

GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

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

Semester-IV

Course Title: Thermal Engineering

(Course Code: 4346502)

Diploma program in which this course is offered	Semester in which offered
Mechanical Engineering (CAD/CAM)	4 th Semester

1. RATIONALE

This course will provide the basic knowledge of Thermal engineering required for a mechanical engineer. It would develop basic knowledge and skills related to boilers, boiler mounting and accessories, steam turbines, condensers, cooling towers, air compressors, heat transfer, internal combustion engines, refrigeration and air conditioning. This course essentially provides adequate knowledge in the field of thermal engineering required for the mechanical engineer specializing in CAD/CAM.

2. COMPETENCY

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

- **Understand basic concepts of thermal engineering and the working of boilers & its accessories, condensers, cooling towers, internal combustion engines, refrigeration and air conditioners. To understand heat transfer phenomena and air compressors.**

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	Identify the various features of boilers, mountings and accessories, turbines, condensers and cooling towers.
CO-2	Explain the operational aspects of different internal combustion engines
CO-3	Understand the working of Air compressor.
CO-4	Describe the working principle of refrigeration and air conditioning systems.
CO-5	Appreciate the importance of different parameters for various mode of heat transfer.

4. TEACHING AND EXAMINATION SCHEME

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

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	Functional study of steam boilers, along with their mountings and accessories.	I	04
02	Functional study of various turbines, condensers and cooling towers. *	I	04
03	Operational study of Internal Combustion engines and their parts. *	II	04
04	Demonstration of reciprocating air compressor and its parts. *	III	04
05	Operational study of refrigeration and air conditioning System and its components. *	IV	04
06	Demonstration of various tools for refrigeration and air conditioning tubing operation.	IV	04
07	Functional study of various types of heat exchangers. *	V	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 Third-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 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		
1	Knowledge	30
2	Quality of Report	30
3	Participation	20
4	Punctuality	20
Total		100

Sample rubrics Performance Indicators for the PrOs

Demonstration type PrOs					
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	20%	Excellent focused attention in the exercise.	Moderately focused attention on exercise.	Focused limited attention in the exercise.	Participation is minimum.
Punctuality	20%	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, mountings and accessories, turbines, condensers and cooling towers.	1,2
2.	Models (cut section) of 4-stroke Petrol engine, 4-stroke Diesel engine, 2-stroke Petrol engine, 2-stroke Diesel engine, Carburetor, Spark plug, Fuel Injector, Fuel pump, MPFI system.	3
4.	Models (cut section) of reciprocating centrifugal and axial type air compressor.	4

5.	Models of VCRS, compressor, condenser, expansion devices, evaporator.	5
7.	Thermometer and Psychrometer.	5
8.	Refrigeration and air conditioning tubing operation kit.	6
9.	Models of various heat exchangers like double pipe heat exchanger, shell and tube type heat exchanger, plate type heat exchanger etc.	7

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.

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 Thermal Energy Systems	1.a Explain the construction and working of boilers. 1.b Function and location of boiler mountings and accessories. 1.c Explain the construction and working principle of a Steam turbine. 1.d Describe the working of jet & surface condensers. 1.e Describe the working of cooling towers.	1.1 Steam boiler Concept, definition as per Indian Boilers Regulation (IBR), Classifications and Applications. 1.2 Construction and working of steam boilers. i. Cochran boiler ii. Babcock and Wilcox boiler iii. Packaged boiler iv. Fluidized bed combustion boiler 1.3 Function & Location of different boiler mountings like Water level indicator, Pressure gauge, Safety valve and Fusible plug. 1.4 Function & Location of different boiler accessories like Economizer, Air preheater and Superheater

		<p>1.5 Steam turbine</p> <ol style="list-style-type: none"> i. Concept & classifications ii. Construction and working of impulse and reaction turbine <p>1.6 Steam condensers Construction and working of Jet condensers and surface condensers.</p> <p>1.7 Cooling Towers</p> <ol style="list-style-type: none"> i. Concept & classification ii. Construction and working of natural draft and mechanical draft cooling towers.
Unit – II Internal Combustion Engines	<p>2.a Describe ICEs with classification.</p> <p>2.b Explain various components and terminology used in ICEs.</p> <p>2.c Describe the working principle, construction and working of the ICEs.</p> <p>2.d Explain needs and types of alternate fuels & their applications.</p>	<p>2.1. IC Engine</p> <ul style="list-style-type: none"> - Concept & working principle - Major components & Its functions - Terminology - Classifications <p>2.2. P-V and T-S diagram of otto and diesel cycle (without derivation).</p> <p>2.3. Construction and working of four Stroke petrol and diesel engine</p> <p>2.4. Construction and working of two stroke petrol and diesel engine</p> <p>2.5. Alternative fuels Alcohols, Hydrogen, LPG, Biogas, CNG, Biofuel</p>
Unit-III Air Compressors	<p>3.a Explain the principle, construction and working of air compressors.</p> <p>3.b Explain various components used in air compressors.</p>	<p>3.1. Concepts, classification and applications.</p> <p>3.2. Construction and working of Reciprocating air compressor (single stage & multi-stage)</p> <p>3.3. Construction and working of dynamic (centrifugal & axial) air compressor</p>

Unit-IV Refrigeration and Air- Conditioning	<p>4.a Describe the processes and components of VCRS with functions of each component.</p> <p>4.b Plot the various VCRS processes on P-H diagram</p> <p>4.c List characteristics of refrigerants used for VCRSs.</p> <p>4.d Plot and interpret various air conditioning processes on psychometric chart.</p> <p>4.e Explain working of various air-conditioners.</p>	<p>4.1 Concept of refrigerators and heat pumps</p> <p>4.2 Reverse Carnot cycle and Bell column cycle (Without COP derivation)</p> <p>4.3 Construction and working of Vapor Compression Refrigeration Cycle, P-V, T-S and P-h diagram</p> <p>4.4 Application of VCRS Domestic refrigerator, Ice plant, Water cooler</p> <p>4.5 Refrigerant - Types and Properties of refrigerants - Eco friendly refrigerants</p> <p>4.6 Air conditioning - Properties of air - Psychometric chart - Psychometric processes - Construction and working of window and split air conditioner</p>
Unit-V Heat Transfer	<p>5.a Describe modes of heat transfer.</p> <p>5.b Determination of heat transfer through cylinder and wall.</p> <p>5.c Calculate the overall heat transfer coefficient and LMTD.</p>	<p>5.1. Various modes of heat transfer.</p> <p>5.2. Conduction heat transfer- Fourier's law- explanation (Without derivation), thermal conductivity, heat transfer through a plain wall, composite wall and cylinder (Simple numerical)</p> <p>5.3. Convection heat transfer, coefficient of convection, Newton's law of convection (simple numerical), Free and forced convection</p> <p>5.4. Radiation heat transfer, Black body concept, emissivity, reflectivity, absorptivity, Stefan and Boltzmann's law.</p> <p>5.5. Heat exchanger: - Concept, classification and application - Logarithmic Mean Temperature Difference (LMTD) (Without derivation) (simple numerical)</p>

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Thermal Energy Systems	09	7	4	3	14
II	Internal Combustion Engines	08	6	8	-	14
III	Air Compressors	05	3	5	-	08
IV	Refrigeration and Air-Conditioning	10	6	6	4	16
V	Heat Transfer and Heat Exchangers	10	5	6	7	18
Total		42	29	27	14	70

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

10. SUGGESTED STUDENT ACTIVITIES

Sr. No.	Activity.
1.	Visit of any power plant/ industry where various items like boiler, air compressors, heat exchanger, cooling tower, condenser etc. can be shown to students.
2.	Prepare a model of simple heat exchanger in modelling software.
3.	Enlist IC Engine specifications which is available in your laboratory.
4.	Visit any automobile service center in the nearby area.
5.	Enlist specifications of VCRS system which is available in your laboratory.
6.	Enlist specifications of air compressor which is available in your laboratory.
7.	Identify and enlist 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	Boilers, Boiler mountings and accessories, Steam Turbines, Steam Condensers and Cooling Towers	<ul style="list-style-type: none"> ○ Real-life examples, Demonstration of natural systems, Movies/Animations. ○ Numericals, Massive Open Online Courses (MOOCs).
II	Internal Combustion Engines	
III	Air Compressors	
IV	Refrigeration and Air-Conditioning	
V	Heat Transfer and Heat Exchangers	

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned at the beginning of the semester. The number of students in 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 at least COs with in

integration of PrOs, UOs, and ADOs. The duration of the micro project should be about **4-5 (four to five) 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.

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1. Prepare a lay out of thermal power plant using software like open office draw, Microsoft visio, RFlow etc.
2. Thermal analysis of simple heat exchanger using analysis software like ANSYS, Autodesk Inventor Nastran etc.
3. Prepare a lay out of refrigeration and air conditioning system using software like open office draw, Microsoft visio, RFlow etc.
4. Thermal analysis of composite wall taking different materials in analysis software like ANSYS, Autodesk Inventor Nastran etc. (Faculty can assign different shape and material to group of students.). Also compare result of analysis with theoretical result.
5. Prepare a tabulated summary of the types of air compressors available in the market. (Summary includes type, specification, rate, and applications).
6. Prepare a tabulated summary of the types of four-stroke Petrol and diesel engines used in a vehicle which are available in the market. (Summary includes number of cylinders, capacity, types of cooling system, types of ignition system, types of governing system, types of fuel supply system etc).
7. Prepare a chart of possible minor fault and remedies while driving two wheelers and four wheels.
8. Prepare a chart of installation and maintenance of A.C. at home or office.

13. SUGGESTED LEARNING RESOURCES

Sr. No.	Title of Book	Author	Publication
1.	Thermodynamics: An Engineering Approach	Yunush A. Cengel Michael A. Boles	Tata Mcgraw- Hill.
2.	A Course In Power Plant Engineering	Arora and Domkundwar	DhanpatRai Publication
3.	A Textbook of Power Plant Engineering	R K Rajput	Laxmi. Publications
4.	Heat Engines	Pandya and Shah	Charotar Publishing House.
5.	Thermodynamics and Heat power Engineering	Mathur and Mehta	Tata Mcgraw- Hill.
6.	Thermal Engineering	R K Rajput	Laxmi. Publications

7.	A Text book of Thermal Engineering	R S Khurmi & J.K. Gupta	S Chand & Co.
8.	Thermal engineering	P.L.Ballaney	Khanna Publication
9.	Thermal Science and Engineering	Dr. D.S.Kumar	S.K.Kataria & Sons.
10.	IC Engine	Mathur and Sharma	DhanpatRai Publication
11.	Refrigeration and air conditioning	Arora & Domkundwar	Khanna publication.
12.	A Text Book of Refrigeration and Air Conditioning	R S Khurmi	Eurasia Publishing House
13.	Refrigeration & Air-Conditioning	R.K.Rajput	S.K.Kataria & Sons.
14.	Heat and mass transfer	R K Rajput	S. Chand & Co.
15.	Heat and mass transfer	D S Kumar	S K Kataria & Sons

14. SOFTWARE/LEARNING WEBSITES

1. https://www.youtube.com/watch?v=EGFDqqX_Iek&list=PLLy_2iUCG87BT8H9uMufjrcPF5e6Qd2bz&index=7
2. https://www.youtube.com/watch?v=h1Yt4ibYXfA&list=PLLy_2iUCG87BT8H9uMufjrcPF5e6Qd2bz&index=12
3. https://www.youtube.com/watch?v=DuLFDzQVTU4&list=PLLy_2iUCG87BT8H9uMufjrcPF5e6Qd2bz&index=16
4. <http://nptel.ac.in/courses/112105128/>
5. <http://www.youtube.com/playlist?list=PLE2DA184A2E479885>
6. <http://www.kolpak.com/asset/?id=tugvr>
7. <https://www.kwangu.com/work/psychrometric.htm>
8. <http://people.tamu.edu/~i-choudhury/psych.html>
9. https://www.youtube.com/playlist?list=PLwdnzlV3ogoXHbVnKWL1BYOo_8PpyNtnC
10. <http://vlabs.iitkgp.ernet.in/rtvlas/exp1/index.html#>
11. <https://vlab.amrita.edu/index.php?sub=1&brch=194&sim=709&cnt=4>
12. <https://vlab.amrita.edu/index.php?sub=1&brch=194>
13. <https://www.spiraxsarco.com/resources-and-design-tools/steam-tables/superheated-steam-region>

15. PO-COMPETENCY-CO MAPPING

Semester IV	Thermal Engineering (4346502)						
	POs						
Competency & Course Outcomes	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7
		Basic & Discipline-specific knowledge	Problem Analysis	Design/development of solutions	Engineering Tools, Experimentation & Testing	Engineering practices for society, sustainability & environment	Project Management
Competency	Apply basic concepts, laws, and principles of thermal engineering to operate and maintain the equipment and machines working on thermal systems.						
CO-1: Identify the various features of boilers, mountings and accessories, turbines, condensers and cooling towers.	2	-	-	-	2	-	3
CO-2: Explain the operational aspects of different internal combustion engines.	2	2	-	-	2	-	3
CO-3: Understand the working of Air compressor.	2	2	-	-	2	-	2
CO-4: Describe the working principle of refrigeration and air conditioning systems	2	2	-	-	2	-	3
CO-5: Appreciate the importance of different parameters for various mode of heat transfer.	3	2	2	-	2	2	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.) J.M.Bhatt	G. P. Junagadh	9428573088	jaydeepbhatt54@gmail.com
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BOS RESOURCE PERSONS

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