**GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)**

**Competency-focused Outcome-based Green Curriculum-2021 (COGC-2021)**
Semester-III

**Course Title: Mechanical Operation**
(Course Code: 4330501)

| Diploma programmer in which this course is offered | Semester in which offered |
|---|---|
| Chemical Engineering | Third |

## 1. RATIONALE

The operations of chemical plants require use of material handling and size reduction equipments, screens, agitator, mixers, centrifuges, cyclones, filters, storage & conveying of solids and other mechanical separation equipments. Therefore students must have information about the principles, construction, working and application of these equipments so that they can plan for their efficient use in plants. In this course the students would also learn simple calculations to judge the performance of these equipments.

## 2. COMPETENCY

The course content should be taught and implemented with the aim to develop different types of skills so that students are able to acquire following competencies:

- **Plan and supervise operation of mechanical operation equipments.**

## 3. COURSE OUTCOMES (COs)

The practical exercises, the underpinning knowledge and the relevant soft skills associated with the identified competency are to be developed in the student for the achievement of the following COs:

a) Use fundamentals of mechanical operation.
b) Apply concept of size reduction, separation, agitation-mixing, Storage and Conveying of Solid & Fluid.
c) Operate size reduction equipment, separators, agitators, mixers and conveyors.
d) Calculate properties of solid particles, power consumption, and resistance, crushing law constants, efficiency and material balance.

## 4. TEACHING AND EXAMINATION SCHEME

| Teaching Scheme (In Hours) | | | Total Credits (L+T+P/2) | Examination Scheme | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | Theory Marks | | Practical Marks | | Total Marks |
| L | T | P | C | CA | ESE | CA | ESE | |
| 3 | 0 | 4 | 5 | 30 | 70 | 50 | 50 | 200 |

(*): Out of 30 marks under the theory CA, 10 marks are for assessment of the micro-project to facilitate the integration of COs, and the remaining 20 marks are the average of 2 tests to be taken during the semester for assessing the attainment of the cognitive domain UOs required for the attainment of the COs.

Legends: L-Lecture; T – Tutorial/Teacher Guided Theory Practice; P - Practical; C – Credit, CA - Continuous Assessment; ESE - End Semester Examination.

## 5. SUGGESTED PRACTICAL EXERCISES

The practical/exercises should be properly designed and implemented with an attempt to develop different types of practical skills **(Course Outcomes in psychomotor and affective domain)** so that students are able to acquire the competencies **(Programme Outcomes).** Following is the list of practical exercises for guidance.

**Note**: Here only Course Outcomes in psychomotor domain are listed as practical/exercises. However, if these practical/exercises are completed appropriately, they would also lead to development of Programme Outcomes/Course Outcomes in affective domain as given in a common list at the beginning of curriculum document for this programme. Faculty should refer to that common list and should ensure that students also acquire those Programme Outcomes/Course Outcomes related to affective domain.

| Sr. No. | Practical Outcomes (PrOs) | Unit No. | Option | Approx. Hrs. Required |
|---|---|---|---|---|
| 1. | Measure volume surface mean diameter, mass mean diameter, number of particles using a sieve shaker. | I | | **4** |
| 2. | Perform differential and cumulative screen analysis | III | | **4** |
| 3. | Test Kicks law for crushing in Jaw crusher. | II | | **4** |
| 4. | Test Bond's law for crushing in a Roll crusher. | II | | **4** |
| 5. | Test Rittinger's law for grinding in a Ball mill and measure critical speed. | II | | **4** |
| 6. | Measure efficiency and cut diameter of Cyclone Separator. | IV | | **4** |
| 7. | Determine rate of settling by Sedimentation. | IV | | **4** |
| 8. | Measure rate of filtration, filter medium & cake resistance in Gravity filtration. | IV | **Any three** | **4** |
| 9. | Measure rate of filtration, filter medium & cake resistance in Vacuum filtration. | IV | | **4** |
| 10. | Measure cake resistance, filter media resistance in Pressure filtration. | IV | | **4** |
| 11. | Measure rate of filtration, cake resistance, filter media resistance in Centrifuge. | IV | | **4** |
| 12. | Measure efficiency of separation in froth flotation cell. | III | **Any two** | **4** |
| 13. | Measure efficiency of separation in Magnetic separator. | III | | **4** |
| 14. | Measure efficiency of separation in Electrostatic separator. | III | | **4** |

| | | | | |
|---|---|---|---|---|
| 15. | Evaluate mixing index in mixer. | V | | **4** |
| 16. | Measure power consumption in baffled and unbaffled Agitation vessel. | V | | **4** |

***Note***

*More **Practical Exercises** can be designed and offered by the respective course teacher to develop the industry relevant skills/outcomes to match the COs. The above table is only a suggestive list.*

## 6. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

These major equipments with broad specifications for the PrOs is a guide to procure them by the administrators to use in uniformity of practical's in all institutions across the state.

| Sr. No. | Equipment Name with Broad Specifications | PrO. No. |
|---|---|---|
| **1** | Sieve shaker – Sieve dia – 100 mm to 200 mm, no of sieve – 6-8 and Pan, Opening – as per standards (micro or coarse particle) | 1,2 |
| **2** | Jaw crusher – 10-50 kg/hr capacity, Suitable for operation on 415V, 50Hz, 3 Phase, AC supply with energy meter | 3 |
| **3** | Laboratory Roll crusher – 5-25 kg/hr capacity, Suitable for operation on 415V, 50Hz, 3 Phase, AC supply with energy meter | 4 |
| | Laboratory Ball mill - 5kg capacity, Suitable for operation on 415V, 50Hz, 3 Phase, AC supply with energy meter | 5 |
| **4** | Cyclone separators – Product Particle as per requirement, Suitable for operation on 220V, Power: 1000W with energy meter | 6 |
| **5** | Batch Sedimentation Set up (Lab Scale Model using Glassware) | 7 |
| **6** | Gravity filter (Lab scale model using Glassware) | 8 |
| **7** | Vacuum Filter (Lab scale model using Glassware and Vacuum pump) | 9 |
| **8** | Laboratory filter Press - Suitable for operation on 220V, Power: 1000W | 10 |
| **9** | Basket centrifuge - Suitable for operation on 415V, 50Hz, 3 Phase, AC supply | 11 |
| **10** | Froth flotation Cell, 5-15 kg/hr capacity, Suitable for operation on 220V, Power: 1000W with energy meter | 12 |
| **11** | Magnetic separator suitable for operation on 220V, Power: 1000W | 13 |
| **12** | Electrostatic separator. | 14 |

| Sr. No. | Equipment Name with Broad Specifications | PrO. No. |
|---|---|---|
| **13** | Double cone mixer - Suitable for operation on 220V, Power: 1000W | 15 |
| **14** | Ribbon Blender- Suitable for operation on 220V, Power: 1000W | 15 |
| **15** | Sigma Mixer- Suitable for operation on 220V, Power: 1000W | 15 |
| **16** | Agitation vessel setup – Suitable for operation on 220V, Power: 1000W with energy meter (with removable baffles) | 16 |

## 7. AFFECTIVE DOMAIN OUTCOMES

The following ***sample*** Affective Domain Outcomes (ADOs) are embedded in many of the above-mentioned COs and PrOs. More could be added to fulfill the development of this course competency.

a) Follow ethical practices.
b) Practice good housekeeping.
c) Demonstrate working as a leader/a team member during brainstorming.

The ADOs are best developed through the laboratory/field based exercises. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

i. 'Valuing Level' in 1st year
ii. 'Organization Level' in 2nd year.
iii. 'Characterization Level' in 3rd year.

## 8. UNDERPINNING THEORY

The major Underpinning Theory is formulated as given below and only higher level UOs of *Revised Bloom's taxonomy* are mentioned for development of the COs and competency in the students by the teachers. (Higher level UOs automatically include lower level UOs in them). If required, more such higher level UOs could be included by the course teacher to focus on attainment of COs and competency.

| Unit | Unit Outcomes (UOs) | Topics and Sub-topics |
|---|---|---|
| **Unit – I Fundamental of Mechanical Operation** | 1a. Define Unit Operation and Unit Process<br>1b. Differentiate Unit Operation and Unit Process | 1.1 Fundamentals of Unit Operation and Unit Process<br>1.2 Examples of Unit Operation and Unit Process |
| | 1c. Describe specific properties of solids | 1.3 Define & Calculate<br>● Particle density and Bulk density |

| | | |
|---|---|---|
| | | ● Sphericity<br>● Equivalent diameter<br>● Specific surface area<br>● Volume surface mean diameter<br>● Mass mean diameter<br>● Shape factor<br>● Number of particles in solid |
| **Unit– II Size Reduction** | 2a. Explain size reduction with applications | 2.1 Principles of Size reduction and its application |
| | 2b. Select Size reduction equipments | 2.2 Factors for selection of size reduction equipment |
| | 2c. Calculate Energy and power requirement in comminution | 2.3 Energy and power requirement in comminution |
| | 2d. Explain Empirical laws of size reduction and work Index | 2.4 Laws of size reduction:<br>(i) Rittinger's law<br>(ii) Bond's law<br>(iii) Kick's law<br>2.5 Calculate Power required for size reduction using empirical laws and calculation of work Index. |
| | 2e. Explain Different Size reduction equipments | 2.6 Principle, construction, working and Application of<br>● Jaw crusher<br>● Gyratory crusher<br>● Roll Crusher<br>● Ball mill<br>● Hammer mill |
| | 2f. Compute Angle of nip for Roll Crusher | 2.7 Derive equation of angle of nip<br>2.8 Calculation of angle of nip for Roll crusher |
| | 2g. Calculate Critical speed of Ball mill | 2.9 Derivation of equation of critical speed for Ball Mill<br>2.10 Calculation of operating speed and critical speed for Ball Mill |
| | 2h. Explain Open and Close circuit grinding | 2.11 Difference between open circuit and close circuit grinding |
| **Unit– III Solid-Solid separation** | 3a. Explain Screening<br><br>3b. Compare types of screen analysis<br><br>3c. Derive formula for | 3.1 Basics of Ideal and Actual Screen<br>3.2 Types of Screen Analysis<br>● Cumulative analysis<br>● Differential analysis<br>3.3 Capacity and effectiveness of |

| | | |
|---|---|---|
| | effectiveness of screen<br><br>3d. Calculate capacity and effectiveness of screen<br><br>3e. Explain different screening equipment | screen<br>● Derivation of formula for overall effectiveness of screen<br>● Calculation of capacity and effectiveness of screen<br>3.4 Principle, Construction, Working & Application of<br>● Trommel, grizzlies, vibrating screen |
| | 3b. Explain different Solid separation equipments | 3.5 Principle, Construction, Working & Application of<br>● Hydraulic Jig<br>● Double cone classifier<br>● Electrostatic precipitator<br>● Magnetic separator<br>● Froth flotation cell |
| | 3c. Select solid separation equipment | 3.6 Factors affecting selection of equipment for solid separation |
| **Unit– IV Solid- fluid Separation** | 4a. Describe filtration and Differentiate constant rate and constant pressure filtration<br>4b. Characterize filter media<br><br>4c. Explain filter aids and its application<br><br>4d.Explain cake resistance, filter media resistance for various conditions<br>4e. Classify equipments for liquid-solid separation | 4.1 Basics of filtration<br>● Constant Rate filtration<br>● Constant Pressure filtration<br>4.2 Filter media and its characteristics<br>4.3 Filter Aid & its application<br><br>4.4 Cake Resistance, Filter medium Resistance<br>● Constant Rate filtration<br>● Constant Pressure filtration<br>4.5 Principle, construction, working and application of<br>● Filter Press<br>● Rotary Drum Filter<br>● Leaf Filter<br>● Basket Centrifuge |
| | 4f. Explain sedimentation<br><br>4g. Draw batch sedimentation curve<br><br>4h. Explain Gravity Thickener | 4.6 Basic of Sedimentation<br>● Hindered settling<br>● Free settling<br>4.7 Batch Sedimentation Experiment<br>● Interphase height Vs Time curve for batch sedimentation<br>4.8 Principle, construction, |

| | | |
|---|---|---|
| | | working and application of Gravity Thickener |
| | 4i. Explain Terminal settling velocity | 4.9 Terminal settling velocity |
| | 4j. Describe Cyclone Separator | 4.10 Principle, construction, working and application of Cyclone Separator |
| | 4k. Calculate Cut diameter and efficiency of cyclone | 4.11 Cut diameter and Efficiency ofCyclone Separator |
| **Unit– V Agitation and mixing** | 5a. Describe agitation and mixing<br>5b. Classify impellers<br>5c. Compare various impellers<br>5d. Explain vortex formation and prevention<br>5e. Explain factors affecting agitation<br>5f. Calculate power consumption<br>5g. Describe Agitated vessel | 5.1 Define agitation and mixing<br>5.2 Classification of Impellers and brief explanation<br>5.3 Vortex formation and swirling<br>5.4 Methods for Prevention of Vortex<br>5.5 Factors affecting on agitation and Mixing<br>5.6 Calculation of Mixing index & Power Consumption<br>5.7 Principle, construction, working and application of Agitated vessel |
| | 5h. Explain different Types of Mixers | 5.8 Principle, construction, working and application of<br>● Ribbon blender<br>● Kneaders<br>● Banbury mixer<br>● Muller mixer |
| **Unit VI Storage & Conveying of Solid and Fluid** | 6a. Describe different Storage of Solids | 6.1 Angle of repose<br>6.2 Bulk storage<br>6.3 Storage in bins and silos |
| | 6b Explain different types of Conveyor | 6.4 Types of Conveyors<br>● Screw conveyors<br>● Belt conveyors<br>● Bucket elevators<br>● Pneumatic conveyor<br>● Hydraulic Conveyor |

***Note**: The UOs need to be formulated at the 'Application Level' and above of Revised Bloom's Taxonomy' to accelerate the attainment of the COs and the competency.*

## 9. SUGGESTED SPECIFICATION TABLE FOR QUESTIONPAPER DESIGN

| Unit | Unit Title | Teaching Hours | Distribution of Theory Marks | | | |
|---|---|---|---|---|---|---|
| | | | R Level | U Level | A Level | Total Marks |
| I | Fundamental of Mechanical Operation | 04 | 2 | 2 | 3 | 07 |
| II | Size Reduction | 10 | 4 | 5 | 8 | 17 |
| III | Solid-Solid Separation | 07 | 3 | 4 | 4 | 11 |
| IV | Solid-Fluid Separation | 10 | 4 | 5 | 8 | 17 |
| V | Agitation and Mixing | 07 | 3 | 5 | 3 | 11 |
| VI | Storage and Conveying | 04 | 2 | 3 | 2 | 07 |
| **Total** | | **42** | **18** | **24** | **28** | **70** |

## 10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related ***co-curricular*** activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should perform following activities in group and prepare reports of about 5 pages for each activity. They should also collect/record physical evidences for their (student's) portfolio which may be useful for their placement interviews:

Following is the list of proposed student activities like:

1. Assignments
2. Technical Quiz/MCQ Test
3. Presentation on some course topic
4. I-net based assignments
5. Undertake micro-Project in team/individually
6. Students are encouraged to register themselves in various MOOCS such as: Swayam, edx, Coursera, Udemy etc to further enhance their learning

## 11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

a) Guide student(s) in undertaking micro-projects.
b) Diagnosing Essential Missed Learning concepts that will help for students to improve their performance.
c) Guide Students to do Personalized learning so that students can understand the course material at his or her pace.
d) Encourage students to do Group learning by sharing so that learning can be enhanced.
e) About ***20% of the topics/sub-topics*** which are relatively simpler or descriptive in nature is to be given to the students for ***self-learning***, but to be assessed using different assessment methods. Guide students on addressing the issues on environment and sustainability using the knowledge of this course.

## 12. SUGGESTED MICRO-PROJECTS

***Only one micro-project*** is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-project is group-based (group of 3 to 5). However, **in the fifth and sixth semesters**, the number of students in the group should ***not exceed three.***

The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain dated work diary consisting of individual contributions in the project work and give a seminar presentation of it before submission. The duration of the micro project should be about **14-16** ***(fourteen to sixteen) student engagement hours*** during the course. The students ought to submit micro-project by the end of the semester to develop the industry-oriented COs.

A suggestive list of micro-projects is given here. This has to match the competency and the COs. Similar micro-projects could be added by the concerned course teacher:

1. Prepare a chart/model of Size reduction equipments along with their Principle and applications.
2. Prepare chart/model for various types of impellers used in Industry.
3. Interpret results of Cumulative Analysis and Differential Analysis using Microsoft excel.
4. Prepare chart for Vortex formation and swirling and Methods for their prevention.
5. Draw suitability chart for various factors for selection of various mechanical equipment.
6. Prepare 15-20 slides power point presentation showing classification, construction and working of any mechanical equipment.
7. Compare Screen Effectiveness by Manual & Mechanical Method using Literature/ experimental data by the use of Microsoft excel.
8. Prepare Laboratory set up for Batch Sedimentation.
9. Prepare Working model of any mechanical operation equipment.
10. Prepare a demonstrative model of any mechanical operation equipment.

## 13. SUGGESTED LEARNING RESOURCES

| Sr. No. | Title of Book | Author | Publication with place, year and ISBN |
|---|---|---|---|
| 1 | Unit Operations of Chemical Engineering | McCabe and Smith | McGraw Hill Publications, New Delhi |

| Sr. No. | Title of Book | Author | Publication with place, year and ISBN |
|---|---|---|---|
| 2 | Introduction to Chemical Engineering | Badger W. L. and Banchero J. T | McGraw Hill Publications, New Delhi |
| 3 | Unit Operation –I | Gavhane K. A. | Nirali Prakashan, Pune |
| 4 | Mechanical Operations | Swain A.K., G.K.Roy | Tata McGraw Hill Publications, New Delhi |
| 5 | 'Chemical Engineering' Vol.- II, | J.M. Coulson & J.F. Richardson 'Chemical Engineering' Vol.- II, | 6th Ed. Elsevier, 2003 |
| 6 | Transport Processes and Separation Process Principles' | C.G. Geankopolis | 4th Ed, Prentice Hall India, 2003. |

## 14. SOFTWARE/LEARNING WEBSITES

a. https://ndl.iitkgp.ac.in
b. https://onlinecourses.nptel.ac.in
c. https://swayam.gov.in/explorer
d. www.cheresources.com

## 15. PO-COMPETENCY-CO MAPPING

| Semester-III | Mechanical Operation (Course Code:4330501) | | | | | | |
|---|---|---|---|---|---|---|---|
| | POs | | | | | | |
| Competency & Course Outcomes | PO 1 Basic & Discipline specific knowledge | PO 2 Problem Analysis | PO 3 Design/ develop-ment of solutions | PO 4 Engineering Tools, Experimen-tation & Testing | PO 5 Engineering practices for society, sustainabilit y & environment | PO 6 Project Manage-ment | PO 7 Life-long learning |
| **Competency** | ***Select and Operate Mechanical Operation equipment in the Chemical industry.*** | | | | | | |
| Course Outcomes<br>CO a) Use fundamental of mechanical operation. | 2 | - | - | - | - | - | - |
| CO b) Apply concept of size reduction, separation, agitation-mixing, Storage and Conveying of solid and Fluid. | 2 | 2 | 2 | 2 | 2 | 2 | 2 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| CO c) Operate size reduction equipment, separators, agitators, mixers and conveyors. . | 3 | 2 | 2 | 2 | 3 | 2 | 2 |
| CO d)Calculate properties of solid particles, power consumption, and resistance, crushing law constants, efficiency and material balance | 2 | 2 | 2 | 3 | 2 | - | 1 |

*Legend: '**3**' for high, '**2**' for medium, **'1'** for low and **'-'** for no correlation of each CO with PO.*

## 16. COURSE CURRICULUM DEVELOPMENT COMMITTEE

**GTU Resource Persons**

| Sr. No. | Name and Designation | Institute | Contact No. | Email |
|---|---|---|---|---|
| 1. | Mrs. Bhoomi Luckvindersingh Guleria | Government Polytechnic Gandhinagar | 8128349140 | bhoomitrivedi87@gmail.com |
| 2. | Mrs. Bhumika Bhavin Makwana | Shri K.J. Polytechnic, Bharuch | 9662032947 | bhmkrn@gmail.com |