Program Name : **Diploma in Chemical Engineering**

Program Code : **CH**

Semester : **Third**

Course Title : **Mechanical Operations**

Course Code : **22313**

1. RATIONALE

Diploma Chemical engineers (also called technologists) have to work in various process industries like pharmaceutical, petroleum, petrochemical, food, textile, dyes and others. Many Chemical manufacturing processes industries involves small solid particle at some point. Proper handling and design of this fine particle often makes the difference in quality of the product. Many products such as catalyst, pigments and many other are currently manufactured in particulate forms. By learning this subject they will be familiar with different mechanical operation like size reduction, separation, transportation and mixing involved in Chemical industry.

2. COMPETENCY

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- **Use various mechanical engineering equipment in chemical process industry.**

3. COURSE OUTCOMES (COs)

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry oriented COs associated with the above mentioned competency:

a. Use size reduction equipment in chemical process industry.
b. Use the relevant separation methods for solid-solid separation.
c. Select the method for solid-liquid separations.
d. Apply the concept of gas-solid separations.
e. Use the relevant method for transportation of solid in industry.
f. Select the relevant equipment for agitation and mixing.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme			Credit (L+T+P)	Examination Scheme											
				Theory						Practical					
				Paper Hrs.	ESE		PA		Total		ESE		PA		Total	
L	T	P			Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
4	-	4	8	3	70	28	30*	00	100	40	50#	20	50	20	100	40

(*): Under the theory PA, out of 30 marks, 10 marks are for micro-project assessment to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessment 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,* ***ESE*** *-End Semester Examination;* ***PA*** *- Progressive Assessment*

5. COURSE MAP (with sample COs, PrOs, UOs, ADOs and topics)

This course map illustrates an overview of the flow and linkages of the topics at various levels of outcomes (details in subsequent sections) to be attained by the student by the end of the course, in all domains of learning in terms of the industry/employer identified competency depicted at the centre of this map.

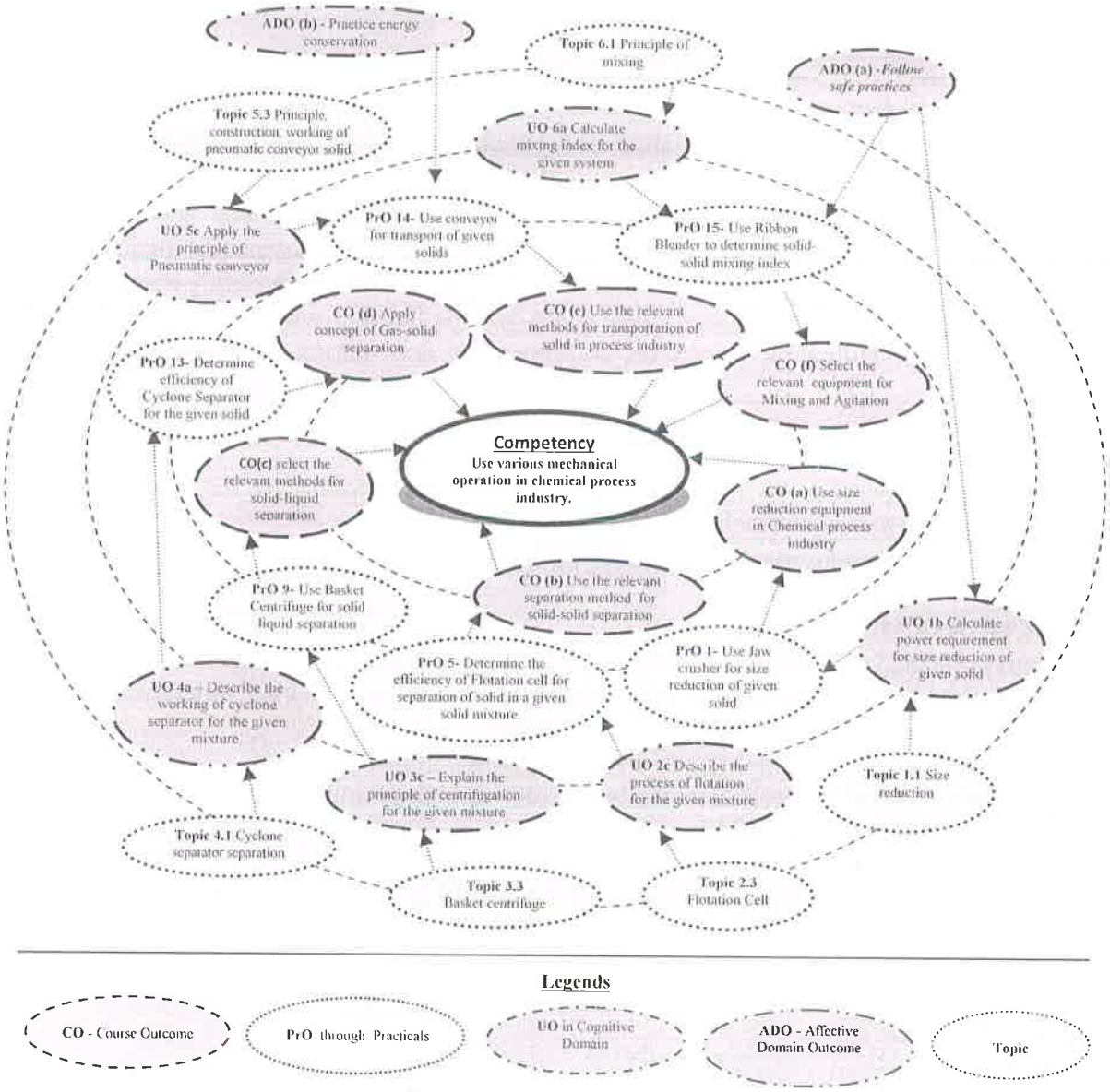

Figure 1 - Course Map

6. SUGGESTED PRACTICALS/ EXERCISES

The practicals in this section are PrOs (i.e. sub-components of the COs) to be developed and assessed in the student for the attainment of the competency:

Sr. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1	Use Jaw crusher for size reduction of given solid and determine the particle size range of product. Part - I	I	02*
2	Use Jaw crusher for size reduction of given solid and determine the	I	02*

Sr. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
	particle size range of product. Part - II		
3	Use hammer mill for size reduction of given solid and determine the particle size rangeof product. Part - I	I	02*
4	Use hammer mill for size reduction of given solid and determine the particle size rangeof product. Part - II	I	02*
5	Use Ball mill to find average particle size by changing the residence time of material. Part - I	I	02*
6	Use Ball mill to find average particle size by changing the residence time of material. Part - II	I	02*
7	Use screen for calculation of effectiveness of screen using different size of particles. Part - I	II	02*
8	Use screen for calculation of effectiveness of screen using different size of particles. Part - II	II	02*
9	Determine the efficiency of Flotation cell for separation of solid in a given solid mixture. Part - I	II	02
10	Determine the efficiency of Flotation cell for separation of solid in a given solid mixture. Part - II	II	02
11	Perform electromagnetic separation applying magnetic Drum separator. Part - I	II	02*
12	Perform electromagnetic separation applying magnetic Drum separator. Part - II	II	02*
13	Use Grizzlies, Trommels, Vibrating Screen for separation of given solid mixture. Part - I	II	02
14	Use Grizzlies, Trommels, Vibrating Screen for separation of given solid mixture. Part - II	II	02
15	Use Plate and Frame filter press for solid liquid separation to draw rate of filtration curve. Part - I	III	02*
16	Use Plate and Frame filter press for solid liquid separation to draw rate of filtration curve. Part - II	III	02*
17	Use Basket Centrifuge for solid liquid separation (with graphical representation). Part - I	III	02*
18	Use Basket Centrifuge for solid liquid separation (with graphical representation). Part - II	III	02*
19	Use vacuum filter for determination of the rate of filtration for solid liquid mixture. Part - I	III	02
20	Use vacuum filter for determination of the rate of filtration for solid liquid mixture. Part - II	III	02
21	Determine terminal settling velocity for different concentration of calcium carbonate slurry using batch sedimentation test. Part - I	III	02*
22	Determine terminal settling velocity for different concentration of calcium carbonate slurry using batch sedimentation test. Part - II	III	02*
23	Use Centrifuge for calculation of percentage of solids recovered from given slurry using centrifuge. Part - I	III	02*
24	Use Centrifuge for calculation of percentage of solids recovered from given slurry using centrifuge. Part - II	III	02*
25	Determine efficiency of Cyclone Separator for the given solid gas	IV	02*

Sr. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
	mixture. Part – I		
26	Determine efficiency of Cyclone Separator for the given solid gas mixture. Part - II	IV	02
27	Use conveyor for transport of given solids. Part - I	V	02*
28	Use conveyor for transport of given solids. Part - II	V	02*
29	Use Ribbon Blender to determine solid-solid mixing index. Part - I	VI	02*
30	Use Ribbon Blender to determine solid-solid mixing index. Part - II	VI	02*
31	Use Sigma mixer for determination of solid -solid mixing index. Part - I	VI	02*
32	Use Sigma mixer for determination of solid -solid mixing index. Part - II	VI	02
	Total		**64**

Note

i. *A suggestive list of PrOs is given in the above table. More such PrOs can be added to attain the COs and competency. A judicial mix of minimum 24 or more practical need to be performed, out of which, the practicals marked as '*' are compulsory, so that the student reaches the 'Precision Level' of Dave's 'Psychomotor Domain Taxonomy' as generally required by the industry.*

ii. *The 'Process' and 'Product' related skills associated with each PrO is to be assessed according to a suggested sample given below:*

S. No.	Performance Indicators	Weightage in %
1	Selection of suitable component, apparatus/instrument	20
2	Preparation of experimental set up	10
3	Setting and operation	10
4	Safety measures	10
5	Physical presence during practical	10
6	Observation and recording	10
7	Interpretation of result and conclusion	10
8	Answer to sample question	10
a.	Submission of report in time	10
	Total	**100**

The above PrOs also comprise of the following social skills/attitudes which are Affective Domain Outcomes (ADOs) that are best developed through the laboratory/field based experiences:

a. Follow safety practices.
b. Practice good housekeeping.
c. Demonstrate working as a leader/a team member.
d. Maintain tools and equipment.
e. Follow ethical practices.

The ADOs are not specific to any one PrO, but are embedded in many PrOs. Hence, the acquisition of the ADOs takes place gradually in the student when s/he undertakes a series of practical experiences over a period of time. Moreover, the level of achievement of the ADOs

according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

- 'Valuing Level' in 1st year
- 'Organizing Level' in 2nd year
- 'Characterizing Level' in 3rd year.

7. MAJOR EQUIPMENT/ INSTRUMENTSREQUIRED

The major equipment with broad specification mentioned here will usher in uniformity in conduct of experiments, as well as aid to procure equipment by authorities concerned.

S. No.	Equipment Name with Broad Specifications	PrO. S. No.
1	Jaw Crusher 3 HP Motor 2.2 KW	01
2	Hammer Mill	02
3	Ball Mill DC Motor 3 HP Motor 2.2 KW	03
4	Set of sieves	04
5	Froth Flotation Cell	05
6	Magnetic drum separator	06
7	Grizzlies/trammel/vibrating screen	07
8	Plate and Frame Filter press	08
9	Basket Centrifuge 2 HP Motor 2.2 KW	09
10	Vacuum filter 2 HP Motor 2.2 KW Stage oil Change	10
11	Measuring cylinder of one lit capacity	11
12	Cyclone Separator	13
13	Conveyors	14
14	Ribbon Blender	15
15	Sigma Mixer 3 HP Motor 2.2 KW	16

8. UNDERPINNING THEORY COMPONENTS

The following topics are to be taught and assessed in order to develop the sample UOs given below for achieving the COs to attain the identified competency. More UOs could be added.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit – I Solid Particle and Size Reduction	1a. Describe with sketches the relevant measurement technique for the given solid particle. 1b. Calculate the power requirement for size reduction of the given solid. 1c. Describe with sketches the size reduction principle for obtaining the required size of the given solid. 1d. Explain the factors affecting the size reduction of the given solid. 1e. Describe the components of	1.1 Solid Particle: Shape and size of particle, Sphericity, Mixed Particle Size, Average Particle Size. Particle size measurement technique. (Only Names) 1.2 Kicks law, Rittinger's law, Bond's Law. crushing efficiency: Statement, formula, application, 1.3 Size reduction: Principle, method, (crushing, grinding), Open and closed circuit Grinding, Factor affecting size reduction. 1.4 Jaw Crusher, gyratory crusher, hammer mill, ball Mill) critical speed of ball mill - working

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	the given size reduction equipment with sketches. 1f. Describe with sketches the procedure to use the given size reduction equipment.	principle, construction, application
Unit– II Solid – Solid Separations	2a. Describe with sketches the screening operations for the given mixture. 2b. Identify relevant equipment for the given screening operation with justification. 2c. Describe with sketches the process of flotation for the given mixture. 2d. Describe with sketches the Electromagnetic separation for the given system of mixture.	2.1 Screening: Concept of operation, Mesh Number, Oversize and undersize particle, cut diameter, Ideal and Actual screen, Capacity and Screen Efficiency, numerical. Types of screen analysis: Differential and cumulative. Factors affecting screening operation. 2.2 Screening Equipment: Principle, construction, working, Grizzlies, Trommels, Vibrating Screen 2.3 Flotation Cell: Concept, industrial application construction, working of froth flotation cell. 2.4 Electromagnetic separation: Magnetic Drum separator Principle, construction, working, industrial application.
Unit– III Solid – Liquid Separation	3a. Describe with sketches the Stokes law for sedimentation process of given system. 3b. Describe the flowchart for working of specified equipment. 3c. Explain with sketches the principle of centrifugation for the given mixture. 3d. Describe with sketches the filtration process for the given equipment.	3.1 Sedimentation: Concept, free and hindered settling, Stokes law (terminal settling velocity), factors affecting the rate of sedimentation. 3.2 Sedimentation Equipment: thickener, clarifier and settling tank: Principle, construction (different zones), working. 3.3 Basket centrifuge principle, construction and working. 3.4 Filtration: Principle, types, factors affecting filtration rate, use of filter aid (example of filter aid). 3.5 Plate and frame filter press, rotary vacuum drum filter.
Unit-IV Gas-Solid Separation	4a. Explain with sketches the working of cyclone separator for the given mixture. 4b. Explain with sketches the working of Electrostatic precipitators for the given	4.1 Cyclone separator: Principle, construction, working. 4.2 Electrostatic precipitators: Principle, construction, working. 4.3 Fabric Filter Principle, construction, working. 4.4 Wet scrubber Principle, construction

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	mixture. 4c. Identify relevant fabric filters for the given mixture. 4d. Describe with sketches the scrubbing process of wet scrubber for the given mixture.	and working.
Unit –V Equipment for Transportation	5a. Apply relevant transportation operation for the given system. 5b. Describe with sketches the components of the given transportation equipment. 5c. Explain with sketches the working principle of the given type of conveyor. 5d. Apply relevant conveyors for the given industrial applications.	5.1 Importance of transportation in Industry. 5.2 Construction and working of transportation equipment such as belt conveyor, screw conveyor, chain conveyor, 5.3 Principle, construction, working of pneumatic conveyor (only positive type) and bucket elevator. 5.4 Industrial applications conveyors.
Unit-VI Mixing and Agitation	6a. Calculate mixing index for the given system. 6b. Draw the diagram of the given mixing equipment. 6c. Identify the relevant agitator for the given industry. 6d. Explain with sketches the process of swirling and vortexing for the given system.	6.1 Principle of mixing (solid-solid, solid-liquid, Liquid-Liquid), mixing index. 6.2 Sigma Mixer, Ribbon blender, Muller mixer: Principle, construction, working. 6.3 Agitators (anchor type, paddle, turbine), flow patterns (radial and axial flow pattern). 6.4 Concept of swirling and vortexing, methods to prevent vortexing.

***Note**: To attain the COs and competency, above listed Unit Outcomes (UOs) need to be undertaken to achieve the 'Application Level' of Bloom's 'Cognitive Domain Taxonomy'*

9. SUGGESTED SPECIFICATION TABLE FORQUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Solid particle and size reduction	14	02	06	08	16
II	Solid – Solid separation	08	02	04	04	10
III	Solid- Liquid separation	14	02	04	08	14
IV	Gas- Solid separation	08	02	02	04	08
V	Equipment for transportation	08	02	04	04	10
VI	Mixing and agitation	12	02	04	06	12
Total		**64**	**12**	**24**	**34**	**70**

Legends: *R=Remember, U=Understand, A=Apply and above (Bloom's Revised taxonomy)*
Note*: This specification table provides general guidelines to assist student for their learning and to teachers to teach and assess students with respect to attainment of UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may vary from above table.*

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 conduct following activities in group and prepare reports of about 5 pages for each activity, also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews:

a. Identify the principle by which size reduction is done in Nut cracker and Filing.
b. Compare Blake Jaw Crusher and Dodge crusher.
c. Prepare list of size reduction equipment used in Cement industry.
d. Prepare list of size reduction equipment used in Paint industry.
e. List various principles by which solid-solid separation can be done.
f. Identify the unit operation used for separation of
g. Iron-wood chips
h. Calcium Carbonate-water
i. Visit nearby industries to study various conveyors.
j. Visit nearby construction sites/industry to study working of various mixing equipment
k. Collect different (at least three) types of filter cloth.

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. Massive open online courses (***MOOCs***) may be used to teach various topics/sub topics.
b. ***'L' in item No. 4*** does not mean only the traditional lecture method, but different types of teaching methods and media that are to be employed to develop the outcomes.
c. About ***15-20% of the topics/sub-topics*** which is relatively simpler or descriptive in nature is to be given to the students for ***self-directed learning*** and assess the development of the LOs/COs through classroom presentations (see implementation guideline for details).
d. With respect to item No.10, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
e. Guide student(s) in undertaking micro-projects.

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 are group-based. However, in the fifth and sixth semesters, it should be preferably be ***individually*** undertaken to build up the skill and confidence in every student to become problem solver so that s/he contributes to the projects of the industry. In special situations where groups have to be formed for micro-projects, 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 Ad. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a

seminar presentation of it before submission. The total duration of the micro-project should not be less than ***16 (sixteen) student engagement hours*** during the course. The student ought to submit micro-project by the end of the semester to develop the industry oriented COs.

A suggestive list of micro-projects are given here. Similar micro-projects could be added by the concerned faculty:

a. **Visit to plant**: Visit the nearby industry and prepare report about various mechanical operations.
b. **Preparation of model**: Prepare model of Belt/screw/bucket conveyor
c. **Preparation of model:** Prepare model of plate and frame filter.
d. **Collection of different samples**: Collect solid particle of different sizes and shapes from process industries/Laboratory.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Unit Operations of Chemical Engineering	Mc Cabe W. L. Smith	Mc Graw Hill Publication, New York, 2005, ISBN 97899339213237
2	Chemical Engineering	J. M. Coulson and Richardson J.F.	Elsevier Publisher, Oxford, 2013 ISBN 9780750644457
3	Introduction to Chemical Engineering	Badger W. L., Banchero J.T.	Mc Graw Hill Publication, New York, 2011 ISBN 9780074630501
4	Mechanical Operation	Anup K Swain HemlataPatra G. K. Roy	Mc Graw Hill Publication , New York, 2010, ISBN 9780070700222

14. SUGGESTED SOFTWARE/LEARNING WEBSITES

a. www.quora.com
b. www.unitoperation.com
c. https://sites.google.com/a/placement.iitm.ac.in/chemical/courses/mechanical-i
d. http://www.myopencourses.com/subject/mechanical-operations-1