GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

Competency-focused Outcome-based Green Curriculum-2023 (COGC-2023)
Semester-V

Course Title: Solid Waste Management
(Course Code: 4351303)

Diploma programme in which this course is offered	Semester in which offered
Environmental Engineering	5th Semester

1. RATIONALE

Solid waste management is a pressing issue, and lack of know how in solid waste management is a great concern for all the Local Self Govt. units & community. Additionally, there is still little awareness on the importance of sound environmental management within the majority of the population. The course on Solid Waste Management gives the student an overview of municipal solid waste management including collection, transfer, transport, and disposal. Methods of processing, basic disposal facilities, disposal options, and the environmental issues of solid waste management will be covered in this course. In addition, this course provides the student with relevant information about municipal solid waste reduction and on hazardous waste management. This course is therefore an essential course for diploma programme in Environmental Engineering

2. COMPETENCY

The course content should be taught and with the aim to develop required skills in students so that they are able to acquire following competencies.

- **Plan for segregation, collection, transportation, recycling and disposal of municipal solid waste in such a way that its impact is minimal on environment, economy and community.**

3. COURSE OUTCOMES (COs)

The practical exercises, the underpinning knowledge and the relevant soft skills associated with this competency are to be developed in the student to display the following COs:

a) Explain municipal solid waste management systems with respect to its characteristics and associated critical considerations in view of emerging technologies.
b) Describe the methods of MSW generation and collection.
c) Identify the relevant method for solid waste handling, separation and storage.
d) Outline the relevant method for solid waste processing and disposal.
e) Characterize hazardous solid waste disposal methods.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)	Total Credits (L+T/2+P/2)	Examination Scheme		
		Theory Marks	Practical Marks	

L	T	P	C	CA*	ESE	CA	ESE	Total Marks
3	-	2	4	30	70	25	25	150

(*): Out of 30 marks under the theory CA, 10 marks are for assessment of the micro-project to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessing the attainment of the cognitive domain UOs required for the attainment of the COs.

***Legends: L**-Lecture; **T** – Tutorial/Teacher Guided Theory Practice; **P** - Practical; **C** – Credit, **CA** - Continuous Assessment; **ESE** - End Semester Examination.*

5. SUGGESTED PRACTICAL EXERCISES

The following practical outcomes (PrOs) are the sub-components of the COs. *Some of the **PrOs** marked **'*'** are compulsory, as they are crucial for that particular CO at the 'Precision Level' of Dave's Taxonomy related to 'Psychomotor Domain'*.

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. required
1	Determine the Volatile and non-volatile matter of MSW	I	04
2	Determine the Kjeldahl nitrogen of municipal solid waste.	I	04
3	Determine the Total nitrogen of municipal solid waste.	I	02
4	Survey your locality and based on it suggest methods of solid waste collection.	II	02
5	Survey your locality and based on it suggest suitable methods of handling, separation and storage of solid waste.	III	04
6	Identify& discuss the methods of processing different types of solid waste (search internet for latest methods).	IV	02
7	Compare different methods of disposal of MSW. (search internet for latest methods).	IV	08
8	Identify methods of hazardous waste disposal during a site visit.	V	02
			Total:28

Note

i. *More **Practical Exercises** can be designed and offered by the respective course teacher to develop the industry relevant skills/outcomes to match the COs. The above table is only a suggestive list.*

ii. *The following are some **sample** 'Process' and 'Product' related skills (more may be added/deleted depending on the course) that occur in the above listed **Practical Exercises** of this course required which are embedded in the COs and ultimately the competency..*

S. No.	Sample Performance Indicators for the PrOs	Weightage in %
	For PrOs 1 to 7	
1	Identification of Glassware and Equipment to perform various test	10
2	Prepare experimental setup accurately	10
3	Observe and record readings accurately	40

4	Calculate results accurately	20
5	Interpret results and their conclusions	10
6	Submission for progressive assessment on time	10
7	Viva Voce	10
	Total	**100**

6. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

This major equipment with broad specifications for the PrOs is a guide to procure them by the administrators to usher in uniformity of practicals in all institutions across the state.

S. No.	Equipment Name with Broad Specifications	PrO. No.
1	• **Sampling containers** • **Kjeldahl Flask** • **UV Spectrophotometer** • **Distillation Assembly** • **Muffle furnace** • **Chemical testing glasswares** • **Hot air oven**	1 to 3

7. AFFECTIVE DOMAIN OUTCOMES

The following ***sample*** Affective Domain Outcomes (ADOs) are embedded in many of the above mentioned COs and PrOs. More could be added to fulfill the development of this competency.

a) Work as a team member/ individual.
b) Follow ethical practices.
c) Follow safe practice on site and in laboratory.
d) Practice of environmental friendly methods and processes.

The ADOs are best developed through the laboratory/field based exercises. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

i. 'Valuing Level' in 1st year
ii. 'Organization Level' in 2nd year.
iii. 'Characterization Level' in 3rd year.

8. UNDERPINNING THEORY

Only the major Underpinning Theory is formulated as higher level UOs of *Revised Bloom's taxonomy* in order development of the COs and competency is not missed out by the students and teachers. If required, more such higher level UOs could be included by the course teacher to focus on attainment of COs and competency.

Unit	Unit Outcomes (UOs)	Topics and Sub-topics
Unit – I **Source, composition**	1a. State Municipal solid waste sources 1b. Describe the advantages of	1.1 Introduction 1.2 Sources of solid waste 1.3 Types of solid waste. 1.4 Composition of solid waste and

Unit	Unit Outcomes (UOs)	Topics and Sub-topics
and Properties of Municipal Solid Waste	determining the composition of Municipal solid waste 1c. Explain types of solid waste. 1d. State types of materials recovered from MSW 1e. State the Physical , Chemical and Biological properties 1f. Describe associated considerations of Municipal Solid Waste (Msw)	its determination. 1.5 Types of materials recovered from MSW. 1.6 Sampling and characteristics of MSW 1.7 Physical properties of Municipal Solid Waste 1.8 Chemical properties of Municipal Solid Waste 1.9 Biological properties of Municipal Solid Waste 1.10Transformation of Municipal Solid Waste.
Unit – II **Solid Waste Generation and Collection**	2a.Describe the functional elements of solid waste management program 2b. Discuss in detail the methods of MSW collection and its generation 2c. State the assumptions for quantities of solid Waste generated and factors affecting solid waste generation rate. 2d. State the quantities of materials recovered from MSW	2.1 Quantities of Solid Waste. 2.2 Measurements and methods to measure solid waste quantities. 2.3 Solid waste generation and collection. 2.4 Factors affecting solid waste generation rate. 2.5 Quantities of materials recovered from MSW.
Unit– III **Handling, Separation and Storage of SolidWaste**	3a. Discuss the importance of onsite handling of solid waste 3b. Explain onsite solid waste handling and separation at commercial and Industrial facilities. 3c. State the storage of solid waste at the sources.	3.1 Handling and separation of solid waste at site. Material separation by pick in, screens, float and separator magnets and electromechanical separator and other latest devices for material separation. 3.2 Waste handling and separation at commercial and industrial facilities. 3.3 Storage of solid waste at the sources.
Unit– IV **Processing and Disposal**	4a. Explain solid waste processing methods 4b. Describe processing steps of residential, commercial and industrial site MSW from various sources with clean flow	4.1 Processing of solid waste at residence e.g. Storage, conveying, compacting, shredding, pulping, granulating etc. 4.2 Processing of solid waste at commercial and industrial site. 4.3 Combustion and energy recovery

Unit	Unit Outcomes (UOs)	Topics and Sub-topics
of Municipal Solid Waste	chart. 4c. Describe different methods & safety precautions used in disposal of MSW. 4d. Compare disposal methods of MSW applying specific criteria. 4e.Compare sanitary land fill and incineration as final disposal system for solid waste 4f.State the effects of combustion – desirable ,undesirable and energy recovery of municipal solid waste 4g.Classify the landfill 4h. Describe the landfill - planning, sitting, permitting , processes , design , operation, Bio reactor landfill, Landfill rehabilitation 4i.Describe the Biochemical processes - Methane generation by anaerobic digestion, composting.	of municipal solid waste, effects of combustion, undesirable effects of combustion. 4.4 Landfill: Classification, planning, sitting, permitting, landfill processes, landfill design, landfill operation, use of old landfill, 4.5 Bio reactor landfill – working, advantages and disadvantages, Landfill rehabilitation 4.6 Differentiate sanitary land fill and incineration as final disposal system for solid waste 4.7 Biochemical processes: Methane generation by anaerobic digestion, composting and other biochemical processes.
Unit– V **Hazardous Solid Waste**	5a. Define the hazardous solid waste 5b. Classify hazardous solid waste with their identification 5c. Describe types of hazardous solidwaste, their characteristics,& their harmful effects on community. 5d. Discuss safe methods of disposal of hazardous waste & their management principals. 5e. Identify pollution due to radioactive waste 5f. Identify pollution due to bio medical waste and e waste	5.1 Definition, identification and classification of hazardous solid waste. Characteristics of Hazardous waste: toxicity, reactivity, infectiousness, flammability, radioactivity, corrosiveness, irritation, bio-concentration, genetic activity, explosiveness. 5.2 Bio-medical waste, its sources, generation, storage, transportation and disposal. 5.3 Radio active waste-Sources, Types, Storage and disposal 5.4 Introduction to bio medical waste and e waste

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A	Total Marks
I	Source, composition and Properties of Municipal Solid Waste	06	04	04	02	10
II	Solid Waste Generation and Collection	08	04	06	02	12
III	Handling, Separation and Storage of Solid Waste	08	04	06	02	12
IV	Processing and Disposal of Municipal Solid Waste	12	10	10	04	24
V	Hazardous Solid Waste	08	04	06	02	12
Total		**42**	**26**	**32**	**12**	**70**

Legends: *R=Remember, U=Understand, A=Apply and above (Revised Bloom's taxonomy)*

Note*: This specification table provides general guidelines to assist student for their learning and to teachers to teach and question paper designers/setters to formulate test items/questions assess the attainment of the UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may vary slightly from above table.*

10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related ***co-curricular*** activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should conduct following activities in group and prepare reports of about 5 pages for each activity, also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews:

a) Explore internet for studying latest methods of handling, collecting, segregating, recycling and disposing MSW and prepare reports.
b) Prepare Charts/Models for different Hazardous Solid Waste treatment processes.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

a) Massive open online courses (***MOOCs***) may be used to teach various topics/sub topics.
b) Guide student(s) in undertaking micro-projects.
c) ***'L' in section No. 4*** means different types of teaching methods that are to be employed by teachers to develop the outcomes.
d) About ***20% of the topics/sub-topics*** which are relatively simpler or descriptive in nature is to be given to the students for ***self-learning***, but to be assessed using different assessment methods.
e) With respect to ***section No.10***, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.

f) Guide students on how to address issues on environment and sustainability

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-project are group-based. However, in the fifth and sixth semesters, it should be preferably be ***individually*** undertaken to build up the skill and confidence in every student to become problem solver so that s/he contributes to the projects of the industry. In special situations where groups have to be formed for micro-projects, the number of students in the group should ***not exceed Six.***

The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The total duration of the micro-project should not be less than ***16 (sixteen) student engagement hours*** during the course. The student ought to submit micro-project by the end of the semester to develop the industry oriented COs.

A suggestive list of micro-projects is given here. This has to match the competency and the COs. Similar micro-projects could be added by the concerned course teacher:

a) Carryout internet survey and prepare a report suggesting methods to manage construction and demolition waste
b) Carryout internet survey and prepare a report suggesting methods to manage bio-medical waste
c) Carryout internet survey and prepare a report suggesting methods to manage e-waste
d) Prepare a chart depicting Functional Elements of MSWM
e) Collect data of MSW generation of India in TPD and prepare bar graph of state wise MSW generation and identify the states with highest MSW generation
f) Prepare a chart depicting various methods of handling and separation of solid waste
g) Prepare a chart depicting various methods of processing of solid waste
h) Prepare a chart depicting various methods of disposal of solid waste
i) Prepare a case study report on waste to energy plant set up using pyrolysis
j) Prepare a case study report on waste to energy plant set up using gasification
k) Prepare a report on Municipal solid waste management rules.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication with place, year and ISBN
1	Integrated solid waste management	George Tchobanoglous and Hillary theisen, Samuel Vigil	McGraw Hill; 2nd edition (28 February 1993) ISBN-13 : 0070632370-978
2	Solid And Hazardous Waste Management	S.C. Bhatia	Atlantic Publishers and Distributors (P) Ltd, January 2023, ISBN-13 : 81269081-978 41

S. No.	Title of Book	Author	Publication with place, year and ISBN
3	Hazardous Waste Management	J. M. Dewan	Discovery Publishing Pvt.Ltd(11 August 2008) ISBN-13 : 8171413515-978
4	Solid Waste Management	Sasikumar K	Prentice Hall India Learning Private Limited (1 January 2009) ISBN-13 : 8120338692-978
5	Solid and Hazardous Waste Management	M. N. Rao	;BSP Books / BS Publications (2020 January 1) nd edition2

14. SOFTWARE/LEARNING WEBSITES

a) www.gpcb.gov.in

b) https://archive.nptel.ac.in/courses/105/103/105103205/

c) www.cpcb.nic.in

d) www.neeri.res.in

e) https://archive.nptel.ac.in/courses/105/106/105106056/

15. PO-COMPETENCY-CO MAPPING

Semester V	Physico chemical treatment of water & waste water (Course Code:4351303)									
	POs and PSOs									
Competency & Course Outcomes	PO 1 Basic & Discipline specific knowledge	PO 2 Problem Analysis	PO 3 Design/ development of solutions	PO 4 Engineering Tools, Experimentation &Testing	PO 5 Engineering practices for society, sustainability & environment	PO 6 Project Management	PO 7 Life-long learning	PSO 1 Environmental planning & deisgn	PSO 2 Environmental Impact Assessment	PSO 3 (If needed)
Competency	i. Plan for segregation, collection, transportation, recycling and disposal of municipal solid waste in such a way that its impact is minimal on environment, economy and community.									
Course Outcomes a) Explain municipal solid waste management systems with respect to its characteristics and associated critical considerations in view of emerging technologies	3	3	2	3	3	3	2	3	3	-
b) Describe the methods of MSW generation and collection	3	3	2	-	3	-	2	3	3	-
c) Identify the relevant method for solid waste handling, separation and storage	3	3	2	-	3	-	2	3	3	-

d) Outline the relevant method for solid waste processing and disposal.	3	3	2	-	3	-	2	3	3	-
e) Characterize hazardous solid waste disposal methods.	3	3	2	-	3	-	2	3	3	-

Legend: '**3'** for high, '**2**' for medium, **'1'** for low or **'-'** for the relevant correlation of each competency, CO, with PO/ PSO

16. COURSE CURRICULUM DEVELOPMENT COMMITTEE

GTU Resource Persons

S. No.	Name and Designation	Institute	Contact No.	Email
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