GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

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

Course Title: Thermal Engineering-I
(Course Code: 4341905)

Diploma program in which this course is offered	Semester in which offered
Mechanical Engineering	4th Semester

1. RATIONALE

Mechanical engineers are supposed to operate and maintain thermal utility equipment in industries. This course will provide the basic knowledge of thermal engineering, which will function as a foundation for applications in significant mechanical engineering and technology fields, notably in thermal power plants. This course would develop basic knowledge and skills related to boilers, boiler mounting and accessories, steam turbines, condensers, cooling towers, air compressors, heat transfer, and heat exchangers. This course will thus very essential for mechanical engineers, especially in power plants, processes, food, pharmaceutical, refineries, etc.

2. COMPETENCY

The course content should be taught and implemented to develop different skills so that students can acquire the following competency.

- **Apply basic concepts, laws, and principles of thermal engineering to operate and maintain the equipment and machines working on thermal systems.**

3. COURSE OUTCOMES (COs)

The practical exercises, the underpinning knowledge, and the relevant soft skills associated with the identified competency are to be developed in the student for the achievement of the following COs:

CO-1	Determine steam properties using a steam table and a Mollier chart.
CO-2	Evaluate the boiler performance based on given parameters and operational data sheets.
CO-3	Identify various features of steam nozzles, steam turbines, condensers, and cooling towers.
CO-4	Calculate the power requirement and volumetric efficiency of air compressors.
CO-5	Determine heat transfer parameters related to heat exchangers for different situations.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P/2)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	CA	ESE	CA	ESE	
2	0	2	3	30	70	25	25	150

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

5. SUGGESTED PRACTICAL EXERCISES

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

Sr. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
01	Determine the steam properties using: a) Steam table b) Mollier chart	1	04
02	Demonstrate Steam boilers.	2	02
03	Demonstrate boiler mountings and accessories.	2	02
04	Determinate boiler efficiency, equivalent evaporation, and heat balance sheet by collecting data from the industry.	2	04
05	Demonstrate various steam turbines.	3	02
06	Demonstrate steam condensers.	3	02
07	Performance test on the condenser to determine the condenser efficiency.	3	02
08	Demonstrate cooling towers.	3	02
09	Performance test on reciprocating air compressor and determine its volumetric efficiency.	4	04
10	Determine the overall heat transfer coefficient and LMTD of a heat exchanger.	5	04
Total (Hours)		**-**	**28**

Note:

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

II. Care must be taken in assigning and assessing the study report as it is a Second-year study report. The study report, data collection, and analysis report must be assigned to a group. A teacher has to discuss the type of data (which and why) before the group starts their market survey.

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.

Sr. No.	Sample Performance Indicators for the PrOs	Weightage in %
For Demonstration type PrOs (PrOs Number: 2, 3, 5, 6 & 8)		
1	Knowledge	30
2	Quality of Report	30
3	Participation	20
4	Punctuality	20
Total		**100**
Experimentation/performance type PrOs (PrOs Number: 1, 4, 7, 9 & 10)		
1	Knowledge	20
2	Procedure follows	15
3	Observation Skill	20
4	Analysis	10
5	Quality of Report	20
6	Punctuality	15
Total		**100**

Sample rubrics Performance Indicators for the PrOs

Demonstration type PrOs (PrOs Number: 2, 3, 5, 6 & 8)					
Criteria	**%**	**10**	**9-8**	**7-6**	**5**
Knowledge	30%	Students give the correct answers 90% or more.	Student give the correct answers between 70-89%.	Student give the correct answers between 50-69%.	Student give the correct answers less than 50%.
Quality of Report	30%	Neat Handwriting, figure, and table. Complete labeling of figure and table.	Only formatting is improper (Location of figures/tables, use of pencil and scale).	A few required elements (labeling/ notations) are missing.	Several elements are missing (content in paragraph, labels, figures, tables).
Participation	25%	Excellent focused attention in the exercise.	Moderately focused attention on exercise.	Focused limited attention in the exercise.	Participation is minimum.
Punctuality	15%	Timely Submission.	Submission late by one laboratory.	Submission late by two laboratories.	Submission late by more than two laboratories.

Experimentation/performance type PrOs (PrOs number: 1, 4, 7, 9 & 10)					
Criteria	**%**	**10**	**9-8**	**7-6**	**5**
Knowledge	20%	Student give the correct answers 90% or more.	Student give the correct answers between 70-89%.	Student give the correct answers between 50-69%.	Student give the correct answers less than 50%.
Procedure follows	15%	Students follow all the procedures with precaution in a logical order.	Students follow all the procedures with some precautions in a logical order.	Students follow all the procedures without precaution in a logical order.	Students follow all the procedures without precaution in an illogical order.
Observation Skill	20%	Excellent focused attention in the exercise.	Moderately focused attention on exercise.	Focused limited attention in the exercise.	Participation is minimum.
Analysis	10%	Student understand the data and analyze correctly the obtained test results.	Student understand most of the data and analyze the obtained test results with help or support.	Student need help to understand some of the data and also in analyzing the obtained test results.	Student always need help to understand the data and also in analyzing the obtained test results.
Quality of Report	20%	Neat Handwriting, figure, and table. Complete labeling of figure and table.	Only formatting is improper (Location of figures/tables, use of pencil and scale).	A few required elements (labeling/ notations) are missing.	Several elements are missing (content in paragraph, labels, figures, tables).
Punctuality	15%	Timely Submission.	Submission late by one laboratory.	Submission late by two laboratories.	Submission late by more than two laboratories.

6. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

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

Sr. No.	Equipment Name	PrO. No.
1.	Models of various steam boilers.	2

2.	Models of various boiler mountings and accessories.	3
3.	Models of various steam turbines.	5
4.	Models of various steam condensers.	6
5.	Models of various cooling towers.	8
6.	Two-stage reciprocating air compressor test rig.	9
7.	Parallel and counter flow heat exchanger test rig.	7, 10

7. AFFECTIVE DOMAIN OUTCOMES

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

a. Work as a leader/ team member.

b. Follow safety practices.

c. Follow ethical practices

d. Maintain tools and equipment

e. Practice environment-friendly methods and processes. (Environment related)

The ADOs are best developed through 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

Based on the higher-level UOs of Revised Bloom's taxonomy formulated for developing COs and competency, the primary underpinning theory is given below. If required, more such UOs could be included by the course teacher to focus on attaining COs and competency.

Unit	Unit Outcomes (UOs) (4 to 6 UOs at different levels)	Topics and Sub-topics
Unit – I Steam Formation and its Properties	1.a Describe the steam formation process and terminology. 1.a Use of steam table and Mollier chart to determine the properties of steam.	1.1 Formation of steam with the concept of a two-phase system. 1.2 Steam types and their representation on PV, T-s, and h-s diagrams. 1.3 Determination of various steam properties: i. Sensible heat ii. Latent heat iii. Superheat iv. Enthalpy v. Entropy vi. Degree of superheat

		1.4 Use of steam table and Mollier chart. 1.5 Simple numerical examples based on steam properties.
Unit – II Steam Generators	2.a The layout of the Steam Power Plant. 2.b Explain the construction and working of boilers 2.c Function and location of boiler mountings and accessories. 2.a Calculate the boiler performance.	2.1 Concept and layout of a thermal power plant. 2.2 Steam boiler: Concept, definition as per Indian Boilers Regulation (IBR). Classifications and Applications. 2.3 Construction and working of steam boilers with draught concept: i. Cochran boiler. ii. Babcock and Wilcox boiler. iii. Packaged boiler. iv. Recent boilers in industries: (a) FBC Boiler (a.1) AFBC, (a.2) CFBC (b) Low NO_x boiler, (c) Waste heat recovery boiler. 2.4 Boiler mountings and accessories i. Function ii. Location. 2.5 Boiler performance i. Evaporative capacity ii. Equivalent of evaporation iii. Efficiency iv. Heat balance sheet, 2.6 Simple numerical examples
Unit-III Steam Turbines, Steam Condensers, and Cooling Towers	3.a Explain the construction and working principle of a Steam turbine. 3.b Importance of compounding in a steam turbine. 3.c Describe the working of surface condensers. 3.d Determine the Effectiveness of condensers. 3.a Describe the working of cooling towers.	3.1 Steam turbine: i. Concept ii. Classifications iii. Construction and working of impulse and reaction turbine iv. The necessity of compounding and its types 3.2 Steam condensers: i. Concept ii. Functions and classification iii. Construction and working of surface condensers. iv. Condenser efficiency v. Simple numerical example 3.3 Cooling Towers: i. Concept ii. Function and classification 3.4 Construction and working
Unit-IV Air Compressors	4.a Explain the principle, construction, and working of air compressors. 4.a Calculate power	4.1 Concepts, classification, and applications. 4.2 Construction and working of Reciprocating air compressor: i. Single stage

	requirement and volumetric efficiency of reciprocating air compressor.	ii. Multi-stage (without & with intercooler) iii. Power required and efficiency iv. Simple numerical 4.3 Construction and working of Dynamic air compressor: i. Centrifugal i. Axial
Unit-V Heat Transfer and Heat Exchangers	5.a Describe modes of heat transfer. 4.b Calculate the overall heat transfer coefficient and LMTD.	5.1 Concept of conduction, convection, and radiation. 5.2 Heat exchanger: i. Concept, classification, and application ii. Logarithmic Mean Temperature Difference (LMTD) (No derivation) 5.3 Simple numerical examples.

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
Unit No.	Unit Title	Teaching Hours	R Level	U Level	A Level	Total Marks
I	Steam Formation and its Properties	06	7	3	4	14
II	Steam Generators	07	4	4	7	15
III	Steam Turbines, Steam Condensers, and Cooling Towers	07	7	10	-	17
IV	Air Compressor	05	3	4	7	14
V	Heat Transfer and Heat Exchangers	03	3	-	7	10
Total		**28**	**24**	**21**	**25**	**70**

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

10. SUGGESTED STUDENT ACTIVITIES

Sr. No.	Activity.
1.	Prepare a chart/presentation to select a particular boiler for a particular application.
2.	Prepare a chart/presentation for a selection criterion for a condenser.
3.	Prepare a chart/presentation for a selection criterion for the cooling tower.
4.	Prepare a chart/presentation to select a particular air compressor for a particular application.
5.	Prepare a chart/presentation to select a particular heat exchanger for a particular application.
6.	Select at least three problems on the boiler performance and prepare a report containing their solutions.
7.	Collect/ download product catalogues with a specification of various types of energy conservation equipment/ devices and heat exchangers of recent trends.

8.	Identify and list at least ten devices that require heat transfer and prevention of heat transfer. Also, state the mode of heat transfer and methods used to prevent heat transfer.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies that the course teacher can use to accelerate the attainment of the various outcomes in this course.

Unit	Unit Title	Strategies
I	Steam Formation and its Properties	
II	Steam Generators	
III	Steam Turbines, Steam Condensers, and Cooling Towers	○ Real-life examples, Demonstration of natural systems, Movies/Animations. ○ Numericals, Massive Open Online Courses (MOOCs)
IV	Air Compressor	○ Real-life examples, Demonstration of natural systems, Movies/Animations. ○ Numericals, Massive Open Online Courses (MOOCs)
V	Heat Transfer and Heat Exchangers	○ Real-life examples, Demonstration of natural systems, Movies/Animations. ○ Numericals, Massive Open Online Courses (MOOCs)

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her at the beginning of the semester. The number of studentsin the group should ***not exceed three.***

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 with in integration of PrOs, UOs, and ADOs. Each student must maintain a dated work diary (Logbook) consisting of individual contributions to the project work and give a seminar presentation before submission. The duration of the micro project should be about **14**-**16** ***(fourteen to sixteen) student engagement hours*** during the course. The students ought to submit a micro-project by the end of the semester to develop the industry-oriented COs.

A representative 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 or using suggested student activity.

A representative list of micro-projects is given here. The concerned faculty can add similar micro-projects based on student activities (chart/presentation/report/model):

1. Prepare a demonstration model of the thermal power plant.
2. Collect information about different thermal power plant in plants located in Gujarat and compare major thermal devices.
3. Prepare a display chart of different types of condensers along the with application.
4. Prepare a display chart of different types cooling towers along the with application.
5. Prepare a tabulated summary of the types of air compressors available in the market. (Summary includes type, specification, rate, and applications).
6. Collect and analyze technical specifications of Reciprocating / Rotary Air Compressors from manufacturers' websites and other resources.
7. Carry out a comparative study of conventional boilers used in power plants and the upcoming latest technologies in a boiler.
8. Arrange a visit and prepare a Report on Thermal Power Plant.

9. Undertake 2 to 5 days of training in a Thermal Power Plant.
10. Make a PowerPoint presentation on the latest industry trends in turbines and condenser.
11. Make a Model of any heat exchanger with parallel and counter flow arrangement in a workshop with 4-6 students in a group.

13. SUGGESTED LEARNING RESOURCES

Sr. No.	Title of Book	Author	Publication
1.	A Textbook of Thermal Engineering	R S Khurmi & J K Gupta	S. Chand & Co.
2.	Thermal Engineering	R K Rajput	Laxmi.Publications
3.	Thermodynamics and Heat Power Engg.	Mathur and Mehta	Tata Mcgraw- Hill
4.	Heat Engines	Pandya and Shah	Charotar Publishing House
5.	Heat and mass transfer	R K Rajput	S. Chand & Co.
6.	Heat and mass transfer	D S Kumar	S K Kataria & Sons
7.	Thermal Engineering	P. L. Ballaney	Khanna Publishers

14. SOFTWARE/LEARNING WEBSITES

1. https://www.spiraxsarco.com/resources-and-design-tools/steam-tables/superheated-steam-region
2. https://virtuallabs.hkust.edu.hk/TubularHeatExchanger/VirtualExperiment
3. https://www.youtube.com/watch?v=EGFDqqX_Iek&list=PLLy_2iUCG87BT8H9uMufjrcPF5e6Qd2bz&index=7
4. https://www.youtube.com/watch?v=h1Yt4ibYXfA&list=PLLy_2iUCG87BT8H9uMufjrcPF5e6Qd2bz&index=12
5. https://www.youtube.com/watch?v=DuLFDzQVTU4&list=PLLy_2iUCG87BT8H9uMufjrcPF5e6Qd2bz&index=16
6. https://www.youtube.com/watch?v=mHcZdknYtkY
7. https://vlab.amrita.edu/index.php?sub=1&brch=194&sim=709&cnt=4
8. https://vlab.amrita.edu/index.php?sub=1&brch=194
9. Aspen plus simulation software
10. EES(Engineering Equation Solver) software

15. PO-COMPETENCY-CO MAPPING

Semester IV	Thermal Engineering-I (4341905)						
	POs						
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
Competency & Course Outcomes	Basic & Discipline-specific knowledge	Problem Analysis	Design/ development of solutions	Engineering Tools, Experimentation& Testing	Engineering practices for society, sustainability & environment	Project Management	Life-longLearning
Competency	Apply basic concepts, laws, and principles of thermal engineering to operate and maintain the equipment and machines working on thermal systems.						
CO-1: Determine steam properties using a steam table and a Mollier chart.	2	2	-	-	-	-	3
CO-2: Evaluate the boiler performance based on given parameters based on operational data sheets.	2	3	-	-	-	-	2
CO-3: Identify various features of steam nozzles, steam turbines, condensers, and cooling towers.	2	-	-	-	2	-	2
CO-4: Calculate the power requirement and volumetric efficiency of air compressors.	-	3	-	3	-	-	2
CO-5: Determine heat transfer parameters related to heat exchangers and other situations.	2	3	-	3	-	-	2

Legend: '3' for high, '2' for medium, '1' for low, and '-' for no correlation of each CO with PO.

16. COURSE CURRICULUM DEVELOPMENT COMMITTEE (GTU Resource Persons)

Sr. No.	Name and Designation	Institute	Contact No.	Email
1.	Prof. (Dr) Pinkesh R. Shah	Government Polytechnic, Kheda	9825472703	pinkeshrshah@gmail.com
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17. BOS Resource Persons

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