Program Name : **Diploma in Chemical Engineering**

Program Code : **CH**

Semester : **Sixth**

Course Title : **Polymer Technology (Elective-II)**

Course Code : **22610**

1. RATIONALE

Diploma chemical engineers have to operate and monitor various chemical manufacturing processes. Polymer manufacturing is one of the important processes in chemical engineering world. They have to deal with various polymerization processes and operate various equipments related to it. They also deal with the safety aspects and environmental concerns related to polymerization process. This course is developed in the way by which the polymer manufacturing plant can be operated and related equipments can be handled in safe manner.

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 polymer manufacturing plant equipment efficiently.**

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) Select relevant type of polymerization to manufacture required polymer.
b) Use relevant process for manufacturing of polymers
c) Select relevant manufacturing process of resin and elastomers.
d) Use relevant operation for plastic processing.
e) Apply relevant treatment methods in fiber processing.

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
3	-	2	5	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 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.

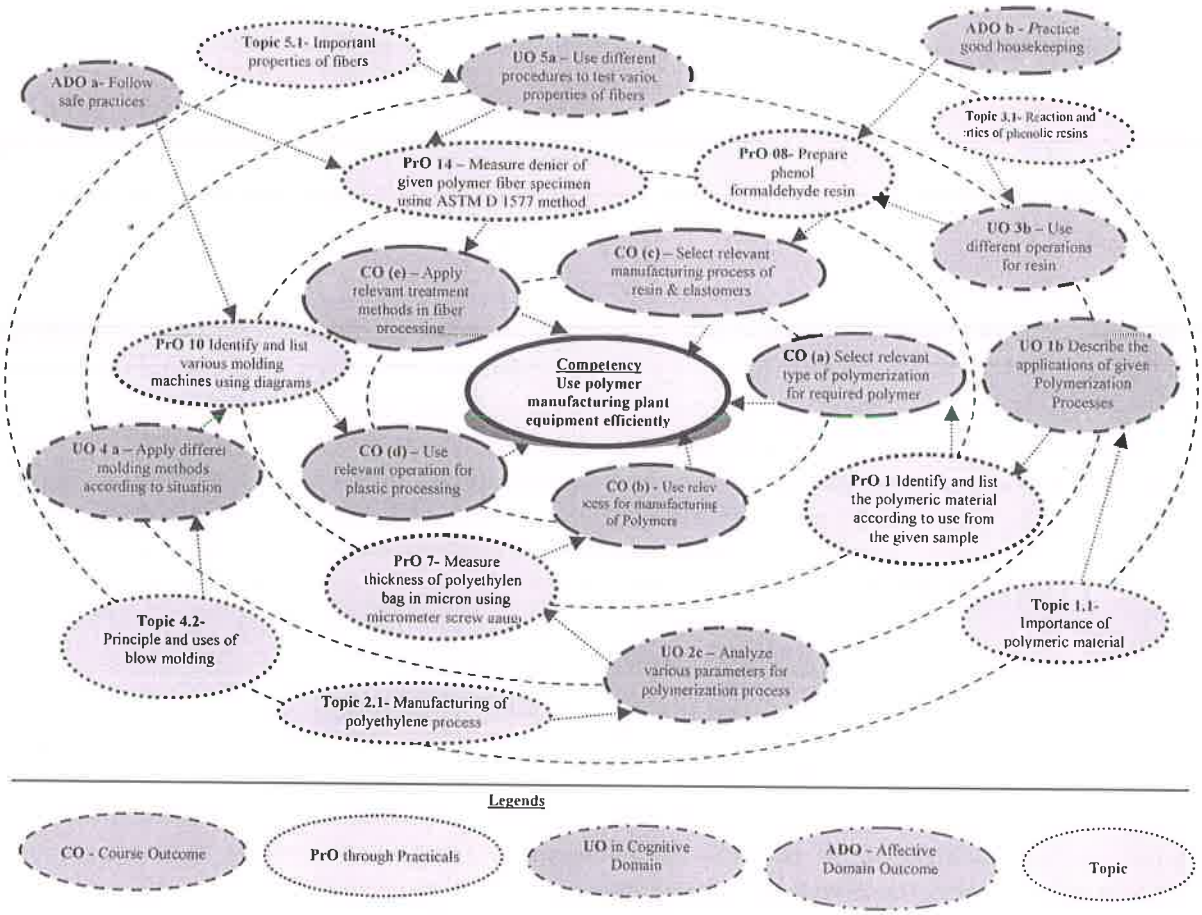

Figure 1 - Course Map

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.	Identify the polymeric material according to use from the given sample.	I	02*
2.	Use the density gradient column to determine the density of given plastic specimen	I	02
3.	Use the displacement method to determine Specific Gravity (Relative Density) of Plastics	I	02*
4.	Use the bomb calorimeter to determine calorific value of plastic derived fuel.	I	02*
5.	Use the flame test Identify the polymeric material	I	02
6.	Identify the polyethylene material according to use from the given sample.	II	02*
7.	Use the micrometer screw gauge to measure thickness of polyethylene sheets in micron	II	02*
8.	Use the polymerization setup to prepare phenol formaldehyde resin	III	02*
9.	Use the polymerization setup to prepare urea formaldehyde resin	III	02*
10.	Identify various molding machines by interpreting the diagrams and charts.	IV	02*

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
11.	View the injection molding and blow molding process animation videos to Compare their.	IV	02*
12.	Use the Universal Tensile Testing Machine to measure tensile strength of given plastic sample	IV	02*
13.	Identify the polymer yarn according to use from the given sample.	V	02*
14.	Use the ASTM D 1577 method to measure denier of given polymer fiber specimen.	V	02*
15.	Use the tensile strength tester to measure tenacity of given fiber yarn specimen.	V	02
16.	Use the magnifying glass to measure the numbers of fibers in given yarn samples.	V	02
	Total		**32**

Note

i. *A suggestive list of PrOs is given in the above table. More such PrOs can be added to attain the COs and competency. A judicial mix of minimum 12 or more practical need to be performed, out of which, the practicals marked as '*' are compulsory, so that the student reaches the 'Precision Level' of Dave's 'Psychomotor Domain Taxonomy' as generally required by the industry.*

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

S. No.	Performance Indicators	Weightage in %
1	Preparation of experimental set up	20
2	Setting and operation	20
3	Safety measures	10
4	Observations and recording	20
5	Interpretation of result and conclusion	10
6	Answer to sample questions	10
7	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) Practice energy conservation.
d) Work as a leader/a team member.
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
- 'Organisation Level' in 2nd year

- 'Characterisation 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. No.
1	Density gradient column (As per ASTM D1505) Resolution 0.0001 g/ml, Accuracy 0.0001 g/ml , with 7x optical microscope	02
2	Universal tensile testing machine (Crosshead Speed Range -10 to 500 mm/min, Maximum Travel Length -800 mm)	12,15, 16
3	Weighing balance (0.1 gm to 100 gm)	14
4	Bomb calorimeter (Combustion Bomb: Halogen and acid resistant stabilized stainless steel , Measurement range: up to 40,000 J/gm)	4
5	Screw Gauge / Micrometer	07

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 Introduction to polymers	1a. Describe with sketches the relevant mechanism used for the given Polymer. 1b. Describe the applications of given Polymerization Processes. 1c. Select relevant building blocks for manufacturing of the given monomers with justification. 1d. State field applications of the given polymers	1.1 Importance of polymeric material in industry and applications of Polymers. 1.2 Polymerization Mechanism- Addition Polymerization and Condensation Polymerization. 1.3 Polymerization Processes- Bulk, Solution, Suspension, Slurry, Emulsion, Gas-Phase. 1.4 Monomers derived from Ethylene and Propylene. 1.5 Polymers and Environment – type of pollution, its effects and recycling
Unit-II Polymer manufacturing	2a. Select the relevant raw material for polymer manufacturing in the given situation with justification 2b. Draw labeled PFD of the given polymer processes 2c. Interpret the given parameters for polymerization process	2.1 Manufacturing of polyethylene by high pressure process-Raw material, catalyst, Process Flow Diagram (PFD) 2.2 Manufacturing of polyvinyl chloride - Raw material, catalyst, PFD of monomer and polymer from monomer 2.3 Manufacturing of Nylon 6-6 Raw material, catalyst, PFD of monomer and polymer from monomer
Unit– III Resins and Elastomers	3a. Classify the given types of resins. 3b. Explain with sketches different operations for the	3.1 Reaction , properties and uses of phenolic resins, amino resins and epoxy resins 3.2 Different types of elastomers,

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	given processing. 3c. Choose relevant type of elastomers in the given situation. 3d. Select the given types of fillers for the specified elastomer with justification	Principle of reinforcement and use in elastomers 3.3 Properties of elastomers- Weather resistance, Elongation , flame resistance, resistance to acid 3.4 Principle of Vulcanization and use in elastomers
Unit– IV Plastic processing	4a. Select the relevant molding method for the given situation. 4b. Select the relevant extrusion/ calendaring method for plastic processing in the given situation with justification 4c. Select the relevant operation for plastic processing for the given job requirement, with justification	4.1 Working principle of following plasing processing equipment: Compression and Injection molding, Blow molding and Reaction injection molding Extrusion and Calendaring, Foaming equipment.
Unit –V Fiber processing	5a. Select the relevant procedures to test the given properties of fibers, with justification. 5b. Explain with sketches the specified principle of spinning. 5c. Select the relevant spinning method for the given fiber production with justification 5d. Select the relevant treatment method for the given fiber processing with justification	5.1 Important properties of fibers in textile uses – Tenacity, Elasticity, Denier, acid resistance 5.2 Definition and applications of Yarn, fiber, denier, tenacity, elongation, stiffness, flex life 5.3 Principle of Wet and dry spinning 5.4 Principle and application of Fiber after treatments- scouring, lubrication, sizing, dyeing, finishing

***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	Introduction to polymers	06	02	04	04	10
II	Polymer manufacturing	10	02	04	06	12
III	Resins and Elastomers	06	02	04	06	12
IV	Plastic processing	14	04	04	12	20
V	Fiber processing	12	02	02	12	16
Total		**48**	**12**	**18**	**40**	**70**

***Legends:** R=Remember, U=Understand, A=Apply and above (Bloom's Revised taxonomy)*
***Note**: This specification table provides general guidelines to assist students 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) Prepare journals based on practical performed in laboratory.
b) Follow the safety precautions.
c) Use various instruments to measure various properties of polymers.
d) Library / Internet survey of various machines used in plastic processing
e) Prepare power point presentation for understanding different process used for manufacturing of polymers

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) Use Flash/Animations to explain various instruments for measurement
f) 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) **Prepare report**: Prepare report on polymer processing industries in India , their products, raw material and applications
b) **Prepare charts**: Prepare charts displaying environmental effects of plastic its effects.
c) **Prepare flow chart:** Prepare flow chart of building blocks used for the production plastics
d) **Collect plastic specimen**: Collect different plastic specimen and write their industrial applications and molding process used for it.

e) **Collect polymer fiber cloths:** Collect polymer cloths and observe types of polymer used in it. Make a flow chart of polymer used in cloths, raw material and process used in it.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Polymer Science and Technology	Ebewele, Robert	CRC Press, New York (2000) ISBN - 0-8493-8939-9
2	Text book of Polymer Science	Billmeyer, Fred	Wiley India, New Delhi 3ed (2007) ISBN - 9788126511105
3	Polymer Science and Technology	Fried, Joel R.	Prentice Hall Professional Technical Reference 3 ed (2014) ISBN- 978-0-13-703955-5
4	Polymer Science and Technology: Plastics, Rubber, Blends and Composites	Ghosh, Premamoy	McGraw Hill Education; 3 edition (2011); ISBN- 9780070707047
5	Modern Technology of Plastic & Polymer Processing industries	NIIR Board	Asia Pacific Business Press Inc 1 ed ISBN: 8178330776
6	Plastics Technology Handbook	Chanda, Manas Roy, Salil K.	CRC Press, New York 4 ed (2007) ISBN -10:0-8493-7039-6

14. SOFTWARE/LEARNING WEBSITES

a. Test for identification of fiber http://content.inflibnet.ac.in/data-server/eacharya-documents/53e0c6cbe413016f234436ed_INFIEP_8/3/ET/8_ENG-3-ET-V1-S1__lesson.pdf
b. Types of polymers http://www.materials.unsw.edu.au/tutorials/online-tutorials/8-polymer-types
c. Textile technology https://textechdip.wordpress.com/contents/textile-fiber/
d. Plastic molding http://www.plasticmoulding.ca/
e. Elastomer https://www.britannica.com/science/elastomer
f. Testing of Polymer https://insights.globalspec.com/article/7810/how-to-perform-tensile-testing-on-polymers
g. Fiber testing https://www.youtube.com/watch?v=9ClNtwHt58A
h. Molding machine http://www.injectionmoldingmachine.in/
i. Injection molding https://www.youtube.com/watch?v=b1U9W4iNDiQ
j. Blow molding https://www.youtube.com/watch?v=8W6P5KU5ONQ