GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

Competency-focused Outcome-based Green Curriculum-2021(COGC-2021)
Semester-V

Course Title: Polymer Technology
(Course Code: 4350507)

Diploma Programme in which this course is offered	Semester in which offered
Chemical Engineering	5th Semester

1. RATIONALE

Polymers have become an un-detachable part of our everyday life. Could you imagine life in the world without polymer products? However, the awareness quotient tends to be on the lower side. This can be enhanced through specific courses designed for the purpose. The recent developments of Polymer Technology have revolutionized the field of material science increasing the use of polymer based substances from building materials to Packing materials, Fancy decoration articles, Electrical engineering, Communications, Automobile, Aircrafts, etc. Polymer Technology has carved a niche in the fields of electronics and electrical materials, textiles, aerospace industry, automobile industry, etc.

The course aims to provide the students with profound educational activities. The Diploma chemical engineers have to deal with identification and characterization of raw material to ensure the quality of polymer product along with different techniques of processing. The content of this course is designed to enable diploma holders to develop the skills required for working in production, processing, testing, marketing and sales department of plastics, rubbers and fibre manufacturing Industries. These areas have been highlighted as they represent the needs of the industry.

2. COMPETENCY

The course content should be taught and curriculum should be implemented with the aim to develop required skills in the students so that they are able to acquire following competency:
Operate polymer manufacturing plants to produce quality products with environment sustainability.

3. COURSEOUTCOMES(COs)

The theory should be taught and practical should be carried out in such a manner that students are able to acquire different learning outcomes in cognitive, psychomotor and affective domain to demonstrate following course outcomes:

i. Select appropriate techniques of polymerization.
ii. Produce plastics using appropriate reactions and unit operations steps.
iii. Produce rubbers using appropriate reactions and unit operations steps.
iv. Produce fibres using appropriate reactions and unit operations steps.
v. Apply selected different polymer processing technique

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	CA	ESE	CA	ESE	150
3	0	2	4	30*	70	25	25	
Passing marks as per updated teaching scheme….				11	25	10	10	

(*):Out of 30 marks under the theory CA,10 marks are for assessment of the micro-project to facilitate the integration of COs, and the remaining 20 marks are the average of 2 tests to be taken during the semester for assessing the attainment 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, **CA** -Continuous Assessment; **ESE**-End Semester Examination.*

5. SUGGESTED PRACTICAL EXERCISES

The practical/exercises should be properly designed and implemented with an attempt to develop different types of skills **(outcomes in psychomotor and affective domain)** so that students are able to acquire the competencies/ programme outcomes. Following is the list of practical exercises for guidance.

***Note**: Here only outcomes mainly in psychomotor domain are listed as practical/exercises. However, if these practical/exercises are completed appropriately, they would also lead to development of certain outcomes in affective domain which would in turn lead to development of **Course Outcomes** related to affective domain. Thus over all development of **Programme Outcomes (**as given in a common list at the beginning of curriculum document for this programme) would be assured.*

Faculty should refer to that common list and should ensure that students also acquire outcomes in affective domain which are required for overall achievement of Programme Outcomes/Course Outcomes.

The following practical outcomes (PrOs) are the sub-components of the COs. *Some of the **PrOs** marked **'*'** (in approx. hr column) are compulsory, as they are crucial for that particular CO at the 'Precision Level' of Dave's Taxonomy related to 'Psychomotor Domain'*.

S. No.	Unit No.	Practical/Exercise (Outcomes in Psychomotor Domain)	Approx. Hours Required
1	I	Prepare classification chart based on properties and uses.	2
2	I	Demonstrate thermosetting and thermoplastic properties	2
3	I	Test the effects of solvents on plastic, rubber and fibre	2
4	I	Test the effects of acids and alkalies on plastic, rubber and fibre	2

5	I	Test effects of temperature on plastic, rubber and fibre	2
6	I	Prepare Glyptal resin	2*
7	II	Determine the acid value of glyptal resin	2
8	II	Prepare thermo-plastics (eg. PMMA, PE)	2*
9	II	Prepare Polystyrene from styrene	2*
10	II	Prepare Phenol Formaldehyde resin from Phenol	2*
11	II	Prepare Urea Formaldehyde resin from Urea	2*
12	II	Prepare Melamine Formaldehyde	2*
13	IV	Prepare cellulose acetate from cellulose	2*
14	V	Perform Vulcanization of Rubber	2*
		Total	**28**

Note

i. More **Practical Exercises** can be designed and offered by the respective course teacher to develop the industry relevant skills/outcomes to match the COs. The above table is only a suggestive list**.**

ii. The following are some 'Process' and 'Product' related skills (more may be added/deleted depending on the course) that occur in the above listed **Practical Exercises** of this course required which are embedded in the COs and ultimately the competency.

Sr. No.	Sample Performance Indicators for the PrOs	weightage in %
1	Handling of apparatus for precise measurements	10
2	Record observations correctly	20
3	Practice and adapt good and safe measuring techniques	10
4	Calculations, Interpretation of results and their conclusion.	20
5	Prepare report of practical in prescribed format	10
6	Solve assignment questions.	20
7	Viva-voce	10
	Total	**100**

6. MAJOR EQUIPMENT/ INSTRUMENTS AND SOFTWARE REQUIRED:

The equipment/instruments required to develop PrOs are mostly glassware's, chemicals, weight balance, titration set up, thermometers, ph papers, filter papers, water-bath, electric heater, hot plate, hot air dryer, and condenser assembly with broad specification. This will ensure the conduction of practical's in all institutions across the state in a proper way so that the desired skills are developed in students.

7. AFFECTIVE DOMAIN OUTCOMES:

The following ***sample*** Affective Domain Outcomes (ADOs) are embedded in many of the above-mentioned COs and PrOs. More could be added to fulfill the development of this competency.

a) Work as a leader/a team member.
b) Follow ethical practices

c) Observe safety measures
d) Good house keeping
e) Time management
f) Practice environmentally friendly methods and processes.

The ADOs are best developed through laboratory/field-based exercises. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

i. 'Valuing Level' in 1st year
ii. 'Organization Level' in 2nd year.
iii. 'Characterization Level' in 3rd year.

8. UNDER PINNING THEORY

The major underpinning theory is given below based on the higher level UOs of *Revised Bloom's taxonomy* that are formulated for development of the Cos and competency. If required, more such higher-level UOs could be included by the course teacher to focus on the attainment of COs and competency.

Unit	Major Learning Outcomes(Course Outcomes in Cognitive Domain according to NBA terminology)	Topics and Sub-topics
Unit – I Fundamental of Polymer technology	1a.Define monomers and polymers with examples	1.1 Definition and examples of monomer with their polymers.
	1b.Classify polymers	1.2 Classification of polymers 1.2.1 Natural and synthetic polymers 1.2.2 Organic and in organic polymers 1.2.3 Thermoplastic and Thermosetting 1.2.4 Plastic, rubber, fibre and resin 1.2.5 Homo polymer and copolymer
	1c.Explain types of polymerization reaction	1.3 Types of polymerization reaction 1.3.1 Addition polymerization 1.3.2 Condensation polymerization
	1d.Illustrate Techniques of polymerization	1.4 Techniques of polymerization 1.4.1 Bulk polymerization, 1.4.2 Solution polymerization 1.4.3 Suspension polymerization, 1.4.4 Emulsion polymerization
Unit – II Properties of Polymers	2a.Conceptualize General and specific properties of Polymers	2.1 General properties of Polymers 2.1.1 Molecular weight 2.1.2 Crystallinity 2.1.3 Glass transition temperature 2.2 Specific Properties of Plastics 2.2.1 Electrical Resistance 2.2.2 Chemical Resistance 2.2.3 Thermal Stability

		2.2.4 Biodegradability 2.3 Specific Properties of Rubbers 2.3.1 Elasticity 2.3.2 Electric Conductivity 2.3.3 Resistance to fatigue 2.4 Specific Properties of Fibres 2.4.1 Resiliency 2.4.2 Elongation 2.4.3 Strength
Unit – III Plastics and manufacturing	3a.List out properties and applications of different plastics 3b.Draw a flow diagram of different plastic manufacturing	3.1 Properties, applications and manufacturing of: 3.1.1 Polyethylene by Ziegler low pressure process for HDPE (High density polyethylene) 3.1.2 Polystyrene 3.1.3 Polytetrafluoro Ethylene (PTTE/teflon) 3.1.4 Melamine
Unit – IV Rubbers and manufacturing	4a.List out properties and applications of different rubbers 4b.Draw a flow diagram of different rubbers manufacturing	4.1 Properties, applications and manufacturing of: 4.1.1 Ethylene Propylene Terpolymers, 4.1.2 Butyl rubber 4.1.3 Polyurethane rubber 4.1.4 Silicone rubber
Unit – V Fibres and manufacturing	5a.List out properties and applications of different fibres 5b.Draw a flow diagram of different fibres manufacturing	5.1 Properties, applications and manufacturing of: 5.1.1 Viscose rayon fibres 5.1.2 Cellulose Acetate fibres 5.1.3 Nylon-6 5.1.4 Glass fibres
Unit – VI Resins and manufacturing	6a.List out properties and applications of different resins 6b.Draw a flow diagram of different resins manufacturing	6.1 Classification of Resin 6.2 Properties, applications and manufacturing of: 6.2.1 Phenol formaldehyde 6.2.2 Polyvinyl Resin 6.2.3 Urea formaldehyde
Unit – VI Polymer Processing	7a.Illustrate different polymer processing	7.1 introduction to polymer processing 7.2 molding 7.2.1 compression molding 7.2.2 injection molding 7.2.3 blow molding 7.2.4 extrusion 7.3 die casting 7.4 calendaring 7.5 fibre spinning 7.5.1 wet spinning 7.5.2 dry spinning 7.5.3 melt spinning

		7.6 vulcanization 7.7 compounding 7.8 coating 7.9 mastication and mixing
Unit – VII Polymer Degradation	8a.Examine types of degradation	8.1 Introduction to degradation 8.2 Types of degradation 8.2.1 Thermal degradation 8.2.3 Mechanical degradation 8.2.4 Ultrasonic degradation

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN:

Unit	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Fundamental of Polymer technology	5	2	2	3	7
II	Properties of Polymers	5	1	3	1	5
III	Plastics and manufacturing	4	3	3	4	10
IV	Rubbers and manufacturing	5	3	3	4	10
V	Fibres and manufacturing	4	3	3	4	10
VI	Resins and manufacturing	5	3	3	4	10
VII	Polymer Processing	12	4	6	5	15
VIII	Polymer Degradation	2	1	1	1	3
Total		42	20	24	26	70

Legends: *R=Remember, U=Understand, A=Apply and above (Revised Bloom's taxonomy)*

Note*: This specification table provides general guidelines to assist students for their learning and to teachers to teach and question paper designers /setters to formulate test items/ questions to assess the attainment of the UOs. The actual distribution of marks at different taxonomy levels (of R, U and A)in the question paper may slightly 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 perform following activities in group and prepare reports of about 5 pages for each activity. They should also collect/record physical evidences for their (student's) portfolio which may be useful for their placement interviews:
Following is the list of proposed student activities like:

1. Assignments
2. Technical Quiz/MCQ Test
3. Presentation on some course topic

4. Internet based assignments
5. Undertake micro-Project in team/individually

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/subtopics.
b) Guide student(s) in undertaking micro-projects/activities.
c) Different types of teaching methods i.e. video demonstration, activity based learning, case study, m-learning need to be employed by teachers to develop the outcomes.
d) Some *of the topics/sub-topics* which is relatively simpler or descriptive is to be given to the students for *self-learning* but to be assessed using different assessment methods.
e) Teachers need to ensure to create opportunities and provisions for *co-curricular activities*.
f) Guide students to address issues on environment and sustainability with reference to using the knowledge of this course
g) OERs, V-lab, and O-labs may be used to teach for the teaching of different concepts.

12. SUGGESTEDMICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her at the beginning of the semester. In the first four semesters, the micro-project is group-based (group of 3 to 5). However, **in the fifth and sixth semesters**, 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 the integration of PrOs, UOs, and ADOs. Each student will have to maintain work diary consisting of individual contributions in the project work and give a seminar presentation of it before submission. The duration of the micro project should be about **14-16** ***(fourteen to sixteen) student engagement hours*** during the course. The students ought to submit micro-project by the end of the semester (so that they develop industry-oriented COs.

A suggestive list of micro-projects is given here. This should relate highly to the competency of the course and the COs. Similar micro-projects could be added by the concerned course teacher.

1	Prepare chart of classification of polymers.
2	Prepare charts of plastic, rubber, fibres and resin with application and properties.
3	Prepare chart for manufacturing of different polymers.
4	Prepare 15-20 slides power point presentation showing manufacturing of polymers and processing equipments.
5	Prepare 15-20 slides power point presentation different property testing of polymers.

6 Prepare a demonstrative model of any processing equipments.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Books	Author	Publication
1	Outlines of Chemical Technology,	Rao,M. Gopal, Sittig, Marshall	Affiliated East West Press (Pvt) Ltd, New Delhi 3rd Edition
2	Chemical Technology, Vol. I & II	Pandey , G. N. and Shukla	Vani books company, Hyderabad2nd Edition
3	Shreve's Chemical Process Industries,	Austin, G.T.	McGraw Hill publication, New Delhi 5th edition
4	Polymer science	Gowarikar, V, R., Viswanathan, N.V. Sreedhar, Jayadev	New Age International Pvt. Ltd., New Delhi
5	Polymer science and Technology	Joel R.; Fried	PHI Learning, New Delhi, 2007, 2nd Edition
6	Text on petrochemicals	Rao, B. K. Bhaskar	Khanna Publishers, Delhi, 1998, 2nd Edition

14. SUGGESTED LEARNING WEBSITES

a) https://ndl.iitkgp.ac.in/
b) https://www.vlab.co.in/
c) https://swayam.gov.in/
d) https://onlinecourses.nptel.ac.in

15. PO-COMPETENCY-CO MAPPING

Semester VI	Polymer Technology (4350507) POs						
Competency &CourseOutcomes	PO1 Basic and Discipline specific knowledge	PO2 Problem Analysis	PO3 Design/ Development of solution.	PO4 Engineering tools, Experimentation and testing.	PO5 Engineering Practices for society, sustainability and environment.	PO6 Project Management	PO7 Life-long learning
Competency	Supervise operation and maintenance of various heat transfer equipments						
CO1: Summarize basic properties of polymers and appropriate polymerization techniques.	2.0	-	-	1.0	1.0	-	2.0
CO2: Identify specific properties of plastics, rubbers and fibers with their uses.	1.0	1.0	1.0	2.0	1.0	1.0	2.0

CO3: Develop various plastics, rubbers and fibers by using proper reaction conditions and operating steps.	2.0	1.0	1.0	3.0	1.0	2.0	1.0
CO4: Select suitable techniques for processing of polymers.	2.0	2.0	2.0	3.0	2.0	3.0	1.0

16. COURSE CURRICULUM DEVELOPMENT COMMITTEE:

Sr. No.	Name and Designation	Institute	Contact No.	Email ID
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