

GUJARAT TECHNOLOGICAL UNIVERSITY (G.T.U.)

Competency-focused Outcome-based Green Curriculum-2023 (COGC-2021) Semester-III

Course Title: Fundamental of Thermodynamics and Heat Transfer
(Course Code: 1336404)

Diploma programs in which this course is offered	Semester in which offered
Renewable Energy	3 rd Semester

1. RATIONALE:

Fundamental of Thermodynamics and Heat Transfer is a branch of science that deals with energy transformations and are primarily concerned with the two forms of energy heat and work. The energy transformations are governed by the various laws of thermodynamics known as zero, first, second and third laws. These laws were deduced from experimental observations and logical reasoning. Extensive applications of thermodynamics can be found in fields ranging from refrigeration and air-conditioning to aerospace. Its principles are used to design energy converting devices, automobile engines, steam and gas turbines, power plants, compressors, HVAC, alternators, propulsion systems of aircraft and rockets, etc. Thus, every student of Diploma Renewable Energy should have a fundamental knowledge of this course.

2. COMPETENCY:

The course should be taught in such a way that it can develop the necessary skills to bridge the gap between theoretical knowledge and its practical application. The students achieve the following competencies after completion of this course:

- **Apply fundamental concepts, laws and principles of thermodynamics and heat transfer on various thermal Devices/systems.**

3. COURSE OUTCOMES (COs)

CO1	Identify thermodynamic properties and systems by interpreting the basic concepts of thermodynamics.
CO2	Apply various thermodynamic laws and gas laws to thermal systems.
CO3	Calculate various parameters of different thermodynamic processes and cycles using P-V and T-s diagrams.
CO4	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				Total Marks
L	T	P		Theory Marks		Practical Marks		
			C	CA	ESE	CA	ESE	
3	0	2	4	30*	70	25	25	150

(*) out of 30 marks under the component of theory CA, 10 marks are allotted for the assessment of the micro-project to facilitate the integration of COs. The remaining 20 marks would be the average of marks of the 2 mid-semester exams to be taken during the semester for assessing the attainment of the cognitive domain. UOs are required for the attainment of the COs.

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

5. UNDERPINNING THEORY

The primary underpinning theory is below based on the higher level UOs of the *Revised Bloom's taxonomy* formulated for developing the COs and competency. 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 Fundamentals of Thermodynamics	1a. Illustrate various terms related to thermodynamics. 1b. Identify thermodynamic properties with appropriate usages. 1c. Describe a Zeroth law of thermodynamics.	1.1 Introduction and applications of Engineering thermodynamics. 1.2 Basic thermodynamic Concepts. (a) State, System, Boundary and Surroundings. (b) Types of Systems and boundaries with examples. (c) Thermodynamic properties, their units and classifications. (d) Energy, Heat, Work, Power and its simple numerical.
Unit	Unit Outcomes (UOs) (4 to 6 UOs at different levels)	Topics and Sub-topics
		(e) Thermodynamic equilibrium. (f) Thermodynamic Process and Cycle. 1.3 Zeroth law of thermodynamics and its application.

<p style="text-align: center;">Unit –II</p> <p style="text-align: center;">First Law of Thermodynamics</p>	<p>2a. Describe the first law of thermodynamics.</p> <p>2b. Apply the first law of thermodynamics to real-life situations.</p> <p>2c. Solve various numerical related to the first law of thermodynamics.</p>	<p>2.1 Statement of the first law of thermodynamics. (a) Law of conservation of energy. (b) Heat and work relation with Joule’s Experiment.</p> <p>2.2 Application of the first law of thermodynamics: a) Open system (Flow Processes). b) Closed system (Non-flow Processes). c) Definition of the flow process, control volume and flow work. d) Steady and unsteady flow processes. e) Steady Flow Energy Equations (SFEE) and its applications in Nozzle, Diffuser, Boiler, Turbine, Compressor, Condenser,</p> <p>2.3 Simple numerical examples based on the above.</p> <p>2.4 Identify the applications of First law of thermodynamics for green environment.</p>
<p style="text-align: center;">Unit–III</p> <p style="text-align: center;">Second Law of Thermodynamics</p>	<p>3a. Describe the second law of thermodynamics.</p> <p>3b. Apply the second law of thermodynamics to real-life situations.</p> <p>3c. Solve various numerical related thermal efficiency & C.O.P..</p> <p>3d. Interpret the entropy, its equations with the unit.</p>	<p>3.1 Limitations of the first law of thermodynamics.</p> <p>3.2 Concept of heat source, heat sink, heat engine, heat pump, refrigerator and simple numerical on thermal efficiency and COP (Coefficient of Performance) respectively.</p> <p>3.3 Statement of the second law of thermodynamics: a) Kelvin Planck Statement b) Clausius Statement</p> <p>3.4 Applications of the second law of thermodynamics. Also identify its applications for green environment.</p>

Unit	Unit Outcomes (UOs) (4 to 6 UOs at different levels)	Topics and Sub-topics
		3.5 Concept of reversibility and irreversibility. List of irreversibility only. 3.6 Definition of Entropy and its T-ds equation. (Without Derivations) 3.7 Statement of the third law of thermodynamics.
Unit-IV Ideal Gases and Thermodynamic Processes	4a. Describe various ideal gas laws. 4b. Derive the relationship of specific heats. 4c. Identify various thermodynamic processes. 4d. Calculate the amount of heat transfer, work transfer & internal energy associated with the process. 4e. Plot various thermodynamic processes on P-V and T-S diagrams. 4f. Solve various numerical.	4.1 Concept of Ideal gas. Boyle's law, Charle's law and Gay-Lussac law for ideal gases. 4.2 Thermodynamic Processes, its representation on P-V (Pressure-Volume) and T-S (Temperature-Entropy) diagram: a) Constant Volume Process b) Constant Pressure Process c) Constant Temperature Process d) Adiabatic Process e) Polytropic Process f) Throttling Process 4.3 Equations of P-V-T relationship, work transfer, heat transfer and internal energy of the above processes. (Without derivations) 4.4 Simple numerical based on the above.
Unit-V Thermodynamic Cycles	5a. Identify thermodynamic processes in a cycle. 5b. Plot various cycles on P-V and T-s diagram. 5c. Solve various numerical related to power-producing cycles.	5.1 Classifications of thermodynamic cycle. 5.2 Carnot cycle and its representation on P-v and T-s diagram. 5.3 Thermal efficiency of Carnot cycle and its simple numerical (without derivation). 5.4 Concept of air standard efficiency. 5.4 Otto, Diesel, Dual and Brayton cycle (Without derivation) representation on P-v & T-s diagram. Equation of air standard efficiency and simple examples. 5.6 Representation of Reversed Carnot cycle and Reversed Brayton cycle on P-V and T-s diagram respectively.

Unit	Unit Outcomes (UOs) (4 to 6 UOs at different levels)	Topics and Sub-topics
Unit-VI Heat Transfer	5a. Describe modes of heat transfer. 5b. Calculate the overall heat transfer coefficient and LMTD.	5.1 Concept of conduction, convection, and radiation. 5.2 Heat exchanger: a) Concept, classification, and application b) Logarithmic Mean Temperature Difference (LMTD) (No derivation) 5.3 Simple numerical examples.

a. 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	Basic Concepts of Thermodynamics	04	05	04	03	10
II	First Law of Thermodynamics	06	04	05	06	12
III	Second Law of Thermodynamics	06	02	03	03	10
IV	Ideal Gases and Thermodynamic Processes	10	03	04	05	14
V	Thermodynamic Cycles	10	03	04	05	14
VI	Heat Transfer	06	02	04	05	10
	Total	42	19	24	27	70

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

Note: This specification table gives general guidelines to assist students in their learning, and to the teachers, for question paper design and teaching methodology to formulate test items/questions to 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 slightly vary from the above table.

b. SUGGESTED PRACTICAL EXERCISES

Sr. No.	Practical Outcomes (PROs)	Unit No.	Approx. Hrs. Required
01	Take any thermal Device/system available in the Institute and identify it based on Types of System (b) Types of Boundary.	I	02
02	Identify and list real situations working on Zeroth law of thermodynamics.	I	02
03	Identify and list real situations working on First law of thermodynamics.	II	02
04	Identify and list real situations working on Second law of thermodynamics.	III	02
05	Plot P-V, T-S diagram of Otto, Diesel, Dual cycles. Tabulate the main points of differences among them.	V	04

06	Determine the overall heat transfer coefficient and LMTD of a heat exchanger.	VI	04
07	Prepare chart on : (1) Heat Exchanger (2) Types of process, (3) Types of thermodynamic cycles, etc.	IV,V,VI	04
08	List out the thermodynamic laws/concepts used in the Solar system. Also, Prepare technical specifications of solar rooftop at your home or nearby areas.	I, IV	02
09	Collect/ download product catalogs with the specification of various types of <i>Air Compressors/I.C.Engines /Refrigerators/Solar Water Heaters/Solar Power Generation/Solar Cooker, etc.</i> used in daily life.	V, VI	04
10	Prepare specification of some Thermal devices / systems available in the Institute / Surrounding.	I, V, VI	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 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 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.

c. 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	Basic Concepts of Thermodynamics	<ul style="list-style-type: none"> Real-life examples. Demonstration of real systems. Movies/Animations. Numericals, Massive Open Online Courses (MOOCs).
II	Ideal Gases and Thermodynamic Processes	
III	First Law of Thermodynamics	
IV	Second Law of Thermodynamics	
V	Thermodynamic Cycles	
VI	Heat Transfer	

d. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to them during the semester. The teacher can assign any activity suggested in section 7 of **“SUGGESTED STUDENT ACTIVITIES”** according to their convenience. While designing the micro-project, it should be kept in mind that it encompasses most of the COs. It should be

the application of the theoretical knowledge into some practical aspect.

e. SUGGESTED LEARNING RESOURCES

Sr. No.	Title of Books	Author	Publication & ISBN
1.	Engineering Thermodynamics	Yunus A. Cengel	Tata McGraw Hill 975-1-25-906256-8
2.	Thermodynamics	R.Yadav	CPH ISBN-13: 9788185444031
3.	Thermodynamics for Engineers	M.L.Mathur	Dhanpatrai & sons 81-200-0029-3
4.	Heat Engines	C.S.Shah & N.C.Pandya	Charotar Publi.House 81-85594-49-X
5.	Elements of Heat Engines Vol.I&II	R.C.Patel	AcharyaBookDepot
6.	Thermodynamics	SAAD	Prentice-Hall
7.	Engineering Thermodynamics- 2 nd Edition	P.K. Nag	Mc-GrawHill Education 978-0-07-026062-7
8.	Applied Thermodynamics	R.C.Patel	Acharya Book Depot
9.	Thermodynamics	Gupta	Pearson 9788131717950
10.	Thermodynamics	J. P. Holman	Tata Mc Graw-Hill
11.	Heat and Mass Transfer	D. S. Kumar	S K Kataria & Sons
12.	Heat and Mass Transfer	R. K. Rajput	S. Chand & Co.

f. SOFTWARE / LEARNING WEBSITES

Sr. No.	Software/Website address	Topic covered
1.	CALPHAD software	Thermodynamic modeling
2.	https://lawofthermodynamicsinfo.com/what-is-thermodynamic-system/	Basic of thermodynamics
3.	https://thermo.pressbooks.com/chapter/chapter-4/	Problems based on first law of thermodynamics
4.	https://www.youtube.com/watch?v=OmhXb-miAhw	Thermodynamic cycles
5.	https://nptel.ac.in/courses/112/105/112105123/	All units
6.	http://www.thermofluids.net/	All units

7.	http://www.grc.nasa.gov/WWW/k-12/airplane/thermo.html	Basic concepts
8.	http://www.youtube.com/watch?v=Xb05CaG7TsQ	First law of thermodynamics
9.	http://www.youtube.com/watch?v=aAfBSJObd6Y	Carnot cycle
10.	http://www.youtube.com/watch?v=DHUwFuHuCdW	Second law of thermodynamics and Heat Engines
11.	http://www.youtube.com/watch?v=GKqG6n6nAmg	Zeroth law of thermodynamics
12.	https://www.youtube.com/watch?v=ty4F30dRdwk	Understanding Entropy
13.	https://www.youtube.com/watch?v=WTtxlaeC9PY	Understanding Second law of thermodynamics
14.	https://www.youtube.com/watch?v=Jsnv8L7HdEk	Thermodynamic Processes
15.	https://virtuallabs.hkust.edu.hk/TubularHeatExchanger/VirtualExperiment	Heat Exchanger

g. PO-COMPETENCY-CO MAPPING

Semester II	Engineering Thermodynamics (Course Code: 4321901)						
	Pos						
Competency & Course Outcomes	PO1 (Basic & Discipline specific knowledge)	PO2 (Problem Analysis)	PO3(Design/development of solutions)	PO4(Engineering Tools, Experimentation Testing)	PO5 (Engineering practices for society, sustainability & environment)	PO6 (Project Management)	PO7 (Life-long learning)
Competency	Apply fundamental concepts, laws and principles of Thermodynamics on various thermal devices/systems.						
CO.1 Identify thermodynamic properties and systems by interpreting the basic concepts of thermodynamics.	3	-	-	-	-	-	2
CO.2 Apply various thermodynamic laws and gas laws to thermal systems.	3	2	-	-	1	-	2

CO.3 Calculate various parameters of different thermodynamic processes and cycles using P-V and T-s diagrams	3	2	1	-	-	-	-
CO. 4 Determine heat transfer parameters related to heat exchangers for different situations.	3	2	-	-	1	-	-

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

h. COURSE CURRICULUM DEVELOPMENT COMMITTEE (GTU Resource Persons)

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