, Design and Research**	**Modern Tool and ICT Usage**	**Society and Multicultural**	**Environment and Sustainability**	**Moral, and Ethical Awareness**	**Individual and Teamwork Skills**	**Communication Skills**	**Project Management and**	**Self-Directed and Life Long**	**PSO 1**	**PSO 2**	**PSO 3**
Outcome 1	-	**1**	**-**	**2**	**1**	**1**	3	3	**1**	**1**	**1**	1	1	2	-
Outcome 2	-	1	**-**	**2**	**1**	**1**	3	**3**	**1**	**1**	**1**	1	1	2	-
Outcome 3	-	**1**	**-**	**2**	**1**	**2**	3	**3**	**1**	**2**	**1**	1	1	2	2
Outcome 4	-	1	**-**	**2**	**1**	**2**	3	**3**	**1**	**2**	**1**	1	1	2	2
Course Average	**-**	**1**	**-**	**2**	**1**	**1.5**	**3**	**3**	**1**	**1.5**	**1**	**1**	1	2	2

Course Unitization Plan

Unit No.	Syllabus Topics	Required Contact Hours	CLOs Addressed	References Used
Unit No. 1	**Introduction to the science of freshwater systems (Limnology)**	**9**		
	Limnology as a Discipline	**1**	**1**	**1,2**
	Origin, abundance, and size distribution of lakes, ponds, impoundments;	**2**	**1**	**1,2**
	Morphology and Zonation	**1**	**1**	**1,2**
	Temperature, stratification, and light in lakes;	**1**	**1**	**1,2**
	Hydrodynamics & mixing	**1**	**1**	**1,2**
	Lakes and reservoirs of Asia	**1**	**1**	**1,2**
	Formation, diversity and distribution of rivers and streams	**1**	**1**	**1,2**
	Wetlands and its global significance	**1**	**1**	**1,2**
Unit No. 2	**Aquatic Chemistry**	**8**		
	Chemicals in freshwater	**1**	**1,3**	**1,2**
	Redox Potential	**1**	**1,3**	**1,2**
	Potential Energy, and Chemical Transformations	**1**	**1,3**	**1,2**
	Oxygen: Forms and Transformations	**1**	**1,3**	**1,2**
	Photosynthesis; Respiration	**1**	**1,3**	**1,2**
	Metabolic Balance of Photosynthesis and Respiration	**1**	**1,3**	**1,2**
	Temperature Effects on photosynthesis and respiration	**1**	**1,3**	**1,2**
	Controls of distribution of Oxygen in the aquatic Environment	**1**	**1,3**	**1,2**
Unit No. 3	**Freshwater aquatic ecosystem's response to global environmental changes**	**6**		
	Biogeochemistry of inland waters and global carbon cycling	**1**	**3**	**1,2**
	Climate change: Impact & response of freshwater aquatic ecosystems	**1**	**3**	**1,2**

	Human alteration of inland water carbon cycling - overview	**1**	**3**	**1,2**
	Eutrophication, Pollution, flow diversion (dams) and their impacts on carbon cycling	**2**	**3**	**1,2**
	Landscape change impact on aquatic carbon processing	**1**	**3**	**1,2**
Unit No. 4	**Fundamentals of ocean**	**9**		
	Earth: an ocean world	**1**	**2**	**3,4**
	Age of earth and ocean	**1**	**2**	**3,4**
	Life originated in the ocean.	**1**	**2**	**3,4**
	Oceanic basins and seabed	**1**	**2**	**3,4**
	Sediments and palaeoceanography.	**1**	**2**	**3,4**
	Water molecule and its thermal properties: Seawater and pure water	**1**	**2**	**3,4**
	Temperature, density, and light profiles of the oceanic water column	**1**	**2**	**3,4**
	Stratification of the oceanic water column	**1**	**2**	**3,4**
	Global temperature modulation by seawater	**1**	**2**	**3,4**
Unit No. 5	**Ocean physical, chemical, biological properties and climate interactions**	**13**		
	Salinity and composition of seawater; Conservative and non-conservative behaviour of seawater constituent	**1**	**4**	**3,4**
	Dissolved gases in seawater	**1**	**4**	**3,4**
	Oceanic pH	**1**	**4**	**3,4**
	Temperature, light, and nutrients	**1**	**4**	**3,4**
	Phytoplankton, photosynthesis & measuring primary productivity;	**1**	**4**	**3,4**
	Iron and Nitrogen limitation;	**1**	**4**	**3,4**
	Pelagic and benthic communities;	**1**	**4**	**3,4**
	Size classification of organisms (pico, nano, micro, meso);	**1**	**4**	**3,4**
	Marine virus, bacteria, and cyanobacteria, and chemosynthesis	**1**	**4**	**3,4**

	Ocean and atmosphere interaction;	**1**	**4**	**3,4**
	Atmospheric circulation and wind pattern, Wind patterns and monsoon	**1**	**4**	**3,4**
	El Niño, La Niña; tropical cyclones;	**1**	**4**	**3,4**
	Upwelling and thermohaline circulation	**1**	**4**	**3,4**
Total Hours		**45**		

Learning Assessment

Bloom's Level of Cognitive Task		Continuous Learning Assessments (50%)								End Semester Exam (50%)	
		CLA-1 (10%)		CLA-2 (10%)		CLA-3 (15%)		Mid Term (15%)			
		Th	Prac	Th	Prac	Th	Prac	Th	Prac	Th	Prac
Level 1	Remember	10	-	-	-		-	10	-	10	-
	Understand	20	-	30	-	20	-	30	-	20	-
Level 2	Apply	70	-	70	-	80	-	60	-	70	-
	Analyse	-	-	-	-	-	-	-	-	-	-
Level 3	Evaluate	-	-	-	-	-	-	-	-	-	-
	Create	-	-	-	-	-	-	-	-	-	-
Total		**100**	**-**	**100**	**-**	**100**	**-**	**100**	**-**	**100**	**-**

Recommended Resources

1. Wetzel's Limnology, Lake and River Ecosystems, 4th Edition, Edited by Jones, I.D., Smol, J.P (2023), Academic Press, ISBN: 978-0-12-822701-5
2. Encyclopaedia of Inland waters. Likens G.E. (2009). Academic Press, ISBN: 978-0-12-370626-3
3. Oceanography: An Invitation to Marine Science, 9th Edition. Garrison, T and Ellis. R (2016). ISBN-13: 978-1-305-10516-4.
4. Introduction to Marine Biology, 3rd Edition. Karleskint, G. Jr., Turner, R., Small, J.W. Jr. (2010). ISBN-13: 978-0-495-56197-2

Course designer

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Freshwater Resources

Course Code	EVS 567	**Course Category**	CE	**L-T-P-C**	2	1	0	3
Pre-Requisite Course(s)		**Co-Requisite Course(s)**		**Progressive Course(s)**				
Course Offering Department	Environmental Science and Engineering	**Professional / Licensing Standards**						

Course Objectives

1. Aims to provide an overview on unique characteristics of freshwater, its distribution in Earth, and explain natural cycle of water.
2. To understand how conflict arise over freshwater and explain the challenges of water management
3. Understand central role of humans in global water cycle.

Course Outcome (COs)

CO's	At the end of the course the learner will be able to	Bloom's Level	Expected Proficiency Percentage	Expected Attainment Percentage
1	Define several terminologies related to freshwater resources and understand water cycle	1	80%	70%
2	Able to understand how climate change and human activities affect water cycle	2	80%	70%
3	Asses the magnitude, variability and quality of surface water and ground water	3	80%	70%
4	Apply the management of drinking water and wastewater and water economies	4	80%	70%

Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)

CLOs	Program Learning Outcomes (PLO)													
	Engineering Knowledge	Problem Analysis	Design and Development	Analysis, Design and Research	Modern Tool and ICT Usage	Society and Multicultural Skills	Environment and Sustainability	Moral, and Ethical Awareness	Individual and Teamwork Skills	Communication Skills	Project Management and Finance	Self-Directed and Life Long Learning	PSO 1	PSO 2	PSO 3
Outcome 1	-	-	-	-	-	**1**	3	3	**1**	**1**	-	1	1	1	-
Outcome 2	-	2	**1**	**1**	**1**	**1**	3	**3**	**1**	**1**	-	2	2	2	1
Outcome 3	-	**1**	**1**	**1**	**1**	**1**	3	**3**	**1**	**1**	-	2	2	2	1
Outcome 4	-	2	**1**	**1**	**1**	**1**	3	**3**	**1**	**1**	-	2	2	2	2
Course Average	-	**1.67**	**1**	**1**	**1**	**1**	**3**	**3**	**1**	**1**	-	**1.75**	1.75	1.75	1.33

Course Unitization Plan

Unit No.	Syllabus Topics	Required Contact Hours	CLOs Addressed	References Used
Unit No. 1	**Freshwater Resources and Water cycle**	8		
	Our freshwater resources – an overview	1	1	1, 3
	Water cycle and drivers of global change in freshwater resources	1	1	1, 3
	State of ground water	1	1	1, 3
	State of rivers and lakes.	2	1	1, 3
	Water and society; Changing water cycle.	1	1	1, 3
	Changing water cycle – Anthropogenic and Climatic influences	2	1	1, 3
Unit No. 2	**State of Groundwater, rivers, and lakes**	10		
	State of aquifers	1	2,3	1, 3
	Groundwater recharge abstraction, and injection	2	2,3	1, 3
	Groundwater movements and chemical constitutes.	2	2,3	1, 3
	Rivers, lakes and their state	2	2,3	1, 3
	Oxygen depletion, algal blooms	2	2,3	1, 3
	Changes in volume reduction of lakes and rivers	1	2,3	1, 3
Unit No. 3	**Water Demands: Agricultural and Energy**	8		
	Water demands for agriculture	1	3	1
	Minimizing the farming water needs	2	3	1
	Efficient irrigation, boosting yields	1	3	1
	Trading for smart water use (virtual water)	2	3	1
	Energy and water demand.	2	3	1
Unit No. 4	**Climate change and water**	8		
	Water as the centre of climate change	2	3,4	1

	Water-related hazards; Floods and draughts, storms, Glaciers snow cover, sea-level rise	3	3,4	1
	Changing patterns of rainfall	1	3,4	1
	Changing water availability- shifting ecosystems	2	3,4	1
Unit No. 5	**Water scarcity, Conflicts, and the future**	11		
	Who owns water	1	4	1,2
	Water privatization and discontents	2	4	1,2
	Freshwater reservoirs (Dams)	1	4	1,2
	Bulk water transfer	1	4	1,2
	Water conflicts and their relationship with water access	2	4	1,2
	Water rights, international laws and institutions dealing with transboundary water conflicts	3	4	1,2
	Water footprint	1	4	1,2
	Total Hours	**45**		

Learning Assessment

Bloom's Level of Cognitive Task		Continuous Learning Assessments (50%)								End Semester Exam (50%)	
		CLA-1 (10%)		CLA-2 (10%)		CLA-3 (15%)		Mid Term (15%)			
		Th	Prac	Th	Prac	Th	Prac	Th	Prac	Th	Prac
Level 1	Remember	20%	-	-	-	-	-	30%	-	10%	-
	Understand	30%	-	30%	-	20%	-	30%	-	20%	-
Level 2	Apply	30%	-	40%	-	50%	-	20%	-	40%	-
	Analyse	20%	-	30%	-	30%	-	20%	-	30%	-
Level 3	Evaluate	-	-	-	-	-	-	-	-	-	-
	Create	-	-	-	-	-	-	-	-	-	-
Total		**100**	**-**	**100**	**-**	**100**	**-**	**100**	**-**	**100**	**-**

Recommended Resources

1. Back to the well – Rethinking the future of water. Marq de villiers (2018). ISBN: 9781773100463.
2. Water law in India – Introduction to Legal Instruments. Cullet and Koonan (2018). Oxford University press; ISBN-13: 9780199472475
3. Water Resources – an integrated approach. Joseph Holden (2014) Routledge – Taylor and Francis. ISBN: 978-0-415-60282-2

Course designer

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Wastewater Treatment								
Course Code	EVS 553	Course Category	CE	L-T-P-C	2	1	0	3
Pre-Requisite Course(s)	-	Co-Requisite Course(s)	-	Progressive Course(s)	-			
Course Offering Department	Environmental Science and Engineering	Professional / Licensing Standards	-					

Course Objectives

1. To understand the concept of wastewater treatment using physico-chemical and biological methods.
2. Discuss advanced concepts of wastewater treatment.
3. To design STP/CEPT's, operational conditions and cost analysis.

Course Outcomes / Course Learning Outcomes (CLOs)

Outcomes	At the end of the course, the learner will be able to	Bloom's Level	Expected Proficiency Percentage	Expected Attainment Percentage
Outcome 1	Explain different wastewaters and its characteristics with collection practices.	2	80%	70%
Outcome 2	Understand basic and advanced treatment methods.	2	80%	70%
Outcome 3	Classify physico-chemical and biological treatment processes	2	80%	70%
Outcome 4	Design of a STP/CEPT including operation and cost analysis.	3	80%	70%

Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)

CLOs	**Program Learning Outcomes (PLO)**														
	Engineering Knowledge	Problem Analysis	Design and Development	Analysis, Design and Research	Modern Tool and ICT Usage	Society and Multicultural Skills	Environment and Sustainability	Moral, and Ethical Awareness	Individual and Team work Skills	Communication Skills	Project Management and Finance	Self-Directed and Life Long Learning	PSO1	PSO2	PSO3
Outcome 1	-	3	-	2	-	2	2	3	2	-	3	-	2	3	3
Outcome 2	1	2	2	1	-	-	1	-	2	-	-	-	1	2	1
Outcome 3	1	1	1	1	-	2	1	-	3	-	-	-	1	1	1
Outcome 4	1	1	1	1	-	2	1	-	3	-	-	-	1	1	1

Course Average	1	1.75	1.33	1.25	-	2	1.25	3	2.25	-	3	-	1.25	1.75	1.25

Course Unitization Plan

Unit No.	Unit Name	Required learning Hours	CLOs Addressed	References Used
Unit 1	**Fundamental and overview**	9	1,2	1, 2
	Wastewater characteristics – wastewater management in India	2	1,2	1, 2
	Wastewater collection and systems design	1	1,2	1, 2
	Factor involved in waste treatment methods	2	1,2	1, 2
	Introduction to microbial metabolism	2	1,2	1, 2
	Microbial growth – modelling suspended growth treatment process	2	1,2	1, 2
Unit 2	**Basic treatment processes**	9	1,2	1, 2
	Types of processes & reactors – mass balance – reactions and mechanisms	2	1,2	1, 2
	Mass transfer	1	1,2	1, 2
	Optimization of a treatment process	2	1,2	1, 2
	Aerobic biological oxidation – nitrification – denitrification	2	1,2	1, 2
	Biological phosphorus removal	1	1,2	1, 2
	Anaerobic fermentation and oxidation	1	1,2	1, 2
Unit 3	**Advanced treatment systems**	9	2,4	1, 2
	Membrane filtration – types & process	2	2,4	1, 2
	Adsorption	1	2,4	1, 2
	Gas stripping – ion exchange – distillation –	2	2,4	1, 2
	Suspended & attached growth biological processes	2	2,4	1, 2
	Process analysis – nitrogen removal – phosphorus removal	2	2,4	1, 2
Unit 4	**Water reuse and sludge management**	9	1,2,3	1, 2
	Sludge thickening	1	1,2,3	1, 2
	Anaerobic digestion	2	1,2,3	1, 2
	Drying beds – settling tanks – sludge dewatering	2	1,2,3	1, 2
	Sludge disposal – water reclamation technologies	2	1,2,3	1, 2
	Reusing wastewater	2	1,2,3	1, 2
Unit 5	**Designing of treatment plants**	9	3,4	1, 2
	Overall planning	1	3,4	1, 2
	plant design – STP & CEPT	2	3,4	1, 2
	Commissioning	2	3,4	1, 2
	Operation of plant	2	3,4	1, 2
	Cost analysis	2	3,4	1, 2
	Total learning hours	**45**		

Recommended Resources

1. Wastewater Engineering Treatment and Reuse, 4th edition, Metcalf and Eddy (2017). McGraw Hill Education. ISBN 978-0-0704-9539-5.
2. Wastewater Treatment for Pollution Control and Reuse, 3rd edition, Arceivala and Asolekar (2006). Mc Graw hill Education. ISBN 978-0-0706-2099-5.

Learning Assessment

Bloom's Level of Cognitive Task		Continuous Learning Assessments (50%)								End Semester Exam (50%)	
		CLA-1 (10%)		CLA-2 (10%)		CLA-3 (15%)		Mid-1 (15%)			
		Th	Prac	Th	Prac	Th	Prac	Th	Prac	Th	Prac
Level 1	Remember	30%	-	30%	-	30%	-	30%	-	60%	-
	Understand										
Level 2	Apply	70%	-	70%	-	70%	-	70%	-	40%	-
	Analyse										
Level 3	Evaluate	-	-	-	-	-	-	-	-	-	-
	Create	-	-	-	-	-	-	-	-	-	-
Total		100%		100%		100%		100%		100%	

Course Designer

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Solid Waste Management								
Course Code	EVS 552	Course Category	CE	L-T-P-C	2	1	0	3
Pre-Requisite Course(s)	-	Co-Requisite Course(s)	-	Progressive Course(s)	-			
Course Offering Department	Environmental Science and Engineering	Professional / Licensing Standards	-					

Course Objectives

1. Aims to identify different types of solid waste and issues associated with them.
2. To understand numerous approaches for sustainable management of solid waste.

Course Outcomes / Course Learning Outcomes (CLOs)

Outcomes	At the end of the course, the learner will be able to	Bloom's Level	Expected Proficiency Percentage	Expected Attainment Percentage
Outcome 1	Understand the types of solid waste and associated environmental and health impacts.	2	80%	75%
Outcome 2	Understand the processing of non-hazardous solid waste and its treatment process.	2	80%	75%
Outcome 3	Apply sustainable solutions for the treatment of hazardous solid waste.	3	80%	75%
Outcome 4	Explain national and international laws of solid waste management.	2	80%	75%

Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)

CLOs	**Program Learning Outcomes (PLO)**														
	Engineering Knowledge	Problem Analysis	Design and Development	Analysis, Design and Research	Modern Tool and ICT Usage	Society and Multicultural Skills	Environment and Sustainability	Moral, and Ethical Awareness	Individual and Team work Skills	Communication Skills	Project Management and Finance	Self-Directed and Life Long Learning	PSO 1	PSO 2	PSO 3
Outcome 1	-	-	-	-	-	-	2	-	-	-	-	-	3	3	3
Outcome 2	1	1	-	-	1	1	3	1	2	2	-	1	3	3	3

Outcome 3	1	1	-	-	1	1	3	1	2	2	-	1	3	3	3
Outcome 4	1	-	-	-	-	-	1	1	-	-	-	1	3	3	3
Course Average	1	1	-	-	1	1	2.25	1	2	2	-	1	3	3	3

Course Unitization Plan

Unit No.	Unit Name	Required Contact Hours	CLOs Addressed	References Used
Unit 1	**Waste Management**	9		
	Introduction to solid waste, classification, sources, characteristics	2	1	1, 2
	Impact of improper waste disposal on environment and health	1	1	1, 2
	Generation of waste, waste minimization, recycling, collection and segregation of waste, transfer and transport, storage, e- waste.	3	1,2	1,2
	Quantifying the different types of solid waste at university campus	3	1	1,2
Unit 2	**Processing technologies for Municipal Solid Waste Management & Plastic Management**	10	1,2	2,3
	Volume reduction, energy generation, resource recovery, composting processes, windrow composting,	2	1,2	2,3
	Vermicomposting, biogas technology, floating drum model, fixed dome model,	1	1,2	2,3
	Recycling, incineration and other thermal processes, refuse-derived fuel	1	1,2	2,3
	Landfills, sanitary landfills, selection criteria of a landfill, metabolism of landfill, leachate, landfill gas recovery, post-closure plan.	3	1,2	2,3
	Plastics waste management: Processing and treatment	3	2	2,3
Unit 3	**Hazardous Waste**	12	2,3,4	1,2,3
	Identification of hazardous waste, generation, physical and chemical properties, characteristics test, segregation and transport of hazardous waste	3	2,3,4	1,2,3,4
	Management and hazardous waste handing rules, agro and mine waste management, ocean dumping.	3	2,3,4	1,2,3,4
	International Convention and their Transboundary Movement of Hazardous Wastes and their Disposal	2	2,3,4	1,2,3,4
	International Convention on the Prior Informed Consent.	1	2,3,4	1,2,3,4
	Procedure for Certain Hazardous Chemicals and Pesticides in International Trade, Indian regulations on chemical and hazardous waste management.	3	2,3,4	1,2,3,4
Unit 4	**Biomedical Waste Management**	8	2,3	2,3,4
	Classification, generation, impact on environment	2	2,4	2,4
	Collection, segregation, transport	2	2,4	2,4
	Hazardous waste landfill, reduction of waste	2	2,3,4	4

	Captive bio-medical waste treatment and disposal facility	2	2,3,4	4
Unit 5	**Solid Waste Rules**	6	2,3,4	1,2,3
	National and International laws on municipal solid waste municipal solid waste, e-waste	3	1,2	1,2,3
	National and International laws on plastic wastes	2	1,2	1,2,3
	National and International laws on biomedical waste	1	2,3,4	2,3,4
	Total	45		

Recommended Resources:

1. Hazardous and Other Wastes (Management and Transboundary Movement) Amendment Rules (2022), https://cpcb.nic.in/uploads/hwmd/HOWM-Sixth-Amendment-Rules-2022.pdf.
2. Urban Mining for Waste Management and Resource Recovery: Sustainable Approaches, CRC Press, Taylor & Francis by P. Pathak, Prangya Rout, CRC Press, (2021).
3. Sustainable Solid Waste Management, Edited by Jonathan W. C. Wong; Rao Y. Surampalli; Tian C. Zhang; Rajeshwar D. Tyagi; and Ammaiyappan Selvam, ASCE (2016).
4. Guidelines for Management of Healthcare Waste as per Biomedical Waste Management Rules (2016), https://cpcb.nic.in/uploads/Projects/Bio-Medical-Waste/Guidelines_healthcare_June_2018.pdf.

Recommended Online Resources:

1. https://cpcb.nic.in/status-of-implementation-of-solid-waste-rules/
2. www.niti.gov.in/sites/default/files/2021-12/Waste-Wise-Cities.pdf.

Learning Assessment

Bloom's Level of Cognitive Task		**Continuous Learning Assessments (50%)**								**End Semester Exam (50%)**	
		CLA-1 (10%)		**Mid-1 (15%)**		**CLA-2 (10%)**		**Mid-2 (15%)**			
		Th	**Prac**	**Th**	**Prac**	**Th**	**Prac**	**Th**	**Prac**	**Th**	**Prac**
Level 1	Remember	60%	-	50%	-	50%	-	30%	-	50%	-
	Understand										
Level 2	Apply	40%	-	50%	-	50%	-	70%	-	50%	
	Analyse	-	-	-	-	-	-	-	-	-	
Level 3	Evaluate	-	-	-	-	-	-	-	-	-	-
	Create	-	-	-	-	-	-	-	-	-	-
Total		100%		100%		100%		100%		100%	

Course Designer

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Carbon Sequestration								
Course Code	OEC 104	Course Category	CE	L-T-P-C	2	1	0	3
Pre-Requisite Course(s)	Nil	Co-Requisite Course(s)	Nil	Progressive Course(s)	Nil			
Course Offering Department	Environmental Science and Engineering	Professional / Licensing Standards						

Course Objectives / Course Learning Rationales (CLRs)

Objective 1: Aim to understand the role of different ecosystems in carbon sequestration.
Objective 2: To understand its role in climate change mitigation and adaptation across ecosystems.
Objective 3: To learn Nature-based Solutions (NBS) through ecosystem restoration.

Course Outcomes / Course Learning Outcomes (CLOs)

	At the end of the course the learner will be able to	Bloom's Level	Expected Proficiency Percentage	Expected Attainment Percentage
Outcome 1	Describe Nature-based Solutions (NBS)	2	80%	70%
Outcome 2	Demonstrate the role of NBS in biodiversity enhancement and ecosystems services	2	80%	70%
Outcome 3	Evaluate the carbon sequestration of given ecosystem through restoration.	4	70%	60%
Outcome 4	Compare the effectiveness of NBS strategies to alternative non-NBS strategies.	3	70%	60%

Course Articulation Matrix (CLO) to (PLO)

CLOs	Program Learning Outcomes (PLO)														
	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design & Research	Modern Tool & ICT Usage	Society & Multicultural Skills	Environment & Sustainability	Moral, & Ethical Awareness	Individual & Teamwork Skills	Communication Skills	Project Management &	Self-Directed & Lifelong Learning	PSO 1	PSO 2	PSO 3
Outcome 1	2	2	-	2	1	2	3	1	2	1	-	1	-	-	-
Outcome 2	2	2	-	2	1	2	3	1	2	1	-	1	-	-	-
Outcome 3	2	2	-	2	1	2	3	1	2	1	-	1	-	-	-

Outcome 4	2	2	-	2	1	2	3	1	2	1	-	1	-	-	-
Course Average	**2**	**2**	**-**	**2**	**1**	**2**	**3**	**1**	**2**	**1**	**-**	**1**	**-**	**-**	**-**

Course Unitization Plan - Theory

Unit No.	Unit Name	Required Contact Hours	CLOs Addressed	References Used
Unit No.1	**Nature-Based Solutions**	**8**	1	1,2,3
	Definition, overview, multifunctionality and the concept of Nature-Based Solutions (NBS)	2	1	1,2,3
	Types, challenges and goals, classification of NBS	2	1	1,2,3
	Context and rationale, Scope and limitations. Process and methods of NBS	2	1	1,2,3
	Global Carbon Cycle. Fast and slow carbon cycles. Carbon neutrality vs net zero Emission; Geological carbon sequestration	2	1	1,2,3
Unit No. 2	**Green Carbon**	**9**	2,3	4,5,6,7
	Forests: Introduction, biodiversity conservation	2	2,3	4,5,6,7
	The natural dynamics of carbon in forest ecosystems.	2	2,3	4,5,6,7
	Carbon dynamics and pools in major forest biomes of the world (Boreal, temperate & tropical)	4	2,3	4,5,6,7
	Importance of carbon sequestration in forests, Grasslands, Savannahs, Peatlands and agro ecosystems.	2	2,3	4,5,6,7
Unit No.3	**Blue Carbon**	**10**	2, 3	6,7,8
	Blue carbon: Oceans, coastal ecosystems, mangroves, freshwater and wetlands	4	2, 3	6,7,8
	Introduction, distribution, carbon sequestration, storage, and emissions	2	2, 3	6,7,8
	Climate change policies, investments, and tools	2	2, 3	6,7,8
	Conservation and restoration.	2	2, 3	6,7,8
Unit No. 4	**Restoration of ecosystems**	**8**	3	7,8,9
	Definition, process, carbon sequestration in restored forests, grasslands, and wetlands	3	3	7,8,9
	Biodiversity and ecosystem functioning in restored ecosystems	2	3	7,8,9
	Conservation, restoration, and management as a tool for carbon sequestration.	3	3	7,8,9
Unit No. 5	**Mitigation and adaptation strategies**	**10**	4	10,11
	Nature climate solutions, NDCs, United Nations Framework on Climate Change, the Kyoto Protocol and Post-Kyoto agreements	3	4	10,11
	Contribution of Blue and Green carbon pools to climate change mitigation. Carbon	3	4	10,11

	farming, carbon crediting, carbon marketing, carbon auditing.			
	Restoration, Biodiversity–productivity relationships: key to nature-based climate solutions	3	4	10,11
	Climate change adaptation potential	1	4	10,11
Total Contact Hours		**45**		

Recommended Resources

1. Robert C. Brears (2020). Nature-Based Solutions to 21st Century Challenges. Taylor and Francis. ISBN: 9781000047714
2. Cohen-Shacham, E., Walters, G., Janzen, C. and Maginnis, S. (eds.) (2016). Nature-based Solutions to address global societal challenges. Gland, Switzerland: IUCN. xiii + 97pp. ISBN: 978-2-8317-1812-5
3. Murti, R. and Sheikholeslami, D. (2021). Nature-based Solutions for recovery – Opportunities, policies and measures. Technical Paper No. 2, IUCN Nature-based Recovery Initiative. Gland, Switzerland: IUCN.
4. Klaus, Lorenz & Rattan, Lala (2018). Carbon Sequestration in Agricultural Ecosystems. Springer International Publishing, 1st edition, ISBN:9783319923178
5. Mark, S, Aston., Mary, L., Tyrell., Deborah, Spalding & Bradford, Gentry (2011). Managing Forest Carbon in a Changing Climate. Springer, ISBN: 9789400722316
6. Maxt, A. Beran (2013). Carbon Sequestration in the Biosphere. Processes and Prospectus. Springer-Verlag Berlin and Heidelberg GmbH & Co. KG. ISBN: 9783642799457.
7. Brajesh K Singh (2018). Soil Carbon Storage: Modulators, Mechanisms and Modeling. Academic Press, ISBN: 9780128127667
8. Crooks, Stephen; Troxler, Tiffany G.; Windham-Myers, Lisamarie (2019). A Blue Carbon Primer: The State of Coastal Wetland Carbon Science, Practice and Policy. CRC Press, ISBN:9780429435362
9. Margaret A. Palmer, Joy B. Zedler, Donald A. Falk (eds.) (2016). Foundations of Restoration Ecology. Island Press/Center for Resource Economics. ISBN: 9781610918282
10. David, A.N. Ussiri & Rattan, Lal (2017). Carbon Sequestration for Climate Change Mitigation and Adaptation. Springer, ISBN-13: 978-3319538433

11. Seddon, N., Sengupta, S., García-Espinosa, M., Hauler, I., Herr, D. and Rizvi, A.R. (2019). Nature-based Solutions in Nationally Determined Contributions: Synthesis and recommendations for enhancing climate ambition and action by 2020. Gland, Switzerland and Oxford, UK: IUCN and University of Oxford. IUCN-2019-030

Learning Assessment (Theory)

Bloom's Level of Cognitive Task		Continuous Learning Assessments (50%)				End Semester Exam (50%)
		CLA-1 (10%)	Mid-1 (15%)	CLA-2 (10%)	CLA-3 (15%)	
Level 1	Remember	60%	60%	60%	60%	60%
	Understand					
Level 2	Apply	40%	40%	40%	40%	40%
	Analyse					
Level 3	Evaluate					
	Create					
Total		**100%**	**100%**	**100%**	**100%**	**100%**

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Water contaminants: Sources, Transport and Remediation strategies

Course Code		Course Category	CE	L-T-P-C	2	1	0	3
Pre-Requisite Course(s)	-	Co-Requisite Course(s)		Progressive Course(s)	-			
Course Offering Department	Environmental Science & Engineering	Professional / Licensing Standards	-					

Course Objectives

1. To understand various aspects of water contaminant sources, transport, quantification, and remediation.
2. To seamlessly integrate pollution and remediation theory into practice.

Course Outcomes (COs)

CO's	At the end of the course, the learner will be able to	Bloom's Level	Expected Proficiency Percentage	Expected Attainment Percentage
1	Understand different sources and types of water contaminants together with their hazardous implications	1	80%	70%
2	Identify and predict water contaminant transport mechanisms	2	80%	70%
3	Acquire knowledge in utilizing advanced analytical techniques for contaminant tracking.	2	80%	70%
4	Design, implement, and assess water contaminant remediation approaches based on adsorption phenomenon.	3	80%	70%

Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)

CLOs	Program Learning Outcomes (PLO)														
	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design & Research	Modern Tool & ICT Usage	Society & Multicultural Skills	Environment & Sustainability	Moral, & Ethical Awareness	Individual & Teamwork Skills	Communication Skills	Project Management &	Self-Directed & Lifelong Learning	PSO 1	PSO 2	PSO 3
Outcome 1	1	2	-	2	-	2	3	1	1	-	-	1	2	2	3
Outcome 2	1	2	-	1	-	-	3	-	-	-	-	1	2	-	1
Outcome 3	1	1	1	1	-	2	3	-	-	-	-	1	1	2	1

Outcome 4	3	3	3	3	1	2	3	-	1	-	-	2	2	2	2
Course Average	**2**	**2**	**1**	**2**	**1**	**2**	**3**	**1**	**1**	**-**	**-**	**1**	**2**	**2**	**2**

Course Unitization Plan

Unit No.	Syllabus Topics	Required Learning Hours	CLOs Addressed	References Used
Unit No. 1	**Introduction to Water Contaminants**	**6**	1, 2	1, 2
	Definition and Significance of Water Contaminants, Overview of different water contaminants and their impacts	2	1, 2	1, 2
	Impact on environmental and human health	2	1, 2	1, 2
	Key regulatory frameworks and standards	2	1, 2	1, 2
Unit No. 2	**Sources of Water Contaminants**	**4**	1, 2	1, 2
	Natural and Anthropogenic sources, Overview of the sources of Legacy and Modern water contaminants	2	1, 2	1, 2
	Dynamic nature of water quality and contaminant interactions	2	1, 2	1, 2
Unit No. 3	**Fate and Transport of Contaminants**	**12**	2, 4	3, 4, 5
	Overview, Basics of Contaminant transport, distribution, and fate in Natural Systems - Surface Flows	4	2, 4	3, 4, 5
	Unsaturated/Saturated Porous Media, Multiphase flow systems	4	2, 4	3, 4, 5
	Contaminant transport mechanisms, Advection, Dispersion, Diffusion	2	2, 4	3, 4, 5
	Contaminant transport mechanisms, Sorption, Retardation, Chemical and Abiotic Processes	2	2, 4	3, 4, 5
Unit No. 4	**Analytical Techniques for Contaminant Tracking**	**11**	1, 3, 4	6, 7
	Overview of different analytical techniques	3	1, 3, 4	6, 7
	Cutting-edge technologies in legacy contaminant's detection, analysis, and quantification	4	1, 3, 4	6, 7
	Advanced technologies for detection	1	1, 3, 4	6, 7
	Advanced technologies for analysis, and quantification of emerging contaminants	3	1, 3, 4	6, 7
Unit No. 5	**Remediation Technologies for Water Contaminants**	**12**	3, 4	8

	Overview of remediation trend, Conventional remediation technologies	4	3, 4	8
	Adsorption-based remediation methods, Advanced oxidation processes, Integrated remediation strategies	4	3, 4	8
	Remediation Optimization	1	3, 4	8
	Isotherms and Kinetics modeling studies	3	3, 4	8
Total Learning Hours		**45**		

Learning Assessment

Bloom's Level of Cognitive Task		**Continuous Learning Assessments (50%)**								**End Semester Exam (50%)**	
		CLA-1 (10%)		**Mid-1 (15%)**		**CLA-2 (10%)**		**Mid-2 (15%)**			
		Th	**Prac**	**Th**	**Prac**	**Th**	**Prac**	**Th**	**Prac**	**Th**	**Prac**
Level 1	Remember	30%	-	30%	-	30%	-	30%	-	60%	-
	Understand										
Level 2	Apply	70%	-	70%	-	70%	-	70%	-	40%	-
	Analyse									-	
Level 3	Evaluate	-	-	-	-	-	-	-	-	-	-
	Create	-	-	-	-	-	-	-	-	-	-
Total		100%		100%		100%		100%		100%	

Recommended Resources:

1. Rao S V. (2007). An Introduction To Water Pollution. Retrieved from https://books.google.com.my/books?id=59dHlRUteEoC

2. Chakraborty, P., & Snow, D. (Eds.). (2022). Legacy and Emerging Contaminants in Water and Wastewater. https://doi.org/10.1007/978-3-030-95443-7

3. Schnoor, J. L. (1996). Environmental modeling : fate and transport of pollutants in water, air, and soil, 682. Retrieved from https://www.wiley.com/en-br/Environmental+Modeling%3A+Fate+and+Transport+of+Pollutants+in+Water%2C+Air%2C+and+Soil-p-9780471124368

4. Dunnivant, F. M., & Anders, E. (2006). A Basic Introduction to Pollutant Fate and Transport: An Integrated Approach with Chemistry, Modeling, Risk Assessment, and Environmental Legislation. *A Basic Introduction to Pollutant Fate and Transport: An Integrated Approach with Chemistry, Modeling, Risk Assessment, and Environmental Legislation*, 1–480. https://doi.org/10.1002/0471758132

5. Council, N. R. (2004). Contaminants in the Subsurface: Source Zone Assessment and Remediation. *Contaminants in the Subsurface: Source Zone Assessment and Remediation*, 1–358. https://doi.org/10.17226/11146

6. Sivasankar, B. (2012). *Instrumental methods of analysis*. N. Delhi: Oxford University Press.

7. Pooja, D., Kumar, P., Singh, P., & Patil, S. (Eds.). (2020). Sensors in Water Pollutants Monitoring: Role of Material. https://doi.org/10.1007/978-981-15-0671-0

8. Bhattacharya, S., Gupta, A. B., Gupta, A., & Pandey, A. (2018). Introduction to Water Remediation: Importance and Methods. *Energy, Environment, and Sustainability*, 3–8. https://doi.org/10.1007/978-981-10-7551-3_1

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Environmental Chemistry & Microbiology

Course Code	EVS 505	**Course Category**	CC	**L-T-P-C**	3	1	0	4
Pre-Requisite Course(s)		**Co-Requisite Course(s)**		**Progressive Course(s)**				
Course Offering Department	Environmental Science and Engineering	**Professional / Licensing Standards**						

Course Objectives

1. Provide students with knowledge of the chemical properties of pollutants as well as about the chemical reactions of various pollutants in the environment.
2. Discuss on the sources, reactions, transport, effects, and fates of various chemical species in air, water, and soil.
3. Provide a comprehensive understanding on the relationships of microorganism, and environmental processes as well as the role of microorganisms in regulating processes at ecosystem to global scales.

Course Outcome (COs)

CO's	At the end of the course the learner will be able to	Bloom's Level	Expected Proficiency Percentage	Expected Attainment Percentage
1	Describe the fundamentals and applied aspects of environmental chemistry.	**2**	80%	70%
2	Apply concepts of environmental chemistry to solve issues related to the pollution of air, water, and soil and their toxicological effects	**4**	80%	70%
3	Relate the physiology of microorganisms to various environmental processes	**3**	80%	70%
4	Connect the knowledge on microorganisms to the global biogeochemical cycles and environmental hazards	**2**	80%	70%

Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)

CLOs	**Program Learning Outcomes (PLO)**														
	Engineering Knowledge	**Problem Analysis**	**Design and Development**	**Analysis, Design and Research**	**Modern Tool and ICT Usage**	**Society and Multicultural Skills**	**Environment and Sustainability**	**Moral, and Ethical Awareness**	**Individual and Teamwork Skills**	**Communication Skills**	**Project Management and Finance**	**Self-Directed and Life Long Learning**	**PSO 1**	**PSO 2**	**PSO 3**
Outcome 1	-	**1**	**-**	**2**	**-**	**-**	3	1	**2**	**2**	**-**	1	2	2	1
Outcome 2	1	2	**1**	**3**	**1**	**-**	3	**1**	**2**	**2**	**1**	1	2	2	3
Outcome 3	-	**2**	**1**	**2**	**1**	**-**	3	**1**	**2**	**2**	**1**	1	2	3	2

Outcome 4	-	3	**1**	**3**	**1**	**-**	3	**1**	**2**	**2**	**1**	1	3	2	3
Course Average	**1**	**2**	**1**	**2.5**	**1**	**-**	**3**	**1**	**2**	**2**	**1**	**1**	2.25	2.25	2.25

Course Unitization Plan

Unit No.	Syllabus Topics	Required Contact Hours	CLOs Addressed	References Used
Unit No. 1	**Fundamentals of Environment Chemistry**	**12**		
	Fundamental of Environmental Chemistry	2	**1,2**	**1**
	Electrochemistry, and redox reactions	2	**1,2**	**1**
	Gibb's energy, Chemical potential, Chemical equilibria, acid-base.	2	**1,2**	**1**
	Reactions and Solubility product	1	**1,2**	**1**
	Solubility of gases in water Carbonate system	1	**1,2**	**1**
	Unsaturated and saturated hydrocarbons	2	**1,2**	**1**
	Source of natural and artificial radiation, Radioactive substances	2	**1,2**	**1**
Unit No. 2	**Chemistry of Air & Water**	**12**		
	Composition of air	**1**	**2**	**1**
	Chemical speciation, ions and radicals in the atmosphere	**1**	**2**	**1**
	Acid rain, Air pollutants, and Ozone	**1**	**2**	**1**
	Thermochemical and Photochemical reactions	**1**	**2**	**1**
	Greenhouse gases	**1**	**2**	**1**
	Structure and properties of water; D.O., B.O.D., and C.O.D	**1**	**2**	**1**
	Redox potential, Carbonates, conductivity, alkalinity	**2**	**2**	**1**
	Inorganic and organic pollutants	**1**	**2**	**1**
	Pesticides, agricultural and industrial pollutants	**1**	**2**	**1**
	Emerging contaminants	**2**	**2**	**1**
Unit No. 3	**Soil and Geochemistry**	**10**	2	
	Physiochemical composition and organic & inorganic components of soil	2	2	**1, 2**
	Stoichiometry of soil (C: N:P ratio),	2	2	**1, 2**
	Reaction in soil solution - Chemisorption, Chelation, Complexations	2	2	**1, 2**
	Trace elements and their mobility	2	2,3	**1, 2**
	Heavy metals (Pb, Cd, Hg, As, etc.) and biochemical aspects.	2	2,3	**1, 2**

Unit No. 4	**Diversity and physiology of microorganisms in environment**	**14**		
	Microbes and our environment	**1**	**3**	**2, 3**
	Prokaryotes, Eukaryotes, and Viruses.	**2**	**3**	**2, 3**
	Microbial distribution in soil, water, and air.	**2**	**3**	**2, 3**
	Microbes in Extreme environments – Low temperature (Antarctic) and high temperature (hot springs) environments, deserts, and acid mines	**2**	**3**	**2, 3**
	Bacterial growth - pure and continuous culture as well as growth in natural environment	**2**	**3**	**2, 3**
	Microbial growth in aerobic and anaerobic conditions;	**2**	**3**	**2, 3**
	Carbon and energy utilization of microbes	**1**	**3**	**2, 3**
	Carbon, nutrients, and physiological response of microbes	**2**	**3**	**2, 3**
Unit No. 5	**Beneficial and hazardous microorganisms and global biogeochemical cycles**	**12**		
	Microbial methods for metal remediation and oil spills	2	**3,4**	**3**
	Environmentally transmitted pathogens – bacteria, Parasites, Viruses,	2	**3,4**	**3**
	Indicator microorganisms	1	**3,4**	**3**
	Global change and microbial infectious diseases.	2	**3,4**	**3**
	Microbial transformation and biogeochemical cycles;	2	**3,4**	**3**
	Microbial metabolism and biogeochemical processes;	1	**3,4**	**3**
	Microbial contribution to climate change – CO2, CH4, N2O emission.	2	**3,4**	**3**
	Total Hours	**60**		

Learning Assessment

Bloom's Level of Cognitive Task		Continuous Learning Assessments (__%)								End Semester Exam (__%)	
		CLA-1 (__%)		CLA-2 (__%)		CLA-3 (__%)		Mid Term (__%)			
		Th	Prac	Th	Prac	Th	Prac	Th	Prac	Th	Prac
Level 1	Remember	10	-	-	-	-	-	20	-	10	-
	Understand	25	-	30	-	20	-	40	-	20	-
Level 2	Apply	40	-	50	-	20	-	20	-	40	-
	Analyse	25	-	20	-	60	-	20	-	30	-
Level 3	Evaluate	-	-	-	-	-	-	-	-	-	-
	Create	-	-	-	-	-	-	-	-	-	-
Total		**100**	**-**	**100**	**-**	**100**	**-**	**100**	**-**	**100**	**-**

Recommended Resources

1. Environmental chemistry. 11th edition, Manahan, Stanley. (2017). CRC press, ISBN: 9780367558871.
2. Soil Microbiology and Biochemistry, 3rd Edition, Paul, E.A., Elsevier (2007). ISBN 13: 978-0-12-546807-7.
3. Environmental Microbiology, 3rd Edition. Pepper, I.L., Gerba, C.P., Jentry, T.J (2015). Academic Press. ISBN: 978-0-12-394626-3. Madsen E.L., Environmental Microbiology: From Genome to Biogeochemistry, 2nd Edition. Willey Blackwell. ISBN 978-1-118-43963-0.

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Ecology & Biodiversity

Course Code	EVS 506	**Course Category**	CC	**L-T-P-C**	3	1	0	4
Pre-Requisite Course(s)	-	**Co-Requisite Course(s)**	-	**Progressive Course(s)**	-			
Course Offering Department	Environmental Science and Engineering	**Professional / Licensing Standards**	-					

Course Objectives

1. To understand the various ecological concepts, principles and factors that determine the size and number of populations in different ecosystems.
2. Aim to impart the knowledge of ecology, which is crucial for better development and management of natural resources and the global environment.

Course Outcome (COs)

CO's	At the end of the course the learner will be able to	Bloom's Level	Expected Proficiency Percentage	Expected Attainment Percentage
1	Understand the basic principles and concepts of ecology.	1	80%	70%
2	Acquire the knowledge and skills needed for field ecology.	2	80%	70%
3	Examine the role of ecology in relation to environmental conservation and management.	3	80%	70%
4	Investigate the role of ecology and biodiversity in environmental regulation	3	80%	70%

Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)

CLOs	**Program Learning Outcomes (PLO)**														
	Engineering Knowledge	**Problem Analysis**	**Design and Development**	**Analysis, Design and Research**	**Modern Tool and ICT Usage**	**Society and Multicultural**	**Environment and Sustainability**	**Moral, and Ethical Awareness**	**Individual and Teamwork Skills**	**Communication Skills**	**Project Management and**	**Self-Directed and Life Long**	**PSO 1**	**PSO 2**	**PSO 3**
Outcome 1	-	1	1	2	-	1	3	1	1	-	-	1	3	3	3
Outcome 2	-	1	-	2	2	1	3	-	1	-	-	1	3	3	3
Outcome 3	-	1	-	2	2	1	3	-	1	-	-	1	3	3	3
Outcome 4	-	1	-	2	2	1	3	-	1	-	-	1	3	3	3
Course Average	-	1	1	2	2	1	3	1	1	-	-	1	3	3	3

Course Unitization Plan

Unit No.	Unit Name	Required Contact Hours	CLOs Addressed	References Used
Unit 1	**Fundamentals of Ecology**	**10**		
	Basic definitions, concepts, and scope:	2	1	2,4,5
	Ecology, multidisciplinary nature and relevance, landscape,	2	1	2,4,5
	Ecosystems, habitat, ecotones, stability, resistance and resilience,	2	1	2,4,5
	Major terrestrial biomes,	2	1	2,4,5
	Abiotic and biotic factors	2	1	2,4,5
Unit 2	**Community Ecology**	**10**		
	Basic concepts, community structure and organization,	2	2,3	1,3,4,5
	Biomass, keystone species, ecotones and edge effects,	2	2,3	1,3,4,5
	Ecological succession: primary and secondary succession, types of succession,	3	2,3	1,3,4,5
	Climax community concepts.	3	2,3	1,3,4,5
Unit 3	**Biodiversity**	**12**		
	Concept, definition and levels, diversity of flora and fauna, keystone species.	2	1,2,3,4	4,5,6,7
	Biodiversity and extinctions, Biodiversity conservation strategies: in situ and ex situ Conservation,	3	1,2,3,4	4,5,6,7
	Biodiversity hotspots, their characteristic flora and fauna.	2	1,2,3,4	4,5,6,7
	Biodiversity indices: Shannon-Wiener index, Simpson index, similarity index, evenness index, frequency, abundance, density, relative density, diversity, biomass estimation;	3	1,2,3,4	4,5,6,7
	Community diversity estimation: alpha, beta and gamma diversity.	2	1,2,3,4	4,5,6,7
Unit 4	**Values and Threats**	**14**		
	Economic values, ecosystem services, social, aesthetic, consumptive, and ethical values,	2	2,3,4	4, 7,8,9
	Biodiversity of India: values and threats, endangered flora and fauna of India.	3	2,3,4	4, 7,8,9
	Invasion, forest fires, disturbance, diseases, habitat loss, habitat degradation, and habitat fragmentation;	3	2,3,4	4, 7,8,9
	Climate change; pollution; hunting; over-exploitation; deforestation;	2	2,3,4	4, 7,8,9

	Hydropower development; invasive species; land use changes;	2	2,3,4	4, 7,8,9
	Overgrazing; man-wildlife conflicts, mass extinction	2	2,3,4	4, 7,8,9
Unit 5	**Conservation and Management**	**14**		
	Biodiversity conservation and management: Types, management, threatened, endangered and extinct species,	2	2,3,4	3,7,8,9
	In-situ and ex-situ conservation and reintroduction,	2	2,3,4	3,7,8,9
	National parks, Sanctuary and Biosphere reserve – difference and location in India. Endemism, hotspots and coldspots of biodiversity, mega diversity,	3	2,3,4	3,7,8,9
	IUCN Red List categorization – guidelines, practice and application,	3	2,3,4	3,7,8,9
	IUCN Red Data Books, Convention on biodiversity (CBD)	2	2,3,4	3,7,8,9
	National Biodiversity Action Plan, National Biodiversity Authority.	2	2,3,4	3,7,8,9
	Total Hours	**60**		

Learning Assessment

Bloom's Level of Cognitive Task		Continuous Learning Assessments (50%)								End Semester Exam (50%)	
		CLA-1 (10%)		Mid-1 (15%)		CLA-2 (10%)		Mid-2 (15%)			
		Th	Prac	Th	Prac	Th	Prac	Th	Prac	Th	Prac
Level 1	Remember	50%	-	50%	50%	50%	50%	50%	-	50%	-
	Understand										
Level 2	Apply	50%	-	50%	30%	50%	30%	50%	-	50%	-
	Analyse										
Level 3	Evaluate	-	-	-	-	-	-	-	-	-	-
	Create	-	-	-	-	-	-	-	-	-	-
Total		100%		100%		100%		100%		100%	

Recommended Resources

1. Global Biodiversity. T. Pullaiah, Apple Academic Press Inc. Vol. 1, 2019.
2. The Ecology of Plants. Gurevitch J., Scheiner S.M., & Fox G.A. Sinauer Associates Inc; 3rd edition, 2020.
3. Biodiversity and Ecosystem functioning: Synthesis and Perspectives. Loreau M. & Inchausti P. Oxford University Press, Oxford, UK, 2012.
4. Ecology and Environment. Rastogi Publications, Meerut – New Delhi. Sharma, P. D., ISBN-10: 8171339654, 2011.
5. Biological invasions: Economic and environmental costs of alien plant, animal, and microbe species. Pimentel, D. CRC Press. 2011.
6. Fundamentals of Ecology. Odum E.P. and Barrett G.W. Cengage India Private Limited; 5th edition. (2017).
7. Biodiversity: An Introduction. Larsen & Keller Education. Jase Fitzgerald (2017).
8. An Advanced Textbook on Biodiversity - Principles and Practice. Oxford and IBH Publications Co. Pvt. Ltd. New Delhi. Krishnamurthy K.V. (2018).
9. Conservation Biology for All. Sodhi, N.S. & Ehrlich, P.R. (Ed.). Oxford University Press. 2010.

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Environmental Laboratory – II

Course Code	EVS 507	**Course Category**	CC	**L-T-P-C**	0	0	6	3
Pre-Requisite Course(s)		**Co-Requisite Course(s)**		**Progressive Course(s)**				
Course Offering Department	Environmental Science and Engineering	**Professional / Licensing Standards**						

Course Objectives

1. The course is aimed to develop sampling and analytical skills of the students which are required for addressing common environmental problems with particular focus on water quality
2. Provide ability for students develop experimental designs for a given environmental problem including sampling, analysis, and interpretation of results
3. Enhance the student's interpretation skills of environmental results and provide necessary expertise in developing technical solutions for environmental issues.

Course Outcome (COs)

CO's	At the end of the course the learner will be able to	Bloom's Level	Expected Proficiency Percentage	Expected Attainment Percentage
1	Understand different analytical methods for water quality monitoring of drinking water, natural waterbodies, and wastewater treatment plants	**2**	**80 %**	**75 %**
2	Illustrate the variation in water quality of different aquatic environments	**3**	**80**	**70 %**
3	Analyse water quality data and prepare reports	**4**	**80**	**70 %**
4	Evaluate the changes in water quality in response to various anthropogenic pressures	**5**	**80**	**70 %**

Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)

CLOs	Program Learning Outcomes (PLO)														
	Engineering Knowledge	Problem	Design and Development	Analysis, Design and	Modern Tool and ICT Usage	Society and Multicultural	Environment and	Moral, and Ethical	Individual and Teamwork	Communication Skills	Project Management	Self-Directed and Life Long	PSO 1	PSO 2	PSO 3
Outcome 1	-	**2**	**2**	**1**	**1**	**2**	3	3	**2**	**1**	**1**	1	2	1	1
Outcome 2	-	2	**2**	**2**	**1**	**1**	3	**3**	**3**	**1**	**1**	1	2	2	1
Outcome 3	-	**3**	**2**	**3**	**1**	**2**	3	**3**	**3**	**2**	**2**	1	1	3	2
Outcome 4	-	3	**2**	**3**	**1**	**2**	3	**3**	**3**	**3**	**2**	2	2	3	3
Course Average	**-**	**2.5**	**2**	**2.25**	**1**	**1.75**	**3**	**3**	**2.75**	**1.75**	**1.5**	**1.25**	1.75	2.25	1.75

Course Unitization Plan

Unit No.	Syllabus Topics	Required Contact Hours	CLOs Addressed	References Used
Unit No. 1	Determination of temperature, pH, conductivity and dissolved oxygen using multiparameter water quality probe	6	1, 2, 3, 4	1,2
	Determination of light intensity in waterbodies using underwater light meter	3	1, 2, 3, 4	3
	Determination of flow rate and discharge rate in freshwater ecosystem.	3	1, 2, 3, 4	3
Unit No. 2	Estimation of dissolved oxygen in water by Winkler's titration method.	6	1, 2, 3, 4	2
	Estimation of BOD in water and wastewater sources.	6	1, 2, 3, 4	1,2
	Estimation of COD in water and wastewater	3	1, 2, 3, 4	1,2
	Determination of hardness of water using titration method	3	1, 2, 3, 4	1,2
	Determination of total alkalinity in water.	3	1, 2, 3, 4	1,2
Unit 3	Measurement of dissolved organic carbon concentration using Total Organic Carbon Analyzer	12	1, 2, 3, 4	1,2
	Determination of Greenhouse gas (CO_2, CH_4, and N_2O) concentration and fluxes in soil and water using Gas Chromatography and floating/static chambers	12	1, 2, 3, 4	1,2
Unit No. 4	Determination of absorbance, and fluorescence properties of dissolved organic matter in water and wastewater	6	1, 2, 3, 4	3
	Estimation of inorganic nutrients (nitrate, nitrite, Ammonia, phosphate) in water and wastewater	6	1, 2, 3, 4	2
	Spectroscopic determination of Chlorophyll pigments	3	1, 2, 3, 4	2
	Determination of iron content in water by Spectrophotometric method	3	1, 2, 3, 4	2
Unit No. 5	Enumeration of culturable bacteria (Colony forming unit) in soil and water	6	1, 2, 3, 4	1
	Gram staining of bacterial cells using light microscope	3	1, 2, 3, 4	1
	Determination of total bacterial count in water and soil using fluorescence microscopy	6	1, 2, 3, 4	1
	Determination of total coliform in water and wastewater using MPN method	6	1, 2, 3, 4	1
	Total Hours	96		

Learning Assessment

Bloom's Level of Cognitive Task		Continuous Learning Assessments (50%)								End Semester Exam (50%)	
		CLA-1 (15%)		CLA-2 (15%)		CLA-3 (20%)		Mid Term (%)			
		Th	Prac	Th	Prac	Th	Prac	Th	Prac	Th	Prac
Level 1	Remember	-	-	-	-	-	-	-	-	-	-
	Understand	-	20	-	-	-	-	-	-	-	20
Level 2	Apply	-	30	-	30	-	-	-	-	-	30
	Analyse	-	30	-	40	-	50	-	-	-	40
Level 3	Evaluate	-	20	-	30	-	50	-	-	-	10
	Create	-	-	-	-	-	-	-	-	-	-
Total		**-**	**100**		**100**		**100**	**-**	**-**	**-**	**100**

Recommended Resources

1. Standard Methods For the Examination of Water and Wastewater, 24th Edition. Edited by Lipps W, C., Braun-Howland, E.B., Baxter, TE (2024). American Public Health Association
2. Grasshoff K, Ehrhardt M, Kremling K, Eds. 1999. Methods of sea water analysis. 3rd edn. Wainheins: VCH Publishers.
3. Wetzel's Limnology, Lake and River Ecosystems, 4th Edition, Edited by Jones, I.D., Smol, J.P (2023), Academic Press, ISBN: 978-0-12-822701-5

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Design Thinking

Course Code	SEC 502	**Course Category**		**L-T-P-C**	1	0	2	2
Pre-Requisite Course(s)		**Co-Requisite Course(s)**		**Progressive Course(s)**				
Course Offering Department	Management	**Professional / Licensing Standards**						

Course Objectives

1. Understand the principles of Design Thinking.
2. Analyse ideas to produce creative solutions.
3. Create effective solutions for real-world problems.

Course Outcome (COs)

CO's	At the end of the course the learner will be able to	Bloom's Level	Expected Proficiency Percentage	Expected Attainment Percentage
1	Understand users' explicit requirements and latent needs	1	70	70
2	Apply structured but open-ended approaches to ideation	2	60	70
3	Design a hands-on project using the Design Thinking process	3	50	80
4	Apply various design thinking tools to solve the chosen project problem	2	60	80

Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)

CLOs	**Program Learning Outcomes (PLO)**													
	Management Knowledge	**Analytical Reasoning and Problem Solving**	**Critical and Reflective Thinking**	**Strategic Thinking and Logical Reasoning**	**Modern Tools and ICT Usage**	**Environment and Sustainability**	**Moral, Multicultural and Ethical Awareness**	**Individual and Teamwork Skills**	**Communication Skills**	**Leadership Readiness Skills**	**Self-Directed and Lifelong Learning**	**PSO 1**	**PSO 2**	**PSO 3**
Outcome 1	2		2				2							
Outcome 2		3	3	3				3						
Outcome 3			3		2	1		3	2	1				
Outcome 4		3	3	3	1			3			2			
Course Average	2	3	3	3	2	1	2	3	2	1	2			

Course Unitization Plan

Unit No.	Syllabus Topics	Required Contact Hours	CLOs Addressed	References Used
Unit No. 1	**Foundation**			
	Understanding of Design Thinking & Its Importance	1	1	1
	Stages of Design Thinking	2	1	1
Unit No. 2	**Empathy**			
	Review existing literature, case studies, and data to gather background information and understand the current knowledge base related to the problem area.	2	1,3	4
	Engage in user studies such as interviews, surveys, and observations to gain firsthand insights from the target audience.	3	1,3	4
	Through observation and empathy, identify the core needs, pain points, and challenges faced by users. This phase aims to build a deep understanding of the user's experience and the context in which the problem exists.	3	1,3	4
Unit No. 3	**Ideate**			
	Delve deeper into the data collected during the research phase to comprehend the problem's scope and context.	2	1,2,3	1,4
	Clearly articulate the problem statement based on the insights gathered. This involves specifying the target audience, the issue at hand, and the desired outcome.	3	2,3	1,4
	Use tools such as mind maps, flowcharts, and other visual aids to map out relationships between different elements of the problem. This helps in identifying patterns, root causes, and key factors that need to be addressed.	5	2,3	1,4
Unit No. 4	**Develop**			
	Brainstorm multiple ideas and potential solutions to the defined problem. Encourage out-of-the-box thinking to explore a wide range of possibilities.	6	2,3,4	2,4
	From the pool of ideas, develop various alternative concepts that offer different approaches to solving the problem.	3	3,4	2,4
	Propose innovative Prototypes that not only address the problem effectively but also add value and provide a unique perspective.	5	3,4	2,4
Unit No. 5	**Test**			
	Create initial mock-ups or sketches of the proposed solutions. These should be simple representations to visualize the concept.	3	4	2,4
	Develop scenarios to understand how the solution would function in real-world situations.	3	4	2,4
	Collect and analyse feedback to understand what works well and what needs improvement. This may involve usability testing sessions, focus groups, or surveys.	4	4	2,4

Learning Assessment

Bloom's Level of Cognitive Task		Continuous Learning Assessments (__%)								End Semester Project (40%)	
		CLA-1 (20%)		CLA-2 (20%)		CLA-3 (20%)		Mid Term (0%)			
		Th	Prac	Th	Prac	Th	Prac	Th	Prac	Th	Prac
Level 1	Remember										
	Understand	10%									
Level 2	Apply	10%		10%		10%				10%	
	Analyse			10%		10%				10%	
Level 3	Evaluate									10%	
	Create									10%	
Total		**20%**		**20%**		**20%**				**40%**	

Recommended Resources

1. Design Thinking – Techniques and Approaches, N. Siva Prasad
2. Nigel Cross (2011), Design Thinking: Understanding How Designers Think and Work, Bloomsbury Publishing India Private Limited.
3. Thomas Lockwood (2009), Design Thinking- Integrating Innovation, Customer Experience and Brand Value, Design Management Institute.
4. HBS – Online – Design Thinking & Innovation – course material

Recommended Online Resources

5. MIT Open Course Ware on Engineering Innovation and Design- https://ocw.mit.edu/courses/esd-051j-engineering-innovation-and-design-fall-2012/

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Environmental Impact Assessment and Audits

Course Code	EVS 508	Course Category	Core	L-T-P-C	2	1	0	3
Pre-Requisite Course(s)	-	Co-Requisite Course(s)	CC	Progressive Course(s)	-			
Course Offering Department	Environmental Science & Engineering	Professional / Licensing Standards	-					

Course Objectives

1. Aim to provide a comprehensive idea about environmental laws and EIA studies.
2. To understand the different steps of environmental audits and ISO for industries.

Course Outcomes (COs)

CO's	At the end of the course, the learner will be able to	Bloom's Level	Expected Proficiency Percentage	Expected Attainment Percentage
1	Understand environmental policies and legislation	1	80%	70%
2	Recognize the significance of environmental clearance.	2	80%	70%
3	Analyze different steps of EIA.	4	80%	70%
4	Assess steps of environmental audits and ISO.	3	80%	70%

Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO) *For M.Sc.*

CLOs	Program Learning Outcomes (PLO)														
	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design & Research	Modern Tool & ICT Usage	Society & Multicultural Skills	Environment & Sustainability	Moral, & Ethical Awareness	Individual & Teamwork Skills	Communication Skills	Project Management & Finance	Self-Directed & Lifelong Learning	PSO 1	PSO 2	PSO 3
Outcome 1	1	2	-	1	-	1	3	1	2	-	1	1	3	3	3
Outcome 2	1	2	-	1	-	1	3	1	2	-	1	1	3	3	3
Outcome 3	1	2	-	1	-	2	3	1	2	-	1	1	3	3	3
Outcome 4	1	2	-	1	-	2	3	1	2	-	1	1	3	3	3
Course Average	1	2	-	1	-	1.5	3	1	2	-	1	1	3	3	3

Course Unitization Plan

Unit No.	Syllabus Topics	Required Learning Hours	CLOs Addressed	References Used
Unit No. 1	**Environment Policies**	**9**	**1**	**1, 2**
	Environmental Policies- Kyoto Protocol and Clean Development Mechanism (CDM)	2	**1**	**1, 2**
	Carbon neutrality.	1	**1**	**1, 2**
	Environmental Legislations-acts, rules,	2	**1**	**1, 2**
	Regulations and notifications.	2	**1**	**1, 2**
	Environmental standards,	1	**1**	**1, 2**
	Criteria for standard setting.	1	**1**	**1, 2**
Unit No. 2	**Environmental Clearance & Framework for EIA**	**10**	**1,2**	**1,2,3**
	Forest clearance: Consent to Establish & Consent to Operate	2	**1,2**	**1,2,3**
	Environmental conservation plan for endangered flora and fauna.	2	**1,2**	**1,2,3**
	Steps of EIA: Screening, scoping, and baseline studies;	2	**1,2**	**1,2,3**
	Environmental Impacts and Mitigation Measures:	2	**1,2**	**1,2,3**
	Analysis of Alternatives	1	**1,2**	**1,2,3**
	Environmental Monitoring Programme; Project Benefits	1	**1,2**	**1,2,3**
Unit No. 3	**Impact Assessments of Different Environments**	**9**	**1,2,3**	**2,3**
	Environmental Impacts; Environmental Impact Analysis	2	**1,2,3**	**2,3**
	Environmental Impact Assessment	2	**1,2,3**	**2,3**
	Environmental Impact Statement	2	**1,2,3**	**2,3**
	Methods for impacts assessment on physical and natural resources.	3	**1,2,3**	**2,3**
Unit No. 4	**Public Hearing (PH) and EIA notification**	**7**	**2,3**	**2,3**
	Public participation in EIA decision	3	**2,3**	**2,3**
	EIA rule notifications and amendments	4	**2,3**	**2,3**
Unit No. 5	**Environmental Audits & ISO**	**10**	**3,4**	**4, 5, 6, 7, 8**
	Objectives, types, planning of audits	2	**3,4**	**4, 5, 6, 7, 8**
	Organization of auditing program, pre-visit data collection.	2	**3,4**	**4, 5, 6, 7, 8**
	Audit protocol; onsite audit; data sampling, inspections,	2	**3,4**	**4, 5, 6, 7, 8**
	Evaluation, and presentation; exit interview; audit report, action plan, management of audits.	2	**3,4**	**4, 5, 6, 7, 8**
	Introduction to ISO 14001 series	1`	**3,4**	**4, 5, 6, 7, 8**
	OHSAS 18001	1	**3,4**	**4, 5, 6, 7, 8**
Total Learning Hours		**45**		

Learning Assessment

Bloom's Level of Cognitive Task		Continuous Learning Assessments (50%)								End Semester Exam (50%)	
		CLA-1 (10%)		Mid-1 (15%)		CLA-2 (10%)		Mid-2 (15%)			
		Th	Prac	Th	Prac	Th	Prac	Th	Prac	Th	Prac
Level 1	Remember	80%	-	80%	-	-	-	-	-	80%	-
	Understand										
Level 2	Apply	20%	-	20%	-	100%	-	100%	-	20%	-
	Analyse										
Level 3	Evaluate		-		-		-		-		-
	Create										
Total		100%		100%		100%		100%		100%	

Recommended Resources:

1. Canter L.(1996). Environmental Impact Assessment. McGraw Hill.
2. Tripathi R. D. (2009). An Introduction to Environmental Audit. Alpha Publications.
3. Anjaneyulu Y., and Valli M. (2020). Environmental Impact Assessment Methodologies. BS Publications.
4. Gyani G., and Lunia A. (2000). Planning and Implementation of ISO14001, Environmental Management System. Raj Publishing House.
5. Woodside G., and Aurrichio P. (1999). ISO 14001 Auditing Manual. McGraw- Hill.
6. Caseio J., (Ed), Published - CEEM Information Services (2000). The ISO: 14000 Handbook.
7. Ritchie I., and Hayes W. (1998). A Guide to the Implementation of the ISO: 14000 Series on Environmental Management -, Prentice Hall, New Jersey.
8. OHSAS & SA Guidelines.

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Geospatial Technologies for Environmental Applications

Course Code	EVS 509	**Course Category**	CC	**L-T-P-C**	2	1	0	3
Pre-Requisite Course(s)	-	**Co-Requisite Course(s)**	-	**Progressive Course(s)**	-			
Course Offering Department	Environmental Science and Engineering	**Professional / Licensing Standards**	-					

Course Objectives

1. To understand and gain knowledge on the principles of remote sensing and GIS, and their applications in various fields.
2. To acquire skills in modern techniques such as mapping, monitoring and modelling etc.

Course Outcome (COs)

CO's	At the end of the course the learner will be able to	Bloom's Level	Expected Proficiency Percentage	Expected Attainment Percentage
1	Acquaint students with basic concepts, principles, applications of remote Sensing and GIS in diverse areas	2	80%	70%
2	Develop skills in preparing maps, interpretation, and analysis of images and modelling	3	80%	70%
3	Familiarize with the recent developments in remote sensing and GIS applications	2	80%	70%
4	Understand the role of remote sensing in planning and management	1	80%	70%

Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)

CLOs	**Program Learning Outcomes (PLO)**														
	Engineering Knowledge	**Problem Analysis**	**Design and Development**	**Analysis, Design and Research**	**Modern Tool and ICT Usage**	**Society and Multicultural**	**Environment and Sustainability**	**Moral, and Ethical Awareness**	**Individual and Teamwork Skills**	**Communication Skills**	**Project Management and**	**Self-Directed and Life Long**	**PSO 1**	**PSO 2**	**PSO 3**
Outcome 1	1	1	1	2	1	-	3	-	1	-	1	-	3	3	3
Outcome 2	1	1	1	1	1	1	3	-	1	-	1	-	3	3	3
Outcome 3	1	1	1	1	1	-	3	-	1	-	1	-	3	3	3
Outcome 4	1	1	1	1	-	-	3	-	1	-	1	-	3	3	3
Course Average	**1**	**1**	**1**	**1**	**1**	**1**	**3**	**-**	**1**	**-**	**1**	**-**	**3**	**3**	**3**

Course Unitization Plan

Unit No.	Syllabus Topics	Required Contact Hours	CLOs Addressed	References Used
Unit No. 1	**Remote sensing**	**9**	**1,2**	**1,2,3**
	Definition, basic concepts	1	**1,2**	**1,2,3**
	Principles of remote sensing, types, system overview, scope	2	**1,2**	**1,2,3**
	Satellite remote Sensing, electromagnetic radiation (EMR)	1	**1,2**	**1,2,3**
	Indian remote sensing satellites	1	**1,2**	**1,2,3**
	Platforms and sensors	1	**1,2**	**1,2,3**
	Digital image processing and image interpretation	2	**1,2**	**1,2,3**
	Resolution– spatial, spectral, radiometric and temporal	1	**1,2**	**1,2,3**
Unit No. 2	**Aerial photography and photogrammetry**	**9**	**1,2**	**1,2,3**
	Basic concepts, definition	1	**1,2**	**1,2,3**
	Specifications for planning and execution	2	**1,2**	**1,2,3**
	Types and information recorded on aerial photographs	1	**1,2**	**1,2,3**
	Photogrammetry fundamentals	2	**1,2**	**1,2,3**
	Measurements from aerial photographs	1	**1,2**	**1,2,3**
	Stereoscopes, stereovision, parallax method (measurement of height of objects)	2	**1,2**	**1,2,3**
Unit No. 3	**Thermal and microwave remote sensing and GIS**	**10**	**2,3,4**	**1,2,3**
	Concept, properties, and applications of thermal infrared radiations	1	**2,3,4**	**1,2,3**
	Microwave remote sensing - introduction, advantages	1	**2,3,4**	**1,2,3**
	Active remote sensing components	1	**2,3,4**	**1,2,3**
	Radar operating principles	1	**2,3,4**	**1,2,3**
	Spatial resolution, return, characteristics	1	**2,3,4**	**1,2,3**
	Interpretation of RADAR images	1	**2,3,4**	**1,2,3**

	Geographical Information system (GIS) - definition, components	1	**2,3,4**	**1,2,3**
	Data and database structures	1	**2,3,4**	**1,2,3**
	Spatial data models - vector and raster	1	**2,3,4**	**1,2,3**
	Data input and output	1	**2,3,4**	**1,2,3**
Unit No. 4	**Image interpretation in remote sensing**	**8**	**2,3,4**	**4,5,6**
	Image interpretation - visual, aerial and satellite	2	**2,3,4**	**4,5,6**
	Digital image processing	2	**2,3,4**	**4,5,6**
	Image restoration	1	**2,3,4**	**4,5,6**
	Image enhancement	1	**2,3,4**	**4,5,6**
	Image information extraction	2	**2,3,4**	**4,5,6**
Unit No. 5	**Applications of remote sensing and GIS**	**9**	**1,2,3,4**	**1,7,8**
	Applications in land use and land cover mapping	1	**1,2,3,4**	**1,7,8**
	Forestry, forest fires, agriculture, soil surveys	1	**1,2,3,4**	**1,7,8**
	Disaster management, water resources	1	**1,2,3,4**	**1,7,8**
	Ecology, environment and oceanography	2	**1,2,3,4**	**1,7,8**
	Working knowledge of Q-GIS	2	**1,2,3,4**	**1,7,8**
	Working knowledge of ArcGIS	2	**1,2,3,4**	**1,7,8**
	Total Hours	45		

Learning Assessment

Bloom's Level of Cognitive Task		Continuous Learning Assessments (50%)								End Semester Exam (50%)	
		CLA-1 (10%)		CLA-2 (15%)		CLA-3 (10%)		Mid Term (15%)			
		Th	Prac	Th	Prac	Th	Prac	Th	Prac	Th	Prac
Level 1	Remember	25%	-	25%	-	25%	-	25%	-	25%	-
	Understand	25%	-	25%	-	25%	-	25%	-	25%	-
Level 2	Apply	50%	-	50%	-	50%	-	50%	-	50%	-
	Analyse	-	-	-	-	-	-	-	-	-	-
Level 3	Evaluate	-	-	-	-	-	-	-	-	-	-
	Create	-	-	-	-	-	-	-	-	-	-
Total		**100%**		**100%**		**100%**		**100%**		**100%**	

Recommended Resources

1. A Text Book on Remote Sensing and GIS, 1st Edition, Singh (2024). Book Rivers. ISBN 9788196544461
2. Introduction to Remote Sensing, 6th Edition, Campbell, Wynne and Thomas (2022). Guilford Press. ISBN 9781462549405
3. Fundamentals of Satellite Remote Sensing: An Environmental Approach, 3rd Edition, Chuvieco (2020). CRC Press. ISBN 9781138583832
4. Remote sensing and image interpretation, 7th Edition, Chipman, Kiefer and Lillesand (2015). Wiley. ISBN 9781118343289
5. Fundamentals of Remote Sensing, 3rd Edition, Joseph and Jeganathan (2018). Orient BlackSwan. ISBN 9789386235466
6. Introductory Digital Image Processing: A Remote Sensing Perspective, 4th Edition, Jensen (2017). Pearson Education. ISBN 9789352864355
7. Principles of Geographical Information Systems, 3rd Edition, Burrough, McDonnell and Lloyd (2015). Oxford University Press. ISBN 9780198742845
8. Principles of Remote Sensing, 1st Edition, Curran (2020). Rawat Publications. ISBN 9788131611067

Recommended Online Resources

1. ESRI Training Catalog - https://www.esri.com/training/catalog/search/
2. Wydział Nauk Geograficznych Tutorial - http://geoinfo.amu.edu.pl/wpk/rst/rst/Front/overview.html
3. Geographic Information Systems (GIS) Specialization - https://www.coursera.org/specializations/gis

Course Designer

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Urban Mining and Sustainability								
Course Code	**EVS 557**	Course Category	**CE**	L-T-P-C	**2**	**1**	**0**	**3**
Pre-Requisite Course(s)		Co-Requisite Course(s)		Progressive Course(s)				
Course Offering Department	Environmental Science and Engineering	Professional / Licensing Standards						

Course Objectives / Course Learning Rationales (CLRs)

1. To show the need for secondary resources through urban mining.
2. To understand the steps of resource sustainability.

Course Outcomes / Course Learning Outcomes (CLOs)

	At the end of the course the learner will be able to	**Bloom's Level**	**Expected Proficiency Percentage**	**Expected Attainment Percentage**
Outcome 1	Identify the sources of secondary materials and their management.	3	80%	75%
Outcome 2	Discuss the challenges associated with secondary materials and their sustainable solutions.	2	80%	75%
Outcome 3	Demonstrate sustainable assessment tools.	2	80%	70%
Outcome 4	Describe the process of creating secondary materials for a sustainable society.	2	80%	70%

Course Articulation Matrix (CLO) to (PLO)

CLOs	**Program Learning Outcomes (PLO)**														
	Engineering Knowledge	**Problem Analysis**	**Design and Development**	**Analysis, Design and Research**	**Modern Tool and ICT Usage**	**Society and Multicultural**	**Environment and Sustainability**	**Moral, and Ethical Awareness**	**Individual and Teamwork Skills**	**Communication Skills**	**Project Management and**	**Self-Directed and Life Long**	**PSO 1**	**PSO 2**	**PSO 3**
Outcome 1	1	1	-	1	-	-	3	-	-	-	-	1	1	2	3
Outcome 2	2	2	-	1	-	1	3	-	-	-	-	1	2	2	3
Outcome 3	2	2	-	1	-	1	3	-	1	-	-	1	3	3	3
Outcome 4	2	2	-	1	-	1	3	-	1	--	-	1	2	2	2
Course Average	**1.75**	**1.75**	**-**	**1**	**-**	**1**	**3**	**-**	**1**	**-**	**-**	**1**	**2**	**2.25**	**2.75**

Course Unitization Plan - Theory

Unit No.	Unit Name	Required Contact Hours	CLOs Addressed	References Used
Unit No. 1	**Introduction to Urban Mining**	**8**	1	1, 2,3
	Definitions of Urban Mining, Waste Management,	2	1	1, 2,3
	Introduction to Waste to resource, Secondary Materials	3	1	1, 2,3
	Urban mining and its tools	3	1,2	1,2,3,4
Unit No. 2	**Sustainability in Urban Mining**	**8**	1,2	1,2,3
	Background of sustainability, Framework for sustainability, Sustainable indicators	4	1,2	1,2,3
	Sustainability Assessment, Global concerns of materials	4	1,2	1,2,3
Unit No. 3	**Sustainability Assessment Tools**	**9**	1,2,3,4	1,2,3,4
	Life cycle assessment on solid waste, Life cycle costing of SW	4	1,2,3,4	1,2,3,4
	Life cycle impacts, Environmental Social and Governance (ESG)	3	1,2,3,4	1,2,3,4
	Industrial aspects of cleaner production and circular economy	2	1,2,3	1,2,3,4
Unit No. 4	**Sustainable Secondary Materials**	**10**	3,4	2,3,4
	Introduction of secondary materials	2	3,4	2,3,4
	Types of secondary materials	2	3,4	2,3,4
	conversion of waste to secondary materials (compost, biogas, construction materials, secondary metals)	4	3,4	2,3,4
	Inhouse search for secondary materials	2	4	1,2,3,4
Unit No. 5	**Urban Mining: Material Recovery**	**10**	2,3,4	1,2,4
	Metal recovery from Batteries	1	2,3,4	1,2,4
	Leaching, Solvent extraction	3	2,3,4	1,2,4
	Electrowinning	3	2,3,4	1,2,4
	Occupational safety measures for the processing of secondary materials	3	1,2,3,4	1,2,3,4
Total Contact Hours		**45**		

Learning Assessment (Theory)

Bloom's Level of Cognitive Task		Continuous Learning Assessments (50%)				End Semester Exam (50%)
		CLA-1 (10%)	Mid-1 (15%)	CLA-2 (10%)	CLA-3 (15%)	
Level 1	Remember	80%	80%	80%	70%	80%
	Understand					
Level 2	Apply	20%	20%	20%	30%	20%
	Analyse					
Level 3	Evaluate	-	-	-	-	-
	Create					
Total		**100%**	**100%**	**100%**	**100%**	**100%**

Recommended Resources

1. **Sustainability for Beginners: Introduction and Business Prospects by Ramadoss Tamil Selvan and Seeram Ramakrishna, World Scientific Publishers, (2022).**
2. **Urban Mining for Waste Management and Resource Recovery: Sustainable Approaches by Pankaj Pathak, P.R. Rout, CRC Press, (2021).**
3. **https://www.unido.org/our-focus-cross-cutting-services/circular-economy.**

4. **Life Cycle Assessment (LCA): A Guide to Best Practice by Walter Klöpffer, Birgit Grahl, Wiley Online Library, (2014).**

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Applied Hydrogeology

Course Code	EVS 556	**Course Category**	CE	**L-T-P-C**	2	1	0	3
Pre-Requisite Course(s)		**Co-Requisite Course(s)**		**Progressive Course(s)**				
Course Offering Department	Environmental Science and Engineering	**Professional / Licensing Standards**						

Course Objectives

1. To assess groundwater recharge, groundwater evolution, hydro geochemistry, flow pattern, geological framework and contaminant mobilization.
2. To articulate the hydrogeological knowledge on analysis on the implementation of water management practices

Course Outcome (COs)

	At the end of the course the learner will be able to	**Bloom's Level**	**Expected Proficiency Percentage**	**Expected Attainment Percentage**
Outcome 1	Summarize the concept of geoscience, particularly in engineering hydrogeology	2	80%	70%
Outcome 2	Articulate the impact of geological formations on groundwater flow patterns and storage	2	80%	70%
Outcome 3	Illustrate the parameters responsible for the contaminant transport in a groundwater system and recharge	3	80%	70%
Outcome 4	Examine the groundwater exploration and possible management strategies in local and catchment scale	4	80%	70%

Course Articulation Matrix (CO) to Program Learning Outcomes (PO)

COs	Program Learning Outcomes (PO)														
	Engineering Knowledge	Problem Analysis	Design and Development	Analysis, Design and	Modern Tool and ICT	Society and Multicultural Skills	Environment and Sustainability	Moral, and Ethical	Individual and	Communication Skills	Project Management and Finance	Self-Directed and Life Long Learning	PSO 1	PSO 2	PSO 3
Outcome 1	1	1	-	1	1	1	3	-	1	-	1	1	0	0	0
Outcome 2	2	1	-	1	1	1	3	-	1	-	1	1	0	0	0
Outcome 3	2	2	2	2	1	1	3	1	1	1	1	2	0	0	0
Outcome 4	3	3	3	3	3	2	3	2	1	1	2	3	0	0	0
Course Average	**1.75**	**1.75**	**1.25**	**1.75**	**1.25**	**1.25**	**3**	**0.75**	**1**	**0.5**	**1.25**	**1.75**	**0**	**0**	**0**

Course Unitization Plan

Unit No.	Unit Name	Required Contact Hours	COs Addressed	References Used
Unit 1	**Concept of hydrogeology**	**9**	1,2	1
	Concept of hydrogeology and its relation to the global hydrologic cycle.	2	1,2	1
	Equation of hydrologic processes.	3	1,2	1
	Concept of surface water-groundwater interaction, hydrogeologic properties of geologic media.	3	1,2	1,2
	Effects and controls of porosity and permeability	1	1,2	1,2
Unit 2	**Surface-Subsurface media and flow of water**	**13**	2,3	1,2,3
	Hydrodynamic equations, and concept of flow, nature of flow, flow lines, potentiometric distributions	2	2,3	1,3
	Concept of basin, unit basin, effect of scale, flow at various scales	3	2,3	3
	Hubbert flow, Tothean flow, various triggers of flow, effects of heterogeneities on scale and nature of flow	3	2,3	3
	Introduction to modelling of flow	3	2,3	3
	Vadose zone hydrology: equations, conditions, and scales	2	2,3	1,3

Unit 3	**Isotopes hydrology**	**10**	3,4	2,3
	Systematic and applications of $\delta^{18}O$, $\delta^{2}H$, $\delta^{34}S$, $\delta^{13}C$ in hydrologic and hydrogeologic events,	5	3	2,3
	Fractionation, patterns, recharge signatures	5	3,4	2,3
Unit 4	**Geochemistry**	**10**	3	1,2,3,4
	Aqueous geochemistry, sources and pathways of groundwater solutes, chemical evolution	4	3	1,2,3,4
	Types of groundwater contaminants	3	3	1,2,3,4
	Contaminant fate and transport	3	4	1,2,3,4
Unit 5	**Case studies on hydrogeology**	**3**	4	1,2,3,4
	Groundwater management strategies, exploration techniques, project development,	1	4	1,2,3,4
	Case studies: Physical hydrogeology	1	4	1,2,3,4
	Case studies: Chemical hydrogeology	1	4	1,2,3,4
Total Contact Hours		**45**		

Learning Assessment

Bloom's Level of Cognitive Task		**Continuous Learning Assessments (50%)**				**End Semester Exam (50%)**
		CLA-1 (10%)	**CLA-2 (15%)**	**CLA-3 (10%)**	**Mid-1 (15%)**	
Level 1	Remember	50%	50%	50%	25%	50%
	Understand					
Level 2	Apply	50%	50%	50%	75%	50%
	Analyse					
Level 3	Evaluate	-	-	-	-	-
	Create					
Total		**100%**	**100%**	**100%**	**100%**	**100%**

Recommended Resources

1. Fetter Jr C. W. and Kreamer, D. (2018) Applied hydrogeology. Waveland Press. ISBN 10: 1-4786-4652-7
2. Gupta, S. K. (2011). Modern hydrology and sustainable water development. John Wiley & Sons. ISBN:9781405171243
3. Tóth, J. (2009). Gravitational systems of groundwater flow: theory, evaluation, utilization. Cambridge University Press. ISBN: 9780511576546

4. Domenico, P. A. and Schwartz, F. W. (1997). Physical and chemical hydrogeology. John wiley & sons. ISBN: 978-0-471-59762-9

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Aquatic Microbial Ecology and Biogeochemistry

Course Code	EVS 555	**Course Category**	CE	**L-T-P-C**	2	1	0	3
Pre-Requisite Course(s)		**Co-Requisite Course(s)**		**Progressive Course(s)**				
Course Offering Department	Environmental Science and Engineering	**Professional / Licensing Standards**						

Course Objectives

1. Provide basic understanding on microbial ecology and biogeochemistry of aquatic ecosystems
2. Provide an overview on processes controlling microbial abundances, growth, and diversity in aquatic environments and provide an understanding on the concept of microbial loop.
3. Provide a comprehensive understanding on ways that microorganisms influence nutrient and organic matter cycling in aquatic ecosystems.
4. Provide an understanding of the oceanic biogeochemical cycles and its implications on global climate change.

Course Outcome (COs)

CO's	At the end of the course the learner will be able to	Bloom's Level	Expected Proficiency Percentage	Expected Attainment Percentage
1	Describe the fundamentals aspects of microbial ecology and biogeochemistry of aquatic systems	**2**	80%	70%
2	Relate the movements of key elements (C, N, P) in aquatic systems to microbial dynamics	**2**	80%	70%
3	Relate the dynamics of microorganisms to greenhouse gas dynamics in aquatic ecosystems	**2**	80%	70%
4	Explore the relationship between global biogeochemical cycles and the ecology of key microbial groups in aquatic environmental	**3**	80%	70%

Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)

CLOs	Program Learning Outcomes (PLO)														
	Engineering Knowledge	Problem Analysis	Design and Development	Analysis, Design and Research	Modern Tool and ICT Usage	Society and Multicultural	Environment and Sustainability	Moral, and Ethical Awareness	Individual and Teamwork Skills	Communication Skills	Project Management and	Self-Directed and Life Long	PSO 1	PSO 2	PSO 3
Outcome 1	-	1	-	2	1	2	3	1	1	1	-	1	2	2	3
Outcome 2	-	1	-	2	1	2	3	1	1	1	-	1	2	2	3
Outcome 3	-	1	-	2	1	2	3	1	1	1	-	1	2	2	3
Outcome 4	-	1	-	2	1	2	3	1	1	1	-	1	2	2	3
Course Average	**-**	**1**	**-**	**2**	**1**	**2**	**3**	**1**	**1**	**1**	**-**	**1**	**2**	**2**	**3**

Course Unitization Plan

Unit No.	Syllabus Topics	Required Contact Hours	CLOs Addressed	References Used
Unit No. 1	**Introduction to Aquatic Microbial Ecology**			
	Phytoplankton: Production, distribution and diversity in various aquatic environment	2	1	1
	Bacteria: Production, distribution and diversity in various aquatic systems	2	1	1
	Role of microbes in nutrient (phosphorus and nitrogen) cycling	1	2	1
	Role of microbes in organic carbon cycling	1	2	1
	Nutrient limitation on the aquatic organisms and their implication	2	1,2	1
	N2 and carbon fixation	1	1,2	1
Unit No. 2	**Biogeochemical cycles in aquatic environment**			
	Movement, storage, and transformation of elements (C, N, P) across hydrosphere and other earth systems	2	1	1, 2
	Composition and reactivity of DOM	1	1	1, 2
	DOM Production and Consumption processes	2	1,2	1, 2
	Chromophoric DOM	1	1	1, 2
	Chromophoric DOM: Movement from soil to streams to open ocean	1	1	1, 2
	DOM and global carbon cycle	2	1	1, 2
Unit No. 3	**Microbial respiration, production, and microbial loop**			
	Aquatic respiration	1	2,3	3
	Respiration at organism (bacteria, plankton, etc.) to ecosystem system level (lakes, coastal, and oceanic systems)	2	2,3	3
	Bacterial production and respiration	1	2,3	2,3
	Microbial Loop in aquatic systems	1	2,3	3
	Role of microbial loop in aquatic carbon cycling	1	2,3	3
	Microbial loop and food webs	1	2,3	3
	Microbial carbon pump	1	2,3	3
	Biogeographic patterns of bacterial communities across soil - freshwater aquatic networks – Ocean continuum.	1	2,3	3
Unit No. 4	**Microbes and Aquatic GHG emission**			
	Emissions of carbon dioxide (CO2), methane (CH4), and nitrous oxide (N2O).	2	3,4	2,3
	Production and consumption processes of GHGs	2	3,4	2,3
	Bio-physical controls on GHG emissions	2	3,4	2,3
	Anthropogenic alteration of aquatic GHG emissions.	3	3,4	2,3
Unit No. 5	**Response of aquatic organisms and matter cycling to global environmental changes**			
	Aquatic biogeochemistry and global carbon cycling	2	3,4	1,2
	Climate change: Impact & response of aquatic ecosystems	1	3,4	1,2
	Eutrophication, Pollution, flow diversion (dams) impacts on carbon cycling	3	3,4	1,2

	landscape change impact on aquatic carbon processing	**1**	**3,4**	**1,2**
	Human impacts on the cycling of carbon with an emphasis and global change	**2**	**3,4**	**1,2**
Total Hours		**45**		

Learning Assessment

Bloom's Level of Cognitive Task		Continuous Learning Assessments (50%)								End Semester Exam (50%)	
		CLA-1 (10%)		CLA-2 (10%)		CLA-3 (15%)		Mid Term (15%)			
		Th	Prac	Th	Prac	Th	Prac	Th	Prac	Th	Prac
Level 1	Remember	20	-	-	-	-	-	20	-	-	-
	Understand	30	-	20	-	10	-	30	-	30	-
Level 2	Apply	30	-	40	-	40	-	30	-	30	-
	Analyse	20	-	40	-	50	-	20	-	40	-
Level 3	Evaluate	-	-		-	-	-	-	-	-	-
	Create	-	-		-	-	-	-	-	-	-
Total		**100**	**-**	**100**	**-**	**100**	**-**	**100**	**-**	**100**	**-**

Recommended Resources

9. Advances in Microbial Ecology, Marshall, K.C. (2013). New York, Plenum Press c1977- ISBN-13: 978-1-4684-7611-8
10. Hansell DA & Carlson, CA (2014). Biogeochemistry of marine dissolved organic matter. 2nd Edition, Academic Press. ISBN: 9780124059405
11. Respiration in Aquatic Ecosystems. Del Giorgio PA & Williams P.A (2005). Oxford University Press ISBN: 0-19-852709- 8

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Hydroinformatics

Course Code	EVS 554	**Course Category**	CE	L-T-P-C	2	1	0	3
Pre-Requisite Course(s)		**Co-Requisite Course(s)**		Progressive Course(s)				
Course Offering Department	Environmental Science and Engineering	**Professional / Licensing Standards**						

Course Objectives

Objective 1: To provide the knowledge and understanding of hydrological modelling, forecasting and management in the context of earth system processes

Objective 2: To illustrate the applicability of geospatial technology and enhance ability to identify the hydrological problems and finding solutions

Course Outcomes (COs)

	At the end of the course the learner will be able to	**Bloom's Level**	**Expected Proficiency Percentage**	**Expected Attainment Percentage**
Outcome 1	Articulate the hydrological cycles and processes	3	80%	70%
Outcome 2	Articulate the type of geospatial data structure and selection of data for hydrological models	3	80%	70%
Outcome 3	Illustrate the selection of hydrological models for local to global problems	3	80%	70%
Outcome 4	Solve hydrological problems by the application of hydro informatics engineering	3	80%	70%

Course Articulation Matrix (CO) to Program Learning Outcomes (PO)

CLOs	**Program Learning Outcomes (PLO)**														
	Engineering Knowledge	**Problem Analysis**	**Design & Development**	**Analysis, Design & Research**	**Modern Tool & ICT Usage**	**Society & Multicultural Skills**	**Environment & Sustainability**	**Moral, & Ethical Awareness**	**Individual & Teamwork Skills**	**Communication Skills**	**Project Management &**	**Self-Directed & Lifelong Learning**	**PSO 1**	**PSO 2**	**PSO 3**
Outcome 1	2	2	2	2	2	1	3	-	2	-	1	1	0	0	0
Outcome 2	2	2	2	2	2	1	3	-	2	-	1	1	0	0	0

Outcome 3	3	3	2	2	3	2	3	1	2	1	2	2	0	0	0
Outcome 4	3	3	3	3	3	2	3	2	2	1	3	3	0	0	0
Course Average	**2.5**	**2.5**	**2.25**	**2.25**	**2.5**	**1.5**	**3**	**0.75**	**2**	**0.5**	**1.75**	**1.75**	**0**	**0**	**0**

Course Unitization Plan – Theory

Unit No.	Unit Name	Required Contact Hours	CLOs Addressed	References Used
Unit No. 1	**Hydrological processes**	**8**	1,2	1,2,3
	Hydrologic Cycle and water balance	2	1,2	1,2,3
	Precipitation, Evaporation, Runoff and watershed process	3	1,2	1,2,3
	Groundwater exploration and management	3	1,2	1,2,3
Unit No. 2	**Hydrological Modelling and Forecasting**	**9**	2,3	1,2,3
	Modelling Concept, Process and Classification	3	2,3	1,2,3
	Hydroclimatic Data Structure Handling and Management	3	2,3	1,2,3
	Flood and Drought Forecasting	3	2,3	1,2,3
Unit No. 3	**Remote Sensing & GIS Applications for Water Resources Engineering**	**9**	1,2,3	2,3,4
	Spatial decision support systems and GIS	3	1,2,3	2,3,4
	Climate data structure and handling	3	1,2,3	2,3,4
	Climate Change Impact Assessment	3	1,2,3	2,3,4
Unit No. 4	**Advance Hydrology**	**11**	3,4	2,3,4,5
	Hydrograph, distribution graph for runoff generation, complex storm hydrograph	2	3,4	2,3,4,5
	Snow hydrology, snow formation and accumulation	1.5	3,4	2,3,4,5
	Fluvial geomorphology, models for hydrologic abstraction processes	2.5	3,4	2,3,4,5
	Aspects of arid zone hydrology	1	3,4	2,3,4,5
	Types of catchment model components and construction	2	3,4	2,3,4,5
	Analysis of time series data – generation of synthetic hydrologic data, etc.	2	3,4	2,3,4,5
Unit No. 5	**Planning, Management & Economics of Water resources projects**	**8**	3,4	3,4,5
	Fundamentals of water resource system analysis	2	3,4	3,4,5
	Objectives & scope of Engineering Economics	2	3,4	3,4,5

	Cost concept, Annual cost comparison, Present worth, Production, Functions, Pricing policies, pricing methods	4	3,4	3,4,5
Total Contact Hours		**45**		

Learning Assessment

Bloom's Level of Cognitive Task		**Continuous Learning Assessments (50%)**				**End Semester Exam (50%)**
		CLA-1 (10%)	**CLA-2 (15%)**	**CLA-3 (10%)**	**Mid-1 (15%)**	
Level 1	Remember	20%	20%	20%	20%	20%
	Understand					
Level 2	Apply	80%	80%	80%	80%	80%
	Analyse					
Level 3	Evaluate	-	-	-	-	-
	Create					
Total		**100%**	**100%**	**100%**	**100%**	**100%**

Recommended Resources

1. Jain, S.K. and Singh, V.P. (2019) Engineering Hydrology: An Introduction to Processes, Analysis and Modelling, Mc-Graw-Hill Education. ISBN: 9781259641978
2. Eslamian, S. (2015) Handbook of engineering hydrology: environmental hydrology and water management. CRC press. ISBN 9780367372835
3. Jensen, J. R. (2009) Remote sensing of the environment: An earth resource perspective 2nd Edition. Pearson Education India (2009). ISBN 978-1-29202-170-6
4. Sachse, A., Rink, K., He, W., and Kolditz, O. Springer. (2015) OpenGeoSys-Tutorial: computational hydrology I: groundwater flow modelling. 978-3-319-52808-3
5. Burrough, P. A., McDonnell, R. A., and Lloyd, C. D. (2015) Principles of geographical information systems. Oxford university press. ISBN: 9780198742845

Course Designer and Co-ordinator

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Energy and Environment								
Course Code	EVS 558	Course Category	CE	L-T-P-C	2	1	0	3
Pre-Requisite Course(s)	-	Co-Requisite Course(s)	-	Progressive Course(s)	-			
Course Offering Department	Environmental Science and Engineering	Professional / Licensing Standards	-					

Course Objectives / Course Learning Rationales (CLRs)

1. To understand the different energy sources and its impact on economy
2. Understanding the technologies in energy use, utilization of energy resources, energy conversion and environmental consequences.
3. Knowledge to explain the relationship between the use of energy and environmental impacts for electricity, heating, and cooling.

Course Outcomes / Course Learning Outcomes (CLOs)

Outcomes	At the end of the course, the learner will be able to	Bloom's Level	Expected Proficieny Percentage	Expected Attainment Percentage
Outcome 1	Understand about conventional and renewable energy technologies and their applications	1	80%	70%
Outcome 2	Explain the various forms of energy along with energy demand and efficiency of different energy conversion technology	2	80%	70%
Outcome 3	Understand the relationship between energy market and its climate change	2	80%	70%
Outcome 4	Evaluate the environmental impact of energy production and consumption	3	80%	70%

Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)

CLOs	Program Learning Outcomes (PLO)														
	Engineering Knowledge	Problem Analysis	Design and Development	Analysis, Design and Research	Modern Tool and ICT Usage	Society and Multicultural	Environment and Sustainability	Moral, and Ethical Awareness	Individual and Teamwork Skills	Communication Skills	Project Management and	Self-Directed and Life Long	PSO 1	PSO 2	PSO 3
Outcome 1	3	-	-	3	-	-	3	3	-	-	-	-	3	3	3
Outcome 2	3	-	-	3	-	-	3	3	-	-	-	-	3	3	3
Outcome 3	3	-	-	3	-	-	3	3	-	-	-	-	3	3	3
Outcome 4	3	-	-	3	-	-	3	3	-	-	-	-	3	3	3
Course Average	3	-	-	3	-	-	3	3	-	-	-	-	3	3	3

Course Unitization Plan

Unit No.	Unit Name	Required Learning Hours	CLOs Addressed	References Used
Unit No. 1	**Energy Scenario**	**9**	**1,2**	**1,2**
	Commercial and Non-Commercial Energy, Primary Energy Resources, Commercial Energy Production, Final Energy Consumption,	3	**1,2**	**1,2**
	Energy Needs of Growing Economy, Long Term Energy Scenario	2	**1,2**	**1,2**
	Energy Pricing, Energy Sector Reforms	1	**1,2**	**1,2**
	Energy and Environment: Air Pollution, Climate Change, Energy Security	3	**1,2**	**1,2**
Unit No. 2	**Basics of Energy Science**	**9**	**1,2**	**1,2,3,4**
	Forms of Energy – Advantages and Limitations - Mechanical Energy - Chemical Energy and Fuels	2	**1,2**	**1,2,3,4**
	Nuclear Energy - Hydro Energy - Renewable Energy –Energy Demand	2	**1,2**	**1,2,3,4**
	Comparison of Fuels such as Wood, Charcoal, Coal	2	**1,2**	**1,2,3,4**

	Kerosene, Diesel, Petrol, Furnace Oil, LPG, Biogas and Electricity on calorific value and cost basis	2	**1,2**	**1,2,3,4**
	Efficiencies of various Energy production	1	**1,2**	**1,2,3,4**
Unit No. 3	**Energy Resources and Radiation**	**9**	**2,4**	**1,3,5**
	Energy resources and their exploitation, nature of its radiation - Mechanism of radiation action on living systems	3	**2,4**	**1,3,5**
	Stochastic and non-stochastic effects; delayed effects, radioactivity from nuclear reactors,	2	**2,4**	**1,3,5**
	fuel processing and radioactive waste, hazards related to power plants,	1	**2,4**	**1,3,5**
	Terrestrial and non-terrestrial radiation, nuclear radiations, ultraviolet radiations, pathways analysis and dose assessment,	2	**2,4**	**1,3,5**
	radiologic age dating, radioactivity risk assessment, criterion for safe exposure	1	**2,4**	**1,3,5**
Unit No. 4	**Energy And Environment Nexus**	**9**	**3,4**	**3,4,5,6**
	Energy Environment Nexus Crisis – Causes and Consequences	2	**3,4**	**3,4,5,6**
	Remedial Measures	1	**3,4**	**3,4,5,6**
	Impact of Energy Consumption and Production on Environment with illustrations	3	**3,4**	**3,4,5,6**
	Role of Energy Economists in solving Energy Crises	3	**3,4**	**3,4,5,6**
Unit No. 5	**Impact of Energy in Environment**	**9**	**1,3,4**	**2,3,4,5,6**
	Methods for production and environmental impacts for electricity, heating, and cooling	2	**1,3,4**	**2,3,4,5,6**
	Energy conversions in industry and buildings – green building	2	**1,3,4**	**2,3,4,5,6**
	Energy flexibility - Electrical energy, electricity as energy carrier and the infrastructure associated with this.	2	**1,3,4**	**2,3,4,5,6**
	Electricity market and price formation - Planning and sizing of energy supply -	1	**1,3,4**	**2,3,4,5,6**
	Energy balance and environmental accounts.	1	**1,3,4**	**2,3,4,5,6**

	Energy use pattern in different parts of the world and its impact on the environment - CO_2 emission in atmosphere	1	**1,3,4**	**2,3,4,5,6**
Total Contact Hours		**45**		

Recommended Resources

1. Non-Conventional Energy Sources, 6th edition, G.D Rai (2022). Khanna publishers. ISBN 978-81-7409-073-7.
2. Energy, Environment, and Sustainability, Avinash Kumar Agarwal (2022). Springer. ISSN 2522-8366.
3. General aspects pf energy management and energy audit, 4th edition, Study material for Energy Managers and Auditors Examination: Paper I (2015). Bureau of Energy Efficiency.
4. Textbook of Renewable Energy, S. C. Bhatia and R.K Guptha (2019). WPI Publishing. ISBN 978-8-1936-4460-7.
5. Introduction to Environmental Engineering and Science, 2nd Edition, Gilbert M. Masters (2004). Pearson Education. ISBN 978-8-1297-0277-7.
6. Energy and the Environment, 4th Edition, Robert A. Ristinen, Jack J. Kraushaar, and Jeffrey T. Brack (2022). Wiley. ISBN 978-1-119-80025-5.

Learning Assessment

Bloom's Level of Cognitive Task		**Continuous Learning Assessments (50%)**								**End Semester Exam (50%)**	
		CLA-1 (10%)		**CLA-2 (10%)**		**CLA-3 (15%)**		**Mid-1 (15%)**			
		Th	**Prac**	**Th**	**Prac**	**Th**	**Prac**	**Th**	**Prac**	**Th**	**Prac**
Level 1	Remember	30%	-	30%	-	30%	-	30%	-	60%	-
	Understand										
Level 2	Apply	70%	-	70%	-	70%	-	70%	-	40%	-
	Analyse										
Level 3	Evaluate	-	-	-	-	-	-	-	-	-	-
	Create										
Total		**100%**		**100%**		**100%**		**100%**		**100%**	

Course Designer

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Process Design and Systems Analysis								
Course Code	EVS 559	**Course Category**	CE	**L-T-P-C**	2	1	0	3
Pre-Requisite Course(s)	-	**Co-Requisite Course(s)**	-	**Progressive Course(s)**	-			
Course Offering Department	Environmental Science and Engineering	**Professional / Licensing Standards**	-					

Course Objectives / Course Learning Rationales (CLRs)

1. To understand the concepts about the process and sustainable product design.
2. This course teaches advanced concepts and problem-solving skills in cost estimation, cost analysis, economic assessment, and profitability analysis.
3. To understand the concept of green engineering design.

Course Outcomes / Course Learning Outcomes (CLOs)

Outcomes	**At the end of the course, the learner will be able to**	**Bloom 's Level**	**Expected Proficiency Percentage**	**Expected Attainment Percentage**
Outcome 1	Understand process flow diagrams, process designing, product designing	1	80%	70%
Outcome 2	Perform manufacturing cost estimation and analysis	4	80%	70%
Outcome 3	Apply economic assessment and profitability analysis of different processes	3	80%	70%
Outcome 4	Explain concepts about green engineering design	2	80%	70%

Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)

CLOs	Program Learning Outcomes (PLO)														
	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design & Research	Modern Tool & ICT Usage	Society & Multicultural Skills	Environment & Sustainability	Moral, & Ethical Awareness	Individual & Teamwork Skills	Communication Skills	Project Management &	Self-Directed & Lifelong Learning	PSO 1	PSO 2	PSO 3
Outcome 1	1	1	1	1	-	-	-	-	-	-	3	-	1	1	3
Outcome 2	1	1	1	2	3	-	-	-	-	-	3	-	2	1	3
Outcome 3	1	1	2	1	3	-	-	2	3	-	-	-	3	1	2
Outcome 4	1	1	2	1	3	-	-	2	3	-	-	-	3	1	2
Course Average	**1**	**1**	**1**	**1**	**3**	**-**	**-**	**2**	**3**	**-**	**3**	**-**	**2.25**	**1**	**2.5**

Course Unitization Plan

Unit No.	Unit Name	Required Learning Hours	CLOs Addressed	References Used
Unit No. 1	**Understanding chemical processes**	**9**	**1,2**	**1, 2**
	Basic process flow diagrams	2	**1,2**	**1, 2**
	Introduction – Block flow diagram – process flow diagram	1	**1,2**	**1, 2**
	Design specifications Hierarchy of process design	2	**1,2**	**1, 2**
	Batch vs. Continuous process – input/output structure	1	**1,2**	**1, 2**
	Recycling and Synthesis Recycle structure – synthesis of PFD from BFD	2	**1,2**	**1, 2**

	Green supply chain	1	**1,2**	**1, 2**
Unit No.2	**Product design and calculations**	**9**	**1,2**	**1, 2**
	Design Strategies for product design – batch processing –	2	**1,2**	**1, 2**
	Tactics for tracing chemicals	2	**1,2**	**1, 2**
	Calculations Calculations for batch and continuous processes –	3	**1,2**	**1, 2**
	understanding processing conditions	2	**1,2**	**1, 2**
Unit No.3	**Capital and manufacturing cost calculations**	**9**	**2,3**	**1, 2**
	Estimation Classification of estimates – estimation of purchased equipment cost	2	**2,3**	**1, 2**
	Estimating total capital cost	1	**2,3**	**1, 2**
	Cost calculations Bare module cost calculations – manufacturing cost calculations	2	**2,3**	**1, 2**
	raw material costs – utility and labour costs	1	**2,3**	**1, 2**
	Stream calculations Treating solid and liquid streams	3	**2,3**	**1, 2**
Unit No. 4	**Engineering economics and profitability analysis**	**9**	**3**	**1, 2**
	Cash flow diagrams – inflation – depreciation	2	**3**	**1, 2**
	Taxation – cash flow	1	**3**	**1, 2**
	Profit – non discounted and discounted profitability	3	**3**	**1, 2**
	Concept of risk – quantifying risk – profit margin analysis	3	**3**	**1, 2**
Unit No. 5	**Green engineering design**	**9**	**1,2,4**	**1, 3, 4**
	Environmental regulations – fate of chemicals	3	**1,2,4**	**1, 3, 4**
	Green chemistry – preventing pollution	3	**1,2,4**	**1, 3, 4**
	Economics of pollution prevention	2	**1,2,4**	**1, 3, 4**
	LCA	1	**1,2,4**	**1, 3, 4**
Total Learning Hours		**45**		

Recommended Resources

1. Analysis, Synthesis, and Design of Chemical Processes, 5th edition, Richard Turton, Richard C. Bailie, Wallace B. Whiting, Joseph A. Shaeiwitz and Debangsu Bhattacharyya (2018). Pearson. ISBN 978-0-1341-7750-2.
2. SuperPro Designer User Guide, intelligen.com/wp content/uploads/2020/05/SuperPro_ManualForPrinting_v11.pdf
3. SimaPro database manual, https://simapro.com/wp-content/uploads/2022/06/DatabaseManualMethods940Superseded.pdf
4. www.openlca.org

Learning Assessment

Bloom's Level of Cognitive Task		**Continuous Learning Assessments (50%)**								**End Semester Exam (50%)**	
		CLA-1 (10%)		**CLA-2 (10%)**		**CLA-3 (15%)**		**Mid-1 (15%)**			
		Th	**Prac**	**Th**	**Prac**	**Th**	**Prac**	**Th**	**Prac**	**Th**	**Prac**
Level 1	Remember	30%	-	30%	-	30%	-	30%	-	60%	-
	Understand										
Level 2	Apply	70%	-	70%	-	70%	-	70%	-	40%	-
	Analyse									-	
Level 3	Evaluate	-	-	-	-	-	-	-	-	-	-
	Create	-	--	-	-	-	-	-	-	-	-
Total		100%		100%		100%		100%		100%	

Course Designer

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Soil pollution and remediation measures

Course Code	EVS 560	**Course Category**	Core Elective	**L-T-P-C**	2	1	0	3
Pre-Requisite Course(s)	-	**Co-Requisite Course(s)**	-	**Progressive Course(s)**	-			
Course Offering Department	Environmental Science and Engineering	**Professional / Licensing Standards**	-					

Course Objectives

1. Provide knowledge of soil, pollutants, and pollution assessment methods.
2. Understand about the soil pollution and remediation measures.

Course Outcome (COs)

CO's	At the end of the course, the learner will be able to	Bloom's Level	Expected Proficiency Percentage	Expected Attainment Percentage
1	Understand about soil and soil processes.	**1**	**80%**	**70%**
2	Discuss the soil-pollutant interaction.	**2**	**80%**	**70%**
3	Illustrate soil sampling techniques and understanding of pollution indices.	**2**	**80%**	**70%**
4	Apply of bio-remediation techniques for the removal of pollutants from soil.	**3**	**70%**	**60%**

Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)

CLOs	**Program Learning Outcomes (PLO)**														
	Engineering Knowledge	**Problem Analysis**	**Design and Development**	**Analysis, Design and Research**	**Modern Tool and ICT Usage**	**Society and Multicultural**	**Environment and Sustainability**	**Moral, and Ethical Awareness**	**Individual and Teamwork Skills**	**Communication Skills**	**Project Management and**	**Self-Directed and Life Long**	**PSO 1**	**PSO 2**	**PSO 3**
Outcome 1	**3**	**-**	**-**	**3**	**-**	**-**	**3**	**3**	**-**	**-**	**-**	**-**	**3**	**3**	**3**
Outcome 2	**3**	**-**	**-**	**3**	**-**	**-**	**3**	**3**	**-**	**-**	**-**	**-**	**3**	**3**	**3**
Outcome 3	**3**	**-**	**-**	**3**	**-**	**-**	**3**	**3**	**-**	**-**	**-**	**-**	**3**	**3**	**3**
Outcome 4	**3**	**-**	**-**	**3**	**-**	**-**	**3**	**3**	**-**	**-**	**-**	**-**	**3**	**3**	**3**
Course Average	**3**	**-**	**-**	**3**	**-**	**-**	**3**	**3**	**-**	**-**	**-**	**-**	**3**	**3**	**3**

Course Unitization Plan

Unit No.	Syllabus Topics	Required Contact Hours	CLOs Addressed	References Used
Unit No. 1	**Soil and soil processes**	**6**	**1**	**4**
	Origin of soil - weathering and paedogenic processes	2	**1**	**4**
	Soil types and classification	2	**1**	**4**
	Soil horizon, soil constituents	1	**1**	**4**
	Soil properties – physical, chemical, and biological	1	**1**	**4**
Unit No. 2	**Soil pollution**	9	**1,2**	**5, 2**
	Introduction to soil pollution	1	**1,2**	**5, 2**
	Soil pollutants – heavy metals, solid waste,	1	**1,2**	**5, 2**
	Soil pollutants - polluted water, bio-medical wastes	1	**1,2**	**5, 2**
	Sources of soil pollution – natural and anthropogenic	2	**1,2**	**5, 2**
	Pollution mechanism	1	**1,2**	**5, 2**
	Soil-pollutant interaction	1	**1,2**	**5, 2**
	Fate of pollutants in soil	2	**1,2**	**5, 2**
Unit No. 3	**Soil sampling and assessment**	**10**	**3**	**1,2,3**
	Soil sampling techniques	1	**3**	**1,2,3**
	Sampling location selection, sampling tools	1	**3**	**1,2,3**
	Sample preparation	1	**3**	**1,2,3**
	Soil analysis – physical, chemical, and	2	**3**	**1,2,3**
	Soil analysis - biological parameters	1	**3**	**1,2,3**
	Human and ecological risk assessment	2	**3**	**1, 2, 3, 6**
	Hazard quotient, ecological risk factor, ecological risk index	1	**3**	**1,2,3**
	Pollution indices – contamination factor, geo-accumulation index, pollution load index	1	**3**	**1,2,3**
Unit No. 4	**Remediation measures**	**10**	**4**	**1, 2**
	Overview of soil remediation measures	1	**4**	**1, 2**
	Physical methods – soil washing, soil replacement	2	**4**	**1, 2**
	Physical methods- encapsulation, thermal desorption	2	**4**	**1, 2**
	Chemical methods – immobilization	1	**4**	**1, 2**
	In-situ remediation	2	**4**	**1, 2**
	Ex-situ remediation	2	**4**	**1, 2**
Unit No. 5	**Microbial and phytoremediation**	**10**	**1, 2, 4**	**1, 2, 3**
	Bio-remediation	1	**1, 2, 4**	**1, 2, 3**
	Microbe-assisted remediation	1	**1, 2, 4**	**1, 2, 3**
	Genomic approaches, Mycoremediation	1	**1, 2, 4**	**1, 2, 3**
	Introduction to Phytoremediation	1	**1, 2, 4**	**1, 2, 3**
	Phytoaccumulation, Phytodegradation, Phytostabilization, Phytoextraction	2	**1, 2, 4**	**1, 2, 3**
	Measurement of phytoremediation potential – biometric growth behaviour	1	**1, 2, 4**	**1, 2, 3**
	Bio-accumulation factor, translocation factor, Hyperaccumulator plant species	1	**1, 2, 4**	**1, 2, 3**
	Cellular mechanism, detoxification, and tolerance	1	**1, 2, 4**	**1, 2, 3**
	Phytochelatins, root exudates	1	**1, 2, 4**	**1, 2, 3**
Total hours		**45**		

Learning Assessment

Bloom's Level of Cognitive Task		Continuous Learning Assessments (%)								End Semester Exam (%)	
		CLA-1 (%)		CLA-2 (%)		CLA-3 (%)		Mid Term (%)			
		Th	Prac	Th	Prac	Th	Prac	Th	Prac	Th	Prac
Level 1	Remember	30	-	30	-	20	-	20	-	20	-
	Understand	20	-	20	-	30	-	30	-	30	-
Level 2	Apply	50	-	50	-	50	-	50	-	50	-
	Analyse	-	-	-	-	-	-	-	-	-	-
Level 3	Evaluate	-	-	-	-	-	-	-	-	-	-
	Create	-	-	-	-	-	-	-	-	-	-
Total		**100**	**-**	**100**	**-**	**100**	**-**	**100**	**-**	**100**	**-**

Recommended Resources

1. Meuser, H., 2012. Soil remediation and rehabilitation: treatment of contaminated and disturbed land (Vol. 23). Springer Science & Business Media. ISBN 978-94-007-5751-6.
2. Duarte, A.C., Cachada, A. and Rocha-Santos, T.A. eds., 2017. Soil pollution: from monitoring to remediation. Academic Press. ISBN 978-0-12-849873-6.
3. Gill, R., Naeem, M., Ansari, A.A. and Gill, S.S., 2023. Phytoremediation and Management of Environmental Contaminants: An Overview. Phytoremediation: Management of Environmental Contaminants, Volume 7, pp.3-14. ISBN978-3-031-17988-4
4. Paul, E. and Frey, S. eds., 2023. Soil microbiology, ecology and biochemistry. Elsevier. ISBN: 9780128234150
5. Yaron, B., Calvet, R. and Prost, R., 1996. Soil pollution: processes and dynamics. Springer Science & Business Media. ISBN: 3-540-60927-X
6. Ashraf, M.A., Maah, M.J. and Yusoff, I., 2014. Soil contamination, risk assessment and remediation. Environmental risk assessment of soil contamination, 1, pp.3-56. ISBN978-953-51-1235-8

Recommended Online Resources

1. NPTEL online course - Environmental Remediation of Contaminated Sites by Prof. Bhanu Prakash Vellanki | IIT Roorkee
2. NPTEL online course - Environmental Soil Chemistry by Prof. Somsubhra ChakrabortyIIT Kharagpur
3. SWAYAM - https://swayam.gov.in/
4. National Digital Library of India - https://ndl.iitkgp.ac.in

Course designer and co-ordinator

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Environmental Entrepreneurship and planning								
Course Code	EVS 561	**Course Category**	CE	**L-T-P-C**	2	1	0	3
Pre-Requisite Course(s)	-	**Co-Requisite Course(s)**	-	**Progressive Course(s)**	-			
Course Offering Department	Environmental Science and Engineering	**Professional / Licensing Standards**	-					

Course Objectives / Course Learning Rationales (CLRs)

1. To develop and strengthen entrepreneurial quality and motivation in students.
2. To impart basic entrepreneurial skills and understandings to run a business efficiently and effectively.
3. To develop skills for effectively managing human resources

Course Outcomes / Course Learning Outcomes (CLOs)

Outcomes	**At the end of the course, the learner will be able to**	**Bloom's Level**	**Expected Proficiency Percentage**	**Expected Attainment Percentage**
Outcome 1	Infer the knowledge and skills needed to run a business	2	80%	70%
Outcome 2	Describe various theories related to the development of leadership skills, motivation techniques, teamwork and effective communication	2	80%	70%
Outcome 3	Apply economic principles to appreciate the functioning of both product and input markets	3	80%	70%
Outcome 4	Use data analysis software for business modelling	3	80%	70%

Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)

CLOs	Program Learning Outcomes (PLO)														
	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design & Research	Modern Tool & ICT Usage	Society & Multicultural Skills	Environment & Sustainability	Moral, & Ethical Awareness	Individual & Teamwork Skills	Communication Skills	Project Management &	Self-Directed & Lifelong Learning	PSO 1	PSO 2	PSO 3
Outcome 1	-	2	-	3	-	-	2	-	3	2	-	1	3	3	3
Outcome 2	-	1	2	2	2	1	3	-	2	2	2	1	3	3	3
Outcome 3	-	1	2	1	1	1	3	-	2	2	1	1	3	3	3
Outcome 4	-	1	2	2	2	-	1	-	1	-	1	1	3	3	3
Course Average	**-**	**1.25**	**1.5**	**2**	**1.25**	**0.5**	**2.25**	**-**	**2**	**2.5**	**1**	**1**	**3**	**3**	**3**

Course Unitization Plan

Unit No.	Unit Name	Required Learning Hours	CLOs Addressed	References Used
Unit No. 1	**ENTREPRENEURAL COMPETENCE**	**6**	**1,2**	**1,2**
	Entrepreneurship concept – Entrepreneurship as a Career	2	**1,2**	**1,2**
	Entrepreneurial Personality - Characteristics of Successful, Entrepreneur	2	**1,2**	**1,2**
	Knowledge and Skills of Entrepreneur	1	**1,2**	**1,2**
	Entrepreneurship Development Training	1	**1,2**	**1,2**
Unit No.2	**Human Resource Management**	**9**	**1,2,3**	**3,4**
	Importance of Human Resource Planning- the concept of best fit employee	3	**1,2,3**	**3,4**
	Training and Executive management -	2	**1,2,3**	**3,4**
	Compensation plan – Reward – Motivation	1	**1,2,3**	**3,4**

	Career management – Development of mentor –	2	**1,2,3**	**3,4**
	Protégé relationships	1	**1,2,3**	**3,4**
Unit No.3	**PLAN PREPARATION**	**12**	**2,3**	**5,6,9**
	Sources of Product for Business - Prefeasibility Study -	3	**2,3**	**5,6,9**
	Criteria for Selection of Product	1	**2,3**	**5,6,9**
	Ownership - Capital - Budgeting Project Profile Preparation	4	**2,3**	**5,6,9**
	Matching Entrepreneur with the Project -	2	**2,3**	**5,6,9**
	Microeconomics and Macroeconomics	2	**2,3**	**5,6,9**
Unit No. 4	**LAUNCHING OF SMALL BUSINESS**	**10**	**1,2,3**	**7,8**
	Finance and Human Resource Mobilization Operations Planning -	3	**1,2,3**	**7,8**
	Market and Channel Selection	1	**1,2,3**	**7,8**
	Growth Strategies - Product Launching – Incubation, Venture capital	3	**1,2,3**	**7,8**
	IT startups -	1	**1,2,3**	**7,8**
	Effective Management of small Business.	2	**1,2,3**	**7,8**
Unit No. 5	**Business modelling**	**8**	**3,4**	**10**
	Descriptive Statistics – Forecasting – Risk analysis and sensitivity analysis	2	**3,4**	**10**
	Networking models- Inventory models	1	**3,4**	**10**
	Data analysis tools	1	**3,4**	**10**
	E- business management national and international trade and Investment	2	**3,4**	**10**
	Case study – Feasibility Report Preparation and Evaluation Criteria.	2	**3,4**	**10**
Total Contact Hours		**45**		

Recommended Resources

1. Entrepreneurship, 11th edition, Robert Hisrich, Dean Shepherd and Michael Peters (2020). Tata McGraw Hill. ISBN 978-1-2600-4373-0.
2. Entrepreneurial Development, 18th edition, S.S.Khanka (2020). S.Chand and Company Limited. ISBN 978-8-1219-1801-5.
3. Human Resource Management, 12th edition, Ivancevich (2012). McGraw Hill. ISBN 978-0-0774-9690-6.
4. Human Resource management, Uday Kumar Haldar and Juthika Sarkar (2012). Oxford. ISBN 978-0-9780-1980-8.
5. Projects – Planning, Analysis, Selection, Implementation and Reviews, 9th edition, Prasanna Chandra (2019). Tata McGraw-Hill. ISBN 978-8-1941-1384-3.
6. Modern management: concepts and skills, 14th edition, Samuel C. Certo and Tervis Certo. Pearson education. ISBN 978-9-3325-6502-9.
7. Economics, 9th edition, William Boyes and Michael Melvin (2012). South-Western College. ISBN 978-1-1118-2613-0.
8. Principles of Economics, 12th edition, Karl E. Case, Ray C. Fair, and E. Oster Sharon (2017). Pearson. ISBN 978-9-3528-6343-3.
9. Essentials of management, 11th edition, Harold Koontz, Heinz Weihrich, and Mark V. Cannic (2020). Tata McGraw-Hill Education.
10. Microsoft Excel 2010: Data Analysis & Business Modeling, 3rd edition, Wayne L. Winston (2011). Microsoft Press. ISBN 978-0735643369.

Learning Assessment

Bloom's Level of Cognitive Task		Continuous Learning Assessments (50 %)								End Semester Exam (50%)	
		CLA-1 (10%)		CLA-2 (10 %)		CLA-3 (15 %)		Mid-1 (15 %)			
		Th	Prac	Th	Prac	Th	Prac	Th	Prac	Th	Prac
Level 1	Remember	50%	-	50%	-	50%	-	50%	-	50%	-
	Understand										
Level 2	Apply	50%	-	50%	-	50%	-	50%	-	50%	-
	Analyse									-	
Level 3	Evaluate	-	-	-	-	-	-	-	-	-	-
	Create	-	-	-	-	-	-	-	-	-	-
Total		**100%**		**100%**		**100%**		**100%**		**100%**	

Course Designer

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Biomass Energy								
Course Code	EVS 562	**Course Category**	CE	**L-T-P-C**	2	1	0	3
Pre-Requisite Course(s)	-	**Co-Requisite Course(s)**	-	**Progressive Course(s)**	-			
Course Offering Department	Environmental Science and Engineering	**Professional / Licensing Standards**	-					

Course Objectives / Course Learning Rationales (CLRs)

Objective 1: To understand the concept of various biochemical waste to energy conversion technologies.

Objective 2: To understand the concept of various thermochemical waste to energy conversion technologies.

Objective 3: Concept of bioenergy system analysis and knowledge of basic aspects of life cycle assessment (LCA).

Course Outcomes / Course Learning Outcomes (CLOs)

Outcomes	**At the end of the course, the learner will be able to**	**Bloom's Level**	**Expected Proficiency Percentage**	**Expected Attainment Percentage**
Outcome 1	Analyze the biomass resource assessment and get knowledge about bioreactors with its kinetic models	2	80%	70%
Outcome 2	Understand the various conversion technologies to generate energy from biomass	1	80%	70%
Outcome 3	Apply the subject knowledge to address the environmental problems	2	80%	70%
Outcome 4	Evaluate the technical, economical and life cycle assessment of bioenergy plant	3	80%	70%

Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)

CLOs	Program Learning Outcomes (PLO)														
	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design & Research	Modern Tool & ICT Usage	Society & Multicultural Skills	Environment & Sustainability	Moral, & Ethical Awareness	Individual & Teamwork Skills	Communication Skills	Project Management &	Self-Directed & Lifelong Learning	PSO 1	PSO 2	PSO 3
Outcome 1	3	3	2	1	2	2	2	3	2	-	2	3	1	2	3
Outcome 2	2	1	1	2	-	2	2	-	3	-	3	3	1	1	2
Outcome 3	2	1	-	2	2	1	1	2	3	-	3	3	1	1	2
Outcome 4	2	1	1	3	2	3	1	3	-	-	3	2	1	1	2
Course Average	**2**	**1**	**1**	**2**	**1.5**	**2**	**1.5**	**2**	**2**	**-**	**2.75**	**2.75**	**1**	**1**	**2**

Course Unitization Plan

Unit No.	Unit Name	Required Learning Hours	CLOs Addressed	References Used
Unit No. 1	**Bioenergy Fundamentals**	**9**	**1,2**	**2,3,4**
	Mass and Energy Balances - Reaction Thermodynamics -Reaction Kinetics	1	**1,2**	**2,3,4**
	Microbial Metabolisms -Metabolic Models	1	**1,2**	**2,3,4**
	Microbial Growth in Batch Culture - Monod Equation for Microbial Growth	3	**1,2**	**2,3,4**
	Mass Balances and Reactions in Fed-Batch and Continuous-Stirred Tank Bioreactors	3	**1,2**	**2,3,4**
	Elemental Balance and Stoichiometric Models	1	**1,2**	**2,3,4**
Unit No. 2	**Bioenergy Feedstocks**	**9**	**1,2**	**1,2,4**
	Lignocellulose-Based Feedstocks - Feedstock	2	**1,2**	**1,2,4**
	Availability and Production -Harvesting and Collection of Crop Residues and Energy Crops	3	**1,2**	**1,2,4**
	Algae-Based Feedstocks -Algal Growth Conditions	3	**1,2**	**1,2,4**

	Steps in Algal-Biodiesel Production	1	**1,2**	**1,2,4**
Unit No. 3	**Biological Conversion Technologies**	**9**	**1,2,3**	**1,2,3,4**
	Pre-treatment of Lignocellulosic Feedstocks - Enzymatic Hydrolysis	2	**1,2,3**	**1,2,3,4**
	Ethanol Fermentation -Fundamentals of Anaerobic Digestion	3	**1,2,3**	**1,2,3,4**
	Anaerobic Digestion Model No. 1 (ADM1)	1	**1,2,3**	**1,2,3,4**
	Biogas Production and Applications - Microbial Fuel Cells	3	**1,2,3**	**1,2,3,4**
Unit No.4	**Thermal Conversion Technologies**	**9**	**1,2,3**	**1,4**
	Fundamentals of Biomass Combustion - Biomass Properties and Pre-processing - Biomass Furnaces	3	**1,2,3**	**1,4**
	Environmental Impact and Emissions of Biomass Combustion	2	**1,2,3**	**1,4**
	Gasification -Gasifiers -Gasification Mass and Energy Balance	3	**1,2,3**	**1,4**
	Applications of Biomass Gasification	1	**1,2,3**	**1,4**
Unit No. 5	**Bioenergy System Analysis**	**9**	**4**	**1,4**
	Techno-Economic Assessment Basic Steps in TEA	3	**4**	**1,4**
	Tools, Software, and Data Sources for Performing TEA	3	**4**	**1,4**
	Life-Cycle Assessment -Procedure for LCA	2	**4**	**1,4**
	Tools Available to Perform LCA	1	**4**	**1,4**
	Total Learning Hours	**45**		

Learning Assessment

Bloom's Level of Cognitive Task		Continuous Learning Assessments (50%)								End Semester Exam (50%)	
		CLA-1 (10%)		CLA-2 (10%)		CLA-3 (15%)		Mid-1 (15%)			
		Th	Prac	Th	Prac	Th	Prac	Th	Prac	Th	Prac
Level 1	Remember	30%	-	30%	-	30%	-	30%	-	60%	-
	Understand										
Level 2	Apply	70%	-	70%	-	70%	-	70%	-	40%	--
	Analyse										
Level 3	Evaluate	-	-	-	-	-	-	-	-		
	Create										
Total		**100%**		**100%**		**100%**		**100%**		**100%**	

Recommended Resources

1. Bioenergy: Principles and applications, Yebo Li and Smair Kumar Khanal (2016). Wiley Blackwell. ISBN 978-1-118-56831-6.
2. Anaerobic Biotechnology for Bioenergy Production: Principles and Applications, S. Harikishan (2008). Wiley-Blackwell. ISBN 978-0-813-82346-1.
3. Biogas Production: From Anaerobic Digestion to a Sustainable Bioenergy Industry, Anuj Kumar Chandel and Nagamani Balagurusamy (2021). Springer. ISBN 978-3-0305-8826-7.
4. Bioenergy and Biofuels from Biowastes and Biomass, Khanal, S.K., Surampalli, R.Y. Zhang, T.C. Lamsal, B.P., Tyagi, R.D. and C.M. Kao (2010). American Society of Civil Engineers. 2010. ISBN 978-0-7844-1089-9.

Course Designer

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Agriculture, food security and climate change

Course Code	EVS 563	**Course Category**	CE	**L-T-P-C**	2	1	0	3
Pre-Requisite Course(s)	-	**Co-Requisite Course(s)**	-	**Progressive Course(s)**	-			
Course Offering Department	Environmental Science and Engineering	**Professional / Licensing Standards**	-					

Course Objectives

1. To understand global agricultural production and consumption patterns.
2. To identify the causes and impacts of climate change on food security at regional and global scales.
3. To explore sustainable solutions in agriculture for food security.

Course Outcome (COs)

CO's	At the end of the course the learner will be able to	Bloom's Level	Expected Proficiency Percentage	Expected Attainment Percentage
1	Understand global patterns in food production and consumption	2	80%	70%
2	Interpret the causes and impacts of climate change on food security	2	80%	70%
3	Analyse the complexities and trade-offs associated with food security	3	80%	70%
4	Examine potential strategies that focus on sustainable food production	3	80%	70%

Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)

CLOs	Program Learning Outcomes (PLO)														
	Engineering Knowledge	Problem Analysis	Design and Development	Analysis, Design and Research	Modern Tool and ICT Usage	Society and Multicultural	Environment and Sustainability	Moral, and Ethical Awareness	Individual and Teamwork Skills	Communication Skills	Project Management and	Self-Directed and Life Long	PSO 1	PSO 2	PSO 3
Outcome 1	3	-	-	3	-	-	3	3	-	-	-	-	3	3	3
Outcome 2	3	-	-	3	-	-	3	3	-	-	-	-	3	3	3
Outcome 3	3	-	-	3	-	-	3	3	-	-	-	-	3	3	3
Outcome 4	3	-	-	3	-	-	3	3	-	-	-	-	3	3	3
Course Average	**3**	**-**	**-**	**3**	**-**	**-**	**3**	**3**	**-**	**-**	**-**	**-**	**3**	**3**	**3**

Course Unitization Plan

Unit No.	Syllabus Topics	Required Contact Hours	CLOs Addressed	References Used
Unit No. 1	**Introduction to agriculture and food security**	**5**	**1**	**1,6**
	Definitions: agriculture, food security, food insecurity	1	**1**	**1,6**
	Food systems: historic and geographical overview	1	**1**	**1,6**
	Major types of agriculture	1	**1**	**1,6**
	Global agricultural production and consumption patterns	2	**1**	**1,6**
Unit No. 2	**Environmental drivers of agriculture**	**10**	**1,2**	**1,3**
	Environmental determinants of agriculture	2	**1,2**	**1,3**
	Water resources and food production: Evapotranspiration	1	**1,2**	**1,3**
	Crop water use, irrigation efficiency, virtual water	1	**1,2**	**1,3**
	Impacts of agriculture on water resources	2	**1,2**	**1,3**
	Soil resources and food production: Soil maps	2	**1,2**	**1,3**
	Overview of nutrients, soil productivity and soil fertility	2	**1,2**	**1,3**
Unit No. 3	**Climate change and agriculture**	**10**	**1,2**	**3,5,6**
	Overview of global climate system	1	**1,2**	**3,5,6**
	Natural variability and human-induced climate change	1	**1,2**	**3,5,6**
	Future climate scenarios and tipping points	1	**1,2**	**3,5,6**
	Global climate zones	1	**1,2**	**3,5,6**
	Agro-climatic zones of India	1	**1,2**	**3,5,6**
	Climate-agriculture interactions	1	**1,2**	**3,5,6**
	Crop phenology, crop responses to increasing temperature	1	**1,2**	**3,5,6**
	Crop responses to ozone and drought	1	**1,2**	**3,5,6**
	Regional insights from AgMIP	1	**1,2**	**3,5,6**

	Future projections of agricultural production	1	**1,2**	**3,5,6**
Unit No. 4	**Food security challenges**	**5**	**3**	**1,3,5**
	Food-energy-environment trilemma	1	**3**	**1,3,5**
	Food security – supply and food waste	1	**3**	**1,3,5**
	Food shocks and vulnerabilities, yield gaps, supply chain impacts	1	**3**	**1,3,5**
	Global Hunger Index	1	**3**	**1,3,5**
	Perspectives from Indian context	1	**3**	**1,3,5**
Unit No. 5	**Emerging technologies for sustainable solutions**	**15**	**4**	**2,4,6**
	Sustainable Development Goals: Zero Hunger (SDG 2) and Climate Action (SDG 13)	1	**4**	**2,4,6**
	Mitigation and adaptation pathways: Agroecology, climate-smart agriculture	1	**4**	**2,4,6**
	Conservation agriculture, urban agriculture	1	**4**	**2,4,6**
	Sustainable intensification	1	**4**	**2,4,6**
	Food supply management	1	**4**	**2,4,6**
	Demand and diet changes	1	**4**	**2,4,6**
	Geospatial applications: precision agriculture, crop phenology	1	**4**	**2,4,6**
	Crop health monitoring, drought assessment	1	**4**	**2,4,6**
	AI/ML in agriculture for pre-harvesting tasks	1	**4**	**2,4,6**
	AI/ML in agriculture for harvesting tasks	1	**4**	**2,4,6**
	AI/ML in agriculture for post-harvesting tasks	1	**4**	**2,4,6**
	Benefits & challenges of using AI/ML in agriculture	2	**4**	**2,4,6**
	Crop simulation modelling	2	**4**	**2,4,6**
Total Contact Hours		**45**		

Learning Assessment

Bloom's Level of Cognitive Task		Continuous Learning Assessments (50%)								End Semester Exam (50%)	
		CLA-1 (10%)		CLA-2 (15%)		CLA-3 (10%)		Mid Term (15%)			
		Th	Prac	Th	Prac	Th	Prac	Th	Prac	Th	Prac
Level 1	Remember	25%	-	25%	-	25%	-	25%	-	25%	-
	Understand	25%	-	25%	-	25%	-	25%	-	25%	-
Level 2	Apply	50%	-	50%	-	50%	-	50%	-	50%	-
	Analyse	-	-	-	-	-	-	-	-	-	-
Level 3	Evaluate	-	-	-	-	-	-	-	-	-	-
	Create	-	-	-	-	-	-	-	-	-	-
Total		**100%**		**100%**		**100%**		**100%**		**100%**	

Recommended Resources

1. Climate Change, Agriculture and Society: Approaches Toward Sustainability, 1st Edition, Alam and Rukhsana (2023). Springer Nature. ISBN 9783031282508
2. Resilience and Food Security in a Food Systems Context, 1st Edition, Béné and Devereux (2022). Springer Nature. ISBN 9783031235351
3. Food Security and Climate Change, 1st Edition, Yadav, Redden, Hatfield, Ebert and Hunter (2023). Wiley Blackwell. ISBN 9781119180647
4. Machine learning in agriculture domain: A state-of-art survey, Meshram, Patil, Meshram, Hanchate and Ramkteke (2021). Artificial Intelligence in the Life Sciences, 1: 100010
5. The State of Indian Agriculture, 1st Edition, Kumar (2020). Sage Publications. ISBN 9789353883348
6. Transformations of Global Food Systems for Climate Change Resilience, 1st Edition, Gadhoke, Brenton and Katz (2024). CRC Press. ISBN 9780367857622.
7. IPCC Special Report on Food Security - https://www.ipcc.ch/srccl/chapter/chapter-5/
8. FAO Report on Climate Change and Food Security: Risks and Responses - https://openknowledge.fao.org/server/api/core/bitstreams/a4fd8ac5-4582-4a66-91b0-55abf642a400/content.

Course Designer

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Bioeconomy								
Course Code	EVS 564	**Course Category**	CE	**L-T-P-C**	2	1	0	3
Pre-Requisite Course(s)	-	**Co-Requisite Course(s)**	-	**Progressive Course(s)**	-			
Course Offering Department	Environmental Science and Engineering	**Professional / Licensing Standards**	-					

Course Objectives / Course Learning Rationales (CLRs)

Objective 1: To reflect on the importance of bioeconomy in the transition economic conditions.

Objective 2: Understand the effect of global and regional bioeconomy and how it reshapes global health and industrial indicators.

Objective 3: To understand the various factors driving bioeconomy

Course Outcomes / Course Learning Outcomes (CLOs)

Outcomes	**At the end of the course, the learner will be able to**	**Bloom's Level**	**Expected Proficiency Percentage**	**Expected Attainment Percentage**
Outcome 1	Understand bioeconomy and circular economy	2	80%	70%
Outcome 2	Apply sustainable industrial processes design	3	80%	70%
Outcome 3	Explain global and regional bioeconomy and different drivers affecting bioeconomy.	2	80%	70%
Outcome 4	Examine future of bioeconomy and challenges. Policy and decision making.	3	80%	70%

Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)

CLOs	Program Learning Outcomes (PLO)														
	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design & Research	Modern Tool & ICT Usage	Society & Multicultural Skills	Environment & Sustainability	Moral, & Ethical Awareness	Individual & Teamwork Skills	Communication Skills	Project Management &	Self-Directed & Lifelong Learning	PSO 1	PSO 2	PSO 3
Outcome 1	-	3	-	3	-	-	3	-	-	-	1	2	3	3	2
Outcome 2	-	3	2	3	-	-	2	-	-	-	1	3	3	2	2
Outcome 3	-	3	2	3	-	-	2	-	-	-	1	3	3	2	2
Outcome 4		3	2	2		2	2				1	2	3	2	2
Course Average	**-**	**3**	**1.5**	**2.75**	**-**	**0.5**	**2.25**	**-**	**-**	**-**	**1**	**2.5**	**3**	**2**	**2**

Course Unitization Plan

Unit No.	Unit Name	Required Learning Hours	CLOs Addressed	References Used
Unit No. 1	**Introduction to Bioeconomy**	**9**	**1**	**1, 2, 3**
	Introduction- What is Bioeconomy?	2	**1**	**1, 2, 3**
	Circular economy	1	**1**	**1, 2, 3**
	Factors affecting bioeconomy	2	**1**	**1, 2, 3**
	State of Bioeconomy today	1	**1**	**1, 2, 3**
	Importance of bioeconomy	3	**1**	**1, 2, 3**
Unit No. 2	**Sustainable Industrial Processes**	**9**	**1,2**	**3,4**
	Importance of biotechnology	2	**1,2**	**3,4**
	Sectors and products of bioeconomy	1	**1,2**	**3,4**
	Industrial processes – Biofuels, Agriculture	3	**1,2**	**3,4**
	Pharmaceuticals, Chemicals	2	**1,2**	**3,4**
	Healthcare Research	1	**1,2**	**3,4**

Unit No. 3	**Global and regional Bioeconomy**	**9**	**2,3**	**3,4**
	Bioeconomy in US	2	**2,3**	**3,4**
	Bioeconomy in Europe	1	**2,3**	**3,4**
	Bioeconomy in Indian Context	3	**2,3**	**3,4**
	COVID economy	1	**2,3**	**3,4**
	Role of bioeconomy in GDP	2	**2,3**	**3,4**
Unit No. 4	**Bioeconomy drivers**	**9**	**1,2,3**	**2,3,5**
	Energy and Biomass – Knowledge based bioeconomy	3	**1,2,3**	**2,3,5**
	Role of science and innovation policy in Bioeconomy	3	**1,2,3**	**2,3,5**
	Role of population, agriculture, food prices, healthcare in Bioeconomy	2	**1,2,3**	**2,3,5**
	Current and emerging business models	1	**1,2,3**	**2,3,5**
Unit No. 5	**Future of bioeconomy**	**9**	**1,2,4**	**5,6**
	Bioeconomy 2030 – Policy Agenda	3	**1,2,4**	**5,6**
	Bioeconomy Blueprint – Regulating the Bioeconomy	3	**1,2,4**	**5,6**
	Transformative technological innovation	2	**1,2,4**	**5,6**
	Cross-cutting issues	1	**1,2,4**	**5,6**
Total Contact Hours		**45**		

Recommended Resources

1. Bioeconomy: Shaping the Transition to a sustainable Biobased Economy. Iris Lewandowski (2018). Springer. ISBN 978-3-319-68151-1.
2. Biorefinery 2030: Future Prospects for the Bioeconomy, Pierre-Alain Schieb, Honorine Lescieux-Katir, Maryline Thénot, Barbara Clément-Larosière (2016). Springer. ISBN 978-3-6625-1679-9.
3. The Bioeconomy to 2030: Designing a Policy Agenda, OECD
4. The Application of Biotechnology to Industrial Sustainability, OECD
5. National Bioeconomy Blueprint, White House, 2012.
6. Indian Bioeconomy Report 2020, 2021. BIRAC.

Learning Assessment

Bloom's Level of Cognitive Task		Continuous Learning Assessments (50%)								End Semester Exam (50%)	
		CLA-1 (10%)		CLA-2 (10%)		CLA-3 (15%)		Mid-1 (15%)			
		Th	Prac	Th	Prac	Th	Prac	Th	Prac	Th	Prac
Level 1	Remember	30%	-	30%	-	30%	-	30%	-	60%	-
	Understand										
Level 2	Apply	70%		70%		70%		70%		40%	
	Analyse										
Level 3	Evaluate										
	Create										
Total		**100%**		**100%**		**100%**		**100%**		**100%**	

Course Designer

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Name of the Course: Membrane Technology for Industrial Water Treatment

Course Code		**Course Category**	Course Elective (CE)	**L-T-P-C**	**2**	**1**	**0**	**3**
Pre-Requisite Course(s)		**Co-Requisite Course(s)**		**Progressive Course(s)**				
Course Offering Department	Department of Environmental Science and Engineering	**Professional / Licensing Standards**						

Course Objectives

1. Understand the principles and theories behind various membrane processes used in industrial water treatment, such as reverse osmosis, ultrafiltration, nanofiltration, and microfiltration.
2. Gain insights into the practical applications of membrane technology in treating industrial wastewater and producing high-quality process water.
3. Stay updated on the latest innovations and emerging trends in membrane technology for industrial water treatment, fostering an awareness of cutting-edge developments in the field.
4. Develop problem-solving skills related to challenges in membrane technology applications, including fouling, scaling, and membrane degradation.

Course Outcome (COs)

CO's	At the end of the course the learner will be able to	Bloom's Level	Expected Proficiency Percentage	Expected Attainment Percentage
1	Recall several terminologies related to membrane technology	**1**	**80%**	**70%**
2	Ability to illustrate different membrane technologies	**2**	**80%**	**70%**
3	Application of how to design and optimize membrane systems for different industrial water treatment scenarios, considering factors like flow rates, membrane materials, and system configurations.	**3**	**80%**	**70%**
4	Demonstrate methods for quality assurance and effective monitoring of membrane processes to ensure the production of water that meets industry standards.	**3**	**80%**	**70%**
5	Interpret real-world case studies and applications where membrane technology has been successfully applied for water treatment in various industries (e.g., municipal water supply, industrial wastewater treatment, desalination).	**3**	**80%**	**70%**

Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)

CLOs	Program Learning Outcomes (PLO)														
	Engineering Knowledge	Problem	Design and Development	Analysis, Design and	Modern Tool and ICT Usage	Society and Multicultural	Environment and	Moral, and Ethical	Individual and Teamwork	Communication Skills	Project Management	Self-Directed and Life Long	PSO 1	PSO 2	PSO 3
Outcome 1	1	**1**	**-**	**2**	**1**	**-**	3	-	**2**	**-**	**1**	3	1	2	2
Outcome 2	1	1	**-**	**2**	**1**	**-**	3	**-**	**2**	**-**	**1**	3	1	2	2
Outcome 3	1	**1**	**-**	**2**	**1**	**-**	3	**-**	**2**	**-**	**1**	3	1	2	2
Outcome 4	1	1	**-**	**2**	**1**	**-**	3	**-**	**2**	**-**	**1**	3	1	2	2
Course Average	**1**	**1**	**-**	**2**	**1**	**-**	**3**	**-**	**2**	**-**	**1**	**3**	1	2	2

Course Unitization Plan

Unit No.	Syllabus Topics	Required Contact Hours	CLOs Addressed	References Used
Unit No. 1	**Introduction on membrane technology**	**8**	**1**	**1,3,6**
	Separation processes in process industry and in environmental application: basic features and relevance.	2	**1**	**1,3,6**
	Fundamentals of membrane technologies.	3	**1**	**1,3,6**
	Membranes and membrane processes classification.	3	**1**	**1,3,6**
Unit No. 2	**Membranes and modules**	**8**	**2,3**	**2,3,7**
	Description of the main polymeric and ceramic membranes and of the manufacture techniques	5	**2,3**	**2,3,7**
	Membrane geometries. Parameters and techniques for membrane characterization	2	**2,3**	**2,3,7**
	Technical features of modules: tubular, spiral wound, hollow fibers, plate, and frame.	2	**2,3**	**2,3,7**
Unit No. 3	**Main membrane processes for liquid streams**	**9**	**2,3,4**	**3,4,8**
	Reverse Osmosis, Nanofiltration, Ultrafiltration, Microfiltration.	3	**2,3,4**	**3,4,8**
	Fields of application and conventional processes. Advantages and limitations.	2	**2,3,4**	**3,4,8**
	Problems and solutions based on RO, UF	4	**2,3,4**	**3,4,8**
Unit No. 4	**Membrane processes and Membrane Contactors**	**10**	**2,4**	**4,5,6,8**
	Ion Exchange membrane-based processes	3	**2,4**	**4,5,6,8**
	Thermal-based separation techniques and Membrane Distillation	5	**2,4**	**4,5,6,8**
	Emerging membrane technology: Forward Osmosis	2	**2,4**	**4,5,6,8**
Unit No. 5	**Fouling, Scaling, Concentration Polarization, and solutions**	**10**	**1,2,4**	**1,5,7**
	Fouling: characteristics and solution strategies.	5	**1,2,4**	**1,5,7**
	Membrane Cleaning Techniques for Fouling Control	5	**1,2,4**	**1,5,7**
	Total Hours	**45**		

Learning Assessment

Bloom's Level of Cognitive Task		Continuous Learning Assessments (60%)								End Semester Exam (40%)	
		CLA-1 (10%)		CLA-2 (10%)		CLA-3 (15%)		Mid Term (25%)			
		Th	Prac	Th	Prac	Th	Prac	Th	Prac	Th	Prac
Level 1	Remember	50%	-	30%	-	30%	-	30%	-	-	-
	Understand	50%	-	20%	-	30%	-	20%	-	50%	-
Level 2	Apply	-	-	50%	-	40%	-	50%	-	50%	-
	Analyse	-	-	-	-	-	-	-	-	-	-
Level 3	Evaluate	-	-	-	-	-	-	-	-	-	-
	Create	-	-	-	-	-	-	-	-	-	-
Total		**100%**		**100%**		**100%**		**100%**		**100%**	

Recommended Resources

1. **Baker, R. W. (2023). Membrane technology and applications. John Wiley & Sons.**
2. **Li, N. N., Fane, A. G., Ho, W. W., & Matsuura, T. (Eds.). (2011). Advanced membrane technology and applications. John Wiley & Sons.**
3. **Nath, K. (2017). *Membrane separation processes*. PHI Learning Pvt. Ltd.**
4. **Nunes, S. P., & Peinemann, K. V. (Eds.). (2006). *Membrane technology: in the chemical industry*. John Wiley & Sons.**
5. **Strathmann, H. (2011). Introduction to membrane science and technology. John Wiley & Sons.**
6. **Shenvi, S. S., Isloor, A. M., & Ismail, A. F. (2015). A review on RO membrane technology: Developments and challenges. Desalination, 368, 10-26.**
7. **Guo, W., Ngo, H. H., & Li, J. (2012). A mini-review on membrane fouling. Bioresource technology, 122, 27-34.**
8. **Lutchmiah, K., Verliefde, A. R. D., Roest, K., Rietveld, L. C., & Cornelissen, E. R. (2014). Forward osmosis for application in wastewater treatment: A review. Water research, 58, 179-197.**

Course Designer and Co-ordinator

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ECOSYSTEM RESTORATION

Course Code		**Course Category**	CE	**L-T-P-C**	2	1	0	3
Pre-Requisite Course(s)		**Co-Requisite Course(s)**		**Progressive Course(s)**				
Course Offering Department	Environmental Science and Engineering	**Professional / Licensing Standards**						

Course Objectives

1. Aims to provide a comprehensive idea about the ecosystem restoration and its importance.
2. Outline the carbon sequestration potential of different ecosystems.

Course Outcome (COs)

CO's	At the end of the course the learner will be able to	Bloom's Level	Expected Proficiency Percentage	Expected Attainment Percentage
1	To gain the knowledge and skills needed to create a blueprint for ecosystem restoration.	2	80%	70%
2	Understand the steps, process, and plan for ecosystem restoration.	2	80%	70%
3	Understand the ecosystem services gain through restoring disturbed ecosystems.	3	80%	70%
4	Able to evaluate the carbon sequestration of various ecosystems through restoration.	4	80%	70%

Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)

CLOs	**Program Learning Outcomes (PLO)**														
	Engineering Knowledge	**Problem Analysis**	**Design and Development**	**Analysis, Design and Research**	**Modern Tool and ICT Usage**	**Society and Multicultural**	**Environment and Sustainability**	**Moral, and Ethical Awareness**	**Individual and Teamwork Skills**	**Communication Skills**	**Project Management and**	**Self-Directed and Life Long**	**PSO 1**	**PSO 2**	**PSO 3**
Outcome 1	1	1	1	2	2	2	3	2	2	1	1	2			
Outcome 2	1	1	1	2	2	2	3	2	2	1	1	2			
Outcome 3	1	1	1	2	2	2	3	2	2	1	1	2			
Outcome 4	1	1	1	2	2	2	3	2	2	1	1	2			
Course Average	1	1	1	2	2	2	3	2	2	1	1	2			

Course Unitization Plan

Unit No.	Unit Name	Required Contact Hours	CLOs Addressed	References Used
Unit 1	**Introduction to Restoration Ecology**	**9**	1	1, 2
	Background, Introduction, Concepts, Rationale for restoration	1	1	1,2
	The ecological context: a species population and landscape perspective.	2	1	1,2
	Ecological dynamics and ecological restoration,	2	1	1,2
	Biodiversity as a goal and driver of restoration.	2	1	1,2
	Landscape ecology and restoration processes.	2	1	1,2
Unit 2	**Ecological foundations: Theory and the Restoration of Populations and Communities**	**9**	1,2	1, 2
	Population and communities' restoration: From theory to practice	2	1,2	1,2
	Eco-physiological Constraints,	2	1,2	1,2
	Invasive species and restoration challenge,	2	1,2	1,2
	Heterogeneity theory, Assembly theory for restoring ecosystem structure and functioning.	3	1,2	1,2
Unit 3	**Restoring Ecological Function**	**10**	2, 3	2, 3
	Nutrient dynamics as determinants and outcomes of restoration	2	2,3	2,3
	Topographic heterogeneity theory and ecological restoration	2	2,3	2,3
	Recovery of ecosystem processes: Carbon and energy flows in restored forests, grasslands and wetlands	3	2,3	2,3
	Biodiversity and ecosystem functioning in restored ecosystems	3	2,3	2,3
Unit 4	**Dimensions, Synthesis and Challenges of Restoration**	**9**	2, 3	2, 3
	Evolutionary restoration ecology, Macroecology and the theory of Island biogeography	3	2,3	2,3
	The influence of climate change on the Science and Practice of restoration Ecology,	3	2,3	2,3
	Persistent and emerging themes in the linkage of theory to restoration practice.	3	2,3	2,3
Unit 5	**Carbon Sequestration**	**8**	2,3,4	2,3,4

	Carbon sequestration via restoration in major forest biomes of the World	3	2,3,4	2,3,4
	Nutrient and water limitations,	2	2,3,4	2,3,4
	Importance through restoration. Restoration as a tool for carbon storage.	3	2,3,4	2,3,4
	Total Hours	**45**		

Learning Assessment

Bloom's Level of Cognitive Task		**Continuous Learning Assessments (50%)**				**End Semester Exam (50%)**
		CLA-1 (10%)	**Mid-1 (15%)**	**CLA-2 (10%)**	**CLA-3 (15%)**	
Level 1	Remember	60%	60%	60%	60%	60%
	Understand					
Level 2	Apply	40%	40%	40%	40%	40%
	Analyse					
Level 3	Evaluate					
	Create					
Total		**100%**	**100%**	**100%**	**100%**	**100%**

Recommended Resources

1. Margaret A. Palmer, Joy B. Zedler, & Donald A. Falk. 2016. Foundations of Restoration Ecology. Second Edition, Island Press, 2000 M Street NW, Suite 650, Washington, DC 20036.
2. Jelte van Andel & James Aronson. 2006. Restoration Ecology: The New Frontier. Blackwell Publishing 350 Main Street, Malden, MA 02148-5020, USA.
3. Andre F. Clewell & James Aronson. 2013. Ecological Restoration: Principles, Values, and Structure of an Emerging Profession, Second Edition. Island Press, 1718 Connecticut Avenue NW, Suite 300, Washington, DC 20009.
4. Klaus Lorenz, & Rattan Lal. 2010. Carbon sequestration in forest ecosystems. Springer Dordrecht Heidelberg London New York.

Course Designer

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Name of the Course: Project Work

Course Code	EVS 511	**Course Category**		**L-T-P-C**	0	4	32	20
Pre-Requisite Course(s)		**Co-Requisite Course(s)**		**Progressive Course(s)**				
Course Offering Department	Environmental Science and Engineering	**Professional / Licensing Standards**						

Course Objectives

1. To understand how to identify a research problem and different solutions to solve it.
2. Experimental design, analysis, and scientific writing.

Course Outcome (COs)

CO's	At the end of the course the learner will be able to	Bloom's Level	Expected Proficiency Percentage	Expected Attainment Percentage
1	Designing research plan for the project	3	80%	70%
2	Experimental design and learning analysis tools	4	80%	70%
3	Experimental work and data validation	4, 5	80%	70%
4	Results analysis and report writing	4, 5	80%	70%

Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)

CLOs	**Program Learning Outcomes (PLO)**														
	Engineering Knowledge	**Problem Analysis**	**Design and Development**	**Analysis, Design and Research**	**Modern Tool and ICT Usage**	**Society and Multicultural**	**Environment and Sustainability**	**Moral, and Ethical Awareness**	**Individual and Teamwork Skills**	**Communication Skills**	**Project Management and**	**Self-Directed and Life Long**	**PSO 1**	**PSO 2**	**PSO 3**
Outcome 1	-	-	1	1	3	-	-	-	2	-	3	3	2	3	3
Outcome 2	-	3	1	1	2	-	3	-	3	-	3	2	2	2	2
Outcome 3	-	3	3	1	2	-	-	-	3	-	3	2	3	2	3
Outcome 4	-	3	3	1	2	-	-	-	3	-	3	2	3	2	3
Course Average	-	3	1	1	2	-	3	-	3	-	3	2	2	2	2

Course Unitization Plan

The students undergo a project work in the fourth semester. Each individual student is allotted with a supervisor. In the period of project work, student must identify the research problem, design the project work plan, complete the experimental/analytical work, and submit the project report. At the end of the project, student should be able to do research in his/her respective fields.

Learning Assessment

Bloom's Level of Cognitive Task		Continuous Learning Assessments (50%)								End Semester Exam (50%)	
		CLA-1 (10%)		CLA-2 (10%)		Mid term 1 (15%)		Mid Term 2 (15%)			
		Th	Prac	Th	Prac	Th	Prac	Th	Prac	Th	Prac
Level 1	Remember								30%		60%
	Understand										
Level 2	Apply								50%		40%
	Analyse										
Level 3	Evaluate								20%		
	Create										
Total									**100%**		**100%**

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