GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

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

Course Title: Ceramic Processing
(Course Code: 4365202)

Diploma programme in which this course is offered	Semester in which offered
Ceramic Technology	Sixth

1. RATIONALE

Diploma holders in ceramics should also be familiar with various forming techniques, body preparation, and the many tools and machinery used in the production of ceramic ware, in addition to the understanding of ceramic raw materials. Particle size and compaction behavior are also taught to students, along with their significance in ceramic processing.

2. COMPETENCY

The course should be taught and curriculum should implement with the aim to develop required skills so that students are able to acquire following competency leading to the achievement of the following competency:-

Utilize the knowledge of particle size and compaction behaviour, sintering mechanism for the fabrication of ceramic products depending on application of product.

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 fabrication process depending on application of product.
b) Explain colloidal processing of ceramic.
c) Analyze the effect of particle size on ceramic ware.
d) Identify Suitable additives, binder for batch compositions and particle packing.
e) Analysis the effect of drying, sintering and calcinations schedules for densification.

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	-	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) 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	List out various types of lubricants and binders.	IV	2
2	Analyze the given Powder for its particle size distribution using Sieve shaker.	III	4
3	Enumerate the many kinds of ceramic fabrication techniques.	I	4
4	Prepare fine particles by ball milling method.	I,II	6
5	Prepare ceramic article by Sol-Gel method.	II	6
6	Apply thin film coating by CVD Method.	I	4
7	Prepare earthen ware brick by dry pressing method.	IV	6
8	Prepare a hallow type wares by slip casting method.	IV	6
9	Prepare a flat type of wares by jiggering Method.	IV	6
10	Prepare hallow wares by jollying method.	IV	6
11	Explain Mechanism of Sintering process.	V	4
12	Explain Hot and Iso-static process for advance ceramic.	V	4
	Minimum Practical Exercises required #		**28 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	Weight age in %

S. No.	Sample Performance Indicators for the PrOs	Weight age in %
1	Prepare of experimental setup	30
2	Perform the practical	30
3	Follow safe practices measures	10
4	Record observations correctly	10
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	Pr.No.
1	Sieve shaker with sieve set	2
2	Rapid pot mill	3
3	Pressing machine	7
4	Jiggering and jolly	9,10

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.

7. 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 **CERAMIC CLASSIFICATION AND FABRICATION**	1a. List out different types of ceramic forming process. 1b.Explain different types of fabrication process.	1.1 Classification of ceramic fabrication methods. Rheological behavior of slurries: - Slip casting in permeable mould, examples of compositions of casting slurries and tape casting. Plastic-Forming processes:- Extrusion Pressing: - dry pressing etc. 1.2 Ceramic fabrication processes.
Unit – II **COLLOIDAL CERAMICS PROCESSING.**	2a. Identify the many kinds of colloidal materials, along with their composition and characteristics. 2b. List the various stabilization methods. 2c. Describe the sol-gel procedure.	2.1 Types of colloids 2.2Electrostatic, Steric and electrostatic stabilizations. 2.3 Attractive surface forces. 2.4 Consolidated colloids' structure. 2.5 Detailed study of rheology of ceramic systems. 2.6 Particle sol-gel processing.
Unit– III **IMPACT OF PARTICLE SIZE ON CERAMIC PRODUCT.**	3a.Explain the characteristic of solid particle. 3b. Explain the different characteristics of a particle in the ceramic ware.	3.1 Characteristics of solid particles. 3.2 Particle shapes, Size, Equivalent particle diameter. 3.3 Surface area, Average particle size & size distribution.
Unit– IV **PROCESSES OF BONDING AND FORMING.**	4a. Particle packing characteristics 4b. describe additives used in processing. 4c. Explain importance of binders, packing of particles.	4.1 Characteristics of packing's of uniform spheres, packing in interstices among coarser particles, packing of continuous size distributions and hindered packing. 4.2 Additives used in processing: water, organic liquids, surfactants, Binder formulations include cellulose and vinyl binders, as well

Unit	Unit Outcomes (UOs) (4 to 6 UOs at Application level)	Topics and Sub-topics
		as clay and molecular binders.
Unit– V **DRYING , CALCINATION AND SINTERING**	5a.Describe drying mechanism. 5b. Explain sintering and sintering process. 5c.Explain about calcinations and factors affecting to the calcinations.	5.1 The drying process, drying mechanism, drying shrinkage and defects and modes of drying. 5.2 Introduction to sintering of ceramics. 5.3 Hot and iso-static processing. 5.4 Binder removal, 5.5 Calcinations & affecting factors.

***Note**:TheUOs 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 QUESTIONPAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	CERAMIC CLASSIFICATION AND FABRICATION.	4	2	4	4	10
II	COLLOIDAL CERAMICS PROCESSING.	10	3	7	4	14
III	IMPACT OF PARTICLE SIZE ON CERAMIC PRODUCT.	8	3	7	4	14
IV	PROCESSES OF BONDING AND FORMING.	10	3	7	8	18
V	DRYING, CALCINATION AND SINTERING.	10	3	7	4	14
Total		**42**	**14**	**32**	**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 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 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) List the Ceramic manufacturing industries in India.
b) Undertake micro-projects in teams
c) Give seminar on any relevant topic.
d) List different use additives and binder.
e) Prepare a poster of sintering process.

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) ***'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) Prepare chart for different fabrication process of ceramic.
b) Collect the samples of binders and additives.
c) Prepare a report on colloidal processing of ceramic.
d) Prepare poster on sintering.
e) Prepare a note on calcinations.
f) Prepare a report on effect of different particle size on ceramic product.

14. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication with place, year and ISBN
1	Ceramic Processing and Sintering	M. N. Rahaman	CRC Press ISBN-978-0824709884
2	Principles of Ceramics Processing	James S. Reed	Wiley-Interscience; ISBN- 978-0471597216

15. SUGGESTED LEARNING WEBSITES

1. https://shodhganga.inflibnet.ac.in/bitstream/10603/108074/12/12_chapter%204.pdf
2. https://www.academia.edu/5600888/Ceramic_Processing_and_Sintering_Rahaman_PDF
3. **https://www.sciencedirect.com/topics/materials-science/colloidal-processing**

PO-COMPETENCY-CO MAPPING

Semester VI	Ceramic Processing (Course Code: 4365202)						
	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	**Utilize the knowledge of particle size and compaction behaviour, sintering mechanism for the fabrication of ceramic products depending on application of product.**						
Course Outcomes							
CO a) Select appropriate fabrication process depending on application of product.	2	2	1	1	1	1	1
CO b) Explain colloidal processing of ceramic.	2	1	-	1	1	-	1
CO c) Analyze the effect of particle size on ceramic ware.	2	2	2	2	1	1	1
CO d) Identify Suitable additives, binder for batch compositions and particle packing.	2	1	2	1	1	1	1
CO e) Analysis the effect of drying, sintering and calcinations schedules for densification.	2	2	2	1	1	1	1

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

17. COURSE CURRICULUM DEVELOPMENT COMMITTEE

GTU Resource Persons

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