

# GUJARAT TECHNOLOGICAL UNIVERSITY

## FOOD PROCESSING TECHNOLOGY

### FOOD ENGINEERING THERMODYNAMICS

**SUBJECT CODE:** 2131404

B.E. 3<sup>RD</sup> SEMESTER

**Type of Course:** Food Processing Technology

**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 principles involved in the thermodynamic analysis of both unit operations and process equipments 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. Knowledge of basic mathematics and science are prerequisite for this subject.

#### Teaching and Examination Scheme:

Teaching Scheme			Credits C	Examination Marks					Total Marks	
L	T	P		Theory Marks			Practical Marks			
			ESE (E)	PA (M) PA ALA		PA (V) ESE OEP		PA (I)		
4	1	0	5	70	20	10	30	0	20	150

#### Content:

Sr. No.	Topics	Teaching Hrs.	Module Weightage
1.	<b>Fundamental Concepts</b> Definitions related to Thermodynamics, Units and Dimensions	3	5
2.	<b>Ideal and Real Gases</b> Concept of ideal gas, Characteristic equation of gas. Gas laws, Universal and Characteristic gas constant. Enthalpy and Specific heat. Deviation of real gas from ideal gas, Compressibility factor and the Van der Waal's equation of state for real gas.	09	15
3	<b>Zeroth Laws of Thermodynamics</b> Zeroth Law, Concept of temperature and its measurement. Equality of temperature, calibration and calculations.	04	5
4.	<b>First Law of Thermodynamics</b> First law of thermodynamics. Concept of processes, Flow processes and control volume, Flow work, Steady flow energy equation, Mechanical work in a steady flow process, Throttling process, Application of first law to open, closed and isolated systems.	08	20
5.	<b>Second Law of Thermodynamics</b>	10	20

	Essence of second law, Thermal reservoir, Heat engines and thermal efficiency, COP of heat pump and refrigerator, Definition of available and unavailable energy, Statement of second law, Carnot cycle, Carnot theorem, Clausius inequality, Concept of entropy, Entropy change for ideal gases.		
6	<b>Thermodynamic Relations</b> Maxwell's equations, thermodynamic property relations for a pure substance, Joule-Kelvin effect, Clausius-Clapeyron equation, Gibbs phase rule, types of equilibrium, and conditions of stability.	07	15
7.	<b>Properties of Pure Substance (steam)</b> Definitions, Steam quality, P-V and T-S phase diagrams, Steam & Water Tables and its application in food engineering operations.	04	5
8.	<b>Psychrometrics</b> 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.	07	15

#### Reference 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

#### Course Outcomes:

At the end of this course students will be able to:

1. 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.
2. 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.
3. 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.
4. 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**, **Mass/Enthalpy/Energy Balance etc. using Steam Tables and Mollier Chart.**
5. 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.

6. To enable students to carry out Psychrometric calculations and use Charts for their applications in food processing.
7. Develop Thermodynamic Relationships for practical food processing applications.

**List of Open Source Software/learning website**

- <http://nptel.ac.in/courses/112103016/>
- <http://imechanica.org/node/9501>
- <http://ocw.nd.edu/aerospace-and-mechanical-engineering/thermodynamics>
- <http://tigger.uic.edu/~mansoori/Thermodynamics.Educational.Sites.html>
- <http://units.handbooks.uwa.edu.au/units/mech/mech4429>
- <http://www.saylor.org/courses/me103>

**ACTIVE LEARNING ASSIGNMENTS:** Preparation of power-point slides, which include videos, animations, pictures, graphics for better understanding theory and practical work – The faculty will allocate chapters/ parts of chapters to groups of students so that the entire syllabus to be covered. The power-point slides should be put up on the web-site of the College/ Institute, along with the names of the students of the group, the name of the faculty, Department and College on the first slide. The best three works should submit to GTU.