



# GUJARAT TECHNOLOGICAL UNIVERSITY

**Program Name: Bachelor of Engineering**

**Level: UG**

**Branch: Chemical Engineering**

**Subject Code: BE04005011**

**Subject Name: Mechanical Operations**

w.e.f. Academic Year:	2024-25
Semester:	4
Category of the Course:	Professional Core Courses

<b>Prerequisite:</b>	Basic knowledge related to properties of solid and solid-fluid interaction.
<b>Rationale:</b>	The main objective of this subject is to study the basic mechanical operations (size reduction, mixing, solid-solid and solid-fluid separation, etc.) taking place in process industry. It also provides platform to study and analyze various properties associated with the solid when it is in flow condition. This subject provides the fundamental knowledge regarding to particle size reduction and enlargement by various methods and also deals with the detail construction & working of equipment's used for mechanical operations.

### Course Outcome:

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

No	Course Outcomes
01	To characterize particles and perform size reduction and size analysis of particles to meet the need of chemical industries.
02	To review the practical importance and relevance of unit operations used for size reduction and separation in chemical industry.
03	To evaluate various operating parameters of filtration and sedimentation equipment.
04	To understand fluid-solid behavior during fluidization and conveying.
05	To identify the different types of mixing and agitation and estimating the power requirement.

### 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)	TW/ SL (I)	ESE (V)	
45	0	30	45	120	04	70	30	20	30	50	200

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

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



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## Course Content:

Unit No.	Content	No. of Hours	% of Weightage
1	<b>Solids and Its Flow Properties:</b> Solids, Characteristics of Solid particles, Properties of particulate masses, Particle size, mixed particle size analysis, Average particle size, Specific surface area of mixture, Number of particles in mixture, Screen analysis, Standard screens, Capacity and effectiveness of screen, Ideal and actual screens, Screening Equipment – Grizzly screens, Gyration screens, Trommels, vibrating screens, Oscillating screens.	8	18
2	<b>Size Reduction:</b> Principles of comminution, Rittinger's and kick's laws, Bond's crushing law and work index, Size reduction equipments, crushers, grinders, ultra fine grinders, Dry versus wet grinding, Cutting machines, Open circuit and closed-circuit operation.	9	20
3	<b>Filtration and Sedimentation:</b> Introduction, Cake filters, Filter media, Filter aids, principles of cake filtration, Filter press, Shell and leaf filters, Rotary vacuum drum filters, Centrifuges, Gravity classifiers, clarifying filter, Sink and float method, Clarifiers and thickeners, Batch sedimentation, Rate of sedimentation, Differential settling methods, sedimentation zones in continuous thickeners, Cyclones separators, Hydrocyclones, bag filter, wet scrubber and Electrostatic precipitator.	10	22
4	<b>Fluidization and Conveying:</b> Conditions for Fluidization, Types of fluidizations, minimum fluidization velocity and pressure drop in fluidized bed, Kozeny-Carman, Burke – Plummer, Ergun Equations, liquid – solid and gas solid systems, Applications of batch and continuous fluidization, Slurry and pneumatic transport, mechanical and pneumatic conveying, elevators, storage bins and silos for solid/liquid/gases.	10	22
5	<b>Mixing and Agitation:</b> Different types of agitators and their selection criteria, Types of Impellers, flow patterns in un-baffled and baffled tanks, Calculation of power required for agitation, Scale up of agitated vessel. Mixing of pastes/liquid/dry powder, pony mixer, ribbon blender, tumbler mixer, and static mixers, gas induction type agitator.	8	18



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## Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
15	20	15	10	10	0

**Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze; E: Evaluate and C: Create and above Levels (Revised Bloom's Taxonomy)**

## Reference Books:

1. Foust A. S. & associates, "Principles of Unit Operations" John Wiley and Sons (1980).
2. McCabe Smith, "Unit Operation in Chemical Engineering" 5<sup>th</sup> ed. McGraw Hill (1985).
3. Perry R.H. & Chilton C.H., "Chemical Engineers Hand Book", 7<sup>th</sup> ed. McGraw hill.
4. Badger and Bencharo, "Introduction to Chemical Engineering". Tata McGraw hill.
5. Coulson and Richardson: Chemical Engineering, Vol. 2, Butterworth Heinemann Pub.
6. Narayanan C.M.& Bhattacharya B.C. "Mechanical Operations for Chemical engineers", Khanna Publishers. 3<sup>rd</sup> Ed.1999.

## List of Experiments: (Minimum 08 experiments need to be performed)

1. To determine the screen efficiency for the given sample by sieve analysis.
2. To determine the screen efficiency for the given sample by vibrating screen.
3. To determine nip angle, Reduction Ratio, Ribbon Factor, Rittinger's constant, Bond's constant, Kick's constant, Work Index as well as Theoretical & Actual Capacity using roll crusher.
4. To determine Rittinger's constant, Bond's constant, Kick's constant and Work Index using jaw Crusher.
5. To determine Rittinger's constant, Bond's constant, Kick's constant and Work Index for ball mill.
6. To study size reduction of material by drop weight crusher.
7. To calculate the overall efficiency of the cyclone separator.
8. To carry out the batch sedimentation tests.
9. To carry out gravity filtration test.
10. To study filter press.
11. To determine separation efficiency by using froth flotation cell.
12. To study the ribbon blender.



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13. To study the basket centrifuge.

### Major Equipment:

Jaw crusher, Gyratory crusher, Roll crusher, Ball mill, Cyclone separator, filter press, Sieve shaker apparatus, Centrifuge, Rotary vacuum drum filter, ribbon blender, hammer mill, etc.

### List of Open Source Software/learning website:

1. Students can refer to video lectures available on the web sites including NPTEL.
2. Students can refer to the CDs which are available with some reference books for the solution of problems using softwares. Students can develop their own programs for the solutions of problems.

**Suggested Activities for Students:** 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 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.

### List of suggested activities for Problem Based Learning:

Sr. No.	Description	No. Of hours	Total Hrs.
1	Technical video demonstration based on subject content and learning related to the content	Duration of video 5h Report preparation 5h	10
2	Assignment writing. Numerical based assignment is preferable.	5 assignments of 2h each.	10
3	Discussion on research paper based on relevant subject. Summarize research paper and evaluation critical parameters	3 research papers can be included. Each one has 5h	15
4	Self-learning on-line course related to the subject	Minimum duration of the course should be 10h	10
5	Complex problem solving of real industrial problem	Maximum problems. Study of the problem and solution finding, Problem related to size reduction, mixing, filtration and/or energy saving in above industrial operations.	10



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<b>6</b>	Industrial exposure for 2-3 days to observe and provide tentative solutions on society/ environment/ health/ any other issue	Duration (15h) for industrial exposure Problem identification and tentative solution (10h)	<b>20</b>
<b>7</b>	Poster/Chart/PowerPoint preparation on technical topics	Poster/Chart/Power point preparation 6h and presentation (max 2 topics to be considered)	<b>12</b>
<b>8</b>	Real world case studies-based learning	Duration of data collection/study 5h Report preparation 5h	<b>10</b>
<b>9</b>	Technical Video Preparation related to subject	Preparation of content 5h Video Preparation and upload at department/ college website 5h	<b>10</b>
<b>Max. Hours to be allotted</b>			<b>45</b>

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