

GUJARAT TECHNOLOGICAL UNIVERSITY



Program Name: Bachelor of Engineering

Level: Undergraduate

Branch: Food Engineering & Technology

Subject Code: BE05051061

Subject Name: Food Engineering Operation I

w. e. f. Academic Year:	2024-25
Semester:	05
Category of the Course:	Professional Elective Course - 2

Prerequisite:	NA
Rationale:	Food engineering operations are essential for the safe processing, preservation, and quality maintenance of food products for the design of the equipment. Thermal processing methods such as blanching, pasteurisation, sterilisation, and drying are widely used to inactivate microorganisms and enzymes to improve the safety of the food for public consumption. Non-thermal technologies such as high-pressure processing, pulsed electric fields, ultrasound, and cold plasma have emerged as innovative techniques to extend shelf life while maintaining nutritional and sensory quality. This course introduces students to the engineering principles, equipment, and applications of thermal and non-thermal food processing technologies.

Course Outcome:

After Completion of the Course, the student will be able to:

No	Course Outcomes
01	Understand fundamental engineering principles in food processing
02	Apply unit operations to design and optimise food processes
03	Analyse mass, energy, and momentum transfer in food systems
04	Develop practical skills in equipment handling and process calculations
05	Understand fundamental engineering principles in food processing

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	15	90	03	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



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

Course Content:

Unit No.	Content	No. of Hours	% of Weightage
1.	Fundamentals of food engineering operations Unit operations for thermal processing of food, including pasteurisation, sterilisation, blanching, chilling, freezing, evaporation, drying, baking, osmotic dehydration and frying. Understanding thermal properties of food materials, including specific heat and thermal conductivity. Basic principles of mass and energy balance in food processing.	10	20
2.	Mechanical operation and instruments Screening instruments and principles, Size reduction mills and principles, types of mixers and agitators, mechanical separation devices including filtration, centrifuge, reverse osmosis, desiccators, ultrafiltration & sedimentation unit.	7	20
3.	Heat transfer equipment Heat exchangers used in the food industry: plate heat exchanger, shell and tube heat exchanger. Design considerations and applications.	8	20
4.	Properties of food materials for equipment design Thermal properties of food materials, including specific heat, thermal conductivity and diffusivity. Physical properties: Density, porosity, viscosity, rheology. Mechanical properties, including textural properties such as hardness, cohesiveness, springiness, chewiness, and gumminess. Electrical and optical properties. Importance of all properties in equipment design.	7	15
5.	Fluid flow operations Fluid statics and dynamics, types of fluids in food processing, Bernoulli's equation and applications, flow measurement devices (Venturimeter, Orifice meter), types of flow in pipes, laminar, turbulent, and Reynold number	5	10
6.	Mass transfer operation Fundamentals of mass transfer, diffusion and Fick's law Drying: Drying mechanisms, drying rate curve, types of dryers (tray, spray, freeze dryer), Evaporation: single and multiple effect evaporators, distillation and extraction.	5	10
7.	Thermal parameters and heat penetration Concept of heat penetration characteristics in food systems during thermal processing. Evaluation of thermal process parameters such as	3	5

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heating rate index, lag factor, cold point determination, and thermal processing time.		
Total	45	100

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
25	20	20	15	20	00

Where R: Remember; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create (as per Revised Bloom's Taxonomy)

The syllabus of Food Engineering Operation I directly contributes to:

SDG 2	Zero Hunger
SDG 3	Good Health and Well-Being
SDG 4	Quality Education
SDG 7	Affordable and Clean Energy
SDG 9	Industry, Innovation and Infrastructure
SDG 12	Responsible Consumption and Production

References/Suggested Learning Resources:

(a) Books:

1. Introduction to Food Engineering – R. Paul Singh & Dennis R. Heldman.
2. Food Processing Technology: Principles and Practice – P. J. Fellows.
3. Principles of Food Processing – Dennis R. Heldman & Richard W. Hartel.
4. Handbook of Food Engineering – Dennis R. Heldman et al.
5. Transport Phenomena in Food Processing – Jorge Weltri-Chanes et al.

(b) Open-source software and website:

1. NPTEL / SWAYAM – Free online courses on food engineering and processing.
2. National Institute of Food Technology Entrepreneurship and Management – Research resources and training materials.
3. Indian Institute of Food Processing Technology – Technical reports, publications, and learning resources.
4. Central Food Technological Research Institute – Open research articles and food technology resources.
5. Food Safety and Standards Authority of India – Guidelines, standards, and food safety documentation.



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Suggested Course Practical List :

1. Determination of thermal conductivity of selected food materials.
2. Determination of specific heat capacity of food samples using calorimetric methods.
3. Study of heat transfer through conduction using a composite wall apparatus.
4. Determination of convective heat transfer coefficient in heating and cooling systems.
5. Determination of drying characteristics and drying rate curve of food materials using a tray dryer.
6. Determination of moisture content and equilibrium moisture content of foods.
7. Study of the pasteurisation process and assessment of microbial reduction.
8. Determination of freezing time of food products and analysis of freezing curves.
9. Study of evaporation and concentration of liquid foods using a laboratory evaporator.
10. Demonstration of non-thermal processing techniques, such as ultrasound or high-pressure processing, for food preservation.

List of Laboratory/Learning Resources Required:

1. Thermal conductivity measurement apparatus
2. Calorimeter for specific heat determination
3. Composite wall heat transfer apparatus
4. Convective heat transfer apparatus
5. Tray dryer or cabinet dryer
6. Moisture analyser or hot air oven
7. Laboratory pasteurisation unit or water bath pasteurizer
8. Deep freezer or freezing unit with temperature probe
9. Laboratory evaporator or rotary evaporator
10. Ultrasonic processor or high-pressure processing demonstration unit
11. Digital thermometer and thermocouples
12. Analytical balance

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 food processing industries to observe instrumentation such as temperature sensors, pressure gauges, flow meters, level sensors, PLC/SCADA-based automation systems	10 h	Report with instrumentation layout, control loops, equipment study, and identification of control points
2	Assignment (Numericals)	Solve problems related to sensor calibration, measurement errors, signal	10 h	Accuracy, method, and understanding of concepts



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		conditioning, transfer functions, and basic control system calculations		
3	Complex Problem Solving	Temperature control in pasteurization, pressure control in evaporation, PID controller tuning, dynamic response of food process systems	10 h	Analytical approach, correctness, and depth of solution
4	Problem Solving / Coding	Simulation using MATLAB/Simulink or NPTEL-based problem solving on process control, instrumentation systems, and automation	10 h	Functionality, correctness, usability, validation
5	Online Course (MOOC)	NPTEL/SWAYAM courses on Process Control, Industrial Instrumentation, Automation in Food Processing	10 h	Course completion certificate and performance
6	Industrial Safety Videos	Study safety in instrumentation systems, electrical safety, sensor handling, calibration procedures, and automation hazards	10 h	Evaluation through report, quiz, or safety protocol analysis
7	Discussion on Research Papers	Review 4–5 research papers on IoT in food processing, smart sensors, digital twins, AI-based process control	20 h	Understanding, critical analysis, and summary presentation
8	Poster / Chart / PPT Presentation	Topics: PLC architecture, SCADA systems, types of sensors, control loops in food industry, automation trends	6 h	Clarity, technical accuracy, presentation effectiveness
9	Model Development	Develop models such as temperature control system, level control system, automated mixing system, conveyor automation	8–12 h	Innovation, demonstration quality, explanation

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