Maharashtra State Board of Technical Education, Mumbai

Teaching and Examination Scheme for Post S.S.C. Diploma Courses

Program Name : Diploma in Chemical Engineering

Program Code : CH | **With Effect From Academic Year: 2017 - 18**

Duration of Program : 6 Semesters | **Duration : 16 Weeks**

Semester : Third | **Scheme - I**

S. N.	Course Title	Course Abbreviation	Course Code	Teaching Scheme			Credit (L+T+P)	Examination Scheme												Grand Total
								Theory						Practical						
								Exam Duration in Hrs.	ESE		PA		Total		ESE		PA		Total	
				L	T	P			Max Marks	Min Marks	Max Marks	Min Marks	Max Marks	Min Marks	Max Marks	Min Marks	Max Marks	Min Marks	Max Marks	Min Marks	
1	Plant Utilities	PUT	22311	4	2	-	6	3	70	28	30*	00	100	40	--	--	--	--	--	--	100
2	Plant Economics and Energy Management	CEP	22312	4	-	2	6	3	70	28	30*	00	100	40	25@	10	25	10	50	20	150
3	Mechanical Operations	MOP	22313	4	-	4	8	3	70	28	30*	00	100	40	50#	20	50	20	100	40	200
4	Technology of Inorganic Chemicals	TIV	22314	4	-	4	8	3	70	28	30*	00	100	40	50#	20	50	20	100	40	200
5	Industrial Stoichiometry	IST	22315	4	2	-	6	3	70	28	30*	00	100	40	--	--	--	--	--	--	100
			Total	**20**	**4**	**10**	**34**	--	**350**	--	**150**	--	**500**	--	**125**	--	**125**	--	**250**	--	**750**

Student Contact Hours Per Week: **34 Hrs.** Medium of Instruction: **English**

Theory and practical periods of 60 minutes each. Total Marks : **750**

Abbreviations: ESE- End Semester Exam, PA- Progressive Assessment, L - Lectures, T - Tutorial, P - Practical

@ Internal Assessment, # External Assessment, *# On Line Examination , ^ Computer Based Assessment

* 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 LOs required for the attainment of the COs.

~ For the courses having ONLY Practical Examination, the PA marks Practical Part - with 60% weightage and Micro-Project Part with 40% weightage

- **If Candidate not securing minimum marks for passing in the "PA" part of practical of any course of any semester then the candidate shall be declared as "Detained" for that semester.**

Program Name : **Diploma in Chemical Engineering**

Program Code : **CH**

Semester : **Third**

Course Title : **Plant Utility**

Course Code : **22311**

1. RATIONALE

Diploma Chemical Engineers have to use various plant utilities like water, air, steam, refrigerant and thermic fluid in different industrial processes. The important utilities required for process plant are water, steam, air and refrigerants. Steam and non steam heating media are important for conversion of raw materials to required product in reactor and to increase or elevate the temperature in chemical processes. Refrigeration is important to maintain the required temperature in process plant. Compressed air, process air are used in processes and instrument air is used in Pneumatic devices and controls. This course is designed to provide basic understanding about the various plant utilities and their applications for process industries.

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 different utilities in chemical process plants for various applications.**

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 different water treatment methods for boiler feed water.
b. Use steam generators and non steam heating systems in chemical process industries.
c. Use industrial air in chemical process industry.
d. Apply refrigeration in various chemical engineering processes.
e. Use Humidification and dehumidification processes for air in chemical industries.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme			Credit (L+T+P)	Examination Scheme											
				Theory						Practical					
L	T	P		Paper Hrs.	ESE		PA		Total		ESE		PA		Total	
					Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
4	2	--	6	3	70	28	30*	00	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.

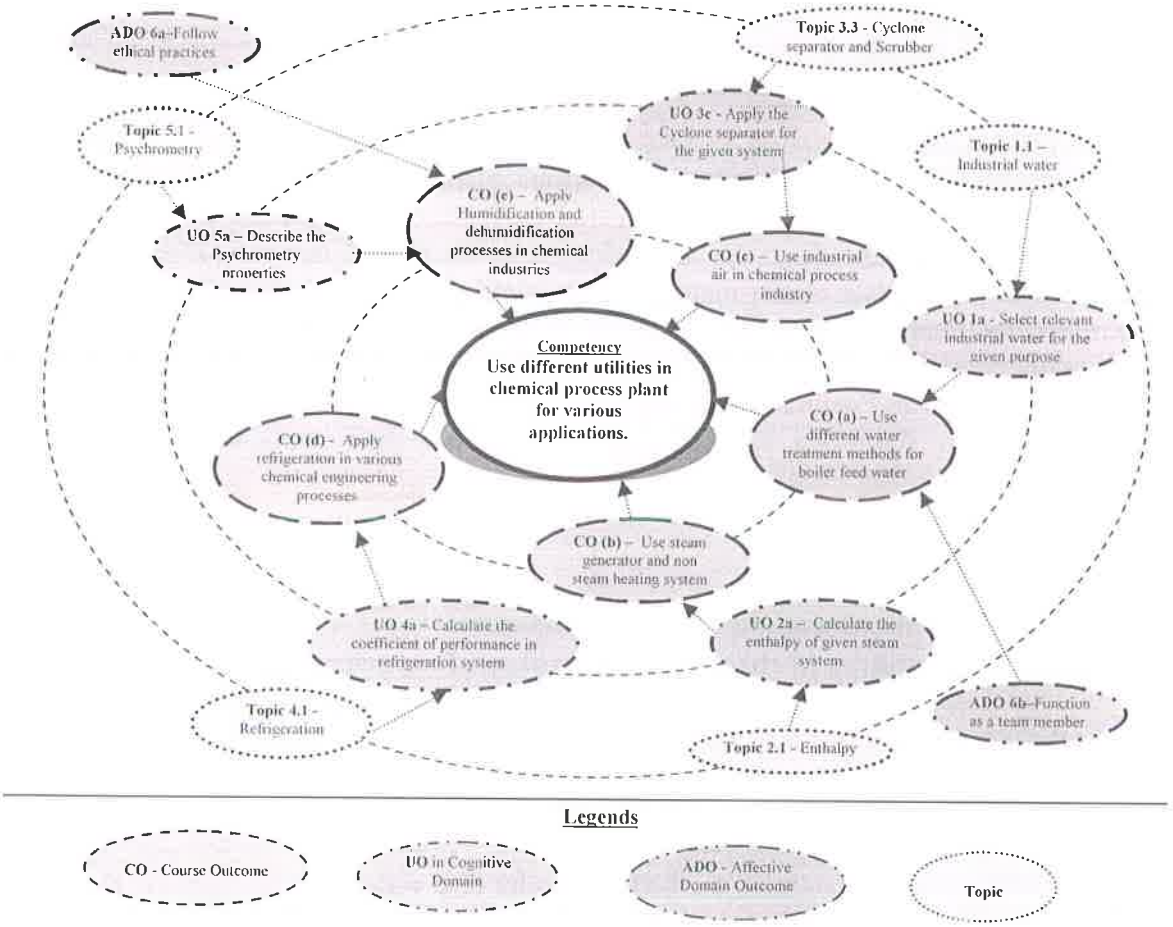

Figure 1 - Course Map

6. SUGGESTED TUTORIALS

S. No.	Tutorial	Unit No.	Approx. Hrs. Required
1	List different sources and characteristics of water.	I	2
2	Determine Temporary hardness of water.	I	2
3	Determine Permanent hardness of water.	I	2
4	To read/interpret different properties of steam using steam table.	II	2
5	Determine enthalpy of wet and dry steam using steam table	II	2
6	Classify boilers based on different parameters.	II	2
7	Differentiate steam heating and non steam heating system.	II	2
8	List different types of boiler mountings with their applications.	II	2
9	List different types of boiler accessories with their applications.	II	2
10	Differentiate single and multistage compressor.	III	2
11	Draw vapour compression refrigeration cycle.	IV	2
12	Draw vapour absorption refrigeration cycle.	IV	2

S. No.	Tutorial	Unit No.	Approx. Hrs. Required
13	Numerical on Calculation of refrigeration effect.	IV	2
14	Numerical on Calculation of coefficient of performance	IV	2
15	Determine humidity by using Psychrometric chart	V	2
16	Calculate dry bulb and wet bulb temperature using psychrometric chart.	V	2
			32

Note: The above tutorial sessions are for guideline only. The remaining tutorial hours are for revision and practice

The above tutorials 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
- 'Organising Level' in 2nd year
- 'Characterising Level' in 3rd year.

7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED:

- Not applicable –

8. UNDERPINNING THEORY COMPONENTS

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

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit – I Industrial Water	1a. Select relevant industrial water for the given purpose. 1b. Calculate the hardness of the given water sample. 1c. Identify various boiler problems due to the given boiler feed water. 1d. Apply the lime soda method of water softening for the given hard water.	1.1 Industrial water: definition, properties and uses 1.2 Hard water, Hardness, Total hardness, permanent hardness, temporary hardness, Numericals. 1.3 Boiler feed water, Scale and sludge formation , Corrosion, Priming and Foaming , Caustic Embrittlement 1.4 Water treatment: Lime Soda Process. Ion Exchange Process, Zeolite Method.
Unit– II Steam, Steam Generators and Non Steam Heating System	2a. Calculate the enthalpy of the given steam system. 2b. Apply the relevant steam for the given system. 2c. Implement boiler act in the given industries.	2.1 Enthalpy: definition, formula, numerical. 2.2 Steam Types: Wet, Dry, Superheated, Saturated and Unsaturated Steam. 2.3 Steam boilers: Classification, construction and working of Bab-Cock and Wilcox, Lancashire, Waste heat and Fluidized bed boilers. 2.4 Boiler mountings and accessories: Water level indicator, Pressure gauge, Steam trap, Pressure reducing valve, Economizer, Preheater, Super heater. 2.5 Boiler Act: Indian boiler act and duties of boiler inspector
	2d. Select relevant thermic fluid for the given temperature range. 2e. Apply the Thermic fluid heater for the given system.	2.6 Thermic fluid: Definition, properties. 2.7 Types of thermic fluid and temperature range. 2.8 Thermic fluid heater: Construction and working difference with steam boiler.
Unit– III Industrial Air	3a. Identify relevant type of industrial air for the given system. 3b. Identify relevant air compressors for the given process. 3c. Apply the Cyclone separator for the given system. 3d. Apply relevant air purifier for the given system.	3.1 Industrial Air: Definition, types and application, compressed air, process air and instrumental air. 3.2 Compressor: definition, types, uses, Single and multistage compressor. 3.3 Cyclone separator and Scrubber: construction, working and uses. 3.4 Air dust collectors, electrostatic precipitator

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit-IV Refrigeration	4a. Calculate the coefficient of performance in the given refrigeration system. 4b. Apply the reverse Carnot cycles for the given system. 4c. Describe with sketches the refrigerant cycle for the given application. 4d. Identify relevant refrigerant for the given system with justification.	4.1 Refrigeration: Definition, unit of refrigeration, coefficient of performance. 4.2 Refrigeration cycles: Reversed Carnot cycle, representation on PV and TS diagram. 4.3 Air refrigeration cycle: Bell Coleman air refrigeration cycle. 4.4 Vapor compression and absorption cycle: Li-Br absorption system 4.5 Refrigerants: Classification, selection criteria and applications.
Unit –V Psychrometry	5a. Identify the Psychrometry properties in the given system with justification. 5b. Apply relevant air condition equipments for the given system. 5c. Solve numerical using the given psychrometric chart. 5d. Select the relevant cooling tower for the given situation with justification.	5.1 Psychrometry: definition, dry bulb temperature, wet bulb temperature, numerical, psychrometric chart, humidity. 5.2 Air condition equipments: Principle, construction and working of humidifier, dehumidifier. 5.3 Cooling Towers: Principle, construction and working of induced draft and forced draft.

***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 FOR QUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Industrial Water	14	04	04	08	16
II	Steam, Steam Generators and Non steam heating system.	20	04	06	10	20
III	Industrial Air	08	02	04	04	10
IV	Refrigeration	12	02	04	06	12
V	Psychrometry	10	02	04	06	12
	Total	**64**	**14**	**22**	**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 related engineering problems with the use of free tutorials available on the internet.
b. Use Steam table and Psychrometric chart.
c. Visit nearby industry to study steam generation by boiler.
d. Participate in seminar on relevant topic.

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 ADOs. 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. **Industrial water softening Report:** Prepare report on water softening methods used by different industries.
b. **Model preparation:** Prepare model displaying the Mountings on various types of the boiler.
c. **Chart preparation:** Prepare charts displaying the accessories used by various industries for boiler.

d. **Identification of refrigerants**: Prepare the list of different refrigerants with specific use in process industry.
e. **Listing of non steam heating systems:** Collect information regarding different Non-steam heating fluids used in industry.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Thermal Engineering	Balleney, P.L	Khanna Publication, New Delhi 1975 ISBN 9788174090317
2	Industrial Water Treatment.	Powel, S.T	Mc Graw Hill, New York. 2009, ISBN 9781118843727
3	Engineering Chemistry	Jain and Jain	Dhanpatrai Publications, New Delhi, 2008, ISBN-9788121903455
4	Refrigeration: Theory and Applications	James K. Carson	McGraw Hills Edition, New York 2011, ISBN: 978-87-403-0363-6
5	A Textbook of Refrigeration & Air Conditioning	Rajput, R.K.	S K Kataria & Sons, New Delhi, 2003 ISBN13: 9789350142554

14. SOFTWARE/LEARNING WEBSITES

a. https://www.swtc.edu/ag_power/air_conditioning/lecture/basic
b. www.boiler.guide
c. www.aquascience.net
d. www.idc-online.com/technical_references/pdfs
e. www.sciencedirect.com
f. www.scopeus.com

Program Name : **Diploma in Chemical Engineering**

Program Code : **CH**

Semester : **Third**

Course Title : **Plant Economics and Energy Management**

Course Code : **22312**

1. RATIONALE

In the development of any country, Energy management and economics plays a very important role. The depletion of fossil fuel, problem of global warming, environmental issues related to energy and effect of all these on business climate are critically faced by chemical industries. Efficient utilization of available resources and development of upgraded technologies for energy conversion are the significant responsibility of a diploma chemical engineer. This will lead the diploma chemical engineers to plant economics. Economics where technology meet business.This course is designed to provide basic understanding about theenergy resources, environmental impact, different renewable energy resources, technologies for energy conservation, management, money and market, capital investment, cost estimation, taxes, depreciation, budgeting and business plans.

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 the principles of energy management and economics inchemical 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. Identify forms of energy and its impact on plant environment.
b. Select the energy source and method for energy conservation.
c. Perform energy conservation audit for chemical process industry.
d. Calculate the cost, taxes and insurance liability for chemical process industry.
e. Estimate the depreciation for chemical process industry.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme			Credit (L+T+P)	Examination Scheme													
				Theory							Practical						
L	T	P		Paper Hrs.	ESE		PA		Total		ESE		PA		Total		
					Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	
4	-	2	6	3	70	28	30*	00	100	40	25@	10	25	10	50	20	

(*): 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 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.

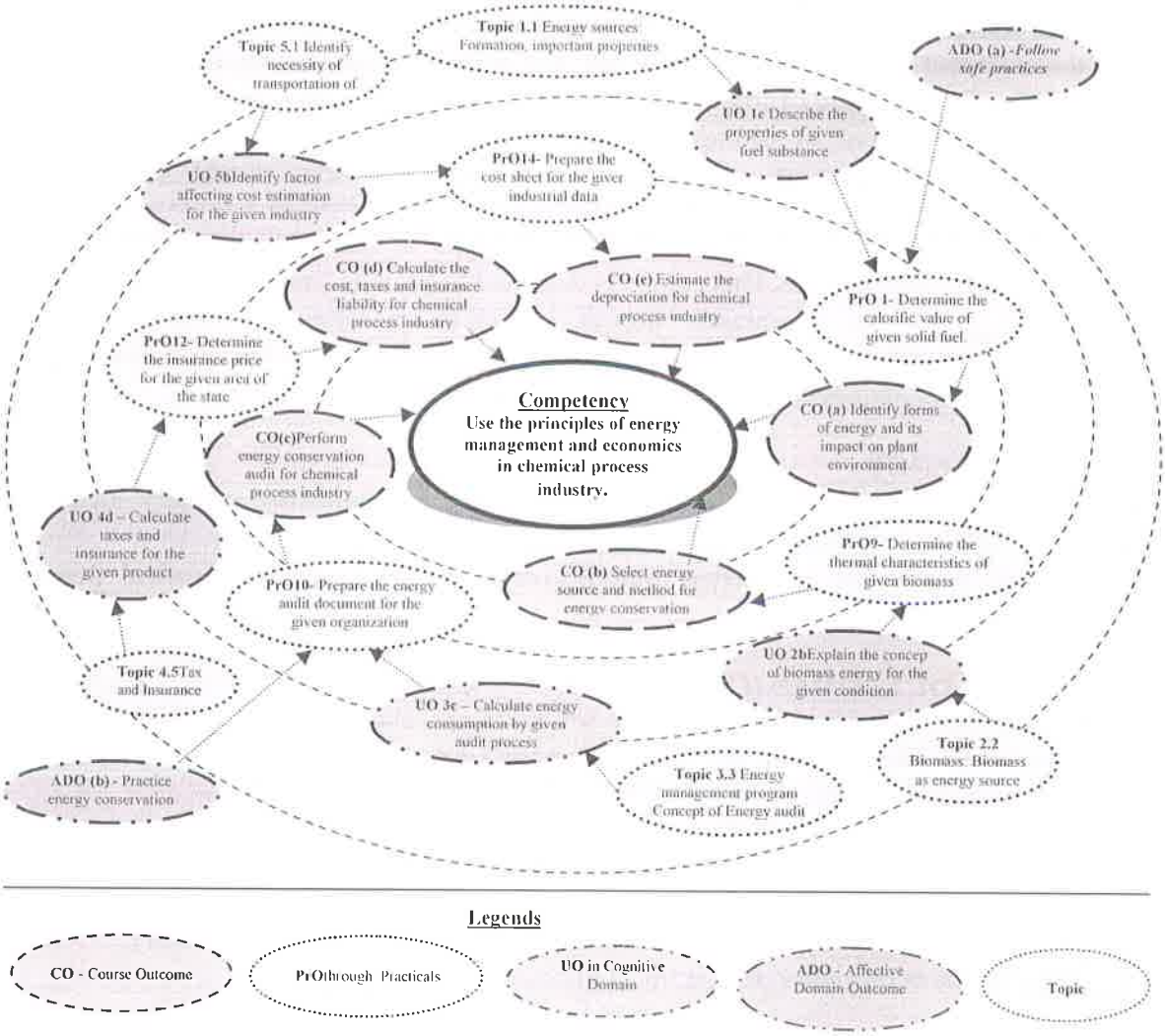

Figure 1 - Course Map

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:

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1	Determine the calorific value of given solid fuel.	I	2*
2	Determine the calorific value of given liquid fuel.	I	2*
3	Determine the calorific value of given Gaseous fuel.	I	2
4	Determine the moisture content in given coal sampl	I	2*

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
5	Determine the volatile content in given coal sample.	I	2
6	Determine the ash content in given solid fuel sample.	I	2*
7	Determine the efficiency of sample solar plate.	II	2*
8	Determine the fuel components from kitchen waste	II	2
9	Determine the thermal characteristics of given biomass.	II	2*
10	Prepare the energy audit document for the given organization.	III	2*
11	Estimate the simple and compound Interest on given project cost in specific conditions.	IV	2
12	Determine the insurance price for the given area of the state.	IV	2*
13	Measure the impact of net profit and sales on stock prices of given company through the implementation of regression equation.	IV	2*
14	Prepare the cost sheet for the given industrial data.	V	2*
15	Prepare the balance sheet for the given company account.	V	2*
16	Measure the profitability of given project using development of cases and virtual situations for the given economic conditions.	V	2*
	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 %
a.	Selection of suitable component, apparatus/instrument	20
b.	Preparation of experimental set up	10
c.	Setting and operation	10
d.	Safety measures	10
e.	Physical presence during practical	10
f.	Observation and recording	10
g.	Interpretation of result and conclusion	10
h.	Answer to sample question	10
i.	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	Bomb's calorimeter	1, 2
2	Junker's calorimeter	3
3	Hot air oven Up to 250°C temperature, gas ventilator and current protection	4, 5
4	Muffel Furnace with 800°C to 1400°C temperature range.	6
5	Digital multimeter : 3 1/2 digit display, 9999 counts digital multimeter measures: V_{ac}, V_{dc} (1000V max) , A_{dc}, A_{ac}(10 amp max) , Hz , Resistance (0 - 100 MΩ) , capacitance and Temperature	7
6	Solar panel with installation kit	7
7	Thermometer with the range of 0-120°C.	9

8. UNDERPINNING THEORY COMPONENTS

The following topicsare to betaught 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 – IEnergy and Energy Policy	1a. Explain the energy policy for the given chemical plant. 1b. Identify different energy sources for the givenapplications with justification. 1c. Describe the properties of the given fuel substance. 1d. Identify the future energy system in the given situation with justification.	1.1 Energy and development:National and International energy policy. Energy sources. Classification of energy sources. Quality and concentration of energy sources. 1.2 Energy Sources: Units of various energy, conversion, calorific value. Formation, important properties, conversion and uses of Coal, Petroleum and Natural Gas. 1.3 Future Energy system. Clean energy technologies.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit– II Renewable . and Non-renewable Sources of Energy	2a. Describewith sketches concept of solar energy for the given application. 2b. Explain the concept of biomass energy for the given condition. 2c. Identify importance of wind energy for the given condition with justification. 2d. Select the type of clean energy for the givenapplication with justification.	2.1 Solar Energy:Concept, Flat plate collector (Liquid & Air). Theory of flat plate collector. Importance of coating. Advanced collector. Solar pond. Solar water heater, solar dryer. Solar stills. 2.2 Biomass: Biomass as energy source. Classification and production. Physicochemical and Thermal characteristics of biomass as fuel. Anaerobic digestion. Biogas production mechanism. Types, installation, operation and maintenance of digesters. Utilization and storage of biogas. 2.3 Wind energy: History, current status and future prospects of wind energy. Wind energy in India. Environmental benefits and problem of wind energy. Economics of wind energy. Introduction, classification, advantages and disadvantages of Hydropower. 2.4 New Energy Sources: Need and types. Hydrogen energy: Production method, storage, transportation and applications. Ocean energy resources. Tidal energy conversion. Geothermal energy concept, origin and power plants.
Unit– III Energy Management and Audit.	3a. Describewith sketches thetype of energy that can be used for the given application. 3b. Explain energy conservation for the given industrial application. 3c. Calculate energy consumption by the data from the given audit process. 3d. Identify the energy management duties of chemical technologist for the given industry.	3.1 Energy: Commercial and Noncommercial energy. Primary energy resources. 3.2 Energy security. Energy conservation and its importance. 3.3 Energy management program. Concept of Energy audit. Types and procedure of energy audit, energy losses & control. 3.4 Energy conservation act. Duties and responsibilities of Energy manager and auditor.
Unit-IVIntroduction to Plant Economics	4a. Describe the concept of market for the given area of plant economics. 4b. Calculate different types of cost for the giventype of chemical industry. 4c. Apply thelaw's of demand	4.1 Economics: Definitions and concept. Different types of market. 4.2 Concept of Cost, Total cost, fixed cost, variable cost, direct and indirect cost. 4.3 Demand and supply: Law of demand and supply. Demand and supply schedule. Methods of measurement.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	and supply for the givenchemical engineering commodity. 4d. Calculate taxes and insurance for the givenchemical engineering product.	4.4 Cost accounting: Basics and procedure of accounting. Methods of accounting. Balance sheet. 4.5 Tax and Insurance: Concept and types. income tax, excise tax, property tax,benefits of insurance.
Unit –V Cost Estimation and Interest.	5a. Calculate the interest onthe given amount and condition with respect to chemical engineering application. 5b. Identifyfactor affecting cost estimationfor the given type of chemical engineering industry. 5c. Calculate depreciation by the given method in the given given chemical engineering industry. 5d. Describe concept of profitability and calculation by the given method with respect to chemical engineering industry.	5.1 Interest: Concept and types of interest.(simple, compound and continuous) 5.2 Cost Estimation: Factor affecting on cost estimation. Total cost, fixed, variable cost. 5.3 Depreciation: Meaning and definition. Purpose of charging and factor affecting on depreciation. Methods of calculation of depreciation. Straight line method, Sinking fund method, Sum of the digit method, Annuity method, Written down value method. 5.4 Profitability: Concept of profitability. Evaluation of profitability by Rate of return on investment method, Net present worth method, Pay out period method. Advantages and disadvantages of above methods.

***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	Energy and Environment	14	02	06	08	16
II	Renewable and nonrenewable sources of energy.	12	02	04	04	10
III	Energy management and audit	14	02	04	08	14
IV	Introduction to Plant Economics	12	02	04	08	14
V	Cost estimation and interest.	12	02	04	10	16
Total		**64**	**10**	**22**	**38**	**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. Visit nearby industry to study energy consumption.
b. Prepare report on energy consumption in your institute.
c. Visit nearby energy auditor to understand auditing process.
d. Prepare list of equipment from nearby industry which conserve energy.
e. Prepare report on different laboratories from institute where energy can be conserved..
f. Suggest method to save energy in institute during practical hour.

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 ADOs. 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 nearby industry and prepare report on technologies adopted for energy conservation.
b. **Visit of chemical process plant**: Prepare flow chart for Energy conservation process.
c. **Prepare the report**: prepare the report for energy conservation of the institute.
d. **Preparation of model**: Prepare model of energy conservation in practical lab.

e. **Collection of different account samples**: Collect the accounting data from different organization/process industries/Laboratory.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Principles of Energy Conversions	Culp, A. W.	Mc Graw Hill, New York, 1991,ISBN 0-07-100991-4
2	Industrial Energy Conservation	Reay, D. A.	Pergammon Press, London, 1979, ISBN: 9780080232744
3	Energy Management Handbook	Turner Wayne C. , Doty Steve Turner, W. C.	The Fairmont Press, Inc.,Georgia, 2007, ISBN: 978-1466578289
4	Management of Energy Environment Systems	Foell, W. K.	John Wiley and Sons, London, 1979, ISBN 13: 9780471997214
5	Chemical Engineering Economics	Garrett, D. E.	Springer, Netherland, 1989, ISBN978-94-011-6544-0
6	Plant design and economics for Chemical Engineers	Max,P.S, Timmerhaus Klaus D, West Ronald E.	Mc Graw Hill Publication, New York, 2003, ISBN: 9781259002113

14. SUGGESTED SOFTWARE/LEARNING WEBSITES

a. https://en.wikipedia.org/wiki/Energy_management
b. http://www.energylens.com/articles/energy-management
c. http://www.capterra.com/energy-management-software/
d. http://guides.lib.utexas.edu/c.php?g=494197&p=3381912

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.

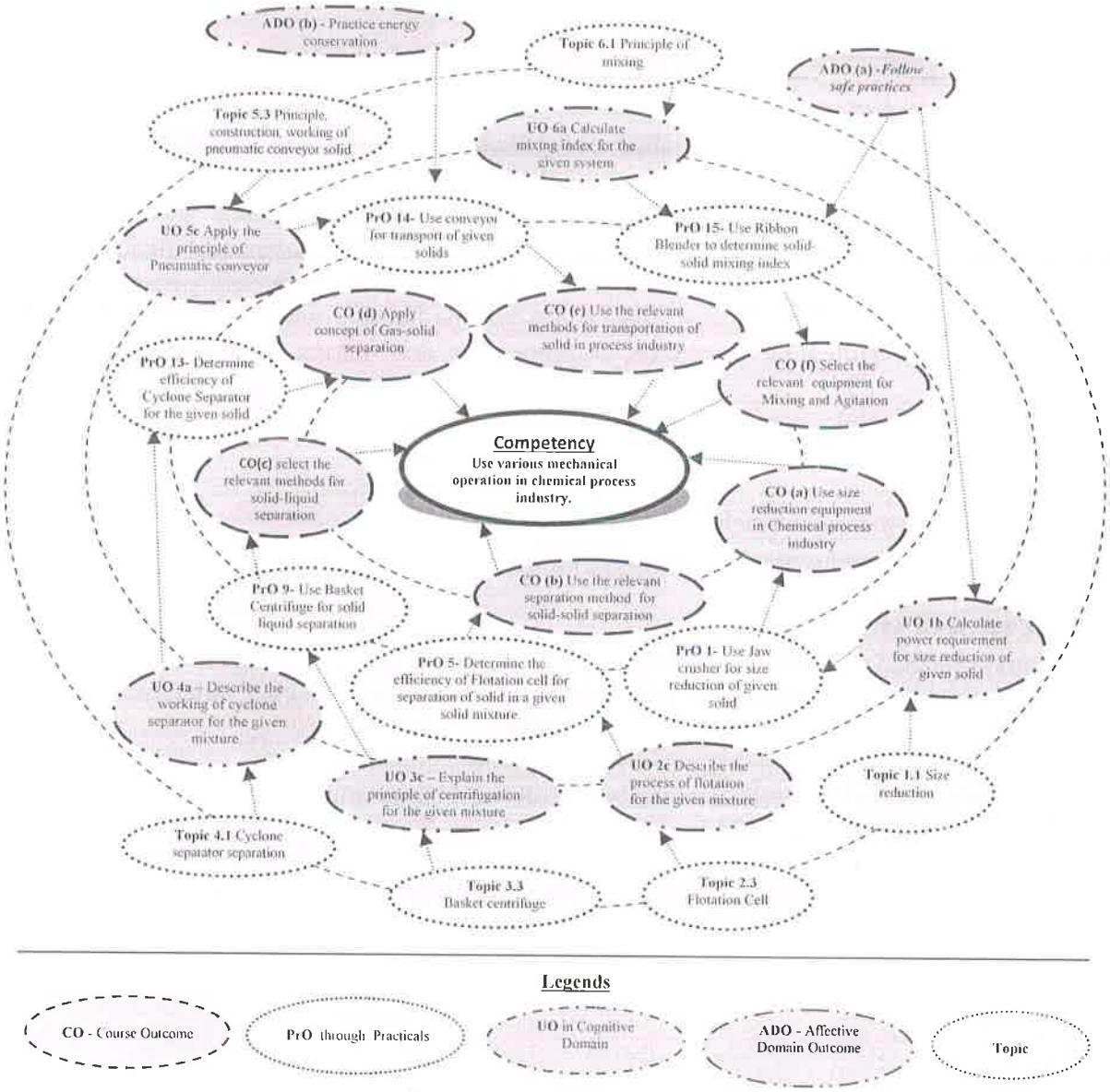

Figure 1 - Course Map

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

Program Name : **Diploma in Chemical Engineering**

Program Code : **CH**

Semester : **Third**

Course Title : **Technology of Inorganic Chemicals**

Course Code : **22314**

1. RATIONALE

Diploma chemical engineers have to work as plant operator. During their course of work they have to deal with various aspects of manufacturing technology. It is essential for them to giving maximum output with minimum cost and pollution .This subject will provide information towards raw materials process and industrial application for manufacturing of inorganic chemicals like acids, fertilizers, cement etc. This course will provide necessary skill to perform the job role.

2. COMPETENCY

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

- **Apply basic concepts of inorganic chemistry in chemical engineering applications.**

3. COURSE OUTCOMES (COs)

The theory 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. Manufacture the inorganic acids in chemical process industries.
b. Prepare Ammonia-based fertilizers in chemical process industries.
c. Select the raw material for Phosphate based fertilizer manufacturing.
d. Prepare Caustic soda in chemical process industries.
e. Synthesize the Cement of known composition.
f. Manufacture industrially important gases.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme			Credit (L+T+P)	Examination Scheme											
				Theory							Practical					
L	T	P		Paper Hrs.	ESE		PA		Total		ESE		PA		Total	
					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.

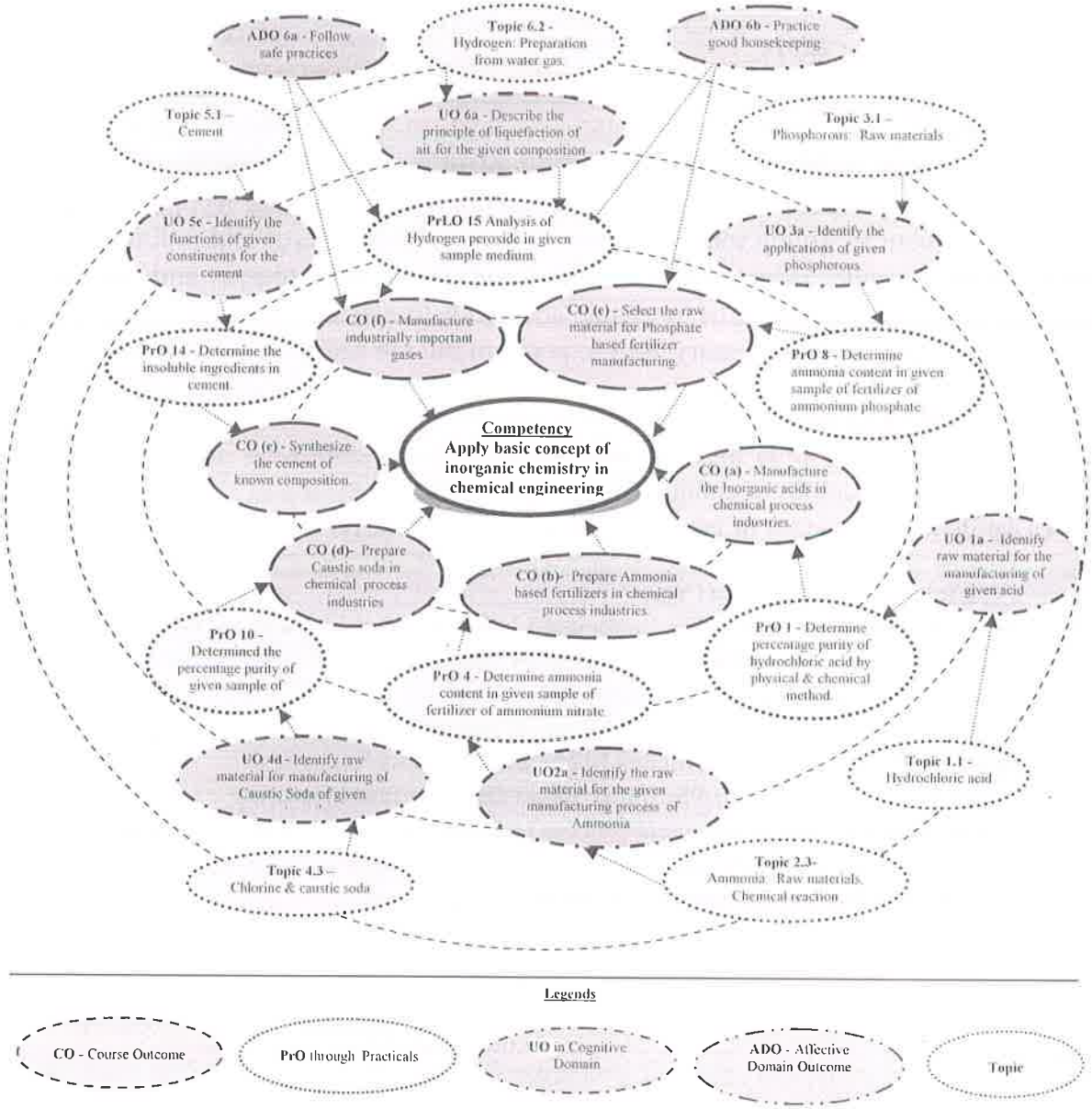

Figure 1 - Course Map

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.

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1	Determine percentage purity of commercial grade hydrochloric acid by physical and chemical method.Part - I	I	02*
2	Determine percentage purity of commercial grade hydrochloric acid by physical and chemical method.Part - II	I	02*

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
3	Determine percentage purity of commercial grade sulfuric acid by physical and chemical method. Part - I	I	02*
4	Determine percentage purity of commercial grade sulfuric acid by physical and chemical method. Part - II	I	02*
5	Determine percentage purity of commercial grade Nitric acid by physical and chemical method. Part - I	I	02*
6	Determine percentage purity of commercial grade Nitric acid by physical and chemical method. Part - II	I	02*
7	Determine the strength of given Nitric acid by pH meter. Part-I	I	02*
8	Determine the strength of given Nitric acid by pH meter. Part-II	I	02*
9	Determine the strength of given Hydrochloric acid by pH meter. Part-I	I	02*
10	Determine the strength of given Hydrochloric acid by pH meter. Part-II	I	02*
11	Determine ammonia content in given sample of fertilizer of ammonium nitrate. Part - I	II	02*
12	Determine ammonia content in given sample of fertilizer of ammonium nitrate. Part - II	II	02*
13	Determine ammonia content in given sample of fertilizer of ammonium sulphate. Part - I	II	02*
14	Determine ammonia content in given sample of fertilizer of ammonium sulphate. Part - II	II	02*
15	Determine ammonia content in given sample of fertilizer of ammonium chloride. Part - I	II	02*
16	Determine ammonia content in given sample of fertilizer of ammonium chloride. Part - II	II	02*
17	Determine nitrogen content in given sample of ammonium fertilizer. Part - I	II	02*
18	Determine nitrogen content in given sample of ammonium fertilizer. Part - II	II	02
19	Determine ammonia content in given sample of ammonium phosphate. Part - I	III	02*
20	Determine ammonia content in given sample of ammonium phosphate. Part - II	III	02
21	Determine the percentage of CaO in given sample of lime stone. Part - I	III	02*
22	Determine the percentage of CaO in given sample of lime stone. Part - II	III	02
23	Determined the percentage purity of given sample of caustic soda. Part - I	IV	02*
24	Determined the percentage purity of given sample of caustic soda. Part - II	IV	02
25	Determined percentage purity of given sample of soda ash. Part - I	IV	02*
26	Determined percentage purity of given sample of soda ash. Part - II	IV	02
27	Determine the calcium content in cement. Part - I	V	02*
28	Determine the calcium content in cement . Part - II	V	02
29	Determine the insoluble ingredients in cement. Part - I	V	02*

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
30	Determine the insoluble ingredients in cement. Part - II	V	02
31	Determine the carbon dioxide from given sample of water. Part - I	VI	02*
32	Determine the carbon dioxide from given sample of water. 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 %
a.	Selection of suitable component, apparatus/instrument	20
b.	Preparation of experimental set up	10
c.	Setting and operation	10
d.	Safety measures	10
e.	Physical presence during practical	10
f.	Observation and recording	10
g.	Interpretation of result and conclusion	10
h.	Answer to sample question	10
i.	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/ 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	Pro. S. No.
1	Beakers (100ml to 500ml)	All Expt.
2	Burette with stand, 50 ml	All Expt.
3	Thermometer	01,02,03
4	Hydrometer	01,02,03,
5	Conical flask (100 to250ml.)	All Expt.
6	pipette (10 to 25ml)	All Expt.
7	Measuring cylinder (10 to 50ml)	All.Expt.
8	Weighing balance	All Expt.
9	Ceramic crucible	09
10	Laboratory oven up to temperature range of 250° C.	09
11	Bottles (250ml)	All Expt.
12	Test Tube (20ml)	All Expt.

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 Inorganic Acids	1a. Identify raw material for the manufacturing of the given acid with justification. 1b. Describe with sketches the process flow diagram for the manufacturing of the given acid. 1c. Identify the components of chemical reaction for the given acid manufacturing with justification. 1d. Describe with sketches the evaporation process for manufacturing the given acid.	1.1 Hydrochloric acid: Raw materials, Chemical reaction, manufacturing process, Process flow diagram, Industrial applications, Economics, Manufacturing industries. 1.2 Sulfuric acid: Raw materials, Chemical reaction, manufacturing process, Process flow diagram, Industrial applications, Economics, Manufacturing industries. 1.3 Nitric acid: Raw materials, Chemical reaction, manufacturing process, Process flow diagram Industrial applications, Economics, Manufacturing industries. 1.4 Phosphoric Acid: Raw materials, Chemical reaction, manufacturing process, Process flow diagram, Industrial applications, Economics, Manufacturing industries.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit– II Ammonia based Fertilizers.	2a. Identify the raw material for the given manufacturing process of Ammonia with justification. 2b. Describe with sketches the given manufacturing process of Ammonium Nitrate. 2c. Describe with sketches the given chemical reaction for Ammonium sulfate manufacturing. 2d. Describe with sketches the the manufacturing of given Urea derivative.	2.1 Ammonia: Raw materials, Chemical reaction, manufacturing process, Process flow diagram, Industrial applications, Economics, Manufacturing industries 2.2 Ammonium Nitrate: Raw materials, Chemical reaction, manufacturing process, Process flow diagram, Industrial applications, Economics, Manufacturing industries 2.3 Ammonium sulfate: Raw materials, Chemical reaction, manufacturing process, Process flow diagram, Industrial applications, Economics, Manufacturing industries 2.4 Urea: Raw materials, Chemical reaction, manufacturing process, Process flow diagram, Industrial applications, Economics, Manufacturing industries
Unit– III Phosphoro us based fertilizer.	3a. Identify the applications of the given phosphorous with justification. 3b. Eliminate the hydrofluoric acid from the given chemical manufacturing process. 3c. Describe with sketches the manufacturing of the given fertiliser. 3d. Describe the conversion process for the given MAP-DAP.	3.1 Phosphorous: Raw materials, Chemical reaction, manufacturing process, Process flow diagram, Industrial applications, Economics and Manufacturing industries 3.2 Super phosphate: Raw materials, Chemical reaction, Manufacturing process, Process flow diagram, Industrial applications, Economics and Manufacturing industries 3.3 Triple Superphosphate: Raw materials, Chemical reaction, manufacturing process, Process flow diagram, Industrial applications, Economics and Manufacturing industries 3.4 Di-Ammonium phosphate: Raw materials, chemical reaction, manufacturing process, process flow diagram, industrial applications, economics and manufacturing industries

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit-IV Potassium based fertilizer and Chloro Alkali Material	4a. Identify the components of mixed fertilizers for the given grades. 4b. Apply the relevant chemical reaction for the given Potassium fertilizer.	4.1 Mixed fertilizer: Definition, grades, Application 4.2 Potassium fertilizer: Raw materials, Chemical reaction, Process flow diagram, Manufacturing Process, Industrial applications, Economics and manufacturing industries.
	4c. Apply electrolysis of brine for the given application. 4d. Identify raw material for manufacturing of Caustic Soda of the given strength.	4.3 Chlorine and caustic soda: Raw materials, Chemical reaction, Process flow diagram, Manufacturing Process, Industrial applications, Economics and Manufacturing industries 4.4 Soda Ash: Raw materials, Chemical reaction, Process flow diagram, Manufacturing Process, Industrial applications, Economics and Manufacturing industries
Unit V Cement and Refractori es	5a. Identify the chemical composition of the given cement. 5b. Identify the functions of the given constituents for the cement. 5c. Apply the principle of setting and hardening for the given composition of cement. 5d. Identify the Refractivity for the given application.	5.1 Cement: Definition, Portland cement, classification, raw materials, chemical composition, function of constituents, setting and hardening, special cements, water proof cement, white portland cement, colored cement, plaster of paris. 5.2 Refractory: definition, types, acidic basic and neutral refractivity, composition, properties, applications.
Unit VI Industrial Gases	6a. Describe the principle of liquefaction of air for the given composition. 6b. Explain the heat economy for the given waste heat boiler. 6c. Describe the concept of absorption for the given manufacturing process. 6d. Apply the process of hydrolysis for the given system.	6.1 Oxygen and Nitrogen: Principle, Linde's and Claude's method 6.2 Hydrogen: Preparation from water gas. 6.3 Carbon dioxide: from flue gases. 6.4 Acetylene: from calcium carbide 6.5 Water gas: preparation using coal 6.6 Producer Gas: By using coal.

***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 FOR QUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Acids	12	02	04	06	12
II	Ammonia based fertilizers	12	02	04	06	12
III	Phosphorous based fertilizer	12	02	04	06	12
IV	Potassium based fertilizer and Chloro Alkali Material	13	02	04	06	12
V	Cement and Refractory	07	02	04	04	10
VI	Industrial Gases	08	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 engineering problems based on real world problems and solve with the use of free tutorials available on the internet.
b. Use software's and digital resources for related topics.

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 ADOs. 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 fertilizer plant : Visit** nearby fertilizer plant and prepare block diagram of process, List of unit operations used, Schematic sketches of each stage of manufacturing processes and process description.
b. **Internet based assignment:** Prepare a power point presentation on a topic " List of inorganic chemicals manufacturing industries in India"
c. **Chemical Engineering aspects in cement Industry (Internet based assignment):** Identify a cement Industry, Make the list of product manufactured, make the list of unit operations and unit processes, Describe the identified unit operations and unit processes, Identify the job role for a chemical engineer in Cement industry, Safety precautions.
d. **Collection of different fertilizer sample from market. (Field assignment) :** Collect two samples from four companies. Classify the samples on the basis of content. identify the location of industry, Prepare a report based on content and cost
e. **Testing procedure of PUC:** Observe procedure of testing for four wheelers, Study pollutants present, Prepare a report for five vehicles.
f. **Profile of PSUs**: Prepare a chart demonstrating profile of typical public sector organization, RCF, IFFCO, ZUARI, 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	Dryden's outline of Chemical Technology.	Gopal Rao, M. and Sitting, Marshal	East West Publisher, London, 2010, ISBN: 9788185938790,
2	Shreve's Chemical Process Industries.	Austin, George T.	McGraw-Hill Book Company, Tacoma, WA, U.S.A,1984 ISBN: 9780070571471
3	Unit Process of Organic synthesis.	Groggins, P.H.	Mc Graw Hill International, New York, 1958 ISBN: 8185938792
4	Reactions and Synthesis	Francis A. Carey, Ri chard J. Sundberg	Springer, Basel, 2012, ISBN: 1-4613-9798-7

14. SUGGESTED 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

Program Name : **Diploma in Chemical Engineering**

Program Code : **CH**

Semester : **Third**

Course Title : **Industrial Stoichiometry**

Course Code : **22315**

1. RATIONALE

Diploma chemical engineers have to deal with various material and energy balance operation; they also have to perform analysis of process data through various computation methods. Industrial Stoichiometry helps diploma chemical engineers to formulate material and energy balance equation applied in the design of different chemical processes. This course is designed by which fundamental information will help the technologists to apply the basic concepts and principles of Industrial Stoichiometry to solve broad-based engineering problems.

2. COMPETENCY

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

- **Apply unit operation and unit process in chemical industries.**

3. COURSE OUTCOMES (COs)

The theory 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 different physical quantities and system of unit in chemical process industries.
b. Use the gas law in various chemical engineering processes.
c. Apply the law of conservation of mass in chemical process industries.
d. Calculate the amount of raw material and product for chemical process.
e. Select the fuel for combustion process in chemical process industry.
f. Apply law of conservation of energy in chemical engineering application.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme			Credit (L+T+P)	Examination Scheme													
				Theory						Practical							
L	T	P		Paper Hrs.	ESE		PA		Total		ESE		PA		Total		
					Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	
4	2	-	6	3	70	28	30*	00	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(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.

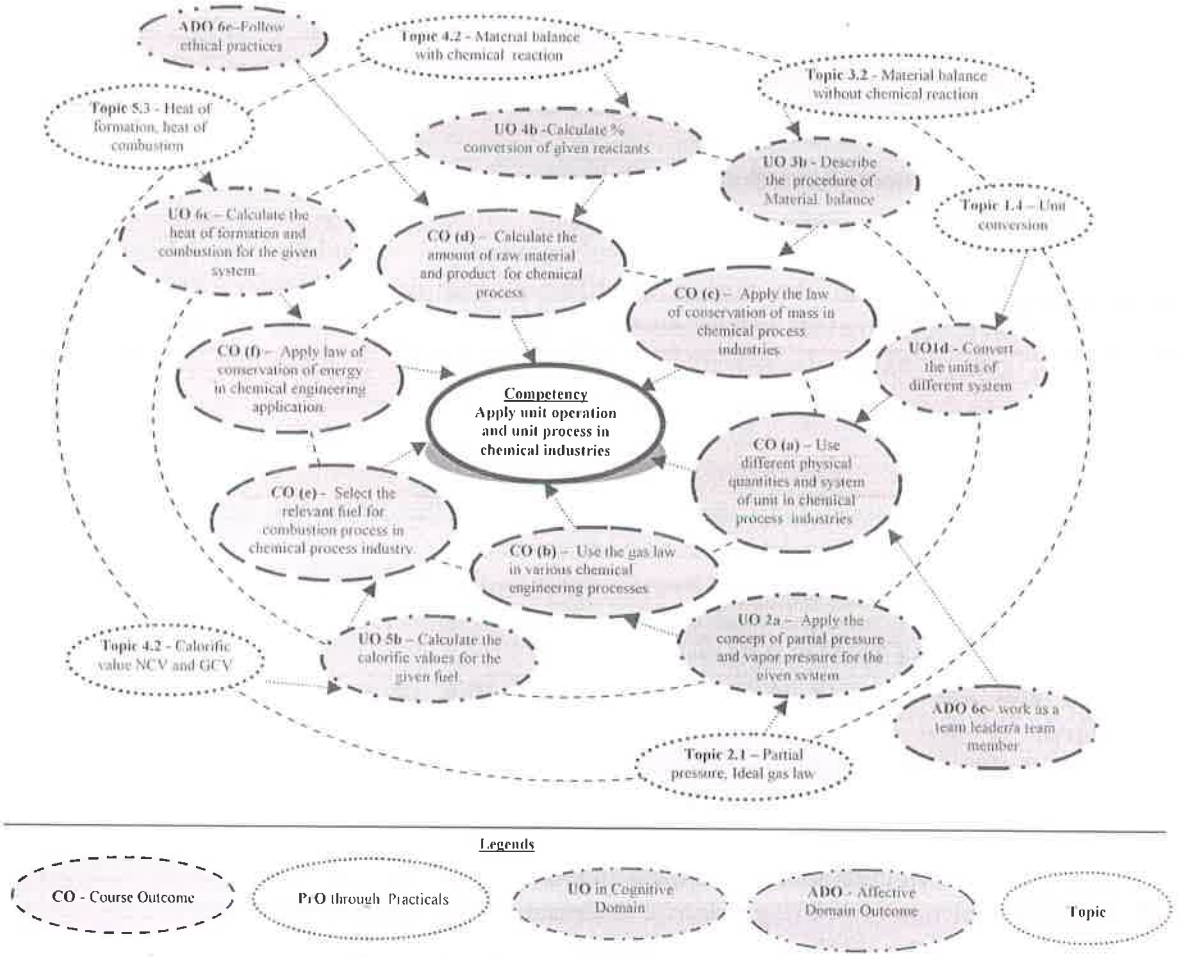

Figure 1 - Course Map

6. SUGGESTED EXERCISES/PRACTICALS/TUTORIALS

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

S. No.	Tutorial	Unit No.	Approx. Hrs. Required
1	Solve numerical based on conversion of units of physical quantity among SI, MKS, CGS and FPS system	I	2
2	Solve numerical using ideal gas law and Dalton law.	II	2
3	Solve numerical using Amagat's law and Raoult's law.	II	2
4	Solve numerical on calculation of average molecular weight, average density and composition of gas in mol and wt %.	II	2
5	Solve numerical on material balance without chemical reaction at steady state condition for distillation, evaporation and drying	III	2
6	Solve numerical on material balance without chemical reaction at steady state condition for absorption and extraction.	III	2

S. No.	Tutorial	Unit No.	Approx. Hrs. Required
7	Solve numerical on material balance without chemical reaction at steady state condition for mixing, blending filtration and crystallization.	III	2
8	Solve numerical on material balance involving chemical reaction to calculate stoichiometric ratio, limiting and excess reactant.	IV	2
9	Solve numerical on calculation of % excess reactant for the given chemical reaction.	IV	2
10	Solve numerical on calculation of composition of product and reactant.	IV	2
11	Numerical on gross and net calorific value for the given fuel.	V	2
12	Numerical on requirement of air and composition of flue gases for combustion process.	V	2
13	Numerical on heat capacities calculation for pure component and mixture.	VI	2
14	Numerical on sensible heat and latent heat.	VI	2
15	Numerical on heat of formation using given data.	VI	2
16	Numerical on standard heat of reaction using heat of formation and heat of combustion data.	VI	2
Total			**32**

Note: The above tutorial sessions are for guideline only. The remaining tutorial hours are for revision and practice

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

7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED:

- Not applicable –

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 Dimensions and Units	1a. Apply the system of unit to the given physical quantities. 1b. Differentiate fundamental and derived quantities of the given system. 1c. Apply the units of different physical quantities to the given system. 1d. Convert the specified units to the given system.	1.1 Dimension and system of units 1.2 Fundamental quantities and derived quantities. 1.3 Units of force, volume, pressure, work, energy, heat and power 1.4 Units: conversion, SI, MKS, CGS and FPS system
Unit– II Law of Gases and Gas Mixtures	2a. Apply the concept of partial pressure and vapor pressure to the given system. 2b. Solve numerical based on the ideal gas law. 2c. Apply Raoult's Law to solve the given problem. 2d. Calculate the average molecular weight and density for the given chemical system.	2.1 Partial pressure, vapor pressure and pure component volume: definition 2.2 Ideal gas law, Dalton's law, Amagat law, Boyle's law and Charles law, Van der waal equation 2.3 Relation between vol%, mol% and pressure% for an ideal gas 2.4 Raoult's and Henry's Law: statement, numerical 2.5 Average molecular weight, density of gas mixture: numerical
Unit-III Material Balance Without Chemical Reactions	3a. Apply the law of conservation of mass for the given system. 3b. Describe the procedure of material balance without chemical reaction for the given chemical system. 3c. Calculate the quantity of raw materials for the given unit operation. 3d. Apply the recycle operations for the given material.	3.1 Law of conservation of mass, Steady and unsteady state operation. 3.2 Material balance without chemical reaction: Concept and procedure. 3.3 Material balance equation for unit operations: definition, block diagram, numerical based on units operations, distillation, drying, extraction, evaporation, crystallization, absorption, filtration, mixing and blending. 3.4 Recycle (Purge) and bypass operation
Unit-IV Material Balance With Chemical Reactions	4a. Apply the stoichiometric equation in identification of the given limiting and excess reactant. 4b. Calculate % conversion of the given reactants. 4c. Calculate % yield of the given product. 4d. Calculate % excess reactant for	4.1 Chemical reaction terms: stoichiometric equation, stoichiometric coefficient, stoichiometric ratio. 4.2 Material balance with chemical reaction: calculation of % conversion, %yield, % excess reactant, composition of product and reactant, numerical.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	the given chemical reaction.	
Unit-V Fuel and Combustion	5a. Select relevant fuel for the given industrial application. 5b. Calculate the calorific values for the given fuel. 5c. Describe the combustion process for the given system. 5d. Calculate the air required for combustion of given fuel.	5.1 Fuel: types of fuel (solid, liquid and gaseous fuel) 5.2 Calorific value NCV and GCV: 5.3 Combustion process: complete combustion and incomplete combustion. 5.4 Composition of flue gases, requirement of air.
Unit– VI Energy Balance	6a. Apply the law of conservation of energy for the given system. 6b. Calculate the heat involved during phase change for the given system. 6c. Apply Hess's law for the calculation of heat of formation for the given chemical system. 6d. Calculate standard heat of reaction for the given system.	6.1 Law of conservation of energy, different forms of energy. 6.2 Heat: types of heat (sensible heat and latent heat) specific heat, heat capacity 6.3 Heat of combustion, heat of formation and Hess's law of constant heat summation 6.4 Heat of reaction, Heat of dilution and dissolution.

***Note**: To attain the COs and competency, above listed Learning Outcomes (LOs) need to be undertaken to achieve the 'Application Level' 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	Dimension and Units	04	02	02	02	06
II	Laws of gases and gas mixtures	10	02	04	04	10
III	Material balance without chemical reactions	16	02	06	10	18
IV	Material balance with chemical reactions	16	02	06	10	18
V	Fuel and combustion	08	02	02	04	08
VI	Energy balance	10	02	04	04	10
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. Use Excel formulae and function for calculation.
b. Draw block diagram and write down overall and component material balance for mechanical operations.
c. Draw block diagram and write down overall and component material balance for various mass transfer operations.
d. Prepare material data sheet for a given process.

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 ADOs. 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. **Preparation of chart:** Prepare a chart of molecular weight and equivalent weight.
b. **Preparation of chart:** Prepare chart on mathematical equation of different laws for gas and gas-liquid mixture.
c. **Visit of chemical process plant**: Prepare block diagram showing material balance for process equipment used in plant which you have visited.
d. **Sample Collation:** Collect the various samples of reactant and prepare the list of physical properties.
e. **Sample Collation:** Collect the samples of various fuels and prepare the relationship chart of their physical properties with temperature.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Stoichiometry	Bhatt B. I. and Vora S. M.	McGraw Hill Education., New Delhi, 2004, ISBN: 0-07-049494-0
2	Basic principle and calculations in chemical engineering	Himmelblau David M. and Riggs	Prentice Hall of India Pvt. Ltd., New York, 2012, ISBN: 01-203-1145-0
3	Chemical Process Principles	Hougen and Watson	Wiley Eastern Ltd., New Delhi, 2004, ISBN 13:9798123909539
4	Elementary Principles of Chemical Processes	Felder R.M. and Rousseau R. W.	John and Wiley Sons , New York, 1978 13:9780471873242
5	Introduction to chemical Engineering	Ghosal S. K. , Sanyal K S. and Datta Siddharth	Mc Graw Hill Publication, New York 2011, ISBN 9780074601402
6	Chemical Engineering Volume 2	Coulson and Richardson	Elsevier Publication, Oxford, 2002, ISBN 978-0-7506-4445-7

14. SUGGESTED SOFTWARE/LEARNING WEBSITES

a. www.unitoperation.com
b. www.dplot.com/ - DPlot
c. Video lectures from NPTEL website