Program Name : **Diploma in Chemical Engineering**
Program Code : **CH**
Semester : **Second**
Course Title : **Chemistry of Engineering Materials**
Course Code : **22233**

1. RATIONALE

Diploma chemical engineers (also called technologists) are also responsible for various processes in chemical industry. Different types of metals, non-metals are used in chemical process industry, where lots of hazardous reactions are carried out. storage, transportation and material of construction are important area in chemical industry. Many metals, nonmetals and plastic materials are used in chemical industry as material of construction, as insulating material. Chemical Engineer should be familiar with basic concepts such as structure of metallic and non-metallic materials, its properties, applications. This course is developed in the way by which fundamental information will help the diploma engineer to apply the basic concepts, applications of metals in various engineering applications, while working in Chemical process industries.

2. COMPETENCY

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

- **Apply the principles of chemistry of engineering materials 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 material structure.
b. Test physical, chemical, mechanical properties of the materials.
c. Select the relevant industrial materials for different applications.
d. Identify the type of corrosion in industrial environments.
e. Select the relevant ferrous metals for the different applications.

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	-	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 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.

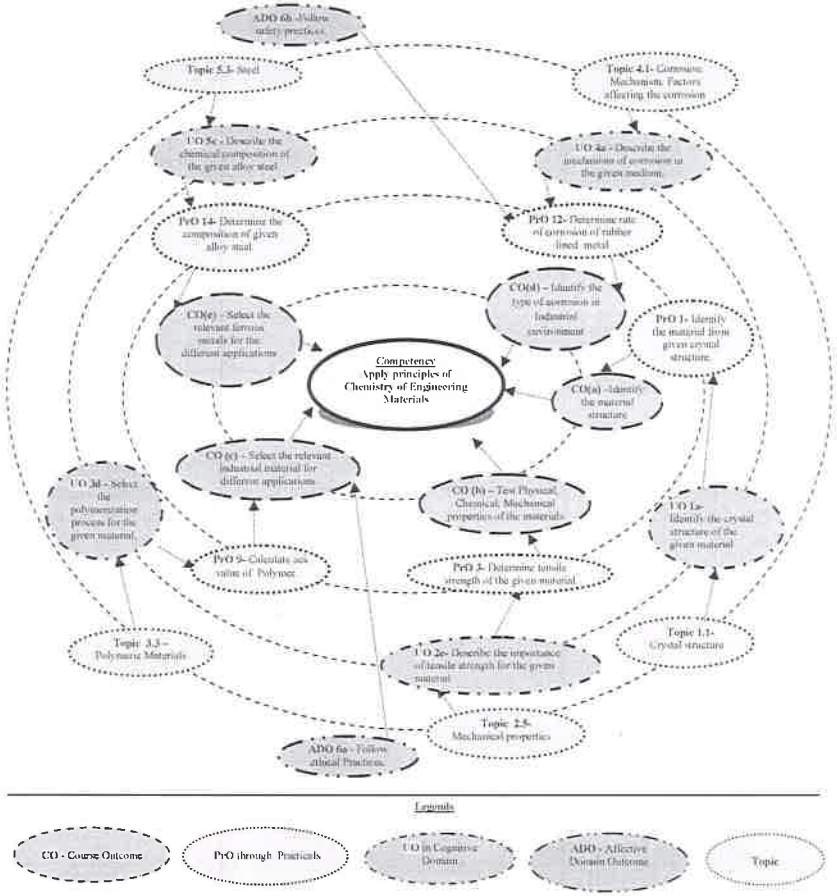

Figure 1 - Course Map

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	Identify the material from given crystal structure.	I	02*
2	Determine the thermal and electrical conductivity of given metal.	II	02*
3	Determine the Tensile strength, Yield strength, Impact Strength of given material.	II	02
4	Determine the melting point of given material.	II	02
5	Determine the porosity and density of given material.	II	02
6	Determine the Malleability, Ductility of given material.	II	02
7	Prepare the thermoplastic material.	III	02*
8	Prepare the thermosetting material.	III	02
9	Calculate acid value of Polymer.	III	02
10	Determine the rate of corrosion in acidic medium.	IV	02*
11	Determine the rate of corrosion in alkaline medium.	IV	02
12	Determine rate of corrosion of rubber lined metal.	IV	02
13	Determine electrode potential of metal and compare its rate of corrosion.	V	02*
14	Determine the composition of given alloy steel.	V	02
15	Determine copper content in Cu-alloy material.	V	02
16	Determine manganese in steel.	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 %
2	Preparation of experimental set up	20
3	Setting and operation	20
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 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 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	Equipments Names with broad specifications	Expt. No.
1	Beakers (100 ml to 500 ml)	All Expt
2	Conical Flask (100 ml to 250 ml)	All Expt
3	Pipette (10 ml to 25 ml)	All Expt
4	Burette with stand	All Expt
5	Conductivity meter	1, 12
6	Different Metallic and Nonmetallic Material	2, 3, 8, 9, 12
7	Metal Sample, alloy sample	12
8	Measuring Cylinder (10 ml to 50 ml)	All Expt

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 Structure of Material and Insulations	1a. Describe the crystal structure of the given material 1b. Describe the properties of the given biomaterial. 1c. Describe the properties of the given insulations. 1d. Identify relevant organic and inorganic insulations for the given system with justification.	1.1 Crystal Structure: Types of structure Atomic structure, Nano structure, Micro structure, Macro structure. Chemical Bonding. Fundamental laws of crystal structure, Bragg's Law. 1.2 Materials in research: Biomaterials, Nanomaterials, Electronic, optical and Magnetic Materials 1.3 Insulating Materials: Heat/Thermal insulations, Sound Insulations, Electrical Insulations. 1.4 Heat/Thermal Insulations: General aspects, requirements, classifications, Organic insulation,(e.g. wool, cotton wool, saw dust, corkboard) and Inorganic insulation (e.g. Slag wool, Glass wool, Charcoal, Asbestos, Gypsum powder)

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit– II Properties of Engineering Materials	2a. Describe chemical reactivity of the given material 2b. Describe the density and porosity of the given material. 2c. Describe thermal conductivity of the given material. 2d. Calculate resistivity and conductivity of the given material. 2e. Describe the importance of tensile strength for the given material	2.1 Chemical Properties: Composition, Chemical reactivity with air, water and acid 2.2 Physical Properties: Dimension, color, Appearance, density, porosity 2.3 Thermal Properties: Melting point, Specific Heat, Heat Capacity, thermal expansion, thermal conductivity, thermal stability, thermal shock resistance, heat resistance 2.4 Electrical Properties: Resistivity and conductivity, Dielectric constant, Dielectric strength, thermo electricity 2.5 Mechanical Properties: Tensile strength, Yield strength, Impact Strength, compressive strength, Hardness, Malleability, Ductility, Brittleness, Fatigue, Creep, Elasticity, Plasticity, Toughness
Unit– III Industrial Materials	3a. Describe properties of the given metallic substance 3b. Differentiate ceramic substances based on the given properties. 3c. Describe the properties of the given thermosetting and thermoplastic polymers. 3d. Select the polymerization process for the given material with justification.	3.1 Metals and Nonmetals: Classification, Properties and uses 3.2 Ceramics: Classification, Clay, Silica, Feldspar, Properties of ceramics: Mechanical, Electrical, Chemical, Thermal. Important Engineering Ceramics, Silicon Carbide, Aluminum Oxide, Engineering application of ceramics 3.3 Polymeric Materials: Thermoplastic and Thermosetting polymers, Polymerization reaction: Addition, Condensation, Co-polymerization
Unit-IV Chemical and Corrosive Environments	4a. Describe the mechanism of corrosion in the given medium. 4b. Identify the different factors affecting rate of corrosion for the given type of material with justification. 4c. Differentiate the mechanism of corrosion in the given acidic and alkaline environment. 4d. Identify the material of construction for the given chemical process with	4.1 Corrosion: Mechanism, Factors affecting the corrosion 4.2 Corrosion by water, steam and soil 4.3 Corrosion in acidic and alkaline environments 4.4 Control and prevention of corrosion: Factors determining choice of materials 4.5 MOC: Process Equipments, handling chemicals (storage vessel and transportation) like Acid, Chlorine (Dry and Wet)

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	justification.	
Unit –V Ferrous metals and alloys	5a. Identify the properties of the given ferrous alloy with justification. 5b. Describe the effects of chemical elements on the given ferrous material. 5c. Describe chemical composition of the given alloy steel. 5d. Identify the special alloy steel for the given application with justification.	5.1 Types of Irons: Pig iron, cast iron, wrought iron 5.2 Effects of chemical elements on Iron: Chromium, copper, magnesium, manganese, Nickel, silicon, phosphorus 5.3 Steel: Classification of steel Based on carbon content, based on deoxidation practice 5.4 Alloy Steels: Purpose of alloying, Preparation of alloys, Classification of alloy, chemical composition, purpose, structural class 5.5 Special alloy steels: Heat resisting steel, Stainless Steel

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	Structure of material and insulations	08	02	02	04	08
II	Properties of engineering materials	14	04	06	08	18
III	Industrial Materials	14	04	06	08	18
IV	Chemical and corrosive environments	14	02	04	06	12
V	Ferrous metals and alloys	14	04	04	06	14
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. Prepare journals based on practical performed in laboratory.
b. Enlists different types of metals and nonmetals in laboratory
c. Visit nearby metal foundry.
d. Prepare the chart for various grades of stainless steel.
e. Collect different types of Fe samples
f. Observe corrosion of different metals in different environments.
g. Draw the atomic structure of various metals. Display chart in Laboratory.

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. **Metal and Nonmetal:** Collect samples of different metal and nonmetal and samples Test physical, chemical, thermal, electrical and mechanical properties
b. **Polymer Industry**: Visit nearby polymer industry and prepare detailed presentation based on the working of the equipment.
c. **Steel Industry**: Visit nearby steel industry and prepare detailed presentation based on the working of the equipment
d. **Corrosion rate**: Prepare chart showing corrosion rate of metals in different environments.
e. Visit nearby small scale industry to collect data about Material of construction.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Material Science and Metallurgy	Khanna O.P.	Dhanpat Rai publications Ltd.; New Delhi, 2014; ISBN-10: 9383182458
2	Material science and metallurgy	Daniel C. Yesudian D.G., Harris S.	SCITECH publications(India) Pvt. Ltd.; Chennai ; 2010; ISBN 10: 8188429449
3	Engineering Chemistry	Dr. Dara S. S. Dr. Umare S.S.	S. CHAND and Company Ltd.; New Delhi; 2011; ISBN: 9788121997652

S. No.	Title of Book	Author	Publication
4	Material Science	Narang B. S.	CBS Publishers and Distributors; Delhi; 1991; ISBN: 16825076329
5	Material Science and Processes	Chaoudhury Hajra S.K.	Indian Book Distributing Company; Mumbai; 1985: ISBN: 9780906216002
6	Engineering Materials	Rangawal S. C.	Charotar Publishing House; Anand; 2016; ISBN: 978-93-85039-17-1

14. SOFTWARE/LEARNING WEBSITES

i. https://en.wikipedia.org/wiki/Materials_science
ii. https://mse.stanford.edu
iii. http://ocw.mit.edu/courses/materials-science-and-engineering/