GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Bachelor of Engineering

Level: Under Graduate

Branch: Food Engineering & Technology

Course / Subject Code: BE04051041

Course / Subject Name: Unit Operations in Food

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

Prerequisite:	NA
Rationale:	This course provides a comprehensive understanding of the fundamental **unit operations involved in food engineering**. It emphasizes the principles of mass and energy conservation, heat and mass transfer, and their applications in operations such as evaporation, mechanical separation, size reduction, crystallization, and distillation. Students will learn the working principles, construction, and performance of various equipment used in these processes. The course helps develop the ability to analyze, design, and optimize food processing systems, ensuring improved efficiency, safety, and product quality in modern food industries.

Course Outcome:

After Completion of the Course, Student will able to:

No	Course Outcomes
01	Explain the principles of mass and energy conservation and their significance in food engineering processes.
02	Describe the construction, working, and performance of different evaporators and mechanical separation equipment.
03	Apply the concepts of size reduction and contact equilibrium separation to improve process efficiency.
04	Analyze operational parameters influencing crystallization and distillation in food processing.
05	Evaluate suitable unit operations and equipment for effective design and optimization of food processing systems.

Teaching and Examination Scheme:

Teaching - Learning Scheme (in Hours per Semester)					Total Credits = TH/30	Assessment Pattern and Marks					Total Marks
						Theory		Tutorial / Practical			
L	T	P	PBL*	TH		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.	**INTRODUCTION TO UNIT OPERATIONS** Importance and scope in food processing, Conservation of mass and energy, Dimensions units, dimensional analysis, Dimensionless ratios and consistency and over view of cleaning, grading and storage of food produce.	6	13
2.	**EVAPORATION AND CONCENTRATION** Unit operations in food processing –conservation of mass and energy – overall view of an engineering process-evaporation – definition – liquid characteristics – single and multiple effect evaporation-performance of evaporators and boiling point elevation – capacity – economy and heat balance- types of evaporators – once through and circulation evaporators – short tube evaporators and long tube evaporators – agitated film evaporator.	8	18
3.	**MECHANICAL SEPARATION** Filtration – definition –filter media – types and requirements-constant rate filtration – constant pressure filtration – filter cake resistance-filtration equipment – rotary vacuum filter – filter press- sedimentation – gravitational sedimentation of particles in a fluid – Stoke‘s law, sedimentation of particles in gas-cyclones – settling under sedimentation and gravitational sedimentation-centrifugal separations – rate of separations – liquid – liquid separation – centrifuge equipment- Membrane technology-types and applications.	7	15
4.	**SIZE REDUCTION** Size reduction – grinding and cutting – principles of comminuting – characteristics of comminuted products – particle size distribution in comminuted products-energy and power requirements in comminuting – crushing efficiency – Rittinger‘s, Bond‘s and Kick‘s laws for crushing-size reduction equipments – crushers – jaw crusher, gyratory crusher-crushing rolls – grinders – hammer mills – rolling compression mills - attrition, rod, ball and tube mills – construction and operation.	8	18

5.	**CONTACT EQUILIBRIUM SEPARATION** Contact equilibrium separation processes – concentrations – gas-liquid and solid liquid equilibrium – equilibrium concentration relationships – operating conditions calculation of separation in contact – equilibrium processes-gas absorption – rate of gas absorption – stage – equilibrium gas – absorption equipment-properties of tower packing – types – construction – flow through packed towers-extraction – rate of extraction – stage equilibrium extraction-equipment for leaching coarse solids – intermediate solids – basket extractor-extraction of fine material – Dorr agitator - continuous leaching – decantation systems – extraction towers-washing – equipments.	8	18
6.	**CRYSTALLIZATION AND DISTILLATION** Crystallization – equilibrium -solubility and equilibrium diagram – rate of crystal growth – equilibrium crystallization-crystallization equipment – classification – construction and operation- tank, agitated batch, Swenson-Walker vacuum crystallizers-distillation – binary mixtures – flash and differential distillationsteam distillation – theory – consumption – continuous distillation with rectification – vacuum distillation - batch distillation – operation and process – advantages and limitations-distillation equipments – construction and operation – factors influencing the operation.	8	18
	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)

References/Suggested Learning Resources:

(a) Books:

1) Reference Book : 1. Geankoplis, C.J. ―Transport Processes and Separation Process Principles‖, 4th Edition, Prentice Hall, 2003.
2) McCabe W.L., Smith J.C. ―Unit Operations in Chemical Engineering‖, 7th Edition, McGraw – Hill Int., 2001,
3) Earle, R.L. 2003. Unit Operations in Food Processing. Pergamon Press. Oxford. U.K.

4) Geankoplis C.J.1999. Transport Process and Unit Operations. Prentice-Hall of India Private Limited, New Delhi..

(b) Open-source software and website:

1) https://agrimoon.com/wp-content/uploads/Engineering-Properties-of-Biological-Materials-and-FoodQuality.pdf

Suggested Course Practical List :

1. Determination of moisture content of different food samples by air oven method
2. Determination of moisture content by infrared moisture balance
3. Solving problems on single and multiple effect evaporator
4. Determination of collection efficiency in cyclone separator.
5. Study of different types of cleaning/grading equipments.
6. Determination of particle size of granular foods by sieve analysis.
7. Determination of performance characteristics in size reduction using the burr mill.
8. Determination of energy requirement in size reduction using the ball mill and hammer mill.
9. Performance evaluation of pin mill and hammer mill.
10. Determination of fineness modulus and average particle size.
11. Study of milling process of cereal crops
12. Study of milling process of pulse crops
13. Study of milling process of oilseed crops
14. Determination of equilibrium moisture content (EMC) of food grain.
15. Study on working of different types of mechanical dryers.

List of Laboratory/Learning Resources Required :

1. Hot air oven
2. Infrared moisture meter
3. Hammer mill
4. Ball mil
5. Burr mill
6. Pin mill
7. Separator

*** 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 a local food processing unit (e.g., dairy, fruit juice plant, oil mill) to observe unit operations like cleaning, evaporation, filtration, and packaging in action.	10 h (Visit + Report)	Report with process flow diagrams, observations of equipment, and identification of critical control points for mass and energy conservation.
2	Assignment (Numericals)	Solve problems related to mass and energy balance, dimensional analysis, and dimensionless ratios (e.g., Reynolds number) in food processing scenarios.	10 h	Report/Presentation based on learning outcomes
3	Complex Problem Solving	Mass/energy balance, drying rate, thermal conductivity, food refrigeration load	10 h	Based on assignment depth and accuracy
4	Problem Solving / Coding	Develop a simple Python script or Excel spreadsheet to calculate the power requirement for a grinder using Rittinger's, Bond's, and Kick's laws for a given food material (e.g., grinding wheat into flour).	10 h	Correctness of the code/formulas, usability of the tool, and accuracy of the output for given test cases.
5	Online Course (Mos)	NPTEL/SWAYAM course on Food Processing, Food Microbiology, Packaging Technology	10 h	Based on completion certificate and assessment scores from the online course.
6	Industrial Safety Videos	Review and discuss videos on food plant safety, hygiene protocols, and machinery safety standards.	10 h	Based on quiz or summary report
7	Discussion on Research Papers	valuate 4-5 research papers on topics like food fortification, novel food packaging, extrusion, or nanotechnology in food.	20 h (5 papers × 4 h)	Evaluation of scientific depth, summary of findings

8	Poster/Chart/Power Point Presentation	Food adulteration detection, cold chain, pasteurization process, millet-based products	6 h	Presentation clarity and content relevance
9	Model Development (Working/ Non-working)	Design and build a small-scale, conceptual model of a Swenson-Walker crystallizer or a simple steam distillation unit to explain its working principle.	8–12 h	Internal/external demonstration and explanation
10	Industrial Exposure (2–3 Days)	Observe processes in fruit processing/grading plant/oil refinery, identify inefficiencies	20 h	Critical evaluation report with suggested solutions

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