GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

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

Course Title: Chemical Engineering Thermodynamics
(Code: 4340503)

Diploma Programme in which this course is offered	Semesterinwhichoffered
Chemical Engineering Thermodynamics	4^{th} Semester

1. RATIONALE

Diploma Chemical engineer has to deal with the laws of thermodynamics which are applied to flow and non-flow processes in the plant to evaluate heat effects and energy transformation calculation accompanying physical and chemical changes, for calculating temperature change and to determine power generation efficiencies of engines and power plants. Understanding of basic concepts and application of thermodynamics are therefore necessary for chemical engineers. Hence the course has been designed to develop these competencies and its associated cognitive and effective domain learning outcomes.

2. COMPETENCY

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- Solve the problems related to heat and work requirements for physical and chemical changes.
- Identify the various phase behavior of different fluids.
- Explain the working principles of heat engine, heat pump and refrigeration and calculate efficiency

3. COURSE OUTCOMES(COs)

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry-oriented COs associated with the above-mentioned competency:

1. Understand the fundamental concepts of thermodynamics
2. Apply the Concept of First Law of Thermodynamics for flow and non-flow processes.
3. Use the equation of state for ideal gas and real gas to predict PVT behavior of fluid.
4. Apply the Concept of second Law of Thermodynamics.
5. Apply the laws of thermodynamics in refrigeration

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits(L+T+P)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	CA	ESE	CA	ESE	
3	-	-	3	30*	70	-	-	100

(*):Out of 30 marks under the theory CA,10 marks are for assessment of the micro-project to facilitate the integration of COs, and the remaining 20 marks are the average of 2 tests tobe taken during the semester for 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

The following practical outcomes (PrOs) are the sub-components of the COs. *Some of the **PrOs**marked **'*'** (in approx. Hrs column) are compulsory, as they are crucial for that particular CO at the 'Precision Level' of Dave's Taxonomy related to 'Psychomotor Domain'*.

Sr. No.	**Practical/Exercise** (Course Outcomes in Psychomotor Domain according to NBATerminology)	Unit No.	Approx. Hrs Required
Not Applicable			

Note

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

ii. 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 %
1	Question answer or Writing steps exercise (Assignment)	30
2	Executing of exercise	30
3	Result	40
	Total	**100**

6. MAJOR EQUIPMENT/INSTRUMENTS AND SOFTWARE REQUIRED

These major equipment/instruments and Software required to develop PrOs are given below with broad specifications to facilitate procurement of them by the administrators/management of the institutes. This will ensure the conduction of practice in all institutions across the state in a proper way so that the desired skills are developed in students.

Sr. No.	Equipment Name with Broad Specifications	PrO. No.
Not Applicable		

7. AFFECTIVE DOMAIN OUTCOMES

The following ***sample*** Affective Domain Outcomes (ADOs) are embedded in many of the above-mentioned COs and PrOs. More could be added to fulfill the development of thiscompetency.

a) Work as a leader/a team member.
b) Follow ethical practices
c) Observe safety measures
d) Good house keeping
e) Time management
f) Practice environmentally friendly methods and processes.

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

The major underpinning theory is given below based on the higher level UOs of *Revised Bloom's taxonomy* that are formulated for development of the Cos and competency. If required, more such higher-level UOs could be included by the course teacher to focus on the attainment of COs and competency.

Unit	Major Learning Outcomes (Course Outcomes in Cognitive Domain according to NBA terminology)	Topics and Sub-topics
Unit– I Introduction and Basic Concept	1a. Describe scope of thermodynamics 1b.Explain the System, surrounding, and properties with examples of chemical engineering field	1.1 Scope and limitations of thermodynamics 1.2 System, surrounding, functions, properties and Process 1.2.1 System-Homogeneous and heterogeneous, Closed and Open, Isolated System, State of System
	1c. Differentiate functions, properties and processes	1.3 Properties -Extensive and intensive 1.4 Function -State and Path function 1.5 Process -Reversible and irreversible process, cyclic process

	1d. Explain type of equilibrium for the given system	1.6 Steady and Equilibrium State 1.7 Thermal, Chemical, Mechanical and thermodynamic equilibrium
	1e. Explain importantphysical quantities	1.8 Force, Pressure, Work, powerand Energy
	1f. Explain Phase Rule	1.9 Gibb's Phase rule, degree of freedom
	1g. Explain Temperature and Zeroth Law of thermodynamics	1.10 Zeroth Law of thermodynamics 1.11 Temperature 1.12 Ideal Gas Temperature Scale
	1h. Solve simple numerical	1.13 Simple examples (numerical)on Force, Pressure, Work and Energy phase rule
Unit– II First Law of Thermody namics	2a. Explain first law and energy - Internal Energy, Enthalpy and Heat capacity concepts with examples of chemical engineering 2b. Apply first law for non-flow & flow process of chemical engineering	2.1 First law of thermodynamics 2.2 Internal Energy, Enthalpy and Heat capacity 2.3 First law for non-flow processes and flow processes of chemical engineering
	2c. Solve simple numerical	2.4 Numerical basedon first law and energy - Internal Energy, Enthalpy and Heat capacity
Unit– III PVT Behavior	3a. Explain PVT behavior of pure fluids	3.1 PVT behavior of pure fluids
	3b. Explain Ideal gas Processes	3.2 Ideal gas and equation of state 3.3 Ideal gas Process: 3.3.1 Constant Volume process 3.3.2 Constant Pressure process 3.3.3 Constant Temperature process 3.3.4 Adiabatic Process 3.3.5 Polytropic Process
	3c. Compare equations of state for real gases	3.4 Equation of state for real gases 3.4.1 Vander Waals Equation 3.4.2 Virial Equation 3.4.3 Compressibility charts
	3d. Solve simple numerical	3.5 Numerical based on Idea gas and real gas equations
Unit–IV Second Law Of Thermo-dynamics	4a. Discuss limitation of first law	4.1 Limitations of first law of thermodynamics
	4b. Describe the concepts of Heat reservoir, Heat engine and Heat pump	4.2 Heat reservoir, Heat engine and Heat pump
	4c. State different statements of Second law	4.3 Clausius Statement 4.4 Kelvin Planck Statement

	4d. Explain Carnot cycle, carnot principle and thermodynamic temperature scale	4.5 Carnot cycle and thermodynamic temperature scale
	4e. Explain Concept of Entropy for the given system	4.6 Concept of Entropy 4.7 Mathematical Expression of entropy
	4f. Calculate entropy change	4.8 Calculation of entropy changes during: 4.8.1 phase change, 4.8.2 ideal gas process 4.8.3 adiabatic mixing process, 4.8.4 isothermal mixing of ideal gases, 4.8.5 chemical reaction
	4g. Solve Numerical	4.9 Numerical based on entropy change and heat engine efficiency
	4h. Explain Third Law of thermodynamics.	4.10 Explain the Statement of Third Law of thermodynamics
Unit– V Refrigeration Cycles and Systems	5a. Refrigeration Cycles and Systems 5b. Describe various refrigeration cycles 5c. Explain various types of Refrigerants and their codes	5.1 Explain refrigeration, COP, Refrigerator capacity 5.2 Vapor-compression cycle and Air-refrigeration cycle (only theory) 5.3 Types of refrigerants and codes 5.4 Choice of refrigerant
	5d. Solve Numerical	5.4 Numerical based on CoP, Refrigerator Capacity

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Introduction and Basic Concepts	09	06	04	03	13
II	First Law of Thermodynamics	09	03	04	06	13
III	PVT behavior	09	04	06	06	16
IV	Second Law of Thermodynamics	10	05	07	06	18
V	Refrigeration Cycles and Systems	05	03	04	03	10
	Total	**42**	**21**	**25**	**24**	**70**

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

Note*: This specification table provides general guidelines to assist students for their learningand to teachers to teach and question paper designers/setters to formulate test items/questionsto 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 above table.*

10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, the following are the suggested student-related ***co-curricular*** activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should perform the following activities in group and prepare small reports of about 5 pages for each activity. They should also collect/recordphysical evidence such as photographs/videos of the activities for their (student's) portfolio which will be useful for their placement interviews:

a) Prepare the presentation on various topics of thermodynamics
b) Practice various different free available thermodynamic simulation tools.
c) Prepare Chart/Poster on PVT diagram
d) Identify different refrigerants

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

a) Massive open online courses (*MOOCs*) may be used to teach various topics/subtopics.
b) Guide student(s) in undertaking micro-projects/activities.
c) Different types of teaching methods i.e. video demonstration, activity based learning, case study, m-learning need to be employed by teachers to develop the outcomes.
d) Some *of the topics/sub-topics* which is relatively simpler or descriptive are to be given to the students for *self-learning* but to be assessed using different assessment methods.
e) Teachers need to ensure to create opportunities and provisions for *co-curricular activities*.
f) Guide students to address issues on environment and sustainability with reference to using the knowledge of this course
g) Tutorial sessions may be organized as given in following table

Sr. No.	Unit No.	Topics/Sub Topics on which Numerical may be given during Tutorial Sessions	Approx. Hrs. Required
1	I	Quiz and Brief questions on Introduction and Concepts of thermodynamics	1
2	I	Numerical based on force, work, energy, pressure	2

3	I	Numerical based on Phase Rule	1
4	II	Numerical based on First Law of thermodynamics, internalenergy, enthalpy, heat capacity etc.	2
5	III	Numerical based on Ideal Gas Processes. Equation of state for real gases (Vander Waal's)	2
6	IV	Numerical based on Entropy change	2
7	V	Numerical based on Carnot engine efficiency, Cop of refrigeration, Tons of refrigeration	4
TOTAL			14

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. In the first four semesters, the micro-project is group-based (group of 3 to 5). However, **in the fifth and sixth semesters**, 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 two or moreCOs which are the integration of PrOs, UOs, and ADOs. Each student will have to maintain a dated work diary consisting of individual contributions in the project work and give a seminar presentation of it before submission. The duration of the microproject should beabout **14-16** ***(fourteen to sixteen) student engagement hours*** during the course. The students ought to submit micro-project by the end of the semester (so that they develop industry-oriented COs.

A suggestive list of micro-projects is given here. This should relate highly to thecompetencyofthecourseandtheCOs.Similarmicro-projectscouldbeaddedbythe concerned course teacher.

a) Prepare a chart on PVT diagram.
b) Prepare model of system showing thermodynamic concepts
c) Prepare chart showing Ideal Gas (Constant Volume) Thermometer
d) Collect the thermodynamic data from any open source (e.g.-V, P-T) and make use of Microsoft Excel® to plot the graph
e) Demonstrate the Joule's Experiment for First Law in simple way.
f) Note down the change in temperature by applying heat to ice.
g) Mention simple example of potential energy and kinetic energy from day-to-day life.
h) Perform simple experiment explaining First and Second Law of thermodynamics (Balloon and water, Balloon and candle)
i) Prepare a chart on flow process
j) Prepare report on Steady state and equilibrium state with appropriate example
k) Prepare chart showing different codes of refrigerants

13. SUGGESTEDLEARNINGRESOURCES

Sr. No.	Title of Books	Author	Publication with place, year and ISBN
1	A Textbook of Chemical Engineering Thermodynamics	Narayan,K.V.	PHI Learning PVT Ltd. New Delhi,2013, ISBN :9788120347472
2	Introduction to Chemical Engineering Thermodynamic	Smith J.M., Van Ness H.C., Abott M.M	McGraw-Hill, New York,1996 ISBN :978-9353168490
3	Chemical Engineering Thermodynamics	Rao Y.V.C	Sangam Books, Hyderabad,1997, ISBN : 9780863116889.
4	Engineering Thermodynamics	P.K.Nag	Tata Mc-Graw-Hill Publishing Company Ltd,New Delhi ISBN:0070591148
5	Chemical Engineering Thermodynamics–I	Gavhane, K.A.	Nirali Prakashan, Pune 2009
6	A Textbook of Engineering Thermodynamics	R. K. Rajput	Publisher: Laxmi Publications, third edition 2007 ISBN 10: 813180058X ISBN 13: 978-8131800584

14. SUGGESTED LEARNING WEBSITES

a) https://nptel.ac.in/
b) www.msubbu.in
c) Resources | Thermodynamics & Kinetics | Chemistry | MIT OpenCourseWare
d) Basic Thermodynamics online course video lectures by IIT Kharagpur (freevideolectures.com)
e) ** TEST, The Expert System for Thermodynamics: A thermodynamics Web Portal ** (thermofluids.net)
f) moran.pdf (krodriguez.net)

15. PO-COMPETENCY-CO MAPPING

<table>
<tr><td rowspan="2">SemesterVI</td><td colspan="7">Chemical Engineering Thermodynamics(4340503)</td></tr>
<tr><td colspan="7">POs</td></tr>
<tr><td>Competency & Course Outcomes</td><td>PO1 Basic & Discipline specific knowledge</td><td>PO2 Problem Analysis</td><td>PO3 Design/development of solutions</td><td>PO4 Engineering Tools, Experimentation & Testing</td><td>PO5 Engineering practices for society, sustainability& environment</td><td>PO6 Project Management</td><td>PO7 Life-long learning</td></tr>
<tr><td>Competency</td><td colspan="7">• Solve the problems related to heat and work requirements for physical and chemical changes.
• Identify the various phase behavior of different fluids.
• Explain the working principles of heat engine, heat pump and refrigerationand calculate efficiency</td></tr>
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CO1. Understand the fundamental concepts of thermodynamics	3	-	1	-	-	-	-
CO2. Apply the Concept of First Law of Thermodynamics for flow and non-flow processes.	**3**	**2**	**1**	**-**	**-**	**-**	**-**
CO3. Use the equation of state for ideal gas and real gas to predict PVT behavior of fluid.	2	1	2	-	-	-	1
CO4. Apply the Concept of second Law of Thermodynamics.	1	1	2	-	1	-	1
CO5. Apply the laws of thermodynamics in refrigeration	1	-	1	-	1	-	1

16. COURSE CURRICULUM DEVELOPMENT COMMITTEE

<u>GTU Resource Persons</u>

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