INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)
Dundigal, Hyderabad -500 043

AERONAUTICAL ENGINEERING

COURSE DESCRIPTOR

Course Title	**ENERGY FROM WASTE**				
Course Code	AEE551				
Programme	B.Tech				
Semester	VII	AE			
Course Type	Elective				
Regulation	IARE - R16				
Course Structure	**Theory**			**Practical**	
	Lectures	**Tutorials**	**Credits**	**Laboratory**	**Credits**
	3	-	3	-	-
Chief Coordinator	Mr. Ch Balakrishna, Assistant Professor				
Course Faculty	Dr. D Govardhan, Professor				

I. COURSE OVERVIEW:

The course is designed to create environmental awareness and consciousness among the present generation to become environmental responsible citizens. The course description is to understand what municipal solid waste, composition is its characteristics and to improve the methods to minimize municipal solid waste. To understand the methods of disposal of solid waste by thermal biochemical and land filling methods and to know the environmental impacts of all types of municipal waste .To get a good knowledge of environmental in context of global trade.

II. COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites	Credits
UG	AHS009	II	Environmental Studies.	3

III. MARKSDISTRIBUTION:

Subject	SEE Examination	CIA Examination	Total Marks
Energy From Waste	70 Marks	30 Marks	100

IV. DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✘	Chalk & Talk	✔	Quiz	✔	Assignments	✘	MOOCs
✔	LCD / PPT	✔	Seminars	✘	Mini Project	✘	Videos
✘	Open Ended Experiments						

V. EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIA examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into five units and each unit carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each unit. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.

The emphasis on the questions is broadly based on the following criteria:

50 %	To test the objectiveness of the concept.
50 %	To test the analytical skill of the concept OR to test the application skill of the concept.

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 30 marks (Table 1), with 25 marks for Continuous Internal Examination (CIE), 05 marks for Quiz/ Alternative Assessment Tool (AAT).

Table 1: Assessment pattern for CIA

Component	**Theory**		**Total Marks**
Type of Assessment	CIE Exam	Quiz/AAT	
CIA Marks	25	05	30

Continuous Internal Examination (CIE):

Two CIE exams shall be conducted at the end of the 8th and 16th week of the semester respectively. The CIE exam is conducted for 25 marks of 2 hours duration consisting of two parts. Part–A shall have five compulsory questions of one mark each. In part–B, four out of five questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Quiz / Alternative Assessment Tool (AAT):

Two Quiz exams shall be online examination consisting of 25 multiple choice questions and are to be answered by choosing the correct answer from a given set of choices (commonly four). Marks shall be awarded considering the average of two quizzes for every course. The AAT may include seminars, assignments, five minutes video and MOOCs.

VI. HOW PROGRAM OUTCOMES ARE ASSESSED:

Program Outcomes (POs)		Strength	Proficiency assessed by
PO 1	**Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	2	Assignments/ Exams
PO 2	**Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences	2	Guest Lectures
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	1	Presentation on real world problems
PO 7	**Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	2	Seminars

3 = High; 2 = Medium; 1 = Low

VII. HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program Specific Outcomes (PSOs)		Strength	Proficiency assessed by
PSO1	**Professional skills:** Able to utilize the knowledge of aeronautical/aerospace engineering in innovative, dynamic and challenging environment for design and development of new products	--	--
PSO2	**Problem-solving Skills:** Imparted through simulation language skills and general purpose CAE packages to solve practical, design and analysis problems of components to complete the challenge of airworthiness	--	--

Program Specific Outcomes (PSOs)		Strength	Proficiency assessed by
	for flight vehicles.		
PSO3	**Practical implementation and testing skills:** Providing different types of in house and training and industry practice to fabricate and test and develop the products with more innovative technologies	--	--
PSO 4	**Successful career and entrepreneurship:** To prepare the students with broad aerospace knowledge to design and develop systems and subsystems of aerospace and allied systems and become technocrats.	--	--

3 = High; 2 = Medium; 1 = Low

VIII. COURSE OBJECTIVES :

The course should enable the students to:	
I	Understand the principles associated with effective energy management and to apply these principles in the day to day life.
II	Develop insight into the collection, transfer and transport of municipal solid waste.
III	Explain the design and operation of a municipal solid waste landfill.
IV	Evaluate the main operational challenges in operating thermal and biochemical energy from waste facilities and device key processes involved in recovering energy from wastes.

IX. COURSE OUTCOMES (COs):

COs	Course Outcome	CLOs	Course Learning Outcome
CO 1	Identify different sources of solid waste and characteristics of municipal solid waste	CLO 1	Apply the knowledge about the operations of Waste to Energy Plants.
		CLO 2	Understand physical and chemical analysis of municipal solid wastes and apply them for a management system that will be set up.
		CLO 3	Analyze the various aspects of Waste to Energy management Systems.
		CLO 4	Design a compost facility, incineration facility and make site selection for a landfill.
CO 2	Classify the methods in disposal of solid waste and the emission of gases, leach ate from landfills	CLO 5	Explain the hierarchical structure in solid waste management and a requirement for an integrated solution.
		CLO 6	Use Geographical Information System for landfill site selection that takes place in Solid Waste Management Plan.
		CLO 7	Collect required data for a Solid Waste management Plan and edit the collected dataset up Solid Waste management Plan.
		CLO 8	Summarize the properties and characteristics of landfills.
CO 3	Understand Biochemical conversion of biomass for	CLO 9	Understand Biochemical conversion of biomass for energy application, Bioenergy systems and process integration.

COs	Course Outcome	CLOs	Course Learning Outcome
	energy application, Bio-energy systems and process integration.	CLO 10	Discuss Thermo chemical conversion of biomass for energy application.
		CLO 11	Understand the concept of bio mass briquetting and its advantages.
		CLO 12	Evaluate the subject from the technical, legal and economical points by learning of all terms related to general solid waste management.
CO 4	Illustrate sources of thermo chemical energy generation and understand Biochemical conversion of biomass for energy application	CLO 13	Apply the knowledge in planning and operations of Waste to Energy plants.
		CLO 14	Analyze the importance of shot creating and uniting Technology.
		CLO 15	Examine the technical points that are required to set up a solid waste management system.
		CLO 16	Apply the legal legislation related to solid waste management.
CO 5	Understand the global scenario of environmental concerns and health hazards by the generation of E- waste	CLO 17	Encourage students to organize recycling events and waste audit.
		CLO 18	Discuss the growth of electrical and electronics in waste to energy industry in India.
		CLO 19	Discuss impact of hazardous e-waste in India
		CLO 20	Understand need for stringent health safeguards and environmental protection laws of India.

X. COURSE LEARNING OUTCOMES (CLOs):

CLO Code	CLO's	At the end of the course, the student will have the ability to:	PO's Mapped	Strength of Mapping
AEE551.01	CLO 1	Apply the knowledge about the operations of Waste to Energy Plants.	PO 1, PO 2, PO 6, PO 7	2
AEE551.02	CLO 2	Understand physical and chemical analysis of municipal solid wastes and apply them for a management system that will be set up.	PO 1, PO 2, PO 6, PO 7	2
AEE551.03	CLO 3	Analyze the various aspects of Waste to Energy Management Systems.	PO 1, PO 2	2
AEE551.04	CLO 4	Design a compost facility, incineration facility and make site selection for a landfill.	PO 1, PO 2, PO 6, PO 7	1
AEE551.05	CLO 5	Explain the hierarchical structure in solid waste management and a requirement for an integrated solution.	PO 1, PO 2, PO 6, PO 7	2
AEE551.06	CLO 6	Use Geographical Information System for landfill site selection that takes place in Solid Waste Management Plan.	PO 1, PO 2, PO 6	2
AEE551.07	CLO 7	Collect required data for a Solid waste management plan and edit the collected Dataset up Solid Waste Management Plan.	PO 1, PO 6, PO 7	3
AEE551.08	CLO 8	Understand Biochemical conversion of biomass for energy application, Bio-energy systems and process integration.	PO 1, PO 2, PO 6, PO 7	1
AEE551.09	CLO 9	Discuss Thermo chemical conversion of Biomass for energy application.	PO 1, PO 2, PO 6, PO 7	1
AEE551.10	CLO 10	Understand the concept of bio mass Briquetting and its advantages.	PO 1, PO 2, PO 7	1
AEE551.11	CLO 11	Evaluate the subject from the technical, legal and economical points by learning of all terms related to general solid waste management.	PO 1, PO 6, PO 7	2

CLO Code	CLO's	At the end of the course, the student will have the ability to:	PO's Mapped	Strength of Mapping
AEE551.12	CLO 12	Use multiple criteria decision making systems for an optimum and sustainable integrated solid waste management system based on entire data.	PO 1, PO 2	2
AEE551.13	CLO 13	Apply the knowledge in planning and operations of waste to Energy plants.	PO 1, PO 6, PO 7	2
AEE551.14	CLO 14	Examine the technical points that are required to set up a solid waste management system.	PO 6, PO 7	2
AEE551.15	CLO 15	Apply the legal legislation related to solid waste management.	PO 2, PO 6	2
AEE551.16	CLO 16	Encourage students to organize recycling events and waste audit.	PO 6, PO 7	2
AEE551.17	CLO 17	Discuss the growth of electrical and electronics in waste to energy industry in India.	PO 6, PO 7	3
AEE551.18	CLO 18	Summarize government regulations on e-waste management	PO 6, PO 7	2
AEE551.19	CLO 19	Explain need for stringent health safeguards	PO 6, PO 7	2
AEE551.20	CLO 20	Understand need for stringent health safeguards and environmental protection laws of India.	PO 6, PO 7	1

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XI. MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES

Course Outcomes (COs)	Program Outcomes (POs)			
	PO 1	PO 2	PO 6	PO 7
CO 1	1	2	1	2
CO 2	2	2	1	1
CO 3	1	2	2	1
CO 4	2		2	2
CO 5			2	1

XII. MAPPING COURSE LEARNING OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES:

Course Learning Outcomes (CLOs)	Program Outcomes(POs)												Program Specific Outcomes (PSOs)			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CLO 1	2	1				2	3									
CLO 2	2	2				2	2									
CLO 3	1	3														
CLO 4	2	2				1	2									

Course Learning Outcomes (CLOs)	Program Outcomes(POs)												Program Specific Outcomes (PSOs)			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CLO 5	2	2				2	2									
CLO 6	3	2														
CLO 7	2					2	2									
CLO 8	3	3				1	1									
CLO 9	3	2				1	1									
CLO 10	2	2					2									
CLO 11	1					3	2									
CLO 12	1	3														
CLO 13	2					3	2									
CLO 14						2	2									
CLO 15	2					2										
CLO 16						3	3									
CLO 17						3	2									
CLO 18						2	2									
CLO 19						2	1									
CLO 20						2	2									

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XIII. ASSESSMENT METHODOLOGIES–DIRECT

CIE Exams	PO 1,PO2, PO 6, PO 7, PSO1,PSO2, PSO3	SEE Exams	PO1, PO2, PO 6, PO 7, PSO1, PSO2, PSO3	Assignments	PO 1, PSO 1	Seminars	PO 7, PSO 2
Laboratory Practices	-	Student Viva	-	Mini Project	-	Certification	-
Term Paper	-						

XIV. ASSESSMENT METHODOLOGIES-INDIRECT

✔	Early Semester Feedback	✔	End Semester OBE Feedback
✘	Assessment of Mini Projects by Experts		

XV. SYLLABUS

Unit-I	INTRODUCTION TO WASTE AND WASTE PROCESSING
Solid waste sources solid waste sources, types, composition, properties, global warming; Municipal solid waste: Physical, chemical and biological properties, waste collection and, transfer stations, waste minimization and recycling of municipal waste, segregation of waste, size reduction, managing waste, status of technologies for generation of energy from waste treatment and disposal aerobic composting, incineration, furnace type and design, medical waste / pharmaceutical waste treatment technologies, incineration, environmental impacts, measures to mitigate environmental effects due to incineration.	
Unit-II	**WASTE TREATMENT AND DISPOSAL**
Land fill method of solid waste disposal land fill classification, types, methods and sitting consideration; Layout and preliminary design of landfills: Composition, characteristics, generation, movement and control of landfill leachate and gases, environmental monitoring system for land fillgases.	
Unit-III	**BIO-CHEMICAL CONVERSION**
Energy generation from waste bio-chemical conversion: Sources of energy generation, anaerobic digestion of sewage and municipal waste, direct combustion of MSW-refuse derived solid fuel.Industrial waste, agro residues and anaerobic digestion.	
Unit-IV	**THERMO-CHEMICAL CONVERSION**
Biogas production, land fill gas generation and utilization, thermo-chemical conversion: Sources of energy generation, gasification of waste using gasifies briquetting, utilization and advantages of briquetting, environmental benefits of bio-chemical and thermo- chemical conversion.	
Unit-V	**E-WASTE MANAGEMENT**
E-waste: E-waste in the global context: Growth of electrical and electronics industry in India, environmental concerns and health hazards; Recycling e-waste: A thriving economy of the unorganized sector, global trade in hazardous waste, impact of hazardous e-waste in India; Management of e-waste: E-waste legislation, government regulations on e-waste management, international experience, need for stringent health safeguards and environmental protection laws of India.	

Text Books:

1. Nicholas P Cheremisinoff, ―Handbook of Solid Waste Management and Waste Minimization Technologies‖, An Imprint of Elsevier, New Delhi, 2003.
2. P AarneVesilind, William A Worrell and Debra R Reinhart, ―Solid Waste Engineering‖, 2 nd edition 2002.
3. M Dutta , B P Parida, B K Guha and T R Surkrishnan, ―Industrial Solid Waste Management and Landfilling practice‖, Reprint Edition New Delhi, 1999.
4. RajyaSabha Secretariat, ―E-waste in India: Research unit‖, Reprint Edition, June, 2011.
5. AmalenduBagchi Design, ―Construction and Monitoring of Landfills‖, John Wiley and Sons, New York, 1994.
6. M. L. Davis and D. A. Cornwell, ―Introduction to environmental engineering‖, International Edition, 2008.
7. C. S. Rao, ―Environmental Pollution Control Engineering‖, Wiley Eastern Ltd. New Delhi, 1995.
8. S. K. Agarwal, ―Industrial Environment Assessment and Strategy‖, APH Publishing Corporation, New Delhi, 1996.
9. Sofer, Samir S. (ed.), Zaborsky, R. (ed.), ―Biomass Conversion Processes for Energy and Fuels‖, New York, Plenum Press, 1981.
10. Hagerty, D.Joseph; Pavoni, Joseph L; Heer, John E., ―Solid Waste Management‖, New York, Van Nostrand, 1973.
11. George Tchobanoglous, Hilary Theisen and Samuel Vigil Prsl: Tchobanoglous, George Theisen, Hillary Vigil, Samuel, ―Integrated Solid Waste management: Engineering Principles and Management issues‖, New York, McGraw Hill, 1993.

Reference Books:

1. C Parker and T Roberts (Ed), ―Energy from Waste‖, An Evaluation of Conversion Technologies, Elsevier Applied Science, London, 1985.
2. KL Shah, ―Basics of Solid and Hazardous Waste Management Technology‖, Prentice Hall, Reprint Edition, 2000.
3. M Datta, ―Waste Disposal in Engineered Landfills‖, Narosa Publishing House, 1997.
4. G Rich et.al, Hazardous, ―Waste Management Technology‖, Podvan Publishers, 1987.
5. AD Bhide, BB Sundaresan, ―Solid Waste Management in Developing Countries‖, INSDOC, New Delhi, 1983.

XVI. COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

Lecture No	Topics to be covered	Course Learning Outcomes (CLOs)	Reference
1	Summarize about solid waste sources and its importance.	CLO 1	T1:3.3 T2:1.2
2	Discuss solid waste properties and its composition.	CLO 1	T1:3.4 T2:1.4
3	Provides the information regarding collection and transfer of solid waste.	CLO 2	T1:3.5 T2:1.5
4	Discuss the need of waste minimization and recycling	CLO 2	T1:3.7 T2:1.8
5	Discuss the need of segregating waste and managing solid waste.	CLO 3	T1: 3.9 T2: 1.10
6	Acquire the knowledge about the technologies for generation of energy from solid waste.	CLO 3	T1:5.5 T2:6.2
7	Acquire the knowledge about the technologies for generation of energy from biomedical waste.	CLO 4	T1:5.6 T2:6.3
8	Discuss the environmental impacts of incineration.	CLO 4	T1:4.3 T2:5.2
9	Illustrate the importance of landfill method of disposal.	CLO 5	T1: 4.4 T2:5.3
10	Discuss the types of land fill disposal.	CLO 5	T1:4.5 T2:5.4
11	Analyze the layout of landfills.	CLO 6	T1:4.6 T2:5.5
12	Summarize the properties and characteristics of landfills.	CLO 6	T1: 4.5.2 T2: 5.6
13	Acquire the knowledge of generating energy from landfills.	CLO 7	T1:4.6 T2:5.5
14	Discuss the emission of gasses and leach ate from landfills.	CLO 7	T1:4.6.2 T2:5.5.2
15	Discuss the environmental monitoring system for land fill gases.	CLO 8	T1:4.7 T2:5.6
16	Discuss about biochemical conversion.	CLO 8	T1:4.7 T2:5.8
17	Illustrate the sources of biochemical conversion.	CLO 9	T1:4.7.2 T2:5.8.2
18	Analyze anaerobic digestion of sewage.	CLO 9	T1:4.8 T2:5.9
19	Analyze direct combustion of MSW.	CLO 10	T1:4.9 T2:5.7
20	Discuss about refuse derived solid fuel.	CLO 10	T1:6.2 T2:5.6
21	Discuss about industrial waste and agro residues.	CLO 11	T1:6.3 T2:5.7

Lecture No	Topics to be covered	Course Learning Outcomes (CLOs)	Reference
22	Understand the concept of Thermo-chemical Conversion.	CLO 11	T1:6.4 T2:5.8
23	Discuss about Biogas production.	CLO 12	T1:6.5 T2:5.3
24	Explain land fill gas generation and utilization	CLO 12	T1:6..6 T2:5.2
25	Illustrate sources of thermo chemical energy generation	CLO 13	T1:6.7 T2:5.3
26	Explain gasification of waste using gasifies briquetting	CLO 13	T1:6.5 T2:7.5
27	Discuss utilization of various waste treatments	CLO 14	T1: 6.2, 6.3
28	Discuss advantages of briquetting	CLO 14	T1: 6.2
29	Summarize environmental benefits of bio-chemical conversion	CLO 15	T1:6.2 T2:7.2
30	Summarize environmental benefits of thermo- chemical conversion	CLO 15	T1:6.3 T2:7.3
31	Outline of E-waste in India	CLO 16	T1:6.4 T2:7.5
32	Summarize E-waste in the global context	CLO 16	T1: 6.2 T2: 5.6
33	Understand the Growth of E waste generated from electrical and electronics industry in India	CLO 16	T1:6.3 T2:5.7
34	Identify environmental concerns and health hazards	CLO 17	T1:6.4 T2:5.8
35	Determine recycling concept Of E-Waste	CLO 17	T1:2.1 T2:9.1
36	Discuss A thriving economy of the unorganized sector	CLO 17	T1:2.2 T2:9.2
37	Discuss global trade in hazardous waste	CLO 17	T1: 2.1 T2: 9.1
38	Discuss impact of hazardous e-waste in India	CLO 18	T1:2.6 R1:5.1
39	Understand management of e-waste	CLO 18	T1:2.7 R1:5.2
40	Outline E-waste legislation	CLO 18	T1:2.8 R1:5.5
41	Summarize government regulations on e-waste management	CLO 19	T1:2.1 R1:5.6
42	Outline international waste management	CLO 19	T1:2.2 R1:5.4
43	Explain need for stringent health safeguards	CLO 19	T1:2.4 R1:5.5
44	Discuss the need for environmental protection laws	CLO 20	T1:2.4 R1:5.5
45	Outline environmental protection laws of India.	CLO 20	T1:2.4 R1:5.5

XVII. GAPS IN THE SYLLABUS-TO MEET INDUSTRY / PROFESSION REQUIREMENTS:

S. NO.	DESCRIPTION	PROPOSED ACTIONS	RELEVANCE WITH POs	RELEVANCE WITH PSOs
1	Case studies on conversion of municipal solid and waste to energy conversion technologies.	Seminars/NPTEL	PO 1	PSO 1, PSO 2
2	Methods for remediation of the Growth of E waste generated from electrical and electronics industry in India	Assignments/ Guest Lectures	PO 2	PSO 3

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