ADAMAS UNIVERSITY

PURSUE EXCELLENCE

KOLKATA

ADAMAS UNIVERSITY

SCHOOL OF ENGINEERING & TECHNOLOGY

Department of Civil Engineering

M.Tech. Environmental Engineering Program

Course File (Lab)

Course Name: Design of Environmental Engineering Systems

Course Code: ENV22016

Course Coordinator: Mr. Sayanta Sikdar/ Ms. Mayurakshi Banerjee

Year: I

Semester: II

6. **Name of the Faculty: Sayanta Sikdar** **Course Code: ENV22016**
7. **Course : Design of Environmental Engineering Systems** **L: 0**
8. **Program : M.Tech (Environmental Engineering)** **T: 0**
9. **Target : 60%** **P: 3**

C: 2

LABORATORY COURSE FILE CONTENTS

Check list Course Outcomes Attainment

S. No.	Contents	Available (Y/N/NA)	Date of Submission	Signature of HOD
1.	Authenticated Syllabus Copy	Y		
2.	Individual Time Table	Y		
3.	Students' Name List (Approved Copy)	Y		
4.	Course Plan, PO, PSO, COs, CO-PO Mapping, COA Plan, Session Plan and Periodic Monitoring	Y		
5.	Rubrics for Assessment of Laboratory Experiments	Y		
6.	**Lab Manual / Lab Learning Materials** a) List of Experiments (Cycle I & Cycle II) b) Detailed Procedure for Experiments & Field Applications c) Viva-Voce Questions d) Smart Lab Experiments if any	Y		
7.	Dissemination of Syllabus and Course Plan to the Students	Y	07.04.2021	
8.	**Continuous Assessment** A. Laboratory Observation B. Laboratory Records C. Evaluation Sheet with Rubrics D. Slow Learners List and RemedialMeasures	Y		
9.	Course End Survey (Indirect Assessment)& Consolidation	Y	15.08.2021	
10.	**End Term Examination** A. Question Paper B. Sample Answer Scripts (Best, Average,Poor) if available C. Evaluation Sheet with Rubrics D. Slow Learners List and Remedial Measures.	Y		
11.	Content Beyond the Syllabus (Proof)	Y		
12.	Innovative Teaching Tools Used	Y	15.08.2021	

Year: I

Semester: II

6. **Name of the Faculty: Sayanta Sikdar** **Course Code: ENV22016**
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C: 2

13.	Consolidated Mark Statement	Y		
14.	CO Attainment (Continuous Assessment + End Term)	Y	26.08.2021	
15.	Gap Analysis & Remedial Measures	Y	26.08.2021	
16.	CO - PO Attainment	Y	26.08.2021	
17.	Class Record (Faculty Logbook)	Y	26.08.2021	

Signature of HOD/ Dean **Signature of Faculty**

Date: 26.08.2021 **Date: 26.08.2021**

Year: I

Semester: II

6. Name of the Faculty: Sayanta Sikdar		**Course Code: ENV22016**
7. Course	**: Design of Environmental Engineering Systems**	**L: 0**
8. Program	**: M.Tech (Environmental Engineering)**	**T: 0**
9. Target	**: 60%**	**P: 3**
		C: 2

ENV22016 (ECE61202)	**Design of Environmental Engineering Systems**	L	T	P	C
Version 1.0		0	0	3	2
Pre-requisites/Exposure					
Co-requisites	Elective I: Environmental System Engineering (ECE61103)				

Syllabus Copy

Course Objectives

1. To familiarize the students with the basics of ecological systems and introduce them to the concept of ecological engineering.
2. To understand the concept and application of ecological modeling.

Course Content

Experiment 1: Development and Evolution of ecosystems- Principles and concepts.
Experiment 2: Energy flow and material cycling-productivity- classification of eco-technology-ecological engineering.
Experiment 3: Classification of systems-Structural and functional interactions of environmental systems-Mechanisms of steady-state maintenance in open and closed systems.
Experiment 4: Modeling and eco-technology- Classification of ecological models-Applications-Ecological economics-Self –organizing design and processes-Multi seeded microcosms.
Experiment 5: Interface coupling in the ecological systems- concepts or energy-determination of sustainable loading of ecosystems.
Experiment 6: Eco-Sanitation- soil infiltration systems-Wetlands and ponds-Source Separation systems-Aqua cultural systems-Agro ecosystems-Detritus based Treatment for solid wastes –marine systems.
Experiment 7: Case Study 1.
Experiment 8: Case Study 2.

Text Books:

1. Ecological Engineering: Principlesand Practice, Kangas, P.C and Kangas, P., Lewis Publishers, New York (2003).
2. Ecological Engineering for Wastewater Treatment, Etnier, C. and Guterstam, B., Lewis Publishers, New York (1996).

Reference Books:

Year: I

Semester: II

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C: 2

1. Basic Ecology, E .P. Odum, H.S Publication (1983).
2. Energy and Ecological Modelling,W.J Mitch, R. W. Bosserman and KlopatekJN,Elsevier Publication (1981).

Faculty Individual Time Table

ADAMAS UNIVERSITY, KOLKATA

SCHOOL OF ENGINEERING & TECHNOLOGY

DEPARTMENT OF CIVIL ENGINEERING

M. Tech (Construction Engineering & Management)

Course Code & Course: CEM21017 & Maintenance and Rehabilitation of Structures
Faculty Coordinator: Sayanta Sikdar

Day & Time	9:30-10:25	10:30-11:25	11:30-12:25	12:25-13:30	13:30-14:25	14:30-15:25	15:30-16:25	16:30-17:25
Monday				L		Maintenance and Rehabilitation of Structures	Soil Mechanics	
Tuesday	Foundation Engineering		Maintenance and Rehabilitation of Structures	U	Design of Environmental Engineering Systems			
Wednesday		Soil Mechanics		N	CAPSTONE PROJECT			
Thursday		Foundation Engineering	Soil Mechanics	C				
Friday	SEMINAR		Maintenance and Rehabilitation of Structures	H		Foundation Engineering		

Signature of HOD — **Signature of Class Coordinator**

Date: 07.04.2021 — **Date: 07.04.2021**

Year: I

Semester: II

6. **Name of the Faculty: Sayanta Sikdar** — **Course Code: ENV22016**
7. **Course : Design of Environmental Engineering Systems** — **L: 0**
8. **Program : M.Tech (Environmental Engineering)** — **T: 0**
9. **Target : 60%** — **P: 3**

C: 2

Students Name List

Roll Number	Registration Number	Name of the Student
PG/02/MTEVE/2020/001	AU/2020/0004291	SNEHASHIS GHOSH
PG/02/MTEVE/2020/002	AU/2020/0004450	SRIJA SINHAROY
PG/02/MTEVE/2020/003	AU/2020/0004454	SUMIT KUMAR KHAN
PG/02/MTEVE/2020/004	AU/2020/0004460	SUSMITA PANDIT

Signature of HOD/Dean **Signature of Class Coordinator**

Date: 07.04.2021 **Date: 07.04.2021**

Year: I
Semester: II

6. **Name of the Faculty: Sayanta Sikdar** **Course Code: ENV22016**
7. **Course : Design of Environmental Engineering Systems** **L: 0**
8. **Program : M.Tech (Environmental Engineering)** **T: 0**
9. **Target : 60%** **P: 3**

C: 2

COURSE PLAN

Target	60% (marks)
Level-1	50% (population)
Level-2	60% (population)
Level-3	70% (population)

1. **Method of Evaluation**

UG	PG
Continuous Assessment (50%)	Continuous Assessment (50%)
End Semester Examination (50%)	End Semester Examination (50%)

*Keep as per Program (UG/PG)

2. **Passing Criteria**

Scale	PG	UG
Out of 10 Point Scale	CGPA – "5.00" Min. Individual Course Grade – "C" Passing Minimum – 40	CGPA – "5.00" Min. Individual Course Grade – "C" Passing Minimum – 35

*Keep as per Program (UG/PG)

3. **Pedagogy**
   - Direct Instruction
   - Kinesthetic Learning
   - Flipped Classroom
   - Differentiated Instruction
   - Expeditionary Learning
   - Inquiry Based Learning
   - Game Based Learning
   - Personalized Learning
4. **Topics introduced for the first time in the program through this course**
   - (New Experiments - Content Beyond Syllabus – Rainwater Harvesting methods)

5. **References:**

Text Books	Web resources	Journals	Reference books
2			2

Signature of HOD/Dean **Signature of Faculty**

Date: 07.04.2021 **Date: 07.04.2021**

Year: I

Semester: II

6. **Name of the Faculty: Sayanta Sikdar** — **Course Code: ENV22016**
7. **Course : Design of Environmental Engineering Systems** — **L: 0**
8. **Program : M.Tech (Environmental Engineering)** — **T: 0**
9. **Target : 60%** — **P: 3**

C: 2

GUIDELINES TO STUDY THE SUBJECT

Instructions to Students:

1. Go through the 'Syllabus' in the LMS in order to find out the Reading List.
2. Get your schedule and try to pace your studies as close to the timeline as possible.
3. Get your on-line SmartLab videos section. Make sure you use them during this course.
4. check your LMS regularly
5. go through study material
6. check mails and announcements on blackboard
7. keep updated with the posts, assignments and examinations which shall be conducted on the blackboard
8. Be regular, so that you do not suffer in any way
9. C**ell Phones and other Electronic Communication Devices:** Cell phones and other electronic communication devices (such as Blackberries/Laptops) are not permitted in classes during Tests or the Mid/Final Examination. Such devices MUST be turned off in the class room.
10. **E-Mail and online learning tool:** Each student in the class should have an e-mail id and a pass word to access the LMS system regularly. Regularly, important information – Date of conducting class tests, guest lectures, via online learning tool. The best way to arrange meetings with us or ask specific questions is by email and prior appointment. All the assignments preferably should be uploaded on online learning tool. Various research papers/reference material will be mailed/uploaded on online learning platform time to time.
11. **Attendance:** Students are required to have minimum attendance of 75% in each subject. Students with less than said percentage shall NOT be allowed to appear in the end semester examination.

This much should be enough to get you organized and on your way to having a great semester! If you need us for anything, send your feedback through e-mail sayanta1.sikdar@adamasuniversity.ac.in Please use an appropriate subject line to indicate your message details.

There will no doubt be many more activities in the coming weeks. So, to keep up to date with all the latest developments, please keep visiting this website regularly.

Year: I

Semester: II

6. **Name of the Faculty: Sayanta Sikdar** **Course Code: ENV22016**
7. **Course : Design of Environmental Engineering Systems** **L: 0**
8. **Program : M.Tech (Environmental Engineering)** **T: 0**
9. **Target : 60%** **P: 3**

C: 2

RELATED OUTCOMES

1. **The expected outcomes of the Program are:**

PO1	**Domain Knowledge:** Apply comprehensive knowledge of principles and concepts for different ecological and environmental systems.
PO2	**Analysis and Design:** Identify and analyze the strategic methodology of environmental engineering systems and its proper management using mathematical and engineering principles.
PO3	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions for Environmental system assessment.
PO4	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern simulation tools for understanding and managing environmental systems.
PO5	**Environment and sustainability:** Understand the need to maintain ecological and environmental systems to achieve sustainable future with all the necessary requirements.
PO6	**Ethics:** Understand the impact of environmental systems in societal, ethical and personal contexts, and demonstrate the knowledge.
PO7	**Individual or team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO8	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and moreover to give and receive clear instructions.
PO9	**Life-long Learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

2. **The expected outcomes of the Specific Program are: (upto3)**

PSO1	PG itself is a Specific Programme. Henceforth no PSO is Required.
PSO2	
PSO3	

Year: I

Semester: II

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C: 2

3. **The expected outcomes of the Course are: (minimum 4 and maximum 6)**

CO1	Apply the concept of ecological engineering in real life environmental engineering problems.
CO2	Infer the concept of eco-engineering in reference of eco-technology.
CO3	Demonstrate the various available ecological models.
CO4	Explain the concepts or energy-determination of sustainable loading of ecosystems.
CO5	Interpret the treatment process of marine systems.

4. **Co-Relationship Matrix**

Indicate the relationships by1- Slight (Low) 2- Moderate (Medium) 3-Substantial (High)

Program Outcomes / Course Outcomes	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9
CO1	3	3	-	-	3	-	-	-	3
CO2	3	3	-	-	3	-	-	-	3
CO3	3	-	3	-	3	-	-	-	-
CO4	3	3	-	-	3	-	-	-	-
CO5	3	3	3	-	3	-	-	-	3
Average	**3**	**3**	**3**	**-**	**3**	**-**	**-**	**-**	**3**

Year: I

Semester: II

6. **Name of the Faculty: Sayanta Sikdar** **Course Code: ENV22016**
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9. **Target : 60%** **P: 3**

C: 2

5. **Course Outcomes Assessment Plan (COA):**

Course Outcomes	**Continuous Assessment* (50 Marks)**		**End Term Exam (50 Marks)**	**Total (100 Marks)**
	Cycle I	**Cycle II**		
CO1	10	NA	10	20
CO2	10	NA	10	20
CO3	10	NA	10	20
CO4	NA	10	10	20
CO5	NA	10	10	20
Total	30	20	50	100

* Internal Assessment –Continuous Assessment

Year: I

Semester: II

6. **Name of the Faculty: Sayanta Sikdar** **Course Code: ENV22016**
7. **Course : Design of Environmental Engineering Systems** **L: 0**
8. **Program : M.Tech (Environmental Engineering)** **T: 0**
9. **Target : 60%** **P: 3**

C: 2

OVERVIEW OF COURSE PLAN OF COURSE COVERAGE

Course Activities:

S. No.	Description	Planned			Actual			Remarks
		From	To	No. of Session	From	TO	No. of Session	
1.	Cycle I Experiments	06.04.2021	11.05.2021	18	06.04.2021	11.05.2021	18	Completed as per Plan. Extra sessions were taken for content beyond syllabus, doubt clearing, PPT presentation by students
2.	Cycle II Experiments	01.06.2021	22.06.2021	12	01.06.2021	22.06.2021	12	Completed as per Plan. Extra sessions were taken for content beyond syllabus, doubt clearing, PPT presentation by students

Total No. of Instructional periods available for the course: 30 Sessions

Signature of HOD/Dean **Signature of Faculty**

Date: 01.07.2021 **Date: 01.07.2021**

Year: I

Semester: II

6. **Name of the Faculty: Sayanta Sikdar** **Course Code: ENV22016**
7. **Course : Design of Environmental Engineering Systems** **L: 0**
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C: 2

SESSION PLAN

Session Plan				Actual Delivery			
Exp.	Date	Topics to be Covered	CO Mapped	Exp.	Date	Topics Covered	CO Achieved
1	06.04.2021	Development and Evolution of ecosystems	CO1	1	06.04.2021	Development and Evolution of ecosystems	CO1
2	13.04.2021	Energy flow and material cycling-productivity- classification of eco-technology-ecological engineering.	CO2	2	13.04.2021	Energy flow and material cycling-productivity- classification of eco-technology-ecological engineering.	CO2
3	20.04.2021	Classification of systems-Structural and functional interactions of environmental systems	CO2	3	20.04.2021	Classification of systems-Structural and functional interactions of environmental systems	CO2
	27.04.2021	Mechanisms of steady-state maintenance in open and closed systems.	CO2		27.04.2021	Mechanisms of steady-state maintenance in open and closed systems.	CO2
4	04.05.2021	Modeling and eco-technology- Classification of ecological models-Applications	CO3	4	04.05.2021	Modeling and eco-technology- Classification of ecological models-Applications	CO3
	11.05.2021	Ecological economics-Self –organizing design and processes-Multi seeded microcosms.	CO3		11.05.2021	Ecological economics-Self –organizing design and processes-Multi seeded microcosms.	CO3

Cycle-I

Remarks: NA

Signature of Faculty

Date: 15.05.2021

Year: I
Semester: II

6. **Name of the Faculty: Sayanta Sikdar** **Course Code: ENV22016**
7. **Course : Design of Environmental Engineering Systems** **L: 0**
8. **Program : M.Tech (Environmental Engineering)** **T: 0**
9. **Target : 60%** **P: 3**

C: 2

SESSION PLAN
Cycle-II

Session Plan				Actual Delivery			
Exp.	Date	Topics to be Covered	CO Mapped	Exp.	Date	Topics Covered	CO Achieved
5	01.06.2021	Interface coupling in the ecological systems- concepts or energy-determination of sustainable loading of ecosystems.	CO4	5	01.06.2021	Interface coupling in the ecological systems- concepts or energy-determination of sustainable loading of ecosystems.	CO4
6	08.06.2021	Eco-Sanitation- soil infiltration systems-Wetlands and ponds-Source Separation systems-Aqua cultural systems-Agro ecosystems-Detritus based Treatment for solid wastes –marine systems.	CO5	6	08.06.2021	Eco-Sanitation- soil infiltration systems-Wetlands and ponds-Source Separation systems-Aqua cultural systems-Agro ecosystems-Detritus based Treatment for solid wastes –marine systems.	CO5
7	15.06.2021	Case Study 1.	CO5	7	15.06.2021	Case Study 1.	CO5
8	22.06.2021	Case Study 2.	CO5	8	22.06.2021	Case Study 2.	CO5

Remarks: NA **Signature of Faculty**

Year: I

Semester: II

6. Name of the Faculty: Sayanta Sikdar Course Code: ENV22016
7. Course : Design of Environmental Engineering Systems L: 0
8. Program : M.Tech (Environmental Engineering) T: 0
9. Target : 60% P: 3

C: 2

Date: 01.07.2021

Year: I

Semester: II

6. Name of the Faculty: Sayanta Sikdar — Course Code: ENV22016
7. Course : Design of Environmental Engineering Systems — L: 0
8. Program : M.Tech (Environmental Engineering) — T: 0
9. Target : 60% — P: 3

C: 2

PERIODIC MONITORING

Attainment of the Course (Learning) Outcomes:

Components	Attainment level	Action Plan	Remarks
Cycle I Continuous Assessment	CO1:	Assessment to be done by Viva-voce on 25.05.2021	Conducted as per schedule, Powerpoint presentations were conducted followed by viva-voce.
	CO2:		
	CO3:		
	CO4:	NA	
	CO5:	NA	
Cycle II Continuous Assessment	CO1:	NA	
	CO2:	NA	
	CO3:	NA	
	CO4:	Assessment to be done by Viva-voce on 29.06.2021	Conducted as per schedule, Powerpoint presentations were conducted followed by viva-voce.
	CO5:		
End Semester	CO1:	Scheduled on 27.07.2021	Conducted as per schedule
	CO2:		
	CO3:		
	CO4:		
	CO5:		
Any Other	CO1:	NA	
	CO2:		
	CO3:		
	CO4:		
	CO5:		

Signature of HOD/ Dean — **Signature of Faculty**

Date: 01.08.2021 — **Date: 01.08.2021**

Year: I
Semester: II

6. **Name of the Faculty: Sayanta Sikdar** **Course Code: ENV22016**
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List of experiments

Cycle-I

Experiment 1: Development and Evolution of ecosystems- Principles and concepts.
Experiment 2: Energy flow and material cycling-productivity- classification of eco-technology-ecological engineering.
Experiment 3: Classification of systems-Structural and functional interactions of environmental systems-Mechanisms of steady-state maintenance in open and closed systems.
Experiment 4: Modeling and eco-technology- Classification of ecological models-Applications-Ecological economics-Self –organizing design and processes-Multi seeded microcosms.

Cycle-II

Experiment 5: Interface coupling in the ecological systems- concepts or energy-determination of sustainable loading of ecosystems.
Experiment 6: Eco-Sanitation- soil infiltration systems-Wetlands and ponds-Source Separation systems-Aqua cultural systems-Agro ecosystems-Detritus based Treatment for solid wastes –marine systems.
Experiment 7: Case Study 1.
Experiment 8: Case Study 2.

Detailed Procedure for Experiments & Field Applications

Experiment 1

What is ecosystem?
An Ecosystem can simply be defined as a system, comprising of all living organisms existing with one another in a unit of space interacting with abiotic components.
Or,
The simplest definition of an ecosystem is that it is a community or group of living organisms that live in and interact with each other in a specific environment.

What is ecosystem development?
Thermodynamically, ecosystem growth is the increase of energy throughflow and stored biomass, and ecosystem development is the internal reorganization of these energy mass stores, which affect transfers, transformations, and time lags within the system.

What is Evolution of ecosystems?

Year: I
Semester: II

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In nature, vegetation or plant communities are changing from time to time. In the same place, the replacement of the old plant community by a new plant community is called vegetation succession. Similarly, an ecosystem is replaced by another ecosystem, which we call the ecosystem evolution.

Fundamental Concepts and Principles of Ecology:
There are certain basic fundamental ecological principles which describe various aspects of living organisms e.g. evolution and distribution of plants and animals, extinction of species consumption and transfer of energy in different components of biological communities, cycling and recycling of organic and inorganic substances, interactions and inter-relationships among the organisms and between organisms and physical environment etc.

Some important fundamental concepts and principles of ecology in terms of eco-system may be outlined as follows:
1. Eco-system is a fundamental well structured and organised unit that brings physical environment and living organisms together in a single framework which facilitates the study of interactions between biotic and abiotic components. Ecosystems are also functional units where in two biotic components, namely autotrophic and heterotrophic components are of major significance.
2. The biotic and abiotic components of biosphere ecosystem are intimately related through a series of large scale cyclic mechanisms which help in the transfer of energy, water, chemicals and sediments in various components of the biosphere.
3. Sustained life on the earth is a characteristic of eco-system, not of individual organisms or population (D.B. Botkin and E. A. Keller 1982).
4. In 1974, M. J. Holliman suggested four environmental principles to describe holistic nature of natural environment which largely influence the biological communities in a biosphere eco-system.
The different principles are as follows:
(i) Nothing actually disappears when we throw it away because all the materials are rearranged and cycled and recycled through a series of cyclic pathways in the natural environment.
(ii) All systems and problems are ultimately if not intimately, inter-related. It does not make squabble over which crisis is most urgent. We cannot afford the luxury of solving problems one by one that is both obsolete and ecologically unsound anyway.
(iii) We live on a planet earth whose resources are finite.
(iv) Nature has spent literally millions of years refining a stable eco-system.

5. According to D. B. Botkin and E.A. Keller (1982) the physical and biological processes follow the principle of uniformitarianism. This principle states that same physical (right from the origin of the planet, earth and its atmosphere) and biological (since the origin of first organism) processes which operate today, operated in the past not necessarily with constant magnitude and frequency with time and will operate in future but at rates that will vary as the environment influenced by human activity.
6. Natural hazards affect adversely the biological communities in general and man in particular when biological processes are associated with natural hazards, yet severe hazards are created.
7. All living organisms and physical environment are mutually reactive. The varying degrees of interactions among organisms, at both inter and intraspecific levels are positive, negative and sometimes neutral.
8. Solar radiation is the main driving force of the eco-system and it is trapped by green plants through the process of photo-synthesis. Energy flow in eco-system is unidirectional and non-cyclic. Eco-system energy flow (energetics) helps eco-system. The energy pattern and energy flow are governed by the laws of thermodynamics.

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9. The energy is transferred from one trophic level to the next higher trophic level but organisms at higher trophic levels receive energy from more than one trophic level.
10. R. L. Linderuan (1942) suggested some principles about the relationships between the trophic levels within a natural ecosystem.

(i) Principle-1:
With an increase in distance between the organisms of a given trophic level and the initial source of energy, the probability of the organisms to depend exclusively on the preceding trophic level for energy decreases.
(ii) Principle-2:
The relative loss of energy due to respiration is progressively greater to higher trophic levels because the species at higher trophic levels being relatively larger in size have to move and work for getting food and therefore more energy is lost due to respiration.
(iii) Principle-3:
Species at progressively higher trophic levels appear to be progressively more efficient in using their available food supply, because increased activity by predators increases their chances of encountering suitable prey species, and in general predators are less specific than their prey in food preference.
(iv) Principle-4:
Higher trophic levels tend to be less discrete than the lower ones because the organisms at progressively higher trophic levels receive energy from more than one source and are generalists in their feeding habit and they are more efficient in using their available food.
(v) Principle-5:
Food-chains tend to be reasonably short. Four vertical links is a common maximum because loss of energy is progressively higher for higher trophic levels and species at higher levels tend to be less discrete.

11. The inorganic and organic substances are circulated among the various components of biosphere through a series of closed system of cycles collectively known as bio- geochemical cycles.
12. The eco-system productivity depends on two factors:
(i) The availability of the amount of solar radiation to the primary producers at trophic level-I.
(ii) The efficiency of the plants to convert solar energy into chemical energy.
There is marked positive correlation between primary productivity and solar radiation.
13. There is inbuilt self-regulating mechanism in natural ecosystem, known as homeostatic mechanisms, through which any change caused by external factors in the eco-system is counter balanced by the responses of the system to the change in such a way that ultimately eco-system or ecological stability is restored. The ecological diversity and complexity enhance ecological or eco-system stability.
The ecological stability can be attained by the following manners:
(i) According to C. S. Elton (1958), increase in the diversity of food webs promotes ecosystem stability.
(ii) According to P.H. MacArthur (1955), the ecosystem stability increases with increase of number of links in the food web.
(iii) According to E.P. Odum (1971), high species diversity of a mature ecosystem representing a climax community is related to more stability of natural eco-system.

14. Eco-system instability results when an eco-system becomes unable to adjust with environmental changes.
15. According to Charles Darwin (1859), evolution of species epitomises the inherently dynamic nature of ecosystem.

16. Darwin's concept of progressive evolution of species was subsequently challenged by Devries and a new concept of mutation was proposed. Mutation is a process of spontaneous evolutionary change which introduces inheritable variations in species.
T. Dobzhansky (1950) suggested the following ideas regarding mutation -
(i) The mutation process furnishes the raw materials for evolution.
(ii) During sexual reproduction, numerous gene patterns are produced.
(iii) The possessors of some gene patterns have greater fitness than the possessors of other patterns in available environment.
(iv) The frequency of superior gene patterns is increased by the process of natural selection while the inferior gene patterns are suppressed.
(v) Groups of some combinations of proven adaptive worth become segregated into closed genetic system, called species.

17. The transition stages of sequential changes from one vegetation community to another vegetation community are called 'sere'. The sere is complete when the succession of vegetation community after passing through different phases, culminates into equilibrium condition. The vegetation community developed at the end of succession is called 'Climax vegetation', 'Climax community' or 'Climax climax.'
18. Besides community succession, the eco-system also undergoes the process of successional changes. There are two fundamental ideas regarding the process of successional changes.
(i) According to E.P. Odum (1962), ecological succession is one of the most important processes which results from the community modifying the environment, (ii) According to R. H. Whittaker (1953), the successional development of ecosystem is characterised by four major changes in the ecosystem viz.
(a) Progressive increase in the complexity and diversity of community;
(b) Progressive increase in the structure and productivity of the eco-system;
(c) Increase in soil maturity;
(d) Increase in relative stability and regularity of populations within the eco-system and stability of the eco-system itself.

19. The eco-system is mainly modified by man through the exploitation of natural resources. Man reduces ecological diversity and complexity by removing a host of biotic communications.
20. Preserving diversity in a world of rapidly shrinking resources will require a prompt and universal response on an appropriate application of ecological knowledge.

<u>Experiment 2</u>

Energy flow and material cycling:

- Sun is the major energy source for ecosystem
- Energy for photosynthesis- Chemical energy
- Key to studying biological systems
- Energy enters as light from sun and leaves the ecosystem as heat (flow)
- Not destroyed, but converted to forms that leave the ecosystem
- Nutrients are cycled within the ecosystem
- "Flow vs. cycle": Chemical **nutrients** and **energy** tend to **flow in the** same direction for most of an **ecosystem**. The **big difference** is that the chemical **nutrients** are ultimately recycled **in the ecosystem** while the **energy** is ultimately lost from the **ecosystem** to the universe at large. **Energy in** any **ecosystem** ultimately comes from the Sun.

- **Nutrient Cycling**
  - Plants are eaten (primary consumers)
  - Energy is used to build organic molecules
  - Death of organisms
  - Decomposers- bacteria and fungi break down complex molecules freeing nutrients for use by the ecosystem

Productivity:

The general term **"Production"** is the creation of new organic matter. When a crop of wheat grows, new organic matter is created by the process of photosynthesis, which converts light energy into energy stored in chemical bonds within plant tissue. This energy fuels the metabolic machinery of the plant. New compounds and structures are synthesized, cells divide, and the plant grows in size over time. The plant requires sunlight, carbon dioxide, water, and nutrients, and through photosynthesis the plant produces reduced carbon compounds and oxygen.

Whether one measures the rate at which photosynthesis occurs, or the rate at which the individual plant increases in mass, one is concerned with **primary production** (definition: the synthesis and storage of organic molecules during the growth and reproduction of photosynthetic organisms). The core idea is that new chemical compounds and new plant tissue are produced. Over time, primary production results in the addition of new plant biomass to the system. Consumers derive their energy from primary producers, either directly (herbivores, some detritivores), or indirectly (predators, other detritivores).

Some Definitions:

- **Primary producers** (usually plants and other photosynthesizers) are the gateway for energy to enter food webs.
- **Productivity** is the rate at which energy is added to the bodies of a group of organisms (such as primary producers) in the form of biomass.
- **Gross productivity** is the overall rate of energy capture. **Net productivity** is lower, adjusted for energy used by organisms in respiration/metabolism.
- Energy transfer between trophic levels is inefficient. Only ~10% of the net productivity of one level ends up as net productivity at the next level.
- **Ecological pyramids** are visual representations of energy flow, biomass accumulation, and number of individuals at different trophic levels.

* ***Gross Primary Production*, *GPP,*** is the total amount of CO_2 that is fixed by the plant in photosynthesis.

* ***Respiration*, *R,*** is the amount of CO_2 that is lost from an organism or system from metabolic activity. Respiration can be further divided into components that reflect the source of the CO_2.

$\mathbf{R_p}$ =Respiration by Plants

$\mathbf{R_h}$ = Respiration by Heterotrophs

$\mathbf{R_d}$ = Respiration by Decomposers (the microbes)

* ***Net Primary Production*, *NPP,*** is the net amount of primary production after the costs of plant respiration are included. Therefore, **NPP = GPP - R**

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* ***Net Ecosystem Production, NEP,*** is the net amount of primary production after the costs of respiration by plants, hetertrophs, and decomposers are all included. Therefore, **NEP = GPP - (R_p + R_h + R_d)**

A measure of Net Ecosystem Production is of great interest when determining the CO_2 balance between various ecosystems, or the entire Earth, and the atmosphere. This will be discussed more in our lectures on climate change and the global carbon cycle.

Note that in these definitions we are concerned only with "primary" and not "secondary" production. Secondary production is the gain in biomass or reproduction of heterotrophs and decomposers. The rates of secondary production, as we will see in a coming lecture, are very much lower than the rates of primary production.

Ecological engineering:
Ecological engineering **has been defined as the design of ecosystems for the mutual benefit of humans and nature. The journal is for those involved in** designing, monitoring**, or** restoring ecosystems**, and serves as a bridge between the fields of ecology and engineering**. Ecological engineering **uses** ecology **and** engineering **to predict, design, construct or restore, and manage ecosystems that integrate "human society with its natural environment for the benefit of both".**
Ecological engineering, defined as the design of sustainable ecosystems that integrate human society with its natural environment for the benefit of both, has developed over the last 30 years, and rapidly over the last 10 years. Its goals include the restoration of ecosystems that have been substantially disturbed by human activities and the development of new sustainable ecosystems that have both human and ecological values. It is especially needed as conventional energy sources diminish and amplification of nature's ecosystem services is needed even more. There are now several universities developing academic programs or departments called ecological engineering, ecological restoration, or similar terms, the number of manuscripts submitted to the journal *Ecological Engineering* continue to increase at an rapid rate, and the U.S. National Science Foundation now has a specific research focus area called ecological engineering. There are many private firms now developing and even prospering that are now specializing in the restoration of streams, rivers, lakes, forests, grasslands, and wetlands, the rehabilitation of minelands and urban brownfields, and the creation of treatment wetlands and phyto-remediation sites. It appears that the perfect synchronization of academy, publishing, research resources, and practice is beginning to develop. Yet the field still does not have a formal accreditation in engineering and receives guarded acceptance in the university system and workplace alike (William J.Mitsch, 2012).

Classification of Ecotechnology:
Ecological engineering may be based on one or more of the following four classes of ecotechnology:

1. Ecosystems are used to reduce or solve a pollution problem that otherwise would be (more) harmful to other ecosystems. A typical example is the use of wetlands for wastewater treatment.

2. Ecosystems are imitated or copied to reduce or solve a pollution problem, leading to constructed ecosystems. Examples are fishponds and constructed wetlands for treating wastewater or diffuse pollution sources.

3. The recovery of ecosystems after significant disturbances. Examples are coal mine reclamation and restoration of lakes and rivers.

4. The use of ecosystems for the benefit of humanity without destroying the ecological balance (i.e., the utilization of ecosystems on an ecologically sound basis). Typical examples are the use of integrated agriculture and development of organic agriculture; this type of ecotechnology finds wide application in the ecological management of renewable resources.

Experiment 3:

System: A system is a network of relationships among parts, elements, or components that interact with and influence one another through the exchange of energy, matter, or information. Systems receive inputs of energy, matter, or information; process these inputs; and produce outputs of energy, matter, or information. Earth's environment consists of complex, interlinked systems. Earth's systems include the complex webs of relationships among species and the interactions of living organisms with the nonliving objects around them. Earth's systems also include cycles that shape landscapes and guide the flow of chemical elements and compounds that support life and regulate climate.

Structure of the Ecosystem:

The structure of an ecosystem is characterised by the organisation of both biotic and abiotic components. This includes the distribution of energy in **our environment**. It also includes the climatic conditions prevailing in that particular environment.

The structure of an ecosystem can be split into two main components, namely:

- Biotic Components
- Abiotic Components

The biotic and abiotic components are interrelated in an ecosystem. It is an open system where the energy and components can flow throughout the boundaries.

Biotic Components -

Biotic components refer to all life in an ecosystem. Based on nutrition, biotic components can be categorised into autotrophs, heterotrophs and saprotrophs (or decomposers).

- **Producers** include all autotrophs such as plants. They are called autotrophs as they can produce food through the process of photosynthesis. Consequently, all other organisms higher up on the food chain rely on producers for food.
- **Consumers** or heterotrophs are organisms that depend on other organisms for food. Consumers are further classified into primary consumers, secondary consumers and tertiary consumers.
    - ***Primary consumers*** are always herbivores that they rely on producers for food.

- ***Secondary consumers*** depend on primary consumers for energy. They can either be a carnivore or an omnivore.
- ***Tertiary consumers*** are organisms that depend on secondary consumers for food. Tertiary consumers can also be an omnivore.
- ***Quaternary consumers*** are present in some food chains. These organisms prey on tertiary consumers for energy. Furthermore, they are usually at the top of a food chain as they have no natural predators.

Decomposers include saprophytes such as fungi and bacteria. They directly thrive on the dead and decaying organic matter. Decomposers are essential for the ecosystem as they help in recycling nutrients to be reused by plants.

Abiotic Components -

Abiotic components are the non-living component of an ecosystem. It includes air, water, soil, minerals, sunlight, temperature, nutrients, wind, altitude, turbidity, etc.

Functions of Ecosystem:

The functions of the ecosystem are as follows:

1. It regulates the essential ecological processes, supports life systems and renders stability.
2. It is also responsible for the cycling of nutrients between biotic and abiotic components.
3. It maintains a balance among the various trophic levels in the ecosystem.
4. It cycles the minerals through the biosphere.
5. The abiotic components help in the synthesis of organic components that involves the exchange of energy.

An ecosystem is a discrete structural, functional and life sustaining environmental system. The environmental system consists of biotic and abiotic components in a habitat. Biotic component of the ecosystem includes the living organisms; plants, animals and microbes whereas the abiotic component includes inorganic matter and energy. Abiotic components provide the matrix for the synthesis and perpetuation of organic components (protoplasm). The synthesis and perpetuation processes involve energy exchange and this energy comes from the sun in the form of light or solar energy. Thus, in any ecosystem we have the following functional components: (i) Inorganic constituents (air, water and mineral salts) (ii) Organisms (plants, animals and microbes), and (iii) Energy input which enters from outside (the sun). These three interact and form an environmental system. Inorganic constituents are synthesized into organic structures by the green plants (primary producers) through photosynthesis and the solar energy is utilized in the process. Green plants become the source of energy for renewals (herbivores) which, in turn become source of energy for the flesh eating animals (carnivores). Animals of all types grow and add organic matter to their body weight and their source of energy is complex organic compound taken as food. They are known as secondary producers. All the living organisms whether plants or animals in an ecosystem have a definite life span after which they die. The dead organic remains of plants and animals provide food for saprophytic microbes, such as bacteria, fungi and many other animals. The saprobes ultimately decompose the organic structure and break the complex molecules and liberate the inorganic components into their environment. These organisms are known as decomposers. During the process of decomposition of organic molecules, the energy which kept the inorganic components bound together in the form of organic molecules gets liberated and dissipated into the environment as heat energy. Thus in an ecosystem energy from the sun, the input is fixed by plants and transferred to animal components. Nutrients are withdrawn from the substrate, deposited in the tissues of the plants and animals, cycled from one feeding group to another, released by decomposition to the soil, water and air and then recycled. The ecosystems operating in different habitats, such as deserts, forests, grasslands and seas are interdependent on one another. The energy and nutrients of one ecosystem may find their way into another so that ultimately all parts of the earth are interrelated, each comprising a part of the total system that keeps the biosphere functioning.

A system can be either closed or open -

A closed system *is a system that is completely isolated from its environment.*

This is the definition commonly used in the system literature, which we have chosen to follow. This is different from the thermodynamics definition, which differentiates between systems that are "closed" (no material flow) and "isolated" (no material or energy flow).

The physical universe, as we currently understand it, appears to be a closed system.

An open system *is a system that has flows of information, energy, and/or matter between the system and its environment, and which adapts to the exchange.*

This a fundamental systems science definition. It differs from the meaning of "open system" in IT and related fields, where the term is used in the sense of "open system architecture" that allows for a vendor-independent, non-proprietary, computer system or device design based on official and/or popular standards.

All physical systems of interest to systems engineering are open systems. However, there can be special cases in systems engineering where it is convenient to treat a system as if it is closed, if there are no significant external relationships or interactions to contend with.

Entropy increases in a closed system. In open systems, the entropy is kept low, or decreases, essentially at the expense of entropy increasing somewhere else, so the entropy of the universe continues to increase. Thus, systems tend to maintain their organisation at the expense of increased disorder elsewhere, which is a common cause of unintended consequences.

It follows that a more fundamental definition of "system" could be "a persistent region of low entropy (= high organisation) in physical or conceptual space-time". Then, it would follow that "systemness is the phenomenon that allows regions of organisation to persist in a dissipative universe".

What Is a Steady State Ecosystem?

Some ecosystems exist in a *steady state,* or *homeostasis.* In steady-state systems, the amount of input and the amount of output are equal. In other words, any matter entering the system is equivalent to the matter exiting the system.

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An *ecosystem* includes living organisms and the environment that they inhabit and depend on for resources. Environmental scientists who study system interactions, or *system dynamics,* have defined a few important patterns to these interactions.

Some lakes exist as steady-state systems in terms of their water volume. For example, a lake that has a stream feeding water into it may also be losing water that soaks into the ground or exits by another stream.

In this way, even though the stream provides a constant input of water into the lake, the lake also experiences a constant and equal output of water. As a result, the total amount of water within the lake stays the same.

Most systems continually shift inputs and outputs to maintain a steady state. Your body temperature, which remains fairly constant, is one example. When your body gets too hot, it releases heat through sweating. When your body gets too cold, it generates more heat through shivering. In this way, your body attempts to keep your temperature at a steady state by making minor adjustments to its energy inputs and outputs.

Like your body temperature, many natural systems respond to inputs by adjusting outputs. In fact, maintaining a steady state without change is difficult (and rare). So as systems try to reach equilibrium, they constantly shift inputs and outputs.

The adjustments that a system makes as inputs enter or outputs exit are called *feedbacks.* The two types of feedbacks are

- **Negative feedbacks:** These feedbacks slow down or suppress changes, sometimes helping the system return to a steady state.

- **Positive feedbacks:** These feedbacks lead to increased change, sending the system further away from a steady state.

Feedbacks often set off a chain of changes, called a *feedback loop,* in the system. For example, the internal regulation of your body temperature is a negative feedback loop. A change in your body temperature triggers parts of the system (your body) to respond by increasing (shivering) or decreasing (sweating) the temperature and sending it back toward a steady state, thus suppressing change.

On the other hand, population growth can create a positive feedback loop. When more births occur, the next generation has more people to have more babies. In time, these babies grow up to have more babies, who grow up to have more babies, and so on. Thus, positive feedback loops can lead to *runaway effects* — sending a system far from its steady state.

Experiment 4:

Ecological modeling:

Ecological modelling is the construction and analysis of mathematical models of ecological processes, including both purely biological and combined biophysical models. Models can be analytic or simulation-based and are used to understand complex ecological processes and predict how real ecosystems might change.

There are three **types of ecological models** which relate to change: temporal, spatial, and spatial–dynamic.

Applications - Ecological models can be **used for** survey, to reveal system properties, establish research priorities, and to test scientific hypotheses. Hence, we consider them **useful** as experimental tools. A basic grouping shows that **ecological models** in general belong to three areas: biodemographic, bioenergetic and biogeochemical.

What is Ecological Economics?
Ecological economics is an interdisciplinary field defined by a set of concrete problems or challenges related to governing **economic** activity in a way that promotes human well-being, sustainability, and justice.

Ecological economics vs. conventional economics –
Ecological economics is a growing trans-disciplinary field that aims to improve and expand economic theory to integrate the earth's natural systems, human values and human health and well-being. In conventional economics, the primary goal is to increase goods and services produced by human industries (built capital), and the gross domestic product (GDP) is a national measure of the total value of goods and services produced annually. Conventional economics assumes that ever-increasing GDP is desirable, possible, and that everyone benefits. Ecological economics takes a broader perspective and recognizes that there are more things that contribute to human well-being than just the amount of stuff, such as health and education (human capital), friends and family (social capital) and the contribution of the earth and its biological and physical systems (natural capital). Its goal is to develop a deeper scientific understanding of the complex linkages between human and natural systems, and to use that understanding to develop effective policies that will lead to a world which is ecologically sustainable, has a fair distribution of resources (both between groups and generations of humans and between humans and other species), and efficiently allocates scarce resources including "natural" and "social" capital. Four main types of capital are considered in ecological economics:

• Built capital is the type of capital we are used to thinking about in conventional economics. It refers to goods and services created by human industry – buildings, cars, appliances, roads, toys, etc.

• Natural capital is a concept that recognizes the importance and value of the goods and services provided by nature. It goes beyond the traditional consideration of natural products as raw materials for conversion into goods (trees into houses or paper) to consider functions that are provided by planetary systems (breathable air, a stable climate) or local ecosystems (flood protection by coastal wetlands, and drinking water purification by forests). Sometimes the monetary value of these ecosystem services can be calculated, such as the cost to replace them with built capital (coastal wetlands with levees). However, some natural services are priceless. They are essential for life, and irreplaceable (breathable air).

• Social capital refers to the positive benefits gained through our interactions with others (friends, family, social groups) and the common structures of our society (languages, institutions, educational system, laws). It makes a major contribution to our collective well-being, but is hard to quantify in monetary terms.

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• Human capital refers to the sum of our own health, personal experiences, education, talents, skills and interests. Collective human capital (and social capital) cannot be maximized unless there is social justice, equivalent access to the opportunities that our society provides.

What is sustainability and how does it relate to Ecological Economics?

Ecological economics reminds us that "sustainability" is a multi-faceted goal by focusing on the complex interrelationship between different elements of sustainability: ecological sustainability, social sustainability and economic sustainability. It reminds us of the complexity of the many interacting systems that make up the biosphere and the uncertainty that is a fundamental characteristic of all complex systems. Ecological economics is concerned with the problem of assuring sustainability in the face of uncertainty, and aims to maintain the resilience of ecological and socioeconomic systems by conserving and investing in natural, social and human assets. Ecological economics also seeks true economic efficiency. Economic efficiency and good economic decision making are not possible if all of the costs and benefits are not considered or included in prices. Often current market prices do not capture the full costs of an economic activity that depletes resources or damages natural systems (natural capital); or inflicts costs to human health and well-being (social and human capitals) caused by pollution or other side effects of the activity. These excluded costs are called "externalities", defined as costs that are not included in the price of the product but are shouldered by a third party, outside the producer/seller and buyer/consumer. Capture of these costs in the market would provide a powerful incentive to move towards sustainability.

Self –organizing design and processes:

A self-organizing system produces complex organization from randomness without external intervention. Most of the systems involved in environmental management are self-organizing, and two examples are discussed briefly in this section to illustrate the point. However, it should be noted that some relevant systems do not appear to be self-organizing. These include groundwater aquifers, and man-made systems such as pollution-control equipment.

It is intuitively obvious that ecosystems are selforganizing, but nevertheless, it is worth demonstrating that they fulfill the formal criteria. They are clearly far from thermodynamic equilibrium, and use natural energy flows to maintain themselves. They are governed by recursive rules, many of which are nonlinear, as shown by the typical structure of ecosystem models. Examples of positive feedback are not hard to identify. For instance, in many parts of Australia, death or removal of native vegetation from an area may result in increased soil and water salinity and the death of further vegetation. Ecosystem behavior cannot be deduced from that of component parts, as evidenced by the need for simulation models. Moreover, it is significantly determined by internal processes within regional climatic and geological constraints. System evolution occurs due to both human and natural disturbances. "We used to think that a forest was basically a group of species that had evolved together or been together for a very long time. Now what we find is that a forest community is a group of species that may have recently migrated together and then, in the future, might migrate in separate directions" (Oliver, cited by Dayton 1990). "The only constant factor in our forest ecosystems is change" (Shea and Underwood 1990).

Multi seeded microcosms:

Ecological microcosms are small ecosystems held in containers. Starting originally as a way to bring the beauty and complexity of nature into schoolrooms and living rooms the world over, these small "worlds" have become a major research tool. They are useful for studying the way ecosystems work and for the very practical purpose of determining what happens to toxic substances in ecosystems. Microcosms are important because

they are a way to study whole, simplified ecosystems, and because they can be replicated for experimental studies at reasonable cost. This book is a review of the extensive but scattered papers and reports on microcosms, with emphasis on the concepts of systems ecology that emerge from the hypotheses and experimental tests.
Some of the most successful investigators have emulated nature by fostering waves of immigration into their **microcosms**. This is usually termed mul- tiple **seeding**. Organisms from similar, but geographically different sources are placed in the **microcosm**, and the system is allowed to establish its own web of interactions.

Experiment 5:

Energy that is not used in an **ecosystem** is eventually lost as heat. **Energy** and nutrients are passed around through the food chain, when one organism eats another organism. ... In each case, **energy** is passed on from one trophic level to the next trophic level and each time some **energy** is lost as heat into the environment.

Energy is transferred between organisms in food webs from producers to consumers. The energy is used by organisms to carry out complex tasks.
The vast majority of energy that exists in food webs originates from the sun and is converted (transformed) into chemical energy by the process of photosynthesis in plants. A small proportion of this chemical energy is transformed directly into heat when compounds are broken down during respiration in plants. The majority of the chemical energy stored in plants is transformed into other forms by an assortment of consumers, such as cows, rabbits, horses, sheep, caterpillars and other insects eating plants.

Some of the stored chemical energy in a producer such as grass is stored as chemical energy in the fat or protein in the first order consumers that eat the grass. This energy is available for higher order consumers. At each stage of a food chain, most of the chemical energy is converted to other forms such as heat, and does not remain within the ecosystem.

What is ecosystem sustainability?

Ecological **sustainability** means that, based on a long-term perspective, we conserve the productivity of the waters, the soil and the **ecosystem**, and reduce our impact on the natural environment and people's health to a level that the natural environment and humanity can handle.

It considers entire **ecosystems**, with their complex connections, rather than individual sites or species; It aims to balance human social, economic and cultural needs (the delivery of essential **ecosystem** services) with **ecosystem sustainability** (maintaining healthy, productive and resilient **ecosystems** in the long term).

For **sustainability**, **ecosystems** use sunlight a non-depleteable non-polluting form of energy. For **sustainability**, **ecosystems** break down and recycle all wastes as nutrients. For **sustainability**, Herbivore populations must be kept in check so that overgrazing and destruction of the **ecosystem** does not occur.

There are three main components required for sustainability in an ecosystem:

- *Energy availability* – light from the sun provides the initial energy source for almost all communities
- *Nutrient availability* – saprotrophic decomposers ensure the constant recycling of inorganic nutrients within an environment
- *Recycling of wastes* – certain bacteria can detoxify harmful waste byproducts (e.g. denitrifying bacteria such as *Nitrosomonas*)

Experiment 6:

Eco-Sanitation:

Ecological sanitation (Ecosan) is a new concept in handling substances that have so far been termed wastewater or watercarried waste for disposal. It is a hygienic system of human waste disposal to retrieve and re-use the nutrients like nitrogen, phosphorus and potassium from human waste, and to economise the use of water. It is based on the idea that urine, faeces and water are resources in an ecological loop and, recycling of nutrients helps ensure food security. Ecosan aims to promote the development, implementation and dissemination of socially and culturally acceptable and sustainable sanitation approaches. These approaches are hygienically safe and environmentally sound. The main objectives of Ecosan are to:

* reduce the health risks associated with sanitation, water contamination and waste disposal * prevent the pollution of surface and underground water * reduce, through recycling of grey water, wastewater discharged to sewers * prevent the degradation of soil fertility * optimise the management of nutrients and water resources for agricultural purposes, by recovering nutrients from urine and faeces.

Ecological engineering for wastewater treatment or ecological sanitation (ecosan) implies that principles of ecology are applied to design and implementation of wastewater treatment systems (see aso sustainable sanitation, linking up sustainable sanitation water management and agriculture). In nature, everything operates in cycles (see also the water cycle and the nutrient cycle). For wastewater treatment, reuse and recycling therefore become important issues when ecological thinking is applied. Minimising the reliance on fossil fuels is another criteria, which may influence design and selection of system type. Ecological thinking also means tailoring the wastewater treatment system to local contexts including natural, economic, social, and/or religious conditions (see also module 7: socioeconomic aspects and economic, socio-cultural issues and development issues). Ecological sanitation is not fixed to any one system, but emphasizes the need for a holistic systems approach based on ecological thinking in order to design sustainable treatment systems (see also linking up sustainable sanitation with water management and agriculture and sanitation systems).
Recycling may be facilitated if the wastewater is source separated into blackwater (toilet waste – urine and faeces) and greywater (water from showers, sinks, kitchen) because the majority of resources (plant nutrients as nitrogen, phosphorus, potassium and organic matter) in wastewater are present in our excreta. Hygienising excreta opens interesting possibilities for co-treatment with other organic waste from households and/or agriculture, and the generation of bioenergy.

The simplest natural systems (ponds, wetlands, soil infiltration, see also soak pits and nonplanted filters) can operate by gravity alone and may not need mechanical devices; hence, they are often favoured because of low energy requirements. Ecological sanitation is therefore often associated with natural systems and systems that utilize source separation (i.e. urine diversion, such as urine diversion flush toilet, UDDTs) in order to reclaim and recycle resources in wastewater as plant nutrients, organic matter and water. The main focus of wastewater research at UMB is connected to natural and source separating recycling systems.

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Conventional sanitary systems (centralized collection system and technically complex treatment processes) can produce a better ecological result by optimising resource gains and minimising resource use. Energy can be obtained from wastewater through the use of heat pumps and biogas generation from sludge (see also energy from sludge). When optimised in this way, conventional systems are not necessarily ecologically inferior solutions.
It is unlikely that one single system can solve all future sewerage problems. Large investments have been made in conventional sewage systems which will be in operation for decades, but conventional systems will evolve as the principles of ecological thinking are communicated to the engineering society. Totally new systems, as well as hybrid or combination systems, will appear. Schools that teach ecological engineering and consultants and companies that implement ecological engineering will have advantages in the market because they can offer a broader range of solutions, solutions that more easily fulfill local requirements. A variety of systems are needed to meet the natural constraints of different regions, differing legislations, different sociological conditions, different budgets, health considerations and personal needs and preferences.

Soil infiltration systems:

Soil infiltration refers to the **soil's** ability to allow water movement into and through the **soil** profile.

A soil storage and infiltration system collects rainfall runoff from the roofs of buildings and directs it underground where it infiltrates into the soil. The system consists of gutters and downspouts to collect roof runoff, a catch basin to capture trash and fine particles, underground trenches that store the water while it soaks slowly into the soil, and an observation port to aid in maintenance. When the trench is filled with water during a storm, the excess water flows from the gutter and onto the ground surface. A soil storage and infiltration system decreases the volume of runoff, contains potential pollutants, and increases the amount of water entering the ground to recharge our groundwater systems.

Wetlands and ponds:

A wetland is an area of land that is saturated with water**.** Wetlands play many important roles in the environment including water purification, flood prevention, stabilizing shorelines, and serve as habitat for fish, shellfish, waterfowl and other wildlife. There are many different kinds of wetlands and many ways to categorize them. NOAA classifies wetlands into five general types: marine (ocean), estuarine (estuary), riverine (river), lacustrine (lake), and palustrine (marsh). Common names for wetlands include marshes, estuaries, mangroves, mudflats, mires, ponds, fens, swamps, deltas, coral reefs, billabongs, lagoons, shallow seas, bogs, lakes, and floodplains, to name just a few!

Often found alongside waterways and in floodplains, wetlands vary widely due to differences in soil, topography, climate, water chemistry, and vegetation. Large wetland areas may also be comprised of several smaller wetland types.

Wetland habitats serve essential functions in an ecosystem, including acting as water filters, providing flood and erosion control, and furnishing food and homes for fish and wildlife. They do more than sustain plants and animals in the watershed, however. Many wetlands are not wet year-round because water levels change with the seasons. During periods of excessive rain, wetlands absorb and slow floodwaters, which helps to alleviate property damage and may even save lives.

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C: 2

Wetlands also absorb excess nutrients, sediments, and other pollutants before they reach rivers, lakes, and other waterbodies. They are also great spots for fishing, canoeing, hiking, and bird-watching, and are enjoyable outdoor "classrooms" for people of all ages.

Freshwater wetlands on the Refuge are diverse habitats and include swamps, marshes, seeps, springs, bogs, and seasonal wetlands. Ponds, such as those created by beavers, are also included in this habitat type. They are home to a variety of wildlife and serve as nurseries for amphibians, dragonflies and fish. Aquatic plants often have less structure because they will be supported by water at least part of the time. Freshwater wetlands and surrounding vegetation support a variety of birds such as great blue herons, marsh wrens, common yellowthroats, red-winged blackbirds, and song sparrows.

Freshwater marsh and bog communities scattered throughout the refuge host plants such as skunk cabbage, yellow pond lily, pondweeds, bladderworts, grasses, sedges, and rushes.

Source Separation systems:

Ecological sanitation is not fixed to any one system, but emphasises the need for a holistic systems approach based on ecological thinking in order to design sustainable treatment systems (see also **sanitation systems** and **sustainable treatment systems**). Recycling is an important aspect of ecological sanitation. It is facilitated if the wastewater is source separated. This lecture has focus on source separating systems (such as **urine diversion** or **separate sewers**) and recycling of waste and wastewater resources to agriculture (**linking up sustainable sanitation with water management and agriculture** and **recharge and reuse**). To address issues of poor sanitation and water scarcity in developing countries, innovative wastewater management systems should be proposed, based on considerations of life cycle and local environmental impacts. Source-separation separates urine, feces, and gray water, enhancing the reuse of nutrients, and is considered a promising wastewater treatment method.

Aqua cultural systems:

Aquaculture is a method used to produce food and other commercial products, restore habitat and replenish wild **stocks**, and rebuild populations of threatened and endangered species. There are two main types of aquaculture—**marine** and **freshwater**.

Types of aquaculture systems:

Aquaculture systems range from very extensive, through semi-intensive and highly intensive to hyper-intensive. When using this terminology the specific characterization of each system must be defined, as there are no clear distinctions and levels of intensification represent a continuum.

Farming systems are also diverse for example including:

- Water-based systems (cages and pens, inshore/offshore).
- Land-based systems (rainfed ponds, irrigated or flow-through systems, tanks and raceways).
- Recycling systems (high control enclosed systems, more open pond based recirculation).
- Integrated farming systems (e.g. livestock-fish, agriculture and fish dual use aquaculture and irrigation ponds).

Various aquatic organisms are grown in different ways including:

- Fish (ponds, polishing ponds, integrated pond systems).
- Seaweeds and macrophytes (floating/suspended culture, onshore pond/tank culture).
- Molluscs (bottom, pole, rack, raft, long-line systems also culture based fisheries)
- Crustaceans (pond, tank, raceway, culture based fisheries).
- Other minor invertebrates, such as echinoderms, coelenterates, seahorses, etc (tanks, ponds, culture based fisheries)

The phases of aquaculture include broodstock holding, hatchery production of seed, nursing systems, grow-out systems, and quarantining.

Together, this mix of intensity, culture systems, species, farming systems and different phase of culture create an extreme diverse collection of aquaculture systems and technologies.

Agro ecosystems:
An **agroecosystem** is the basic unit of study in agroecology, and is somewhat arbitrarily defined as a spatially and functionally coherent unit of agricultural activity, and includes the living and nonliving components involved in that unit as well as their interactions.
It's different from a natural ecosystem for four main characteristics: simplification: a farmer favours a plant species removing all other **animal** or plant species which could damage it. the **energy** intake employed by men in the form of machinery, fertilizers, pesticides, selected seeds, processings.

Agroecosystems, in particular through sustainable use of soils, may provide **important** regulating, as well as provisioning services including climate change mitigation and food production.

The difference between natural and artificial ecosystems There are several differences between natural and artificial ecosystems, including sustainability, diversity and purpose. A natural ecosystem has a diverse amount of species and plants, whereas artificial ecosystems are limited. Natural ecosystems are self-sustaining and result from spontaneous natural reaction, while artificial ecosystems require the assistance of humans. A natural ecosystem is the result of interactions between organisms and the environment. For example, an ocean is classified as a marine ecosystem, which consists of algae, consumers and decomposers. A cycle occurs in this type of ecosystem that begins with algae converting energy via photosynthesis. After consumers feed on the algae, energy is transferred between the organisms. Once consumers die in this system, decomposers turn them into organic matter. This process occurs naturally over a period of time, whereas in an artificial ecosystem, human intervention is required. An artificial ecosystem is not self-sustaining, and the ecosystem would perish without human assistance. For example, a farm is an artificial ecosystem that consists of plants and species outside their natural habitat. Without humans, this ecosystem could not sustain itself. The plants and animals need the help of humans to eat and survive. Another major difference between a natural ecosystem and artificial ecosystems is diversity. Natural ecosystems contain more natural factors and organisms. The relationships between organisms, each other and the environment in this ecosystem are more complex than that of artificial ecosystems. Living walls are artificial ecosystems. All living walls require human intervention in order to thrive, in the form of water and nutrient supply, and the management of pests and diseases. Indoor living walls also need the right kind of light. Engineered components, such as the irrigation system, are essential to the functioning of the system; for example, the kind of geotextile used in a hydroponic living wall system will directly influence the ability of the plants to receive the right amount of water – not too much, and not too little. Engineered components also support and influence the biological components of the systems. Human design is thus an essential factor underlying all artificial ecosystems. Living wallsfeature relatively simple designs, compared with the obvious complexity of natural ecosystems. Living walls may feature high levels of ecological novelty, such as combinations of species that have not occurred in the evolutionary history of the organisms or populations involved. If novelty results in conditions that exceed the tolerance of individual organisms, then stress, reduced fitness, changes to community structure and consequences to ecosystem functioning can result. A major cause of novelty in artificial ecosystems comes from their creation from scratch in disconnection from natural ecosystems, often resulting in a lack of biological legacy and ecological memory inherent to the dynamics of natural ecosystems. In natural ecosystems, the soil represents an ecological reservoir containing seeds and an entire food web based on microbial activities, but natural soils rarely form the basis of plant-based artificial ecosystems of living walls. This lack of biological legacy or ecological memory may result in depauperate microbial communities which could have profound effects on ecosystem functioning. Including greater biodiversity in living walls can improve their functionality.

Detritus based Treatment for solid wastes:

Detritus, in ecology, is matter composed of leaves and other plant parts, animal remains, waste products, and other organic debris that falls onto the soil or into bodies of water from surrounding terrestrial communities. Microorganisms (such as bacteria or fungi) break down detritus, and this microorganism-rich material is eaten by invertebrates, which are in turn eaten by vertebrates. Many freshwater streams have detritus rather than living plants as their energy base. If dead organic matter is left in contact with microbes but isolated from higher organisms it will eventually decompose completely, releasing nutrient materials that are available for new cycles of plant production.

For solid waste treatment this detritus matters can be used with the help of Detritivores. Detritivores are smaller organisms that feed on detritus or decomposing organic material, which may have been partially or fully decomposed by the decomposers.

- They primarily feed on dead vegetation.
- They also prepare dead matter for final disassembly by bacteria and fungi.
- Worms and insects are important detritivores. For example, Earthworm, Beetles and Mussels.
- They play a very important role in soil formation
- The detritus feeders are enormously important in the oceans too, because everything that dies eventually comes down to the seafloor or benthos. In the seafloor mud, vast numbers of sea worms and other small organisms prepare dead matter for the final decomposition by bacteria.

Marine systems:

Marine ecosystems are aquatic environments with high levels of dissolved salt. These include the open ocean, the deep-sea ocean, and coastal **marine** ecosystems, each of which have different physical and biological characteristics.

As a Marine system, **Oceans** are some of the most diverse and geographically expansive ecosystems on earth. **Ocean ecosystems** are divided into four zones: intertidal, pelagic, benthic and abyssal.

Marine ecosystems are characterized by factors such as availability of **light**, food and nutrients. Other factors that affect marine ecosystems include **water temperature**, depth and salinity, as well as local topography. Changes in these conditions can change the composition of species that make up the marine community.

Year: I

Semester: II

6. **Name of the Faculty: Sayanta Sikdar** **Course Code: ENV22016**
7. **Course : Design of Environmental Engineering Systems** **L: 0**
8. **Program : M.Tech (Environmental Engineering)** **T: 0**
9. **Target : 60%** **P: 3**

C: 2

Different areas of the ocean can be classified as different types of marine ecosystems. An ecosystem is defined as "a community and the interactions of living and nonliving things in an area." Marine ecosystems have distinct organisms and characteristics that result from the unique combination of physical factors that create them. Marine ecosystems include: the abyssal plain (areas like deep sea coral, whale falls, and brine pools), polar regions such as the Antarctic and Arctic, coral reefs, the deep sea (such as the community found in the abyssal water column), hydrothermal vents, kelp forests, mangroves, the open ocean, rocky shores, salt marshes and mudflats, and sandy shores.

The hydrosphere connects all freshwater and saltwater systems. Salinity, or high salt content, and global circulation make marine ecosystems different from other aquatic ecosystems. Other physical factors that determine the distribution of marine ecosystems are geology, temperature, tides, light availability, and geography.

Some marine ecosystems are very productive. Near-shore regions, including estuaries, salt marshes, and mangrove forests, teem with life. Others, like the abyssal plain at the bottom of the ocean, contain pockets of life that are spread far apart from one another. Some marine ecosystems, like the deep sea, are in constant darkness where photosynthesis cannot occur. Other ecosystems, like rocky shores, go through extreme changes in temperature, light availability, oxygen levels, and other factors on a daily basis. The organisms that inhabit various marine ecosystems are as diverse as the ecosystems themselves. They must be highly adapted to the physical conditions of the ecosystem in which they live. For example, organisms that live in the deep sea have adapted to the darkness by creating their own light source—photophores are cells on their bodies that light up to attract prey or potential mates. Many parts of the ocean remain unexplored and much still remains to be learned about marine ecosystems.

Experiment 7: Case Study 1.

Experiment 8: Case Study 2.

Content Beyond Syllabus – Rainwater Harvesting methods

Viva-Voce questions

1. Explain the history and evolution of ecosystems - Principles and concepts.
2. Outline productivity- classification of eco-technology - ecological engineering.
3. Explain Structural and functional interactions of environmental systems.
4. Illustrate about Classification of ecological models – Applications - Ecological economics - Self –organizing design and processes - Multi seeded microcosms.
5. Express the concepts or energy - determination of sustainable loading of ecosystems.

Year: I

Semester: II

6. **Name of the Faculty: Sayanta Sikdar** **Course Code: ENV22016**
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9. **Target : 60%** **P: 3**

C: 2

6. Explain in details about soil infiltration systems.
7. Illustrate in details about Source Separation systems.
8. What are Aqua cultural systems? Explain in details.
9. Explain about the treatment process of Solid wastes in the marine life.

Continuous Evaluation Sheet

Roll Number	Registration Number	Name of the Student	Continuous Assessment*								
			Cycle I (30)				Cycle II (20)				
			Ex 1 (10)	Ex 2 (5)	Ex 3 (5)	Ex 4 (10)	Ex 5 (10)	Ex 6 (6)	Ex 7 (2)	Ex 8 (2)	Total (50)

Year: I
Semester: II

6. **Name of the Faculty: Sayanta Sikdar** **Course Code: ENV22016**
7. **Course : Design of Environmental Engineering Systems** **L: 0**
8. **Program : M.Tech (Environmental Engineering)** **T: 0**
9. **Target : 60%** **P: 3**

C: 2

PG/02/MTEVE/2020/001	AU/2020/0004291	SNEHASHIS GHOSH	9	5	5	9	9	5	2	2	46
PG/02/MTEVE/2020/002	AU/2020/0004450	SRIJA SINHAROY	10	5	5	10	9	6	2	2	49
PG/02/MTEVE/2020/003	AU/2020/0004454	SUMIT KUMAR KHAN	9	5	4	9	9	5	2	2	45
PG/02/MTEVE/2020/004	AU/2020/0004460	SUSMITA PANDIT	9	5	5	10	9	6	2	2	48

***Depends on Number of Experiments Divide the Total Marks and Prepare Rubrics for Evaluating Experiments**

Signature of HOD/Dean **Signature of Faculty**

Date: 26.08.2021 **Date: 26.08.2021**

Planning for Remedial Classes

					Remedial Classes Held	**Retest on the basis of**	**End Sem Marks**	

Year: I

Semester: II

6. Name of the Faculty: Sayanta Sikdar — Course Code: ENV22016
7. Course : Design of Environmental Engineering Systems — L: 0
8. Program : M.Tech (Environmental Engineering) — T: 0
9. Target : 60% — P: 3

C: 2

Sl. No.	Name of Student	Roll No.	Reg. No.	Mid Sem Marks								Remedial Classes		Improvement (Y/N)
					Date									
					Venue									
					Time									
1.	Nil	Nil	Nil	Nil	Nil	Nil	Nil					Nil	Nil	NA

Signature of HOD/ Dean

Signature of Faculty

Date: 26.08.2021

Date: 26.08.2021

COURSE END SURVEY

INDIRECT ASSESSMENT

Sample format for Indirect Assessment of Course outcomes:

Year: I
Semester: II

6. **Name of the Faculty: Sayanta Sikdar** **Course Code: ENV22016**
7. **Course : Design of Environmental Engineering Systems** **L: 0**
8. **Program : M.Tech (Environmental Engineering)** **T: 0**
9. **Target : 60%** **P: 3**

C: 2

NAME: Snehashis Ghosh
ROLL NO.: PG/02/MTEVE/2020/001
REG. NO..: AU/2020/0004291
COURSE: Design of Environmental Engineering Systems (ENV22016)
PROGRAM: M.Tech (Environmental Engineering)

Please rate the following aspects of course outcomes of "Design of Environmental Engineering Systems".

Use the scale 1-5 (Poor – Excellent) *

Course Outcomes	Statement	1	2	3	4	5
CO1					4	
CO2					4	
CO3				3		
CO4				3		
CO5					4	

Sample format for Indirect Assessment of Course outcomes:

NAME: SRIJA SINHAROY
ROLL NO.: PG/02/MTEVE/2020/002

Year: I

Semester: II

6. **Name of the Faculty: Sayanta Sikdar** **Course Code: ENV22016**
7. **Course : Design of Environmental Engineering Systems** **L: 0**
8. **Program : M.Tech (Environmental Engineering)** **T: 0**
9. **Target : 60%** **P: 3**

C: 2

REG. NO..: AU/2020/0004450
COURSE: Design of Environmental Engineering Systems (ENV22016)
PROGRAM: M.Tech (Environmental Engineering)

Please rate the following aspects of course outcomes of "Design of Environmental Engineering Systems".

Use the scale 1-5 (Poor – Excellent) *

Course Outcomes	Statement	1	2	3	4	5
CO1						5
CO2					4	
CO3					4	
CO4						5
CO5					4	

Sample format for Indirect Assessment of Course outcomes:

NAME: SUMIT KUMAR KHAN

Year: I
Semester: II

6. **Name of the Faculty: Sayanta Sikdar** **Course Code: ENV22016**
7. **Course : Design of Environmental Engineering Systems** **L: 0**
8. **Program : M.Tech (Environmental Engineering)** **T: 0**
9. **Target : 60%** **P: 3**

C: 2

ROLL NO.: PG/02/MTEVE/2020/003
REG. NO..: AU/2020/0004454
COURSE: Design of Environmental Engineering Systems (ENV22016)
PROGRAM: M.Tech (Environmental Engineering)

Please rate the following aspects of course outcomes of "Design of Environmental Engineering Systems".

Use the scale 1-5 (Poor – Excellent) *

Course Outcomes	Statement	1	2	3	4	5
CO1						5
CO2					4	
CO3						5
CO4					4	
CO5					4	

Sample format for Indirect Assessment of Course outcomes:

Year: I

Semester: II

6. **Name of the Faculty: Sayanta Sikdar** **Course Code: ENV22016**
7. **Course : Design of Environmental Engineering Systems** **L: 0**
8. **Program : M.Tech (Environmental Engineering)** **T: 0**
9. **Target : 60%** **P: 3**

C: 2

NAME: SUSMITA PANDIT
ROLL NO.: PG/02/MTEVE/2020/004
REG. NO..: AU/2020/0004460
COURSE: Design of Environmental Engineering Systems (ENV22016)
PROGRAM: M.Tech (Environmental Engineering)

Please rate the following aspects of course outcomes of “Design of Environmental Engineering Systems”.

Use the scale 1-5 (Poor – Excellent) *

Course Outcomes	Statement	1	2	3	4	5
CO1						5
CO2					4	
CO3						5
CO4					4	
CO5						5

Year: I
Semester: II

6. Name of the Faculty: Sayanta Sikdar — Course Code: ENV22016
7. Course : Design of Environmental Engineering Systems — L: 0
8. Program : M.Tech (Environmental Engineering) — T: 0
9. Target : 60% — P: 3
C: 2

INDIRECT ASSESSMENT CONSOLIDATION

ADAMAS UNIVERSITY, KOLKATA SCHOOL OF DEPARTMENT OF CO Indirect Assessment		
Programme:	Academic Year:2020-21	Batch: 2020-22
Course Code & Name:		
Course Outcome	**Students Feed Back (5)**	**Attainment (100)**
CO1	4.75	95
CO2	4	80
CO3	4.25	85
CO4	4	80
CO5	4.25	85
Signature of HOD/Dean Date: 26.08.2021		Signature of Faculty Date: 26.08.2021

Year: I

Semester: II

6. **Name of the Faculty: Sayanta Sikdar** **Course Code: ENV22016**
7. **Course : Design of Environmental Engineering Systems** **L: 0**
8. **Program : M.Tech (Environmental Engineering)** **T: 0**
9. **Target : 60%** **P: 3**

C: 2

Evaluation Sheet (End Semester)

Roll Number	Registration Number	Name of the Student	Marks (50)
PG/02/MTEVE/2020/001	AU/2020/0004291	SNEHASHIS GHOSH	45
PG/02/MTEVE/2020/002	AU/2020/0004450	SRIJA SINHAROY	49
PG/02/MTEVE/2020/003	AU/2020/0004454	SUMIT KUMAR KHAN	47
PG/02/MTEVE/2020/004	AU/2020/0004460	SUSMITA PANDIT	46

Signature of HOD/Dean **Signature of Faculty**

Date: 26.08.2021 **Date: 26.08.2021**

Year: I

Semester: II

6. Name of the Faculty: Sayanta Sikdar — Course Code: ENV22016
7. Course : Design of Environmental Engineering Systems — L: 0
8. Program : M.Tech (Environmental Engineering) — T: 0
9. Target : 60% — P: 3

C: 2

Planning for Remedial Classes – End Semester

Sl. No.	Name of Student	Roll No.	Reg. No.	End Sem Marks	Remedial Classes Held							Retest on the basis of Remedial Classes	Supple Exam Marks	Improvement (Y/N)
					Date									
					Venue									
					Time									
1.	Nil	Nil	Nil	Nil	Nil	Nil	Nil					Nil	Nil	NA

Signature of HOD/ Dean

Signature of Faculty

Date: 26.08.2021

Date: 26.08.2021

Year: I

Semester: II

6. **Name of the Faculty: Sayanta Sikdar** **Course Code: ENV22016**
7. **Course : Design of Environmental Engineering Systems** **L: 0**
8. **Program : M.Tech (Environmental Engineering)** **T: 0**
9. **Target : 60%** **P: 3**

C: 2

Consolidated Mark Statement

Roll Number	Registration Number	Name of the Student	Marks			
			Continuous Assessment (50)		End Semester (50)	Total (100)
			Cycle I (30)	Cycle II (20)		
PG/02/MTEVE/2020/001	AU/2020/0004291	SNEHASHIS GHOSH	28	18	45	91
PG/02/MTEVE/2020/002	AU/2020/0004450	SRIJA SINHAROY	30	19	49	98
PG/02/MTEVE/2020/003	AU/2020/0004454	SUMIT KUMAR KHAN	27	18	47	92
PG/02/MTEVE/2020/004	AU/2020/0004460	SUSMITA PANDIT	29	19	46	94

Signature of Dean/HOD **Signature of Faculty**

Date: 26.08.2021 **Date: 26.08.2021**

Year: I

Semester: II

6. **Name of the Faculty: Sayanta Sikdar** **Course Code: ENV22016**
7. **Course : Design of Environmental Engineering Systems** **L: 0**
8. **Program : M.Tech (Environmental Engineering)** **T: 0**
9. **Target : 60%** **P: 3**

C: 2

Year: I

Semester: II

6. Name of the Faculty: Sayanta Sikdar — Course Code: ENV22016
7. Course : Design of Environmental Engineering Systems — L: 0
8. Program : M.Tech (Environmental Engineering) — T: 0
9. Target : 60% — P: 3

C: 2

CO ATTAINMENT – GAP ANALYSIS & REMEDIAL MEASURES

ADAMAS UNIVERSITY, KOLKATA SCHOOL OF DEPARTMENT OF CO ATTAINMENT - GAP ANALYSIS & REMEDIAL MEASURES							
Batch :	2020-22					Academic Year: 2020-21	
Course Code & Name		Name of the Coordinator				Year & Semester	
						I & I	
CO	Direct Assessment	Indirect Assessment	CO Attainment	Target	CO Attainment Gaps	Action for Bridge the Gap	Target Modification
CO1	100	95	99	70	-29		90
CO2	100	80	96	70	-26		90
CO3	100	85	97	70	-27		90
CO4	100	80	96	70	-26		90
CO5	100	85	97	70	-27		90

Signature of HOD/Dean

Date: 26.08.2021

Signature of Faculty

Date: 26.08.2021

Year: I

Semester: II

6. Name of the Faculty: Sayanta Sikdar — Course Code: ENV22016
7. Course : Design of Environmental Engineering Systems — L: 0
8. Program : M.Tech (Environmental Engineering) — T: 0
9. Target : 60% — P: 3

C: 2

CO-PO ATTAINMENT

ADAMAS UNIVERSITY, KOLKATA SCHOOL OF DEPARTMENT OF CO-PO ATTAINMENT																		
Programme :		Year & Sem: I & I		Academic Year: 2020-21			Batch:2020-22											
Course Code	Course Name	CO-PO	PO1	PO2	PO3	PO4	PO5	PO6	PO 7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	
ENV22016	Design of Environmental Engineering Systems	Relationship	CO1, CO2, CO3, CO4, CO5	CO1, CO2, CO4, CO5	CO3, CO5	NA	CO1, CO2, CO3, CO4, CO5	NA	NA	NA	CO1, CO2, CO5	NA	NA	NA	NA	NA	NA	

Year: I

Semester: II

6. Name of the Faculty: Sayanta Sikdar — Course Code: ENV22016
7. Course : Design of Environmental Engineering Systems — L: 0
8. Program : M.Tech (Environmental Engineering) — T: 0
9. Target : 60% — P: 3

C: 2

		Mapping Value	3	3	3	NA	3	NA	NA	NA	3	NA	NA	NA	NA	NA	NA
		Attainment	2.91	2.91	2.91	NA	2.91	NA	NA	NA	2.92	NA	NA	NA	NA	NA	NA

Signature of HOD/Dean

Signature of Faculty

Date: 26.08.2021

Date: 26.08.2021

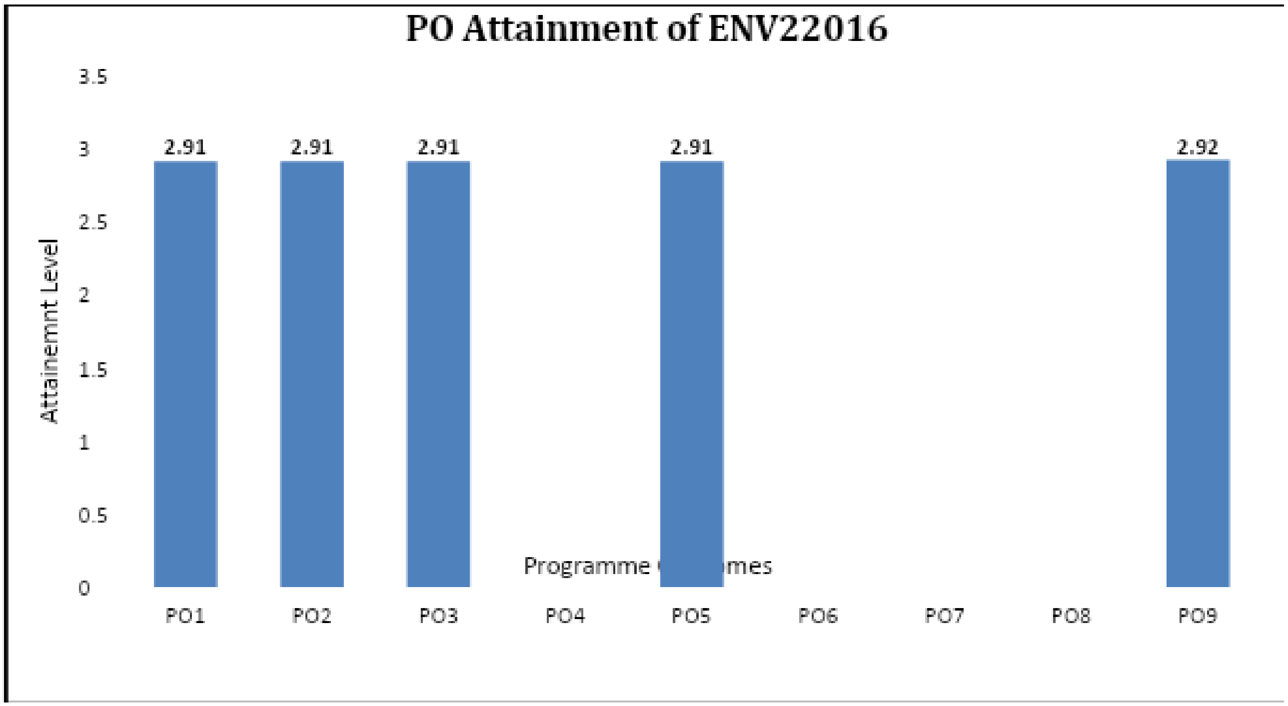
PO ATTAINMENT OF THE COURSE

Year: I

Semester: II

6. Name of the Faculty: Sayanta Sikdar Course Code: ENV22016
7. Course : Design of Environmental Engineering Systems L: 0
8. Program : M.Tech (Environmental Engineering) T: 0
9. Target : 60% P: 3

C: 2



Signature of HOD/Dean **Signature of Faculty**

Date: 26.08.2021 **Date: 26.08.2021**

Year: I

Semester: II

6. **Name of the Faculty: Sayanta Sikdar** **Course Code: ENV22016**
7. **Course : Design of Environmental Engineering Systems** **L: 0**
8. **Program : M.Tech (Environmental Engineering)** **T: 0**
9. **Target : 60%** **P: 3**

C: 2

INSTRUCTIONS FOR FACULTY

Instructions for Faculty

- Faculty should keep track of the students with low attendance and counsel them regularly.
- Course coordinator will arrange to communicate the short attendance (as per University policy) cases to the students and their parents monthly.
- Experiment covered in each lab should be recorded in the table of RECORD OF CLASS TEACHING (Suggested Format).
- Internal assessment marks should be communicated to the students twice in a semester.
- The file will be audited by respective Academic Monitoring and Review Committee (AMRC) members for theory as well as for lab as per AMRC schedule.
- The faculty is required to maintain these files for a period of at least three years.
- This register should be handed over to the head of department, whenever the faculty member goes on long leave or leaves the Colleges/University.
- For labs, continuous evaluation format (break-up given in the guidelines for result preparation in the same file) should be followed.
- Department should monitor the actual execution of the components of continuous lab evaluation regularly.
- Instructor should maintain record of experiments conducted by the students in the lab weekly.
- Instructor should promote students for self-study and to make concept diary, due weightage in the internal should be given under faculty assessment for the same.
- Course outcome assessment: To assess the fulfilment of course outcomes two different approaches have been decided. Degree of fulfillment of course outcomes will be assessed in different ways through direct assessment and indirect assessment. In Direct Assessment, it is measured through quizzes, tests, assignment, Mid-term and/or End-term examinations. It is suggested that each examination is designed in such a way that it can address one or two outcomes (depending upon the course completion). Indirect assessment is done through the student survey which needs to be designed by the faculty (sample format is given below) and it shall be conducted towards the end of course completion. The evaluation of the achievement of the Course Outcomes shall be done by analyzing the inputs received through Direct and Indirect Assessments and then corrective actions suggested for further improvement.
- **Submission Targets of Course Contents:**
    - **S. No. 1 to 7 : Before Starting the Course**
    - **S. No. 8& 9 : After Mid Semester Examination**
    - **S. No. 10 to 13 : Immediately After End Semester Examination**
    - **S. No. 14 to 17 : After Declaration of Result of the Course**