



GUJARAT TECHNOLOGICAL UNIVERSITY

BACHELOR OF ENGINEERING SYLLABUS

Subject Code: BE04051021

Course / Subject Name: Food Engineering Thermodynamics

w. e. f. Academic Year:	2025-26
Semester:	04
Category of the Course:	Compulsory Subject

Prerequisite:	Nil
Rationale:	Knowledge of food engineering thermodynamics is required to design, operate and understand any system involving the interchange between heat and work or the conversion of material to produce heat and vice-versa. To establish the fundamentals of food engineering thermodynamics such that they can be applied to a range of processes and systems commonly encountered by food engineers. The course aims to teach the principals involved in the thermodynamic analysis of both unit operations and process equipment to provide a strong grounding required for system design and operation. It seeks to provide the necessary background so that the thermodynamic analysis of unknown systems can be approached in a logical and methodological manner. The emphasis is to make students understand the fundamentals of energy transactions in food engineering unit operations and apply these for on the field applications.

Course Outcome:

After Completion of the Course, Student will able to:

No	Course Outcomes
01	Ability to apply the Knowledge of Fundamental concepts to Practical Food Engineering Systems such as Pumps, Compressor, Boilers, Engines, Turbines, Nozzles, Diffusers, Heat Exchanges, Condensers etc. as well as Non-Flow systems for their Thermodynamic Analysis. Determination of Thermodynamic Properties, Work Transfer, Heat Transfer, Mass/Energy /Enthalpy Balance etc
02	Ability to apply the Knowledge of Fundamental concepts to Food equipment such as Refrigerator & Heat Pump as well as for Non-Flow System for their Thermodynamic Analysis viz:- Determination of Temperatures, Heat Transfer, Work Transfer, Refrigerating / Heating Effect, COP etc
03	Ability to apply the Knowledge of Fundamental concepts to Food Engineering Devices as well as Non-Flow Systems for their Thermodynamic Analysis viz:- Determination of Entropy Changes, Heat /Work Transfer, Available Energy, Availability, Energy Destruction, Irreversibility, Exergy Change etc.
04	Ability to apply concepts to Food Engineering Devices with pure substance as working fluid for their Thermodynamic Analysis viz:- Determination of various Thermodynamic Properties Pressure, Volume, Temperature, Enthalpy, Internal energy, Entropy, Dryness Fraction, Work / Heat Transfer



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05	Ability to apply the Knowledge of Fundamental concepts to Practical Engineering Devices such as Compressors, Gas Turbines, Nozzles, Diffusers, Heat Exchangers as well as Non-Flow Systems with Ideal Gas or Mixture of Ideal Gases as working fluid for their Thermodynamic Analysis.
06	Psychrometric calculations and use Charts for their applications in food Processing.
07	Develop Thermodynamic Relationships for practical food processing applications.

Teaching and Examination Scheme:

Teaching - Learning Scheme (in Hours per Semester)					Total Credits = TH/30	Assessment Pattern and Marks					Total Marks
L	T	P	PBL*	TH		Theory		Tutorial / Practical			
						ESE (E)	PA (M)	PA/ (I)	PBL (I)	ESE (V)	
45	0	30	45	120	04	70	30	20	30	50	200

Where L = Lecture, T= Tutorial, P= Practical, TW/SL = Term-Work / Self-Learning, TH = Total Hours, ESE = End- Semester Examination, PA = Progressive Assessment

*** Problem Based Learning (PBL) aims to accommodate learning beyond syllabus as per clause 9.4 of NBA manual**

Course Content:

Unit No.	Content	No. of Hours	% of Weightage
1.	Fundamental Concepts : Definitions related to Thermodynamics, Units and Dimensions	03	8
2.	Ideal and real gases : Concepts of ideal gas, characteristics equation of gas. Universal and characteristics gas constant. Enthalpy and specific heat, deviation of real gas from ideal gas, compressible factor and the Van der Waal's equation of state for real gas	06	12
3.	Laws of thermodynamics : Zeroth law: concepts of temperature. Equality of temperature, Zeroth law of thermodynamics	05	10
4.	First law : First law of thermodynamics. Concepts processes, flow processes and control volume, flow work, steady flow energy equation, mechanical, mechanical work in a steady flow process, throttling process, application of first law to open systems.	08	18
5.	Second law : Essence of second law, thermal reservoir, heat engines and thermal efficiency, COP of heat pump and refrigerator, definition of available and non-available energy, statement of second law, Carnot cycle, Carnot's theorem	08	18



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6.	Properties of Pure Substance: Definition, Steam & Water Tables and its application in food engineering operations.	07	16
7.	Psychrometrics: Psychrometric parameters and their relationships, Psychrometric properties of air. Psychrometric Charts, Mixing of air streams, Heating and cooling processes, Humidification and dehumidification processes and their applications in food processing.	08	18
Total		45	100

References Books:

1. Engineering Thermodynamics by P. K. Nag (TMH)
2. Thermodynamics and Heat Engines - Vol I by Yadav, R (Central Publishing House, Allahabad)
3. Engineering Thermodynamics by Rogers, P H and Mayhew, H
4. Thermodynamics by Holman, J P (TMH)
5. An Introduction to Thermodynamics, Y.V.C. Rao, New Age International (P) Ltd., Publishers

Suggested Course Practical List:

1. Tutorials on thermodynamic air cycles.
2. Study of Ideal Gas Equation and Determination of Universal Gas Constant (R)
3. Comparative Study of Ideal Gas and Real Gas Behavior
4. Calculation of Specific Heat and Enthalpy Change of Air at Constant Pressure
5. Study of Deviation of Real Gases from Ideal Gas Behavior using Compressibility Factor (Z)
6. Study and application of P V and T S chart in refrigeration, P H chart (or) Mollier diagram in refrigeration
7. Study of Throttling Process and Joule-Thomson Effect using a Throttling Calorimeter
8. Application of First Law of Thermodynamics to Open and Closed Systems
9. Study of Available and Unavailable Energy in a Thermodynamic System
10. Energy Analysis of Carnot Cycle and Determination of Maximum Efficiency
11. Application of Steam Tables for Thermodynamic Property Calculation
12. Determination of Relative Humidity, Dew Point, and Humidity Ratio of Air
13. Study of Humidification and Dehumidification of Air in Food Processing Applications
14. Application of Psychrometrics in Food Drying Operations
15. Analysis of Psychrometric Processes Using Wet and Dry Bulb Temperatures



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List of Laboratory/Learning Resources Required:

Equipment:

1. Gas law apparatus (Boyle's and Charles' law setup)
2. Pressure gauge
3. Temperature sensor / thermocouple
4. Manometer
5. Air heater setup
6. Voltmeter and ammeter
7. Compressibility factor chart
8. Throttling calorimeter
9. Calorimeter
10. Temperature and pressure sensors
11. Steam generator / boiler model
12. Steam tables
13. Psychrometer (wet and dry bulb thermometers)
14. Hygrometer
15. Psychrometric chart

List of Open-source software and website:

1. NPTEL
2. <http://nptel.ac.in/courses/112103016/>
3. <http://imechanica.org/node/9501>
4. <http://ocw.nd.edu/aerospace-and-mechanical-engineering/thermodynamics>
5. <http://tigger.uic.edu/~mansoori/Thermodynamics.Educational.Sites.html>

List of suggested activities for Problem Based Learning:

Sr. No.	Activity Name	Suggested Topics/Focus Area	Hours	Evaluation Criteria
1	Industry/Research Laboratory Visit	Visit to food processing unit, R&D center, food testing lab (e.g., dairy, bakery, oil mill, FSSAI lab)	10 h (Visit + Report)	Submission of visit report with observations and learning Ability to relate theory to practical systems
2	Technical Video-Based Learning	Observation of food processing operations (heating, cooling, drying, refrigeration)	10 h	Report/Presentation based on learning outcomes
3	Assignment Writing (Numericals)	Energy balance calculations in food heating/cooling Enthalpy, entropy, and specific heat problems and Psychrometric problems (humidity ratio, relative humidity, enthalpy)	10 h	Based on assignment depth and accuracy



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4	Problem Solving / Coding	Thermodynamic calculations using software (MATLAB, Python, EES)	10 h	Based on Correctness of code and calculations
5	Online Course (MOOCs)	NPTEL/SWAYAM course Food Thermodynamic principles applied to food processing	10 h	Based on completion certificate and assessment
6	Complex Problem Solving	Multi-step problems involving energy balance, heat transfer, phase change and Drying system design, refrigeration load calculation, freezing time estimation	10 h	Logical reasoning and stepwise calculations
7	Industrial Safety Videos	Food plant safety, thermal processing and steam systems, handling of boilers, heat exchangers, and refrigeration units	10 h	Based on quiz or summary report
8	Discussion on Research Papers	analysis of energy relationships, mathematical analysis of energy relationships.	20 h (5 papers × 4 h)	Evaluation of scientific depth, summary of findings
9	Poster/Chart/Power Point Presentation	Key thermodynamics concepts: First law, Second law, Entropy, Enthalpy	6 h	Presentation clarity and content relevance
11	Industrial Exposure (2-3 Days)	Understanding energy usage in heating, cooling, drying and refrigeration	20 h	Critical evaluation report with suggested solutions
12	Group Discussion (Technical Trends)	Food sustainability, functional foods, AI in food industry, alternative proteins	1 h per GD	Technical input and communication skill
13	Case Study-Based Learning	Real case: Energy efficiency in dairy plants, cold storage, drying units, breweries, or frozen food plants	10 h	Report with fact analysis and regulatory links
14	Application / Software Development	Energy balance, psychrometry, refrigeration cycle simulations	10 h	Based on functionality and usability

- All records pertaining to the evaluation and assessment of self-learning activities must be properly maintained and preserved at the institute level. These records should be made available to the university upon request.
- Institutes are encouraged to utilize digital platforms, such as Microsoft Teams, for effective record-keeping and to ensure transparency in the evaluation and assessment of self-learning activities.

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