GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

Competency-focused Outcome-based Green Curriculum-2022 (COGC-2022)
Semester-IV

CourseTitle: Refractory
(Course Code: 4345205)

Diploma programmes in which this course is offered	Semester in which offered
Ceramic engineering	4th Semester

1. RATIONALE

Diploma ceramic students have wide scope in Refractory industries. **"**Refractory" is the material which with stand high temperature and it's widely used in construction of furnace and kilns. So they should familiar with basic knowledge of Refractory like Definition, classification, Raw material, processing, manufacturing, properties. Refractory is essential foundation for next curriculum of Advance refractory.

2. COMPETENCY

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

Plan and supervise manufacturing of refractory products.

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) Describe the fundamentals of refractory.
b) Select suitable refractory raw materials for refractory products.
c) Describe the processing of refractory raw material.
d) Describe the manufacturing process.
e) Identify the suitable shaping methods, drying and firing for refractory products.
f) Describe the suitable recycling method for refractory waste.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (CI+T/2+P/2)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
CI	T	P	C	CA	ESE	CA	ESE	
3	-	4	5	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) that are the sub-components of the COs. *Some of* the PrOs marked '*' are compulsory*, as they are crucial for that particular CO. These PrOs need to be attained at least at the 'Precision Level' of Dave's Taxonomy related to 'Psychomotor Domain'*.

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. required
1	Prepare list of different types of refractory products with their application.	I	2
2	Identify various raw materials used in refractory industry.	II	4
3	Perform crushing and grinding operation of a given raw material.	III	4
4	Determine the Grading Sieve analysis of different grog and raw materials.	IV	4
5	Determine the moisture content of a given sample of refractory.	II	4
6	Prepare fire bricks and cutting in to Various shape	IV	6
7	Preparation of following refractory standard brick. (I.S.6, I.S.7, I.S.8 etc)	IV,V	10
8	Preparation of refractory crucibles	IV,V	6
9	Determine Drying Shrinkage of given refractory sample	V	2
10	Determine Firing Shrinkage of given refractory sample.	V	2
11	Determine water absorption of a given refractory sample.	II	4
12	Industrial visit of refractory manufacturing products. Identify the different raw materials. Prepare the flow chart of refractory products. Explain the process of batch mixing. Explain the shaping process of refractory. Explain the drying and firing process of refractory product. Explain the testing process of refractory products. Explain the application of that product.	I-VI	8
	Minimum Practical Exercises required #		**56 hrs**

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	Perform the practical	30
3	Follow safe practices measures	10
4	Record observations correctly	20
5	Interpret the result and conclude	20
Total		**100**

6. MAJOR EQUIPMENT/ INSTRUMENTS AND SOFTWARE REQUIRED

These major equipment/instruments and Software required to develop PrOs are given below with broad specifications to facilitate procurement of them by the administrators/management of the institutes. This will ensure conduction of practical in all institutions across the state in proper way so that the desired skills are developed in students.

S. No.	Equipment Name with Broad Specifications	PrO.No.
1	Sieve shaker with sieve set	4-8
2	Digital weight balance	4-8,11
3	Water bath	11
4	Hot air oven	5,9,11
5	Electric Raising Hearth furnace	6-8,10
6	Pastel and Mortar	3,5-8
7	Pressing machine	6,7

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) Practice environmental friendly methods and processes.

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

The major Underpinning Theory is formulated as given below and only higher level UOs of *Revised Bloom's taxonomy* are mentioned for development of the COs and competency in the students by the teachers.(Higher level UOs automatically include lower level UOs in them). 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 level)	Topics and Sub-topics
Unit – I Fundamentals of refractory	1a. Define refractory. 1b. Able to classify the refractory 1c. Able to explain the general properties and uses of refractories. 1d. Explain the present status and scope of refractory industries.	1.1Defination of refractory. 1.2 Classification of refractory based on occurrence, chemical characteristics, fusion temperature. 1.3 General properties and uses of refractory. 1.4 Brief scope of refractory industries. 1.5 List out refractory manufacturing industry in Gujarat and India.
Unit – II Refractory Raw Materials	2a. List out different types of refractory raw material. 2b. Identify different Raw Materials with their properties.	2.1Types of refractory raw materials. 2.2Detail study of refractory raw materials, such as fire clay, china clay etc. 2.3Study of properties, chemical formula, molecular weight and uses of Silica, Sillimanite and Kynite, Andalucite, Mullite and Bauxite, Magnetite, Dolomite, Zirconia, Chromites,Graphite etc.
Unit – III Processing & Machines	3a.Explain crushing and grinding of raw materials 3b.Explain construction and Function of Equipments.	3.1Methods of crushing, grinding, mixing, ageing of refractory materials. 3.2Details of machines used for crushing and grinding of refractory materials such as disintegrator, edge runner, mill, etc. 3.3Details of mixing machines and equipments such as Muller, pan roller mixer, elevator and hopper etc. 3.4 Details of body making and formulation

Unit	Unit Outcomes (UOs) (4 to 6 UOs at Application level)	Topics and Sub-topics
Unit – IV Manufacturing methods	4a. Describe different manufacturing process. 4b. Distinguish various manufacturing process of bricks 4c. Select appropriate refractory raw materials for brick making.	4.1 Methods of manufacturing of refractory products. 4.2 Manufacturing process of Chromite Brick, Dolomite Brick, Megnesite Brick, chrome-magnetite bricks, Mullite Brick, Sillimanite Brick and Grog. 4.3 Grading of grogs.
Unit – V Shaping, Drying, Firing of refractory	5aPerform shape of refractory articles. 5b Carry out Drying and Firing Technique of the Article.	5.1Various methods of shaping of refractory. 5.2General principles of drying and Firing. 5. 3Brief details regarding Dryers used for Drying refractory bricks 5.4 3Brief details regarding kilns used for firing refractory bricks
Unit – VI Recycling of Industrial Wastes	6a. Justify the need of understanding recycling of industrial waste like Grog. 6b Relate sustainability and recycling of industrial waste. 6c Suggest methods for recycling Grog with examples.	6.1 Concept of recycling waste. 6.2 Sustainability and recycling 6.3 Methods to recycle Refractory waste.

***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.*

10. SUGGESTED SPECIFICATION TABLE FOR QUESTIONPAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Fundamentals of refractory	6	6	6	0	12
II	Refractory Raw Materials	8	4	5	5	14
III	Processing & Machines	8	2	6	6	14
IV	Manufacturing methods	10	3	8	3	14
V	Shaping, Drying, Firing of refractory	6	2	5	3	10
VI	Recycling of Industrial Wastes	4	2	2	2	6
Total		**42**	**19**	**32**	**19**	**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 from above table.*

11. 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 small reports (of 1 to 5 page for each activity). For micro project report should be as per suggested format, for other activities students and teachers together can decide the format of the report. Students should also collect/record physical evidences such as photographs/videos of the activities for their (student's) portfolio which will be useful for their placement interviews:

a) Prepare list of some Refractory articles.
b) Undertake micro-projects in teams
c) Give seminar on any relevant topic.
d) Undertake a market survey for Refractory products.
e) Prepare showcase portfolios.
f) Prepare charts containing details of various Refractory products.

12. 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) ***'CI" 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 assessing during 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 using the knowledge of this course.
g) Guide students for using data manuals.

13. 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 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 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 work load on each students due to the micro-project should be about ***14 to 16(Fourteen to sixteen) student engagement hours*** (i.e. about one hour per week) during the course. The students ought to submit micro-project by the end of the semester (so that they develop the industry-oriented COs).

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

a) **Refractory industries in India**: Identify the different ceramic industries located in different parts of India and prepare the report. (**Duration: 8-10 hours**)
b) **Raw materials:** collection of different types of Refractory raw material samples.
c) **Refractory products:** collection of different types of Refractory samples of different shapes.
d) **Refractory manufacturing process**: identify different defects in refractory products.

14. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication with place, year and ISBN
1	Elements of Fuels, Furnaces & Refractories	O.P.Gupta	Khanna publications;2016; 9788120351578
2	Refractory Technology: Fundamentals and Applications	Ritwik Sarkar	CRC press;2016; 1498754252
3	Refractory Materials :Processing, Properties and Applications	Subir Biswas	Ane Books Pvt. Ltd; 2021, 978-9390658725
4	REFRACTORIES Production And Properties	J H Chesters	W P;2005; 978-1845691202

15. SUGGESTED LEARNING WEBSITES

a) https://en.wikipedia.org/wiki/Refractory
b) https://www.cumi-murugappa.com/refractories/ind_carbon.html
c) http://www.firebricks.co.in/
d) https://www.corrosionpedia.com/2/1426/corrosion-101/refractory-metals-properties-types-and-applications
e) https://www.worldrefractories.org/about-refractories
f) https://www.refractorymetal.org/types-of-refractory-materials-applications/

16. PO-COMPETENCY-CO MAPPING

Semester IV	REFRACTORY (Course Code: 4355205)						
	POs						
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
Competency	Plan and supervise manufacturing of refractory products.						
Course Outcomes CO a) Describe the fundamentals of refractory.	3	-	1	1	-	-	1
CO b) Select suitable refractory raw materials for refractory products.	3	1	1	1	1	-	1
CO c) Describe the processing of raw material.	1	2	1	3	1	1	1
CO d) Describe the manufacturing process.	2	2	3	2	1	1	1
CO e) Identify the suitable shaping methods, drying and firing for refractory products.	2	2	2	3	-	1	1
CO f) Describe the suitable recycling method for refractory waste.	2	1	1	2	2	1	1

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

15. COURSE CURRICULUM DEVELOPMENT COMMITTEE

GTU Resource Persons

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