GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)
Competency-focused Outcome-based Green Curriculum-2021 (COGC-2021)
VI– Semester

Course Title: **Plastic Materials-II**
(Course Code: 4362304)

Diploma programme in which this course is offered	Semester in which offered
Plastics Engineering (Sandwich Pattern)	Sixth

1. RATIONALE

In today's plastic-age, to satisfy the need of end-user, many advanced polymers have been developed. Diploma plastic engineer has to deal with the production as a responsible technician and first line supervisor in the industries. Thus he should be acquainted with various properties of: specialty polymers, alloys & blends of polymers to deal with advanced applications of such materials. To comply with environmental issues particularly: plastic waste, biodegradable polymer works as a solution. This course has been design to develop a capacity of the learner to select polymer for a specific application.

2. COMPETENCY

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

Select appropriate advanced materials for a product, correlating its properties, which fulfill all required functional and other end-use requirements.

3. COURSE OUTCOMES (COs)

The practical exercises, the underpinning knowledge and the relevant soft skills associated with this competency are to be developed in the student to display the following COs:

a) Select appropriate material for a specific application.
b) Compare various properties among specific polymeric groups.
c) Select the Blend components.
d) Compare properties of different biopolymers.
e) Select a proper plastic material for appropriate applications of the sector.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T/2+P/2)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	CA	ESE	CA	ESE	
3	0	2	4	30*	70	25	25	150

(*): Out of 30 marks under the theory CA, 10 marks are for assessment of the 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 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 following practical outcomes (PrOs) are the sub-components of the COs. *Some of the* ***PrOs*** *marked* ***'*'*** *are compulsory, as they are crucial for that particular CO at the 'Precision Level' of Dave's Taxonomy related to 'Psychomotor Domain'.*

Sr. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. required
1	Select a plastic material among PI, PAI & PEI for aircraft component application.	1	02
2	Select a specialty polymer, based on its properties, for sliding component product.	1	02
3	Select suitable polymer for the rechargeable battery.	2	04
4	Prepare a product of Wood Plastic Composite (WPC).	2	04
5	Select blend components to make efficient alloy & blend for automobile product.	3	02
6	Select blend components to make efficient alloy & blend for washing machine part.	3	02
7	Select PLA as a bio-degradable polymer for eco-friendly purpose.	4	04
8	Select bio-degradable polymer for eco-friendly application.	4	04
9	Select polymer for agriculture & medical applications	5	02
10	Select polymer for sports applications.	5	02
	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 **sample** '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.*

S. No.	Sample Performance Indicators for the PrOs	Weightage in %
1	Prepare of experimental setup	20
2	Operate the equipment setup or circuit	20
3	Follow safe practices measures	10
4	Record observations correctly	20
5	Interpret the result and conclude	30
Total		**100**

6. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

This major equipment with broad specifications for the PrOs is a guide to procure them by the administrators to usher in uniformity of practicals in all institutions across the state.

S. No.	Equipment Name with Broad Specifications	PrO. No.
1	Mould for Wood Plastic Composite	4

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 fulfil the development of this competency.

a) Work as a leader/a team member.
b) Follow ethical practices.
c) Practice environmental friendly methods and processes to avoid metal waste.

The ADOs are best developed through the 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. UNDERPINNING THEORY

Only the major Underpinning Theory is formulated as higher level UOs of *Revised Bloom's taxonomy* in order development of the COs and competency is not missed out by the students and teachers. If required, more such higher level UOs could be included by the course teacher to focus on attainment of COs and competency.

Unit	*Unit Outcomes (UOs)* (4 to 6 UOs at Application and above level)	*Topics and Sub-topics*
Unit - I Specialty Polymers	1a. List out various specialty polymers 1b. Compare properties of various specialty polymers 1c. List out applications of specialty polymers 1d. Select appropriate material for a specific application	Properties and Applications of: 1.1 Polyimides (PI) 1.2 Polyetherimide (PEI) 1.3 Poly(amide-imide) (PAI) 1.4 Polysulphone (PSO) 1.5 Polyethersulphone (PES) 1.6 Polyphenylenesulphide (PPS) 1.7 Polyetheretherketone (PEEK)
Unit - II ***Specific Polymeric groups***	2a. Name various polymeric materials used in particular applications 2b. List out various properties of a specific polymeric group 2c. Compare various properties among specific polymeric groups 2d. Select a polymer for the specific applications	Properties & Applications of : 2.1 High Temperature Polymers 2.2 Fire Resisting Polymers 2.3 Liquid Crystal Polymers (LCP) 2.4 Electro-active Polymers 2.4.1 Inherently Conductive Polymers 2.4.2 Photoconductive Polymers 2.4.3 Polymers in Fiber Optics 2.5 Thermoplastic Elastomers (TPEs) 2.6 Hydrogels and Smart Polymers 2.7 Wood Polymer Composites (WPC)

Unit – III Polymer Alloys & Blends	3a. Define various terms for Alloy and Blends 3b. Characterize Alloy and Blends 3c. Select the Blend components 3d. Differentiate various Blend Preparation techniques	3.1 Introduction & definitions of terms related to Alloys & Blends. 3.2 Importance of Polymer alloys & blends 3.3 Selection of blend components. 3.4 Steps in polymer blend design. 3.5 Blend Preparation techniques 3.5.1 Melt blending 3.5.2 Solution blending 3.5.3 Latex or dispersion mixing 3.6 Properties and applications of alloys and blends: 3.6.1 PP/EPDM 3.6.2 PC/ABS 3.6.3 PC/PBT (Xenoy) 3.6.4 PPO/Nylon 3.6.5 PPO/PS (Noryl) 3.6.6 ABS/PVC
Unit – IV Biodegradable Polymers	4a. Define Biodegradable polymers 4b. Classify biopolymers 4c. Compare properties of different biopolymers 4d. List out factors affecting biodegradability 4e. Set processing parameters for Injection/Extrusion process	4.1 Introduction & definition of related terms. 4.2 Classification of biodegradable polymers 4.3 Properties and applications of biodegradable polymers: 4.3.1 Natural polymers (starch , cellulose) 4.3.2 Microbial polyesters (PHA,PHB) 4.3.3 Polylactic acid (PLA) 4.3.4 Polycaprolactone (PCL) 4.3.5 Water Soluble Polymers 4.3.6 Degradable Polymers 4.3.6.1Packaging Application 4.3.6.2Medical and Related Applications 4.4 Factors affecting biodegradability 4.5 Processing of biodegradable polymers (Injection & Extrusion)

Unit –V Trends in Polymer Applications	5a. Enlist sectors where polymeric materials are widely used 5b. Identify an unique property for a sector 5c. Identify various polymers used in different sectors 5d. Select a proper plastic material for appropriate applications of the sector	Polymer's applications in the sector of: 5.1 Packaging 5.2 Building and Construction 5.3 Automotive Applications 5.4 Aerospace Applications 5.5 Agriculture 5.6 Medical and Biomedical Applications 5.7 Sports

***Note**: The UOs need to be formulated at the 'Application Level' and above of Revised Bloom's Taxonomy' to accelerate the attainment of the COs and the competency.*

8. 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	Specialty Polymers	07	03	05	04	12
II	Specific Polymeric Groups	09	03	08	04	15
III	Polymer Alloys & Blends	08	03	07	04	14
IV	Biodegradable Polymers	10	03	08	04	15
V	Trends in Polymer Applications	08	03	03	08	14
Total		**42**	**15**	**31**	**24**	**70**

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

***Note**: This specification table provides general guidelines to assist student for their learning and to teachers to teach and question paper designers/setters to formulate test items/questions 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 vary slightly from above table.*

9. 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:

1. Students will visit nearby advanced plastic manufacturing industry.
2. Fetch new polymers used in specialty applications.
3. Identify new areas of applications of polymers.
4. Prepare list of properties and applications of specialty polymers.
5. Prepare list of properties and applications of polymer alloys and blends.
6. Explore the importance of biodegradable polymers and latest trends in it with the help of internet.

10. 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) Guide student(s) in undertaking micro-projects.
c) ***'L' in section No. 4*** means different types of teaching methods that are to be employed by teachers to develop the outcomes.
d) About ***20% of the topics/sub-topics*** which are relatively simpler or descriptive in nature is to be given to the students for ***self-learning***, but to be assessed using different assessment methods.
e) With respect to ***section No.11***, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
f) Guide students on how to address issues on environment and sustainability.

g) Visit to nearby industries/workshops
h) Video/animation films on advanced plastic material applications.
i) Video/animation films on various applications of bio-degradable polymers.

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 is given here. This has to match the competency and the COs. Similar micro-projects could be added by the concerned course teacher:

a) Prepare a chart for different types of advanced polymeric materials with respect to its properties and applications.
b) Collect various types of advanced polymeric materials.
c) Ask student to prepare PPT by exploring internet and present in the class seminar.
d) Instruct students to explore the market and prepare the report (with samples of polymers) about their specification, utility, cost etc.

13. SUGGESTED LEARNING RESOURCES

Sr. No.	Title of Book	Author	Publication with place, year and ISBN
1.	Hand Book Biodegradable Polymers	Catia Bastioli	Rapra Technology Limited, 2005, 9781859573891
2.	Green Plastics	Stevens	Princeton University Press, 2001, 978-0691049670
3.	Biodegradable polymers for industrial applications	Ray Smith	Woodhead Publishing Limited, 2005, 978-0849334665
4.	Plastics Materials	Brydson	Butterworth-Heinemann, 1999, 9780750641326
5.	Polymer Alloys & Blends	R.P.Singh	Asian Books, 2002, 9788186299296
6.	Engineering Thermoplastics	James Margolis	CRC Press, 1985, 9780849326462
7.	Plastics Technology Handbook	Manas Chanda & Roy	CRC Press, 2017, 9781498786218
8.	Principles of Polymer Science	Bahadur & Sastry	Alpha Science International, 2007, 9788173196553
9.	Polymers Blends & Alloys	L.A.Uttracki	Hanser Publications, 1990, 9780195207965
10.	Engineering Polymers	Dyson	Chapman & Hall, 1990, 9780412020810

14. SOFTWARE/LEARNING WEBSITES

1. www.en.wikipedia.org
2. http://cdn.intechopen.com/pdfs-wm/34065.pdf
3. http://ed.iitm.ac.in/~shankar_sj/Courses/ED5312/Materials_for_Automobiles17.pdf
4. www.europeanplasticfilms.eu/docs/AustralianReportonBiodegradablePlastics.pdf
5. http://www.sdplastics.com/ensinger/aerodef.pdf
6. www.icmpp.ro/sustainableplastics/files/Biodegradable_plastics_and_polymers.pdf
7. web.stanford.edu/cheme160/lectures

15. PO-COMPETENCY-CO MAPPING

Semester VI	Plastic Materials-II (Course Code: 4362304)									
	POs and PSOs									
Competency & Course Outcomes	PO 1 Basic & Discipline specific knowledge	PO 2 Problem Analysis	PO 3 Design/ development of solutions	PO 4 Engineering Tools, Experimentation &Testing	PO 5 Engineering practices for society, sustainability & environment	PO 6 Project Management	PO 7 Life-long learning	PSO 1 An ability to apply principles of material selection, product & mold/die design and development in plastic engineering.	PSO 2 An ability to conduct safe and environment friendly manufacturing and recycling of plastic products.	PSO 3 (If needed)
Competency **Select appropriate advanced materials for a product, correlating its properties, which fulfill all required functional and other end-use requirements.**	2	2	2	2	3	1	2	2	3	-
Course Outcomes										
1. Select appropriate material for a specific application.	2	1	2	2	1	1	1	2	1	-
2. Compare various properties among specific polymeric groups.	2	2	1	1	1	1	1	2	1	-
3. Select the Blend components	2	2	1	2	2	1	1	2	1	-
4. Compare properties of different biopolymers.	2	1	1	1	3	1	2	2	3	-
5. Select a proper plastic material for appropriate applications of the sector.	2	1	2	2	3	1	2	2	2	-

Legend: '**3**' for high, '**2**' for medium, '**1**' for low or '**-**' for the relevant correlation of each competency, CO, with PO/ PSO

16. COURSE CURRICULUM DEVELOPMENT COMMITTEE

GTU Resource Persons

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