Program Name : **Diploma in Chemical Engineering**
Program Code : **CH**
Semester : **Second**
Course Title : **Fundamentals of Chemical Engineering**
Course Code : **22231**

1. RATIONALE

Diploma chemical engineers (also called technologists) work as first line managers in chemical process industries. While performing routine activities; knowledge of unit operations and unit processes, basic concepts like pH, solubility, specific gravity, electrical conductivity and methods of expressing composition of solutions and mixtures is necessary. In addition to this, awareness of safe working practices is also necessary for eliminating the causes of accidents. This course is designed to equip the students with necessary knowledge and skills for effectively performing the job role.

2. COMPETENCY

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

- **Use the fundamentals of chemical engineering in chemical industries.**

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. Identify the chemicals for the given engineering application.
b. Implement standard safety practices in chemical laboratory
c. Prepare solutions and mixtures of different composition.
d. Determine the different properties of solution.
e. Select the relevant unit operations and unit processes for chemical industry.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme			Credit (L+T+P)	Examination Scheme											
				Theory						Practical					
					ESE		PA		Total		ESE		PA		Total	
L	T	P		Paper Hrs.	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
4	-	2	6	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 with the various levels of outcomes (details are in the subsequent sections) to be attained by the student by the end of the course, in all domains of learning terms of the industry/employer identified competency depicted at the centre of this map.

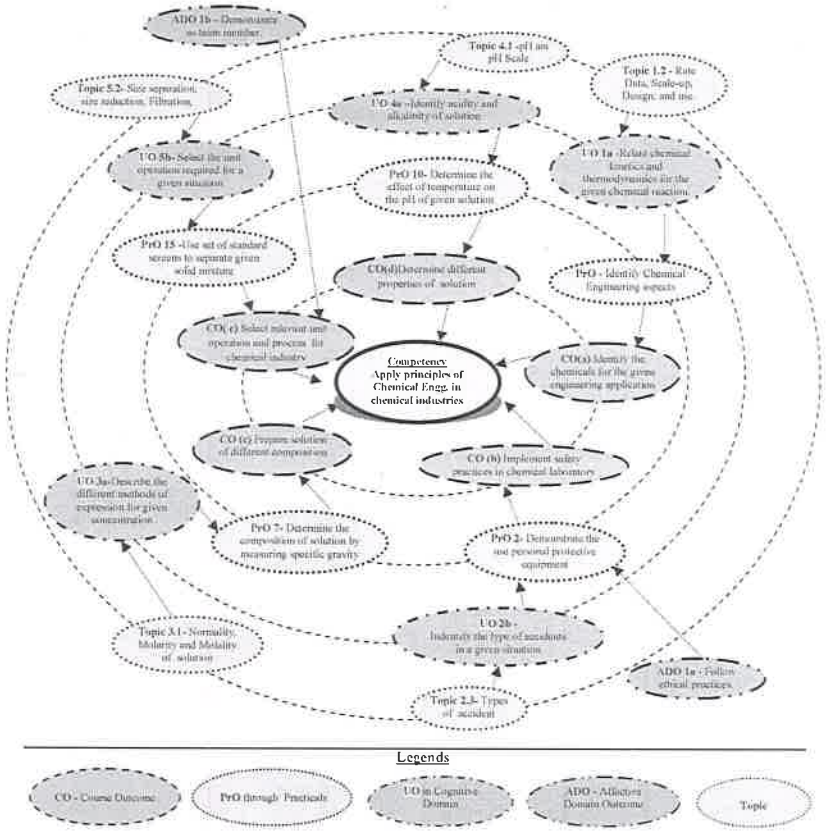

Figure 1 - Course Map

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.

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1	Visit chemical laboratory, identify hazards and write a report on safety provisions.	II	02*

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
2	Demonstrate the use of personal protective equipments.	II	02
3	Prepare the solution of given Normality	III	02*
4	Prepare the solution of given Molarity	III	02
5	Prepare the solution of given Molality	III	02
6	Measure the dry bulb and wet bulb temperature using whirling hygrometer	III	02
7	Determine the composition of solution by measuring specific gravity.	III	02
8	Prepare mixture of petrol and kerosene and measure the specific gravity of mixture.	III	02
9	Prepare the solution of given pH	IV	02*
10	Determine the effect of temperature on the pH of given solution.	IV	02
11	Determine the electrical conductivity of salt solutions of the given concentration.	IV	02
12	Determine the composition of solution by measuring Refractive Index.	IV	02
13	Prepare the saturated solution of the given salt (e.g. KCl)	IV	02
14	Determine the moisture content in the given solid sample	V	02*
15	Use set of standard screens to separate given solid mixture.	V	02
16	Use magnetic separator to separation mixture of sawdust and iron fillings	V	02
	Total		**32**

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 12 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	Observations and Recording	10
6	Interpretation of result and Conclusion	20
7	Answer to sample questions	10
8	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 safe practices.

b. Practice energy conservation

c. Follow ethics.

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
- 'Organising Level' in 2nd year and
- 'Characterising Level' in 3rd year.

7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

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	Exp. S. No.
1	Personal Protective equipments a. Apron, b. Ear Plug , c. Ear Muff , d. Face shield, e. Splash goggle , f.Acid/ Alkali proof hand gloves, g. Thermal hand gloves, h. Safety Shoes, i. Helmet, j. Eye rinse bottle, k. Eye wash basin, l. Canister mask	02
2	Glass wares	02,03,04
3	Dry bulb and wet bulb thermometer	03
4	Digital Weighing balance (1 mg accuracy)	02,03,04
5	Specific gravity bottle	07
6	pH Meter	08
7	Electrical Conductivity Meter	09
8	Refracto Meter	10
9	Ceramic crucible	12
10	Laboratory oven	12
11	Set of standard screens	13
12	Magnetic Separator	14

8. UNDERPINNING THEORY COMPONENTS

The following topics/subtopics should be taught and assessed in order to develop UOs in cognitive domain for achieving the COs to attain the identified competency.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit – I Chemistry and Chemical Engineering	1a. Describe the use of scale-up and design concept for the given chemical system. 1b. Relate chemical kinetics and thermodynamics for the given chemical reaction. 1c. Identify the reactors for the given Chemical Industries with justification.	1.1 Evolution of Chemical Engineering, Relationship between Chemistry and Chemical engineering 1.2 Rate Data, Scale-up, Design: Definition and use. 1.3 Chemical kinetics: Definition, use, relation between chemical kinetics and thermodynamics. 1.4 Reactors: Definition and classification

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	1d. Identify the chemicals for the given engineering application with justification.	1.5 Types of Chemical Industries on the basis of application, a. Basic Chemicals b. Fine Chemicals c. Specialty Chemicals.
Unit– II Safety in Chemical Laboratory	2a. Identify the given symbols related to chemical hazards with justification. 2b. Identify the type of accidents in the given situation. 2c. Select personnel protective equipments for the given situation with justification with justification. 2d. Choose the first aid measures for the given situation with justification.	2.1 Hazards, Hazards symbols (Bio Hazard, Toxic, Corrosive, Flammable) 2.2 Standard safety Instructions 2.3 Types of Accidents ; Trivial, Minor and Major, Causes of accidents in laboratories Unsafe conditions, Unsafe act 2.4 Apron, Splash goggle, Face shield, Helmet, Ear Plug, Ear Muff, Hand Gloves (Acid /Alkali proof) and Thermal gloves 2.5 First aid measure 2.6 Measures in case of eye injury (Chemical/impact), burn, accidental ingestion, skin contact , inhalation of toxic fumes 2.7 Emergency exit route and Assembly point
Unit– III Basic Concepts and calculations	3a. Describe the different methods of expression for the given concentration and composition of solution. 3b. Measure the density/ specific gravity of the given material. 3c. Measure the temperature of the given dry bulb and wet bulb. 3d. Use Dalton's and Amagat's law for determination of the given composition of gas.	3.1 Concentrations of solutions: Methods of expression, Strength, Molarity, Normality, Molality. 3.2 Composition of mixtures: Methods of expression, wt %, mole %, vol% and interconversions 3.3 Specific Gravity: measurement, specific gravity bottle 3.4 Temperature, dry bulb and wet bulb temperature 3.5 Daltons law and Amagats law and application of above laws
Unit-IV Properties of solutions	4a. Identify acidity and alkalinity of the given solutions by measuring pH with justification 4b. Describe the effect of the given composition and pH on electrical conductivity. 4c. Calculate refractive index of the given solution. 4d. Determine composition of the given solution. 4e. Determine the maximum solubility of the given salt.	4.1 pH and pH Scale: Principle, construction and working of pH meter with glass electrode Application of pH measurement in industry 4.2 Electrical Conductivity and its unit. Relationship between concentration of salt solution and electrical conductivity effect of pH on electrical conductivity Principle, Construction and Working of Conductivity Meter Application of electrical conductivity measurement 4.3 Refractive Index , Its dependence on composition and temperature 4.4 Principle, construction, working and application of Abbe's refractometer

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
		4.5 Solubility, saturation solubility, Effect of temperature and solvent on a solubility of a solute.
Unit –V Unit Operations and Unit Processes	5a. Identify the given unit operation with justification. 5b. Select the unit operation required for the given situation with justification. 5c. Describe the different unit processes in given situation. 5d. Identify Chemical engineering aspects in the given situation with justification.	5.1 Definition and classifications of Unit Operations:Mechanical operations, electro- Mechanical operation, thermal operations, Symbols of unit operations (as per IS 3232) 5.2 Size separation, size reduction, Filtration, Mixing, Sedimentation, Magnetic Separation, Electro dialysis, Electrostatic separation. 5.3 Distillation, Leaching, Drying, Evaporation, Crystallization, Absorption, Adsorption 5.4 Unit Process: Definition and applications 5.5 Oxidation, Reduction, Sulphonation, Nitration, Dehydrogenation, Pyrolysis, Calcination, Hydrogenation, Hydration, Dehydration, Esterification

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

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Scope of Chemical Engineering	06	02	02	04	08
II	Laboratory safety	10	02	04	04	10
III	Basic Concepts and calculations	12	04	04	06	14
IV	Properties of solutions	16	04	04	08	16
V	Unit operations and Unit Processes	20	04	08	10	22
Total		**64**	**16**	**22**	**32**	**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:

a. Identify the unit operations and unit processes involved in a given chemical

processes.
b. Study the effect of temperature on the solubility of a given salt.
c. Compensation knob and note the change in value of pH displayed.
d. Visit all laboratories in the department and identify the types of equipments /setups.
e. Prepare chart of standard symbols for various equipments as per IS 3232.
f. Prepare chart based on various job roles performed by diploma chemical engineers.
g. Prepare presentation based on opportunities for chemical engineers in various chemical and allied industries.
h. prepare presentation of application of different unit processes in chemical manufacturing and prepare a table of unit process versus product manufactured.
i. Prepare list chemical name chemicals, their use in daily life.
j. List various types of pH meters, refractometers
k. Select any chemical manufacturing process and identify unit operations and unit processes involved.

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 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 assigned to him/her in the beginning of the semester. S/he ought to submit it by the end of the semester to develop the industry oriented COs. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. 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.

In the first four semesters, the micro-project could be group-based. However, in higher semesters, it should 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. A suggestive list is given here. Similar micro-projects could be added by the concerned faculty:

a. **Water treatment plant:** Visit nearby water treatment plant and prepare the report with Block diagram of water treatment process, List of unit operations used
b. **History of Chemical Engineering:** Prepare a power point presentation on a topic " Chemical Engineering history and evolution"

c. **Petroleum refinery (Internet based assignment):** Identify a petroleum refinery and Make the list of product manufactured, list of unit operations and unit processes identify the job role for a chemical engineer in petroleum industry with Safety aspects
d. **Domestic water purifier (Field assignment):** Visit 3 to 4 domestic water purifier from near by locality or service center, identify purification stages and prepare a report based on function of each stage
e. **Four wheeler service stations:** Visit the four wheeler service station and study wastewater recycling arrangement and prepare a report.
f. **Industrial disaster:** Prepare a report on **Bhopal Gas tragedy** containing cause of accident, Safety preparedness of a company and Impact of accident.
g. **Laboratory Chemicals:** Prepare the list of Chemicals used in Laboratory on the basis of physical state and Hazards and technical specification
h. **Profile of PSUs**: Prepare a chart demonstrating profile of typical public sector organization, BPCL, HPCL, IOCL, ONGC containing product manufactured, block diagram, technical specification of product manufactured, safety aspects related to product, unit operations and processes involved.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Unit Operations of Chemical Engineering	Mc Cabe, W. L. Smith, Harriott	Mc Graw Hill International; 2010; ISBN: 007-124710-6
2	Introduction to Chemical Engineering	Ghosal S. K., Sanyal Shyamal K., Datta S.	Tata Mc Graw Hill Publications; 2006; ISBN: 0-07-460140-7
3	Unit Operations of Chemical Engineering	Walter L. Badger, Julius T. Banchero	Mc Graw Hill International, 1955; ISBN: 9780070850279
4	Stoichiometry	Bhatt B. I., Vora S. M.	Tata Mc Graw Hill Publications New Delhi; 1984; ISBN: 9780070964044
5	Mechanical Operations	Swain Anup K., Patra Hemlata, Roy G K.	Mc Graw Hill Publication; 2010; ISBN: 0070700222
6	Fundamentals of Chemical Engineering	S.N. Saha	Dhanpat Rai Publishing Company New Delhi, 2012, ISBN:81-87433-55-8

14. SOFTWARE/LEARNING WEBSITES

a. www. people.clarkson.edu
b. www.creatingtechnology.org
c. www.pafko.com/history
d. www.thechemicalengineer.com/
e. www.iisc.ernet.in
f. www.tep.engr.tu.ac.th
g. www.ichemeblog.org/
h. https://www.acs.org/chemicalsafety
i. www.chemistry.harvard.edu