GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

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

Course Title: Thermal Engineering-II
(Course Code: 4351903)

Diploma program in which this course is offered	Semester in which offered
Mechanical Engineering	5th Semester

1. RATIONALE

The course on thermal engineering covers a wide range of topics related to the principles of thermodynamics and their practical applications in various engineering systems. Students will learn about Internal Combustion Engines (ICEs), gas turbines, refrigeration, air conditioning, and IC engine fuels, which are all critical components of thermal system/device. The course will deliver the working principles of IC engine, including the several type of engines, their components, and their applications. The course will cover ICE fuels and their properties. It also covers the gas turbine cycles, effect of variable and its applications. Finally, course will also cover refrigeration and air conditioning systems, including the principles of heat transfer, refrigerants. Overall, this course provides a comprehensive understanding of thermal systems/devices and their applications, which are essential for engineers who is working in various industries.

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 select and operate the IC engines, gas turbines, refrigerators and air conditioners.**

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	Analyze performance of internal combustion engines using performance parameters and heat balance sheet.
CO-2	Select IC engine fuels and related support system for internal combustion engines.
CO-3	Identify salient features of open and closed cycles gas turbines.
CO-4	Analyze the performance of refrigeration system using standard procedures.
CO-5	Estimate air conditioning parameters for particular appliances.

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	
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	Demonstrate various IC engine and its components. *	I	02
02	Prepare an actual valve timing diagram of given IC engine. *	I	02
03	Perform a test on four stroke Petrol engine test rig. also prepare a heat balance sheet. *	I	04
04	Perform a test on four stroke Diesel engine test rig. also prepare a heat balance sheet. *	I	04
05	Measure a friction power of multICylinder petrol engine using Morse test.	I	02
06	Measure and analyze the emitted gases from IC engine (in context of pollution).	II	02
07	Demonstrate various gas turbines and its components. *	III	02
08	Demonstrate various tools for refrigeration tubing operation. *	IV	02
09	Determine the COP of VCRS system. *	IV	02
10	Demonstrate leak detection with various leak detection techniques, evacuation and refilling of refrigerant	IV	02
11	Determine of properties of air. *	V	02
12	Determine of capacity of window / split air-conditioner. *	V	02
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 (PrOs Number: 1, 7, 8 & 10)		
1	Knowledge	30
2	Quality of Report	30
3	Participation	20
4	Punctuality	20
Total		**100**
Experimentation/performance type PrOs (PrOs Number: 2, 3, 4, 5, 6, 9, 11 & 12)		
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: 1, 7, 8, & 10)					
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: 2, 3, 4, 5, 6,9, 11 & 12)					
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: - 4-stroke Petrol engine cut section	01

	- 4-stroke Diesel engine cut section - 2-stroke Petrol engine cut section - 2-stroke Diesel engine cut section - Carburetor cut section - Spark plug cut section - Fuel Injector cut section - Fuel pump cut section - MPFI system	
2.	Actual cut section of 4-stroke Diesel engine for valve timing diagram.	02
3.	Four stroke Petrol engine test rig.	03
4.	Four stroke Diesel engine test rig.	04
5.	MultICylinder 4-stroke Petrol engine test rig for Morse test.	05
6.	Exhaust gas analyzer: - Petrol engine - Diesel engine	06
7.	Models/charts of: - Gas turbines	07
8.	Refrigeration tubing operation kit.	08
9.	VCRS test rig.	09
10.	I. Leak detection kit. II. Evacuation and refilling station for refrigeration system.	10
11.	Psychometer and thermometer for wet bulb and dry bulb temperatures.	11
12.	Window/split air conditioner test rig.	12

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 Internal Combustion Engines	1.a Describe ICEs with classification. 1.b Explain various components and terminology used in ICEs. 1.c Describe the working principle, construction and working of the ICEs. 1.d Explain various systems used for ICEs. 1.e Calculate the ICEs performance parameters.	1.1 IC Engine - Concept - Working principle - Major components & Its functions - Terminology - Classifications 1.2 Cycles on P-v and T-s diagram on which IC engines work 1.3 Four Stroke Petrol Engine - Construction & Working 1.4 Four Stroke Diesel Engine - Construction & Working 1.5 Two Stroke Engines - Construction & Working of Petrel Engine - Construction & Working of Diesel Engine 1.6 Theoretical and actual valve timing diagrams 1.7 Fuel Injection system - Carburation - Fuel pump - Multi Point Fuel Injection (MPFI) - CRDI 1.8 Cooling System 1.9 Lubrication system 1.10 Ignition system 1.11 Governing & Scavenging system 1.12 Exhaust system (considering pollution reduction) 1.13 Supercharging & Turbocharging 1.14 Performance testing of IC engines - Performance parameters (Indicated power, Brake power, Friction Power, A/F ratio, specific fuel consumption, efficiencies) - Heat balance sheet - Morse test 1.15 Simple numericals.
Unit– II IC Engine Fuels	2.a List characteristics and properties of fuels used for ICEs. 2.b Explain various petroleum	2.1 Fuels - Concept - Types/classifications - Properties/characteristics

	and alternative fuels for ICEs. 2.c Measure and analyze the pollution parameters.	2.2 Petroleum fuels - Natural gas - Gasoline or petrol - Diesel - Fuel Oil - Kerosene 2.3 Alternative fuels - Alcohols - Hydrogen - LPG - Biogas - CNG - Biofuel - Supply requirement for CNG and LPG 2.4 Rating of engine fuels - Octane Number - Cetane Number 2.5 Pollution and control - Emission norms - Effect emitted gases 2.6 Analysis of exhaust gas
Unit-III Gas Turbines	3.a Describe the concept of gas turbine. 3.b Explain a working of open and closed cycle gas turbines. 3.c List the effect of operating variables in gas turbines. 3.d Calculate the performance parameter of gas turbines.	3.1 Concept and classifications 3.2 Brayton cycle - P-v and T-s diagram - Actual cycle 3.3 Open and closed cycle gas turbine 3.4 Performance improvement methods - Intercooling - Reheating - Regeneration 3.5 Essential gas turbine power plant components - Compressor - Combustion chamber - Turbine 3.6 Usages of gas turbine 3.7 Gas turbine fuels 3.8 Simple numericals
Unit– IV Refrigeration	4.a Describe the processes and elements of VCRS with functions of each element. 4.b Operate VCRSs, observe the changes in properties of refrigerant during each process on VCRS and calculate / analysis the performance using thermodynamic charts/ diagrams.	4.1 Concept of refrigerators and heat pumps 4.2 Reverse Carnot cycle and Bell column cycle 4.3 Vapor Compression Refrigeration Cycle - Major components - P-v, T-s and P-h diagram - Working - Mathematical analysis 4.4 Performance of VCRS 4.5 Effect of Change in operating condition 4.6 Simple numerical on VCRS performance 4.7 Application of VCRS

	4.c Calculate various performance parameters of VCRS. 4.d List characteristics of refrigerants used for VCRSs.	- Domestic refrigerator - IC plant - Water cooler 4.8 Vapor Absorption Refrigeration System (VARS) 4.9 Refrigerant - Characteristics - Properties of refrigerants - Commonly used refrigerants - Eco friendly refrigerants
Unit–V Air-Conditioning	5.1 Plot and interpret various air conditioning processes on psychometric chart. 5.2 Measure various air properties. 5.3 Explain working of various air-conditioners.	5.1 Air conditioning - Concept - Types - Applications 5.2 Properties of air - Psychometric relations - Humidity and temperature measurement 5.3 Psychometric chart - Psychometric processes 5.4 Simple numericals 5.5 Air conditioner - Window air conditioner - Split air conditioner

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	Internal Combustion Engines	14	7	7	7	21
II	IC Engine Fuels	06	3	7	0	10
III	Gas Turbines	08	3	4	7	14
IV	Refrigeration	09	4	4	7	15
V	Air-Conditioning	05	3	0	7	10
Total		**42**	**20**	**22**	**28**	**70**

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

10. SUGGESTED STUDENT ACTIVITIES

Sr. No.	Activity.
1.	Enlist IC Engine specifications which is available in your laboratory.
2.	Search different ICE components from scrap and identify type of defect/ failure.
3.	Visit any Industry working on IC Engine manufacturing/ running or power plant working on IC Engine.
4.	Visit any automobile service center in nearby area.
5.	Visit any Petrol/ Diesel/ CNG/ LPG station and study different fuel filling systems along with different parameters affected.

6.	Enlist VCRS system specifications which is available in your laboratory.
7.	Prepare chart VCRS/ VARS.
8.	Visit cold storage plant, ice plant and air-conditioning Plant to observe VCRS or VARS.
9.	Preparation of small model of VCRS.
10.	Built up/ evacuate VCRS available at your institute.
11.	Prepare property table for different types of refrigerants/ alternate fuels.
12.	Undertake 2 to 5 days of training in an automobile workshop.

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	Internal Combustion Engines	○ Real-life examples, Demonstration of natural systems, Movies/Animations. ○ Numericals, Massive Open Online Courses (MOOCs).
II	IC Engine Fuels	
III	Gas Turbines	
IV	Refrigeration	
V	Air-Conditioning	

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 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 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.

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/animation):

1. Prepare a demonstration model of IC engine parts on wooden board.
2. Prepare a demonstration model of pistons of different size on wooden board.
3. Prepare a demonstration model of connecting rods of different size on wooden board.
4. Prepare a display chart of different types IC engine systems.
5. Prepare a display chart of different types of IC engine fuels.
6. Make a PowerPoint presentation on the latest industry trends in IC engines.
7. Prepare a tabulated summary of the types of four-stroke Petrol 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).

8. Prepare a tabulated summary of the types of two-stroke 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).
9. Prepare a tabulated summary of the types of four-stroke 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).
10. Prepare a chart of possible minor fault and remedies while driving two wheelers and four wheels.
11. Prepare chart of CNG/LPG/Diesel/ Petrol engine fueling system.
12. Make a PowerPoint presentation on the latest trends in IC engines fuels.
13. Carry out a comparative study of gas turbines used in power plants and the upcoming latest technologies in a gas turbine.
14. Make a PowerPoint presentation on the latest industry trends in gas turbines.
15. Prepare a tabulated summary of the types of refrigerators used for domestic, dairy products, soft drinks which are available in the market. (Summary includes cooling capacity, types of compressors, types of refrigerants, types of expansion system, types of evaporation system etc).
16. Prepare a tabulated summary of the types of air conditioners used in a home, office, mall, cinema and vehicle which are available in the market. (Summary includes tonnage capacity, types of compressors, types of refrigerants, types of expansion system etc).
17. Prepare a chart of installation and maintenance of A.C. at home or office.
18. Collect and analyse technical specifications of split air conditioner from manufacturers' websites and other resources.
19. Collect and analyze technical specifications of refrigerator from manufacturers' websites and other resources.

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.	Heat Engines	Pandya and Shah	Charotar Publishing House.
3.	Thermodynamics and Heat power Engineering	Mathur and Mehta	Tata Mcgraw- Hill.
4.	Heat Engines	D. A. Wrangham	Cambridge University Press.
5.	Thermal Engineering	R K Rajput	Laxmi. Publications
6.	A Text book of Thermal Engineering	R S Khurmi & J.K. Gupta	S Chand & Co.
7.	Thermal engineering	P.L.Ballaney	Khanna Publication

8.	Thermal Science and Engineering	Dr. D.S.Kumar	S.K.Kataria & Sons.
9.	IC Engine	Mathur and Sharma	DhanpatRai Publication
10.	Principles of Refrigeration	Dossat	Pearson Education
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. SOFTWARE/LEARNING WEBSITES

1. http://nptel.ac.in/courses/112105128/
2. http://www.youtube.com/playlist?list=PLE2DA184A2E479885
3. http://www.kolpak.com/asset/?id=tuqvr
4. https://www.kwangu.com/work/psychrometric.htm
5. http://people.tamu.edu/~i-choudhury/psych.html
6. https://www.youtube.com/playlist?list=PLwdnzlV3ogoXHbVNKWL1BYOo_8PpyNtnC
7. http://vlabs.iitkgp.ernet.in/rtvlas/exp1/index.html#

15. PO-COMPETENCY-CO MAPPING

Semester V	Thermal Engineering-II (4351903)						
	POs						
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-longLearning
Competency	Apply basic concepts, laws, and principles of thermal engineering to select and operate the IC engines, gas turbines, refrigerators and air conditioners.						
CO-1: Analyze performance of internal combustion engines using performance parameters and heat balance sheet.	2	3	2	3	-	2	3
CO-2: Select IC engine fuels and related support system for internal combustion engines.	2	-	-	-	3	-	2
CO-3: Identify salient features of open and closed cycles gas turbines.	2	-	-	-	-	-	2
CO-4: Analyze the performance of refrigeration system using standard procedures.	-	3	2	3	2	2	2
CO-5: Estimate air conditioning parameters for particular appliances.	2	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)

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17. BOS RESOURCE PERSONS

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