JNIVERSITY, CHENNAI

UNDERGRADUATE CURRICULUM (UNIVERSITY DEPARTMENTS)

Campus: Alagappa College of Technology

Department: Ceramic Technology

Programme: B. Tech Ceramic Technology

Regulations: 2023 (Revised 2024), with effect from the AY 2024 – 25 to all the students of UG Programme.

OVERVIEW OF CREDITS

Sem	PCC	PEC	ESC	HSMC	ETC	OEC	SDC	UC	SLC	Total
I			6	11			4	1		**21**
II			10	11			3	1		**25**
III	18			4			2			**24**
IV	17						2	3		**22**
V	16						4	3	1	**24**
VI		9			3	3	4	3		**22**
VII	6	9			3	3	4			**25**
VIII							8			**8**
Total	**57**	**18**	**16**	**26**	**6**	**6**	**31**	**11**	**1**	**171**
% of Category	**34**	**11**	**8**	**15**	**4**	**4**	**18**	**6**	**1**	**100**

CATEGORY OF COURSES

PCC – Professional Core Course

PEC – Professional Elective Course

ETC – Emerging Technology Course

OEC – Open Elective Course

SLC – Self Learning Course

ESC – Engineering Science Course

HSMC – Humanities Science and Management Course

SDC – Skill Development Course

UC – University Course

For Honours & Minor Degree, please refer the Regulations 2023 (Revised 2024).

SEMESTER – I							
S. NO.	COURSE CODE	COURSE NAME	COURSE TYPE#	PERIODS / WEEK		CREDITS	CATEGORY
				L-T-P	TCP*		
1	EN23C01	Foundation English	LIT	2-0-2	4	3	HSMC
2	MA23C01	Matrices & Calculus	T	3-1-0	4	4	HSMC
3	PH23C01	Engineering Physics	LIT	3-0-2	5	4	HSMC
4	ME23C01	Engineering Drawing & 3D Modelling	LIT	2-0-4	6	4	SDC
5	EE23C03	Basics of Electrical and Electronics Engineering	LIT	2-0-2	4	3	ESC
6	ME23C05	Basics of Mechanical Engineering	T	2-0-0	2	2	ESC
7	UC23H01	தமிழர்மரபு / Heritage of Tamil	T	1-0-0	1	1	UC
8	-	NCC/NSS/NSO/YRC	-	0-0-2	2	-	UC
9	-	Audit Course – I	-	-	-	-	UC
				TOTAL CREDITS		21	

SEMESTER – II							
S. NO.	COURSE CODE	COURSE NAME	COURSE TYPE#	PERIODS / WEEK		CREDITS	CATEGORY
				L-T-P	TCP*		
1	EN23C02	Professional Communication	LIT	2-0-2	4	3	HSMC
2	MA23C02	Ordinary Differential Equations & Transform Techniques	T	3-1-0	4	4	HSMC
3	CY23C01	Engineering Chemistry	LIT	3-0-2	5	4	HSMC
4	CS23C02	Computer Programming in Python	LIT	3-0-2	5	4	ESC
5	ME23C03	Engineering Mechanics	T	3-1-0	4	4	ESC
6	ME23C04	Makerspace	LIT	1-0-4	5	3	SDC
	CE23C03	Basic Civil Engineering	T	2-0-0	2	2	ESC
7	UC23H02	தமிழரும்தொழில்நுட்பமும்/ Tamils and Technology	T	1-0-0	1	1	UC
				TOTAL CREDITS		25	

SEMESTER – III							
S. NO.	**COURSE CODE**	**COURSE NAME**	**COURSE TYPE#**	**PERIODS / WEEK**		**CREDITS**	**CATEGORY**
				L-T-P	**TCP***		
1	MA23C05	Probability and Statistics	T	3-1-0	4	4	HSMC
2	CT23301	Physical Foundation of Material Science	T	3-0-0	3	3	PCC
3	CT23302	Ceramic Raw Materials	LIT	3-0-2	5	4	PCC
4	CT23303	Processing of Ceramic Raw Materials	LIT	3-0-2	5	4	PCC
5	CT23304	Ceramic Fabrication Processes	T	3-0-0	3	3	PCC
6	CT23305	Unit Operations in Ceramic Industries	LIT	3-0-2	5	4	PCC
7	-	Skill Development Course I	-	-	-	2	SDC
8	-	Audit Course–II	-	-	-	-	UC
TOTAL CREDITS						**24**	

SEMESTER – IV							
S. NO.	**COURSE CODE**	**COURSE NAME**	**COURSE TYPE#**	**PERIODS / WEEK**		**CREDITS**	**CATEGORY**
				L-T-P	**TCP***		
1	CT23401	Thermodynamics for Ceramic Engineers	T	2-1-0	3	3	PCC
2	CT23402	Phase Diagrams and Phase Transformations	T	3-0-0	3	3	PCC
3	CT23403	Properties of Ceramics	LIT	3-0-2	5	4	PCC
4	CT23404	Ceramic Whitewares	LIT	3-0-2	5	4	PCC
5	CT23405	Sintering of Ceramics	T	3-0-0	3	3	PCC
6	-	Skill Development Course II	-	-	-	2	SDC
7	CT23U01	Standards – Ceramic Technology	T	1-0-0	1	1	UC
8	UC23U01	Universal Human Values	LIT	1-0-2	3	2	UC
TOTAL CREDITS						**22**	

SEMESTER – V (PREFERENCE FOR FOREIGN EXCHANGE)							
S. NO.	**COURSE CODE**	**COURSE NAME**	**COURSE TYPE#**	**PERIODS / WEEK**		**CREDITS**	**CATEGORY**
				L-T-P	**TCP***		
1	CT23501	Mechanical Behavior of Ceramic Materials	LIT	3-0-2	4	4	PEC
2	CT23502	Ceramic Characterization Techniques	LIT	3-0-2	4	4	PEC
3	CT23503	Glass and Glass Ceramics	LIT	3-0-2	4	4	PEC
4	CT23504	Refractories	LIT	3-0-2	4	4	PEC
5	-	Industry Oriented Course I	-	-	-	1	SDC
6	CT23U02	Sustainability Course – Ceramic Technology	T	3-0-0	3	3	UC
7	CTL2301	Self-Learning Course # (Minimum Duration 15 h)	-	0-0-2	2	1	SLC
8	-	Skill Development Course III	-	-	-	2	SDC
			TOTAL CREDITS			**23**	
COURSES FOR HONORS DEGREE							
S. NO.	**COURSE CODE**	**COURSE NAME**	**COURSE TYPE#**	**PERIODS / WEEK**		**CREDITS**	**CATEGORY**
				L-T-P	**TCP***		
1.	CT23D01	Capstone Design Project – Level I	CDP	0-0-12	12	6	SDC
(OR)							
1.		Honors – I (Professional Elective)	T	3-0-0	3	3	PEC
2.		Honors – II (Professional Elective)	T	3-0-0	3	3	PEC

SEMESTER – VI (PREFERENCE FOR FOREIGN EXCHANGE)							
S. NO.	**COURSE CODE**	**COURSE NAME**	**COURSE TYPE#**	**PERIODS / WEEK**		**CREDITS**	**CATEGORY**
				L-T-P	**TCP***		
1	CT23601	Creative and Innovative Project	L	0-0-4	4	2	SDC
2	UC23E01	Engineering Entrepreneurship Development	LIT	2-0-2	4	3	UC
3	-	Professional Elective – I	T	3-0-0	3	3	PEC
4	-	Professional Elective – II	T	3-0-0	3	3	PEC
5	-	Professional Elective – III	T	3-0-0	3	3	PEC
6	-	Open Elective – I	T	3-0-0	3	3	OEC
8	-	Emerging Technology Course I	T	3-0-0	3	3	ETC
9	-	Industry Oriented Course II	-	-	-	1	SDC
TOTAL CREDITS						**21**	
COURSES FOR HONORS DEGREE							
S. NO.	**COURSE CODE**	**COURSE NAME**	**COURSE TYPE#**	**PERIODS / WEEK**		**CREDITS**	**CATEGORY**
				L-T-P	**TCP***		
1.	CT23D02	Capstone Design Project – Level II	CDP	0-0-12	12	6	SDC
(OR)							
1.		Honors Elective – III (Professional Elective)	T	3-0-0	3	3	PEC
2.		Honors Elective – IV (Professional Elective)	T	3-0-0	3	3	PEC

SEMESTER – VII							
S. NO.	**COURSE CODE**	**COURSE NAME**	**COURSE TYPE#**	**PERIODS / WEEK**		**CREDITS**	**CATEGORY**
				L-T-P	**TCP***		
1	CT23701	Abrasives and Cutting Tools	T	3-0-0	3	3	PCC
2	CT23702	Process Monitoring and Control in Ceramic Industries	T	3-0-0	3	3	PCC
3	-	Emerging Technology Course II	T	3-0-0	3	3	ETC
4	-	Professional Elective – IV	T	3-0-0	3	3	PEC
5	-	Professional Elective – V	T	3-0-0	3	3	PEC
6	-	Professional Elective – VI	T	3-0-0	3	3	PEC
7	-	Industry Oriented Course III	-	-	-	1	SDC
8	-	Open Elective – II	T	3-0-0	3	3	OEC
9	CT23703	Industrial Training/Internship [4 weeks during summer]	IPW	0-0-0		2	SDC
TOTAL CREDITS						**24**	
COURSES FOR HONORS DEGREE							
S. NO.	**COURSE CODE**	**COURSE NAME**	**COURSE TYPE#**	**PERIODS / WEEK**		**CREDITS**	**CATEGORY**
				L-T-P	**TCP***		
1.	CT23D03	Capstone Design Project – Level III	CDP	0-0-12	12	6	SDC
(OR)							
1.		Honors Elective – V (Professional Elective)	T	3-0-0	3	3	PEC
2.		Honors Elective – VI (Professional Elective)	T	3-0-0	3	3	PEC

SEMESTER – VIII							
S.NO	**COURSE CODE**	**COURSE NAME**	**COURSE TYPE**	**PERIODS/ WEEK**		**CREDITS**	**CATEGORY**
				L-T-P	**TCP**		
1.	CT23801	Project Work / Internship cum Project Work	SDC	0-0-16	16	8	SDC
	TOTAL CREDITS					**8**	

PROFESSIONAL ELECTIVES

VERTICAL I – REFRACTORY							
S. NO.	**COURSE CODE**	**COURSE NAME**	**COURSE TYPE#**	**PERIODS / WEEK**		**CREDITS**	**CATEGORY**
				L-T-P	**TCP***		
1.	CT23001	Monolithic Refractory	T	3-0-0	3	3	PEC
2.	CT23002	Process Metallurgy	T	3-0-0	3	3	PEC
3.	CT23003	Refractory Design and Installation	T	3-0-0	3	3	PEC
4.	CT23004	Refractories for Iron and Steel Industry	T	3-0-0	3	3	PEC
5.	CT23005	Refractories for Non-Ferrous Metallic and Chemical Industries	T	3-0-0	3	3	PEC
6.	CT23006	Refractories for Glass and Ceramic Industries	T	3-0-0	3	3	PEC

VERTICAL II – FUNCTIONAL CERAMICS							
S. NO.	**COURSE CODE**	**COURSE NAME**	**COURSE TYPE#**	**PERIODS / WEEK**		**CREDITS**	**CATEGORY**
				L-T-P	**TCP***		
1.	CT23007	Electronic Ceramics	T	3-0-0	3	3	PEC
2.	CT23008	Advanced Glass and Glass-Ceramics	T	3-0-0	3	3	PEC
3.	CT23009	Bio-Ceramics	T	3-0-0	3	3	PEC
4.	CT23010	Fuel Cells and Sensors	T	3-0-0	3	3	PEC
5.	CT23011	Carbon Technology	T	3-0-0	3	3	PEC
6.	CT23012	Ceramic Coatings	T	3-0-0	3	3	PEC

VERTICAL III – GLASS AND GLASS CERAMICS							
S. NO.	**COURSE CODE**	**COURSE NAME**	**COURSE TYPE#**	**PERIODS / WEEK**		**CREDITS**	**CATEGORY**
				L-T-P	**TCP***		
1.	CT23013	Raw materials and Structure Formation of Glass	T	3-0-0	3	3	PEC
2.	CT23014	Properties and Testing Methods of Glass	T	3-0-0	3	3	PEC
3.	CT23015	Glass Ceramics	T	3-0-0	3	3	PEC
4.	CT23016	Glasses for Special Applications – I	T	3-0-0	3	3	PEC
5.	CT23017	Glasses for Special Applications – II	T	3-0-0	3	3	PEC
6.	CT23018	Photosensitive Glass and Glass Ceramics	T	3-0-0	3	3	PEC

VERTICAL IV – MATERIAL SCIENCE							
S. NO.	**COURSE CODE**	**COURSE NAME**	**COURSE TYPE#**	**PERIODS / WEEK**		**CREDITS**	**CATEGORY**
				L-T-P	**TCP***		
1.	CT23019	Material Selection and Design	T	3-0-0	3	3	PEC
2.	CT23020	Fracture Mechanics and Failure Analysis	T	3-0-0	3	3	PEC
3.	CT23021	Smart Ceramics	T	3-0-0	3	3	PEC
4.	CT23022	Non-destructive Material Testing and Evaluation	T	3-0-0	3	3	PEC
5.	CT23023	Surface Engineering for Ceramics	T	3-0-0	3	3	PEC
6.	CT23024	Recycling of Materials and Sustainability	T	3-0-0	3	3	PEC

VERTICAL V – CERAMIC PROCESSING							
S. NO.	**COURSE CODE**	**COURSE NAME**	**COURSE TYPE#**	**PERIODS / WEEK**		**CREDITS**	**CATEGORY**
				L-T-P	**TCP***		
1.	CT23025	Statistical Process control and Simulation in Ceramic Processing	T	3-0-0	3	3	PEC
2.	CT23026	Advanced Sintering Techniques	T	3-0-0	3	3	PEC
3.	CT23027	Colloidal Ceramic Processing	T	3-0-0	3	3	PEC
4.	CT23028	Ceramic Matrix Composites	T	3-0-0	3	3	PEC
5.	CT23029	Machining and Joining of Ceramics	T	3-0-0	3	3	PEC
6.	CT23030	Ceramic Additive Manufacturing	T	3-0-0	3	3	PEC

EMERGING TECHNOLOGIES

S. NO.	**COURSE CODE**	**COURSE NAME**	**COURSE TYPE#**	**PERIODS / WEEK**		**CREDITS**	**CATEGORY**
				L-T-P	**TCP***		
1.	CT23E01	Semiconductor Technology	T	3-0-0	3	3	ETC
2	CT23E02	Ultra-high Temperature Materials	T	3-0-0	3	3	ETC
3.	CT23E03	Artificial Intelligence and Machine Learning Fundamentals	T	3-0-0	3	3	ETC
4.	CT23E04	IoT Concepts and Applications	T	3-0-0	3	3	ETC
5.	CT23E05	Data Science Fundamentals	T	3-0-0	3	3	ETC
6.	CT23E06	Augmented Reality/ Virtual Reality	T	3-0-0	3	3	ETC

SKILL BASED COURSES

S. NO.	COURSE CODE	COURSE NAME	COURSE TYPE#	PERIODS / WEEK		CREDITS	CATEGORY
				L-T-P	TCP*		
1.	CT23S01	Ceramic Designing and Simulation Tools	L	0-0-4	4	2	SDC

ADDITIONAL COURSES FOR LATERAL ENTRY DIPLOMA AND B.Sc STUDENTS

S. NO.	COURSE CODE	COURSE NAME	COURSE TYPE#	PERIODS / WEEK		CREDITS	CATEGORY
				L-T-P	TCP*		
1.	EE23C03	Basics of Electrical and Electronics Engineering	T	3-0-0	3	3	ESC
2.	ME23C03	Engineering Mechanics	T	3-1-0	4	4	ESC

OPEN ELECTIVE COURSES

S. NO.	COURSE CODE	COURSE NAME	COURSE TYPE#	PERIODS / WEEK		CREDITS	CATEGORY
				L-T-P	TCP*		
1.	CT23901	Ceramic Materials for Engineering Applications	T	3-0-0	3	3	OEC
2.	CT23902	Ceramic Processing	T	3-0-0	3	3	OEC

EN23C01 **FOUNDATION ENGLISH** **L T P C**

2 0 2 3

COURSE OBJECTIVES:

- To develop students' foundational skills in reading, writing, grammar and vocabulary to enable them to understand and produce various forms of communication.
- To enhance students' proficiency in reading comprehension, narrative and comparative writing.
- To comprehend and analyse descriptive texts and visual images
- To articulate similarities and differences in oral and written forms.
- To improve students' proficiency in reading and writing formal letters and emails.

UNIT I BASICS OF COMMUNICATION 6

Reading - Telephone message, bio-note; Writing – Personal profile; Grammar – Simple present tense, Present continuous tense, wh-questions, indirect questions; Vocabulary – Word formation (Prefix and Suffix).

LAB ACTIVITY: 6

Listening – Telephone conversation; Speaking Self-introduction; Telephone conversation – Video conferencing etiquette

UNIT II NARRATION 6

Reading – Comprehension strategies - Newspaper Report, An excerpt from an autobiography; Writing – Narrative Paragraph writing (Event, personal experience etc.); Grammar – Subject-verb agreement, Simple past, Past continuous Tenses; Vocabulary – One-word substitution

LAB ACTIVITY: 6

Listening – Travel podcast; Speaking – Narrating and sharing personal experiences through a podcast

UNIT III DESCRIPTION 6

Reading – A tourist brochure, Travel blogs, descriptive article/excerpt from literature, visual images; Writing –Descriptive Paragraph writing, Grammar – Future tense, Perfect tenses, Preposition; Vocabulary – Descriptive vocabulary

LAB ACTIVITY: 6

Listening – Railway / Airport Announcements, Travel Vlogs; Speaking – Describing a place or picture description

UNIT IV COMPARE AND CONTRAST 6

Reading – Reading and comparing different product specifications - Writing – Compare and Contrast Essay, Coherence and cohesion; Grammar – Degrees of Comparison; Vocabulary – Transition words (relevant to compare and contrast)

LAB ACTIVITY: 6

Listening – Product reviews, Speaking – Product comparison based on product reviews - similarities and differences

UNIT V EXPRESSION OF VIEWS **6**

Reading – Formal letters, Letters to Editor ; Writing – Letter writing/ Email writing (Enquiry / Permission, Letter to Editor); Grammar – Compound nouns, Vocabulary – Synonyms, Antonyms

LAB ACTIVITY: **6**

Listening – Short speeches; Speaking – Making short presentations (JAM)

TOTAL: 60 PERIODS

TEACHING METHODOLOGY

Interactive lectures, role plays, group discussions, listening and speaking labs, technology enabled language teaching, flipped classroom.

EVALUATION PATTERN

Internal Assessment
- Written assessments
- Assignment

Lab assessment
- Listening
- Speaking

External Assessment
- End Semester Examination

LEARNING OUTCOMES

By the end of the courses, students will be able to

- Use appropriate grammar and vocabulary to read different types of text and converse appropriately.
- Write coherent and engaging descriptive and comparative essay writing.
- Comprehend and interpret different kinds of texts and audio visual materials
- Critically evaluate reviews and articulate similarities and differences
- Write formal letters and emails using appropriate language structure and format

TEXT BOOKS:

1. “English for Engineers and Technologists” Volume I by Orient Blackswan, 2022
2. “English for Science & Technology - I” by Cambridge University Press, 2023

REFERENCES

1. “Interchange” by Jack C.Richards, Fifth Edition, Cambridge University Press, 2017.
2. “English for Academic Correspondence and Socializing” by Adrian Wallwork, Springer, 2011.
3. “The Study Skills Handbook” by Stella Cortrell, Red Globe Press, 2019
4. www.uefap.com

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1										√		√
CO2										√		
CO3										√		√
CO4										√		
CO5										√		√

MA23C01	MATRICES AND CALCULUS	L	T	P	C
		3	1	0	4

OBJECTIVES:

- To develop the use of matrix algebra techniques in solving practical problems.
- To familiarize the student with functions of several variables.
- To solve integrals by using Beta and Gamma functions.
- To acquaint the student with mathematical tools needed in evaluating multiple integrals.
- To acquaint the students with the concepts of vector calculus which naturally arise in many engineering problems.

UNIT I MATRICES 9+3

Eigenvalues and Eigenvectors of a real matrix – Properties of Eigenvalues and Eigenvectors- Cayley-Hamilton theorem (excluding proof) – Diagonalization of matrices - Reduction of Quadratic form to canonical form by using orthogonal transformation - Nature of a Quadratic form.

UNIT II FUNCTIONS OF SEVERAL VARIABLES 9+3

Limit, continuity, partial derivatives – Homogeneous functions and Euler's theorem - Total derivative – Differentiation of implicit functions – Jacobians -Taylor's formula for two variables - Errors and approximations – Maxima and Minima of functions of two variables – Lagrange's method of undermined multipliers.

UNIT III INTEGRAL CALCULUS 9+3

Improper integrals of the first and second kind and their convergence – Differentiation under integrals - Evaluation of integrals involving a parameter by Leibnitz rule – Beta and Gamma functions-Properties – Evaluation of single integrals by using Beta and Gamma functions..

UNIT IV MULTIPLE INTEGRALS 9+3

Double integrals – Change of order of integration – Double integrals in polar coordinates – Area enclosed by plane curves – Triple integrals – Volume of Solids – Change of variables in double and triple integrals-
Evaluation of double and triple integrals by using Beta and Gamma functions.

UNIT V VECTOR CALCULUS 9+3

Gradient of a scalar field, directional derivative – Divergence and Curl – Solenoidal and Irrotational vector fields - Line integrals over a plane curve - Surface integrals – Area of a curved surface – Volume Integral - Green's theorem, Stoke's and Gauss divergence theorems (without proofs)– Verification and applications in evaluating line, surface and volume integrals.

TOTAL: 60 PERIODS

Laboratory based exercises / assignments / assessments will be given to students wherever applicable from the content of the course.

General engineering applications / branch specific applications from the content of each units wherever possible will be introduced to students.

Suggested Laboratory based exercises / assignments / assessments :

Matrices

1. Finding eigenvalues and eigenvectors
2. Verification of Cayley-Hamilton theorem
3. Eigenvalues and Eigenvectors of similar matrices
4. Eigenvalues and Eigenvectors of a symmetric matrix
5. Finding the powers of a matrix
6. Quadratic forms

Functions of Several Variables

1. Plotting of curves and surfaces
2. Symbolic computation of partial and total derivatives of functions

Integral Calculus

1. Evaluation of beta and gamma functions
2. Computation of error function and its complement

Multiple Integrals

1. Plotting of 3D surfaces in Cartesian and Polar forms

Vector Calculus

1. Computation of Directional derivatives
2. Computation of normal and tangent to the given surface

OUTCOMES:

CO 1 :Use the matrix algebra methods for solving practical problems.
CO 2 :Use differential calculus ideas on several variable functions.
CO 3 :Apply different methods of integration in solving practical problems by using Beta and Gamma functions.
CO 4 :Apply multiple integral ideas in solving areas and volumes problems.
CO 5 :Apply the concept of vectors in solving practical problems.

TEXT BOOKS:

1. Joel Hass, Christopher Heil, Maurice D.Weir "'Thomas' Calculus", Pearson Education., New Delhi, 2018.
2. Grewal B.S., "Higher Engineering Mathematics", Khanna Publishers, 45th Edition, New Delhi, 2020.
3. James Stewart, Daniel K Clegg & Saleem Watson "Calculus with Early Transcendental Functions", Cengage Learning, 6th Edition, New Delhi,2023.

REFERENCES:

1. Erwin Kreyszig, "Advanced Engineering Mathematics", 10th Edition, Wiley India Pvt Ltd., New Delhi, 2018.
2. Greenberg M.D., "Advanced Engineering Mathematics", Pearson Education2nd Edition, 5th Reprint, Delhi, 2009.
3. Jain R.K. and Iyengar S.R.K., "Advanced Engineering Mathematics",Narosa Publications, 5th Edition, New Delhi, 2017.
4. Narayanan S. and Manicavachagom Pillai T. K., "Calculus" Volume I and II, S. Viswanathan Publishers Pvt. Ltd., Chennai, 2009.
5. Peter V.O'Neil, "Advanced Engineering Mathematics", Cengage Learning India Pvt., Ltd, 7 th Edition, New Delhi , 2012.
6. Ramana B.V., "Higher Engineering Mathematics", Tata McGraw Hill Co. Ltd., 11th Reprint, New Delhi, 2010.

CO – PO Mapping:

Course Outcomes	PROGRAMME OUTCOMES											
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**P10**	**P11**	**P12**
CO1 :	3	3	2	3	1	2	1	1	1	1	1	3
CO2 :	3	3	2	3	1	2	1	1	1	1	1	3
CO3 :	3	3	2	3	1	2	1	1	1	1	1	3
CO4 :	3	3	2	3	1	2	1	1	1	1	1	3
CO5 :	3	3	2	3	1	2	1	1	1	1	1	3

PH23C01	ENGINEERING PHYSICS	L	T	P	C
	(Common to all branches of B.E/B.Tech Programmes)	3	0	2	4

COURSE OBJECTIVES

- To familiarize with crystal structure, bonding and crystal growth.
- To impart knowledge on Mechanics of Materials.
- To impart knowledge of oscillations, sound and Thermal Physics
- To facilitate understanding of optics and its applications, different types of Lasers and fiber optics.
- To introduce the basics of Quantum Mechanics and its importance.

UNIT I CRYSTAL PHYSICS 9+6

Crystal Bonding – Ionic – covalent – metallic and van der Walls's/ molecular bonding. Crystal systems - unit cell, Bravais lattices, Miller indices - Crystal structures - atomic packing density of BCC, FCC and HCP structures. NaCl, Diamond, Graphite, Graphene, Zincblende and Wurtzite structures - crystal imperfections- point defects - edge and screw dislocations – grain boundaries. Crystal Growth – Czocharalski method – vapor phase epitaxy – Molecular beam epitaxy- Introduction to X-Ray Diffractometer.

1. Determination of Lattice parameters for crystal systems.
2. Crystal Growth – Slow Evaporation method
3. Crystal Growth Sol – Gel Method

UNIT II MECHANICS OF MATERIALS 9+6

Rigid Body – Centre of mass – Rotational Energy - Moment of inertia (M.I)- Moment of Inertia for uniform objects with various geometrical shapes. Elasticity –Hooke's law - Poisson's ratio - stress-strain diagram for ductile and brittle materials – uses- Bending of beams – Cantilever - Simply supported beams - uniform and non-uniform bending - Young's modulus determination - I shaped girders –Twisting couple – Shafts. Viscosity – Viscous drag – Surface Tension.

4. Non-uniform bending -Determination of Young's modulus of the material of the beam.
5. Uniform bending -Determination of Young's modulus of the material of the beam
6. Viscosity – Determination of Viscosity of liquids.

UNIT III OSCILLATIONS, SOUND AND THERMAL PHYSICS 9+6

Simple harmonic motion - Torsional pendulum –- Damped oscillations –Shock Absorber - Forced oscillations and Resonance –Applications of resonance.- Waves and Energy Transport –Sound waves – Intensity level – Standing Waves - Doppler effect and its applications - Speed of blood flow. Ultrasound – applications - Echolocation and Medical Imaging. Thermal Expansion – Expansion joints – Bimetallic strip – Seebeck effect – thermocouple -Heat Transfer Rate – Conduction – Convection and Radiation.

7. Torsional pendulum-Determination of rigidity modulus of wire and moment of inertia of the disc
8. Melde's string experiment - Standing waves.
9. Ultrasonic interferometer – determination of sound velocity and liquids compressibility

UNIT IV OPTICS AND LASERS 9+6

Interference - Thin film interference - Air wedge- Applications -Interferometers–Michelson Interferometer -– Diffraction - CD as diffraction grating – Diffraction by crystals -Polarization - polarizers -– Laser – characteristics – Spontaneous and Stimulated emission- population – inversion - Metastable states - optical feedback - Nd-YAG laser, CO_2 laser, Semiconductor laser - Industrial and medical applications - Optical Fibers – Total internal reflection – Numerical aperture and acceptance angle – Fiber optic communication – Fiber sensors – Fiber lasers.

10. Laser - Determination of the width of the groove of the compact disc using laser.
    Laser Parameters
    Determination of the wavelength of the laser using grating
11. Air wedge -Determination of the thickness of a thin sheet/wire
12. Optical fibre - Determination of Numerical Aperture and acceptance angle
    -Determination of bending loss of fibre.
13. Michelson Interferometer (Demonstration)

UNIT V QUANTUM MECHANICS 9+6

Black body radiation (Qualitative) – Planck's hypothesis – Einstein's theory of Radiation - Matter waves–de Broglie hypothesis - Electron microscope – Uncertainty Principle – The Schrodinger Wave equation (time-independent and time-dependent) – Meaning and Physical significance of wave function - Normalization - Particle in an infinite potential well-particle in a three-dimensional box - Degenerate energy states - Barrier penetration and quantum tunneling - Tunneling microscope.

14. Photoelectric effect – Determination of Planck's constant.
15. Black Body Radiation (Demonstration)
16. Electron Microscope (Demonstration)

TOTAL: 75 PERIODS

COURSE OUTCOMES:

After completion of the course, the students will be able to

CO1: Understand the significance of crystal structure and bonding. Learn to grow crystals.
CO2: Obtain knowledge on important mechanical and thermal properties of materials and determine them through experiments.
CO3: Conceptualize and visualize the oscillations and sound.
CO4: Grasp optical phenomenon and their applications in real life.
CO5: Appreciate and evaluate the quantum phenomenon.
CO6 Develop skill set to solve engineering problems and design experiments.

TEXT BOOKS:

1. Raymond A. Serway, John W. Jewett, Physics for Scientists and Engineers, Thomson Brooks/Cole, 2013.
2. D. Halliday, R. Resnick and J. Walker, Principles of Physics. John Wiley & Sons, 10th Edition, 2015.
3. N. Garcia, A. Damask and S. Schwarz, Physics for Computer Science Students,

Springer-Verlag, 2012.
4. Alan Giambattista, Betty McCarthy Richardson and Robert C. Richardson, College Physics, McGraw-Hill Higher Education, 2012.

REFERENCES:

1. R. Wolfson, Essential University Physics. Volume 1 & 2. Pearson, 2016.
2. D. Kleppner and R. Kolenkow. An Introduction to Mechanics, McGraw Hill Education, 2017.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1		1							
CO2	3	2	1	1								
CO3	3	2	1	1								
CO4	3	2	1	1	1							
CO5	3	2	1	1	1							
CO6	3	2	1	2								

ME23C01	ENGINEERING DRAWING AND 3D MODELLING	L	T	P	C
		2	0	4	4

COURSE OBJECTIVES

After successful completion of this course, the students will be able to:

1. Understand and use the engineering curves in engineering applications and projection techniques to construct conic curves, points and lines.
2. Develop skills in projecting surfaces and solids and create 2D models using CAD software.
3. Develop skills in 3D projection and 3D 20odelling of simple parts manually as well as using CAD software.
4. Understand and apply sectioning techniques to solids and assemble components.
5. Develop skills in lateral surface development and sheet metal design.

INTRODUCTION

Manual drawing tools (Mini Drafter, Set Squares, Protractor, Compass, and different grades of pencil). **'**BIS' specifications and rules of Engineering Drawing – Arrows (2H thin line body, HB Filled head and L:W = 3:1 ratio), lettering (Digital fonts, font sizes pertaining to usage and representation), types of line and their syntax (Drawing based – Continuous thin & thick, dashed, dashed dotted and Application based – extension, dimensioning, construction, projection, reference, axis, section, hatching, and break lines), scaling (up, down and equal), and dimensioning. Placing and positioning the 'A3' size drawing sheet over the drawing table. Principal planes and projection, Division of line and circle in to equal parts, and construction of polygons

UNIT i: ENGINEERING CURVES, PROJECTION OF POINTS AND LINES 6+12

Construction of conic curves with their tangent and normal – ellipse, parabola, and hyperbola by eccentricity method

Construction of special curves with their tangent and normal – cycloid, epicycloid, and involute

Projection of points and I angle projection of lines inclined to both principal planes by rotating line method and trapezoidal rule – marking their traces.

Lab exercises: Study exercise – Introduction to Sketching (or) Drawing, and modification tools in CAD software (AutoCAD, CREO, CATIA, Solid Works, Inventor, Fusion 360)

Activities based learning: Identification of the curves used in the application given in the flash card, demonstration of the instantaneous centre of rotation of governors with respect to angle of inclination of the arms of the governors

UNIT II PROJECTION OF SURFACES & SOLIDS, AND 2D MODELING 6+12

Projection of surfaces inclined to both the principal planes – polygonal, trapezoidal, rhomboidal and circular

Projection of solids – prisms, pyramids, and axisymmetric solids when the axis inclined to both the principal planes – freely hanging – contour resting condition on either of the planes by rotating object method

Lab exercises: Construction of basic sketches – lines, circle, polygon, spline curves, coils, along with dimensioning. Familiarizing with geometric constraints and their types

Activities based learning: Making the solids using cardboards, shadow mapping and contour drawing at different orientation of the solids using torches,

UNIT III 3D PROJECTION OF SOLIDS AND 3D MODELING OF SIMPLE PARTS 6+12

Free hand sketching – I & III angle projections of engineering parts and components

Isometric projection of combination of solids – prisms, pyramids, axisymmetric solids, frustum

Perspective projection of prisms, pyramids and axisymmetric solids by visual ray method

Lab exercises: 3D Modeling and 2D drafting of machine parts

Activities based learning: Flipped classroom for Free hand sketching, Jig saw activity for Isometric projection, arts and crafts for perspective view

UNIT IV SECTION OF SOLIDS AND SECTIONED DRAFTING OF ASSEMBLED COMPONENTS 6+12

Section of simple and hollow solids – prisms, pyramids and axisymmetric solids, solids with holes/ slots when the section plane perpendicular to one principal plane and inclined to other principal plane (‘On the axis’ and ‘from the axis’ conditions)

Application based – section of beams (I, T, L, and C), section of pipe bracket, wood joints, composite walls, shells, flange of a coupling and other similar applications

Lab exercises: Assembly of parts with respect to engineering constraints, and sectioned drafting of assembled components

Activities based learning: Making of mitered joint in wood, sectioning the beams in different angles of orientation and identifying the true shape

UNIT V LATERAL SURFACE DEVELOPMENT AND SHEET METAL DESIGN 6+12

Lateral surface development of sectioned solids when the section plane perpendicular to VP and inclined to HP.

Application based – construction of funnel, chimney, dish antenna, door latch, trays, AC vents, lamp shade, commercial packaging boxes with respect to sectioning conditions and other similar applications

Lab exercises: Sheet metal design and drafting, drafting of coils, springs and screw threads

Activities based learning: Fabrication of funnels, chimney, lamp shade, boxes using card boards, ply woods, acrylics

Total: 90 Hours

Note: Activities based learning should not be covered in the regular class hours. It should be given as assignments to the group of maximum 3 members

Question pattern suggestion: Part – A (Either or type) (5 × 16 = 80) & Part – B (Compulsory) (1 × 20 = 20)

COURSE OUTCOME:-

After successful completion of the course, the students will be able to:

CO1: Construct and identify different types of conic curves and special curves, and project the points and lines pertaining to engineering applications

CO2: Project and visualize surfaces and solids in different orientations and utilize the CAD tools for designing.

CO3: Create and draft accurate 3D models and 2D drawings of machine parts manually as well as using CAD softwares

CO4: Determine the true shape of a sectioned solid and draft the assemble parts accordingly

CO5: Develop lateral surfaces of sectioned solids and design sheet metal components

TEXTBOOKS:

1. Engineering Drawing" by N S Parthasarathy and Vela Murali
2. Engineering Drawing and Graphics with Auto CAD" by Venugopal K

REFERENCE BOOKS:

1. "Basic Engineering Drawing: Mechanical Semester Pattern" by Mehta and Gupta
2. "Engineering Drawing" by Basant Agrawal and C M Agrawal
3. "Engineering Drawing With Auto CAD" by B V R Gupta
4. "Engineering Drawing" by P S Gill
5. "Engineering Drawing with an Introduction to AutoCAD" by Dhananjay Jolhe
6. "Engineering Drawing" by M B Shah
7. "Fundamentals of Engineering Drawing" by Imtiaz Hashmi
8. "Computer Aided Engineering Drawing" by S Trymbaka Murthy
9. "CAED : Computer Aided Engineering Drawing for I/II Semester BE/Btech Courses" by Reddy K B
10. "Computer-Aided Engineering Drawing" by Subrata Pal

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	3	3	2		1				3	1		3	3	3	2
2	3	3	2		2				3	2		3	3	3	2
3	3	3	3	1	2				3	3		3	3	3	2
4	3	3	3	1	3				3	3		3	3	3	2
5	3	3	3	1	3				3	3		3	3	3	2

		L	T	P	C
EE23C03	BASICS OF ELECTRICAL AND ELECTRONICS ENGINEERING	2	0	2	3

UNIT-I BASIC ELECTRICAL CIRCUITS **6**

Basic Elements: R,L,C- DC Circuits: Ohm's Law - Kirchhoff's Laws –Mesh and Nodal Analysis(Only Independent Sources). AC Circuits: Average Value, RMS Value, Impedance Instantaneous Power, Real Power, Reactive Power and Apparent Power, Power Factor-Steady state Analysis of RL,RC and RLC circuits.

UNIT II AC AND DC MACHINES **6**

Magnetic Circuit Fundamentals -DC Machines - Construction and Working Principle, Types and Application of DC generator and Motor, EMF and Torque Equation.
AC Machines: Principle, Construction, Working and Applications of Transformer -Three phase Alternator - Three Phase Induction Motor.

UNIT III ANALOG AND DIGITAL ELECTRONICS **6**

Operation and Characteristics of electronic devices: PN Junction Diodes, Zener Diode and BJT Applications: Diode Bridge Rectifier and Shunt Regulator.
Introduction to Digital Electronics: Basics Logic Gates-Flip Flops.

UNIT IV SENSORS AND TRANSDUCERS **6**

Solenoids, electro-pneumatic systems, proximity sensors, limit switches, Strain gauge, LVDT, Piezo electric transducer, optical and digital transducers, Smart sensors, Thermal Imagers.

UNIT V MEASUREMENTS AND INSTRUMENTATION **6**

Functional Elements of an Instrument, Operating Principle of Moving Coil and Moving Iron Instruments,Power Measurement, Energy Meter, Instrument Transformers - CT and PT, Multimeter- DSO - Block Diagram Approach.

TOTAL 30

LAB COMPONENET:

1. Verification of ohms and Kirchhoff's Laws.
2. Load test on DC Shunt Motor.
3. Load test on Single Phase Transformer.
4. Load test on 3 Phase Induction Motor.
5. Uncontrolled diode bridge Rectifiers.
6. Application of Zener diode as shunt regulator.
7. Verification of truth table of logic gates and flip flops.
8. Characteristics of LVDT.
9. Three phase power measurement using two wattmeter method.
10. Study of DSO.

COURSE OUTCOMES:

Students will be able to

CO1	Compute the electric circuit parameters for simple circuits.
CO2	Understand the working principles and characteristics of electrical machines.
CO3	Understand the basic electronic devices.
CO4	Understand the basic operating principles of sensors and transducer.
CO5	Understand the operating principles measuring devices

TEXT BOOKS:

1. Kotharai DP and Nagarath IJ, “Basic Electrical and Electronics Enigneering”, McGraw Hill Education, Second Edition, 2020.
2. Bhattacharya SK, “Basic Electrical and Electronics Engineering”, Pearson Education, Second Edition, 2017.

REFERENCES:

1. Mehta V.K. & Mehta Rohit, “Principles of Electrical Engineering and Electronics”, McGraw Hill Education, Second Edition, 2020.
2. Mehta V.K. & Mehta Rohit, “Principles of Electrical Machines”, S. Chand Publishing, second edition 2006.
3. Albert Malvino & David Bates, “Electronic principles”, McGraw Hill Education, Seventh Edition, 2017.

Mapping COs and POs:

COs	Pos												PSOs			
	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	2	1														
CO2	2	1														
CO3	2	1														
CO4	2	1														
CO5	2	1														
Avg	2	1														

ME23C05	BASICS OF MECHANICAL ENGINEERING	L	T	P	C
		2	0	0	2

UNIT I CASTING, FORMING, AND WELDING PROCESSES 6

Sand casting, lathe machine and its parts, lathe machine operations (turning, taper turning, facing, chamfering, etc.), Drilling, forming process – Bulk Deformation (Forging, Rolling), Sheet metal operation (Blanking, punching) – Demonstration of relevant experiments

UNIT II WELDING AND ADDITIVE MANUFACTURING 6

Welding – types, Shielded Metal Arc Welding, gas welding, MIG and TIG welding, Additive manufacturing : Types and its applications - Demonstration of relevant experiments

UNIT III THERMODYNAMICS 6

Basic Terminologies related to Thermodynamics, zeroth Law, First Law of thermodynamics, Second Law of thermodynamics, Third Law of thermodynamics, Vapor compression cycle , Air Conditioner and Refrigerator-Demonstration of relevant experiments

UNIT IV IC ENGINES AND RECENT DEVELOPMENTS 6

Introduction to IC Engine, 2 stroke Engine, 4 Stroke Engine, Petrol Engine, Diesel Engine – Demonstration Electric Vehicles - Introduction & Challenges –Demonstration of relevant experiments.

UNIT V POWER PLANT ENGINEERING 6

Coal based power plants- working, advantages & disadvantages, Hydro Electric power plants- working, advantages & disadvantages, nuclear power plants- Types, working, advantages & disadvantages, solar power plant- working, advantages & disadvantages, wind-based power generation- working, advantages & disadvantages.

TOTAL: 30 PERIODS

COURSE OUTCOMES:

Upon completion of the course, the students will be able to

- **CO1** Discuss the basic concepts of casting, forming, and machining processes
- **CO2** Explain welding, and Additive manufacturing
- **CO3** Discuss the basics laws and application of thermodynamics
- **CO4** Summarize the basics of IC engines, electric vehicles.
- **CO5** Explain various power generation methods

TEXT BOOKS:

1. Nag, P.K., “Engineering Thermodynamics “, IInd Edition, Tata McGraw Hill Publishing Co., Ltd., 1995.
2. Rajput, R .K, “Thermal Engineering”, Laxmi publications (P) Ltd, 2001.
3. Khurmi R.S., and Gupta J.K, “Theory of Machines”, Eurasia Publishing House (P) Ltd., 2004.
4. A TEXTBOOK OF MANUFACTURING TECHNOLOGY by RK Rajput, December 2007, Panchu Publisher

5. A Text-Book of Production Technology Volume I by O.P.KHANNA, Dhanpat Rai publications

REFERENCES:

1. Additive Manufacturing Technologies, Ian Gibson, David Rosen, Brent Stucker, Springer New York, NY, https://doi.org/10.1007/978-1-4939-2113-3.
2. Electric Vehicles, Modern Technologies and Trends, Nil Patel, Akash Kumar Bhoi, Sanjeevikumar Padmanaban, Jens Bo Holm-Nielsen, Spring3er Singapore, https://doi.org/10.1007/978-981-15-9251-5

Mapping COs and POs:

COs	POs												PSOs			
	PO1	PO 2	PO 3	PO4	PO 5	PO 6	PO7	PO 8	PO9	PO1 0	PO1 1	PO 12	PS O1	PS O2	PS O3	PS O4
CO1	3	-	-	-	2	-	2	-	-	-	-	2	3	-	1	-
CO2	3	-	-	-	2	-	2	-	-	-	-	2	3	-	1	-
CO3	3	-	-	-	2	-	2	-	-	-	-	2	3	-	1	-
CO4	3	-	-	-	2	-	2	-	-	-	-	2	3	-	1	-
CO5	3	-	-	-	2	-	2	-	-	-	-	2	3	-	1	-
Avg	3	-	-	-	2	-	2	-	-	-	-	2	3	-	1	-

UC23H01	தமிழர் மரபு	L	T	P	C
		1	0	0	1

அலகு I மொழி மற்றும் இலக்கியம் 3

இந்திய மொழிக் குடும்பங்கள் – திராவிட மொழிகள் – தமிழ் ஒரு செம்மொழி – தமிழ் செவ்விலக்கியங்கள் - சங்க இலக்கியத்தின் சமயச் சார்பற்ற தன்மை – சங்க இலக்கியத்தில் பகிர்தல் அறம் – திருக்குறளில் மேலாண்மைக் கருத்துக்கள் – தமிழ்க் காப்பியங்கள், தமிழகத்தில் சமண பௌத்த சமயங்களின் தாக்கம் - பக்தி இலக்கியம், ஆழ்வார்கள் மற்றும் நாயன்மார்கள் – சிற்றிலக்கியங்கள் – தமிழில் நவீன இலக்கியத்தின் வளர்ச்சி – தமிழ் இலக்கிய வளர்ச்சியில் பாரதியார் மற்றும் பாரதிதாசன் ஆகியோரின் பங்களிப்பு.

அலகு II மரபு – பாறை ஓவியங்கள் முதல் நவீன ஓவியங்கள் வரை – சிற்பக் கலை 3

நடுகல் முதல் நவீன சிற்பங்கள் வரை – ஐம்பொன் சிலைகள்– பழங்குடியினர் மற்றும் அவர்கள் தயாரிக்கும் கைவினைப் பொருட்கள், பொம்மைகள் – தேர் செய்யும் கலை – சுடுமண் சிற்பங்கள் – நாட்டுப்புறத் தெய்வங்கள் – குமரிமுனையில் திருவள்ளுவர் சிலை – இசைக் கருவிகள் – மிருதங்கம், பறை, வீணை, யாழ், நாதஸ்வரம் – தமிழர்களின் சமூக பொருளாதார வாழ்வில் கோவில்களின் பங்கு.

அலகு III நாட்டுப்புறக் கலைகள் மற்றும் வீர விளையாட்டுகள்: 3

தெருக்கூத்து, கரகாட்டம், வில்லுப்பாட்டு, கணியான் கூத்து, ஒயிலாட்டம், தோல்பாவைக் கூத்து, சிலம்பாட்டம், வளரி, புலியாட்டம், தமிழர்களின் விளையாட்டுகள்.

அலகு IV தமிழர்களின் திணைக் கோட்பாடுகள்: 3

தமிழகத்தின் தாவரங்களும், விலங்குகளும் – தொல்காப்பியம் மற்றும் சங்க இலக்கியத்தில் அகம் மற்றும் புறக் கோட்பாடுகள் – தமிழர்கள் போற்றிய அறக்கோட்பாடு – சங்ககாலத்தில் தமிழகத்தில் எழுத்தறிவும், கல்வியும் – சங்ககால நகரங்களும் துறை முகங்களும் – சங்ககாலத்தில் ஏற்றுமதி மற்றும் இறக்குமதி – கடல்கடந்த நாடுகளில் சோழர்களின் வெற்றி.

அலகு V இந்திய தேசிய இயக்கம் மற்றும் இந்திய பண்பாட்டிற்குத் தமிழர்களின் பங்களிப்பு: 3

இந்திய விடுதலைப்போரில் தமிழர்களின் பங்கு – இந்தியாவின் பிறப்பகுதிகளில் தமிழ்ப் பண்பாட்டின் தாக்கம் – சுயமரியாதை இயக்கம் – இந்திய மருத்துவத்தில், சித்த மருத்துவத்தின் பங்கு – கல்வெட்டுகள், கையெழுத்துப்படிகள் - தமிழ்ப் புத்தகங்களின் அச்சு வரலாறு.

TOTAL : 15 PERIODS

TEXT-CUM-REFERENCEBOOKS

1. தமிழக வரலாறு – மக்களும் பண்பாடும் – கே.கே. பிள்ளை (வெளியீடு: தமிழ்நாடு பாடநூல் மற்றும் கல்வியியல் பணிகள் கழகம்).
2. கணினித் தமிழ் – முனைவர் இல. சுந்தரம். (விகடன் பிரசுரம்).
3. கீழடி – வைகை நதிக்கரையில் சங்ககால நகர நாகரிகம் (தொல்லியல் துறை வெளியீடு)
4. பொருநை – ஆற்றங்கரை நாகரிகம். (தொல்லியல் துறை வெளியீடு)
5. Social Life of Tamils (Dr.K.K.Pillay) A joint publication of TNTB & ESC and RMRL – (in print)
6. Social Life of the Tamils - The Classical Period (Dr.S.Singaravelu) (Published by: International Institute of Tamil Studies.
7. Historical Heritage of the Tamils (Dr.S.V.Subatamanian, Dr.K.D. Thirunavukkarasu) (Published by: International Institute of Tamil Studies).
8. The Contributions of the Tamils to Indian Culture (Dr.M.Valarmathi) (Published by: International Institute of Tamil Studies.)
9. Keeladi - 'Sangam City C ivilization on the banks of river Vaigai' (Jointly Published by: Department ofArchaeology & Tamil Nadu Text Book and Educational Services Corporation, Tamil Nadu)
10. Studies in the History of India with Special Reference to Tamil Nadu (Dr.K.K.Pillay) (Publishedby: The Author)
11. Porunai Civilization (Jointly Published by: Department of Archaeology & Tamil Nadu Text Bookand Educational Services Corporation, Tamil Nadu)
12. Journey of Civilization Indus to Vaigai (R.Balakrishnan) (Published by: RMRL) – Reference Book.

UC23H01	HERITAGE OF TAMILS	L T P C 1 0 0 1

UNIT I LANGUAGE AND LITERATURE 3

Language Families in India-Dravidian Languages–Tamil as a Classical Language - Classical Literature in Tamil – Secular Nature of Sangam Literature – Distributive Justice in Sangam Literature - Management Principles in Thirukural - TamilEpicsandImpactofBuddhism&JainisminTamilLand-BakthiLiteratureAzhwarsandNayanmars - Forms of minor Poetry - Development of Modern literature in Tamil - Contribution of Bharathiyarand Bharathidhasan.

UNIT II HERITAGE - ROCK ART PAINTINGS TO MODERN ART – SCULPTURE 3

Hero stone to modern sculpture - Bronze icons - Tribes and their handicrafts-Art of temple car making - Massive Terracotta sculptures, Villagedeities, Thiruvalluvar Statue at Kanyakumari, Making of musical instruments-Mridhangam,Parai, Veenai, Yazh and Nadhaswaram - Role of Temples in Social and Economic Life of Tamils.

UNIT III FOLK AND MARTIAL ARTS 3

Therukoothu, Karagattam, VilluPattu, KaniyanKoothu, Oyillattam, Leatherpuppetry, Silambattam, Valari, Tiger dance - Sports and Games of Tamils.

UNIT IV THINAICONCEPTOFTAMILS 3

Flora and Fauna of Tamils&AhamandPuramConceptfromTholkappiyam and Sangam Literature - Aram Concept of Tamils - Education and Literacy during Sangam Age - Ancient Cities and Ports of Sangam Age - Export and Import duringSangamAge -Overseas Conquestof Cholas.

UNIT V CONTRIBUTION OF TAMILS TO INDIAN NATIONAL MOVEMENT AND INDIAN CULTURE 3

Contribution of Tamils toIndian Freedom Struggle - The Cultural Influence of Tamils over the other parts of India – Self-Respect Movement - RoleofSiddhaMedicine in Indigenous Systems of Medicine – Inscriptions & Manuscripts – Print History of Tamil Books.

TOTAL : 15 PERIODS

TEXT-CUM-REFERENCEBOOKS

1. தமிழக வரலாறு – மக்களும் பண்பாடும் – கே.கே. பிள்ளை (வெளியீடு: தமிழ்நாடு பாடநூல் மற்றும் கல்வியியல் பணிகள் கழகம்).
2. கணினித் தமிழ் – முனைவர் இல. சுந்தரம். (விகடன் பிரசுரம்).
3. கீழடி – வைகை நதிக்கரையில் சங்ககால நகர நாகரிகம் (தொல்லியல் துறை வெளியீடு)
4. பொருநை – ஆற்றங்கரை நாகரிகம். (தொல்லியல் துறை வெளியீடு)
5. Social Life of Tamils (Dr.K.K.Pillay) A joint publication of TNTB & ESC and RMRL – (in print)
6. Social Life of the Tamils - The Classical Period (Dr.S.Singaravelu) (Published by: International Institute of Tamil Studies.

7. Historical Heritage of the Tamils (Dr.S.V.Subatamanian, Dr.K.D. Thirunavukkarasu) (Published by: International Institute of Tamil Studies).
8. The Contributions of the Tamils to Indian Culture (Dr.M.Valarmathi) (Published by: International Institute of Tamil Studies.)
9. Keeladi - 'Sangam City C ivilization on the banks of river Vaigai' (Jointly Published by: Department ofArchaeology & Tamil Nadu Text Book and Educational Services Corporation, Tamil Nadu)
10. Studies in the History of India with Special Reference to Tamil Nadu (Dr.K.K.Pillay) (Publishedby: The Author)
11. Porunai Civilization (Jointly Published by: Department of Archaeology & Tamil Nadu Text Bookand Educational Services Corporation, Tamil Nadu)
12. Journey of Civilization Indus to Vaigai (R.Balakrishnan) (Published by: RMRL) – Reference Book.

NCC Credit Course Level 1*

UC23P01	(ARMY WING) NCC Credit Course Level - I	L T P C 2 0 0 2

NCC GENERAL		**6**
NCC 1	Aims, Objectives & Organization of NCC	1
NCC 2	Incentives	2
NCC 3	Duties of NCC Cadet	1
NCC 4	NCC Camps: Types & Conduct	2
NATIONAL INTEGRATION AND AWARENESS		**4**
NI 1	National Integration: Importance & Necessity	1
NI 2	Factors Affecting National Integration	1
NI 3	Unity in Diversity & Role of NCC in Nation Building	1
NI 4	Threats to National Security	1
PERSONALITY DEVELOPMENT		**7**
PD 1	Self-Awareness, Empathy, Critical & Creative Thinking, Decision Making and Problem Solving	2
PD 2	Communication Skills	3
PD 3	Group Discussion: Stress & Emotions	2
LEADERSHIP		**5**
L 1	Leadership Capsule: Traits, Indicators, Motivation, Moral Values, Honour 'Code	3
L 2	Case Studies: Shivaji, Jhasi Ki Rani	2
SOCIAL SERVICE AND COMMUNITY DEVELOPMENT		**8**
SS 1	Basics, Rural Development Programmes, NGOs, Contribution of Youth	3
SS 4	Protection of Children and Women Safety	1
SS 5	Road / Rail Travel Safety	1
SS 6	New Initiatives	2
SS 7	Cyber and Mobile Security Awareness	1

TOTAL : 30 PERIODS

NCC Credit Course Level 1*

UC23P02	**(NAVAL WING) NCC Credit Course Level – I**	**L T P C** **2 0 0 2**
NCC GENERAL		**6**
NCC 1	Aims, Objectives & Organization of NCC	1
NCC 2	Incentives	2
NCC 3	Duties of NCC Cadet	1
NCC 4	NCC Camps: Types & Conduct	2
NATIONAL INTEGRATION AND AWARENESS		**4**
NI 1	National Integration: Importance & Necessity	1
NI 2	Factors Affecting National Integration	1
NI 3	Unity in Diversity & Role of NCC in Nation Building	1
NI 4	Threats to National Security	1
PERSONALITY DEVELOPMENT		**7**
PD 1	Self-Awareness, Empathy, Critical & Creative Thinking, Decision Making and Problem Solving	2
PD 2	Communication Skills	3
PD 3	Group Discussion: Stress & Emotions	2
LEADERSHIP		**5**
L 1	Leadership Capsule: Traits, Indicators, Motivation, Moral Values, Honour Code	3
L 2	Case Studies: Shivaji, Jhasi Ki Rani	2
SOCIAL SERVICE AND COMMUNITY DEVELOPMENT		**8**
SS 1	Basics, Rural Development Programmes, NGOs, Contribution of Youth	3
SS 4	Protection of Children and Women Safety	1
SS 5	Road / Rail Travel Safety	1
SS 6	New Initiatives	2
SS 7	Cyber and Mobile Security Awareness	1

TOTAL : 30 PERIODS

NCC Credit Course Level 1*

UC23P03	**(AIR FORCE WING) NCC Credit Course Level – I**	**L**	**T**	**P**	**C**
		2	**0**	**0**	**2**

NCC GENERAL		**6**
NCC 1	Aims, Objectives & Organization of NCC	1
NCC 2	Incentives	2
NCC 3	Duties of NCC Cadet	1
NCC 4	NCC Camps: Types & Conduct	2
NATIONAL INTEGRATION AND AWARENESS		**4**
NI 1	National Integration: Importance & Necessity	1
NI 2	Factors Affecting National Integration	1
NI 3	Unity in Diversity & Role of NCC in Nation Building	1
NI 4	Threats to National Security	1
PERSONALITY DEVELOPMENT		**7**
PD 1	Self-Awareness, Empathy, Critical & Creative Thinking, Decision Making and Problem Solving	2
PD 2	Communication Skills	3
PD 3	Group Discussion: Stress & Emotions	2
LEADERSHIP		**5**
L 1	Leadership Capsule: Traits, Indicators, Motivation, Moral Values, Honour Code	3
L 2	Case Studies: Shivaji, Jhasi Ki Rani	2
SOCIAL SERVICE AND COMMUNITY DEVELOPMENT		**8**
SS 1	Basics, Rural Development Programmes, NGOs, Contribution of Youth	3
SS 4	Protection of Children and Women Safety	1
SS 5	Road / Rail Travel Safety	1
SS 6	New Initiatives	2
SS 7	Cyber and Mobile Security Awareness	1

TOTAL : 30 PERIODS

EN23C02	PROFESSIONAL COMMUNICATION	L T P C 2 0 2 3

COURSE OBJECTIVES:

- To read and comprehend different forms of official texts.
- To develop students' writing skills in professional context.
- To actively listen, read and understand written and oral communication in a professional context.
- To comprehend and analyse the visual content in authentic context.
- To write professional documents with clarity and precision

UNIT I CAUSE AND EFFECT 6

Reading – Newspaper articles on Social and Environmental issues; Writing – Instructions, Cause and effect essay; Grammar - Modal verbs; Vocabulary – Cause and effect, Idioms

LAB ACTIVITY: 6

Listening and Speaking – Listen to news reports and summarise in oral form.

UNIT II CLASSIFICATION 6

Reading – An article, social media posts and classifying based on the content; Writing – Definition, Note making, Note taking (Cornell notes etc.) and Summarising; Grammar – Connectives; Vocabulary – Phrasal verbs

LAB ACTIVITY: 6

Listening and speaking: Social interaction (Conversation including small talk)

UNIT III PROBLEM AND SOLUTION 6

Reading – Visual content (Tables/charts/graphs) for comprehension; Writing - Problem and Solution Essay; Grammar – If conditionals; Vocabulary – Sequential words.

LAB ACTIVITY: 6

Listening – Group discussion; Speaking – Participating in a group discussion

UNIT IV REPORT 6

Reading – Formal report on accidents (industrial/engineering); Writing – Industrial Accident report; Grammar – Active and passive voice, Direct and Indirect speech; Vocabulary – Numerical adjectives.

LAB ACTIVITY: 6

Listening / watching – Television documentary and discussing its content, purpose etc.

UNIT V JOB APPLICATION AND INTERVIEW 6

Reading - Job advertisement and company profile; Writing – Job application (cover letter and CV) Grammar – Mixed Tenses; Vocabulary – Collocations related to work environment

LAB ACTIVITY: 6

Listening – Job interview; Speaking – Mock interviews

TOTAL: 60 PERIODS

TEACHING METHODOLOGY

Interactive lectures, role plays, group discussions, listening and speaking labs, technology enabled language teaching, flipped classroom.

EVALUATION PATTERN

Internal Assessment
- Written assessments
- Assignment

Lab Assessment
- Group discussion (Peer assessment)
- Listening

External Assessment
End Semester Examination

LEARNING OUTCOMES

By the end of the courses, students will be able to
- To apply appropriate language structure and vocabulary to enhance both spoken and written communication in formal contexts.
- Comprehend different forms of official documents
- Write professional documents coherently and cohesively.
- Interpret verbal and graphic content in authentic context
- Analyse and evaluate verbal and audio visual materials.

TEXT BOOKS:

1. “English for Engineers and Technologists” Volume 2 by Orient Blackswan, 2022
2. “English for Science & Technology - II” by Cambridge University Press, 2023.

REFERENCES:

1. “Communicative English for Engineers and Professionals” by Bhatnagar Nitin, Pearson India, 2010.
2. ”Take Off – Technical English for Engineering” by David Morgan, Garnet Education, 2008.
3. “Advanced Communication Skills” by Mathew Richardson, Charlie Creative Lab, 2020.
4. www.uefap.com

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1										√		√
CO2										√		√
CO3										√		√
CO4										√		√
CO5										√		√

MA23C02	ORDINARY DIFFERENTIAL EQUATIONS AND TRANSFORM TECHNIQUES	L	T	P	C
		3	1	0	4

OBJECTIVES:

- To acquaint the students with Differential Equations which are significantly used in engineering problems.
- To make the students to understand the Laplace transforms techniques.
- To develop the analytic solutions for partial differential equations used in engineering by Fourier series.
- To acquaint the student with Fourier transform techniques used in wide variety of situations in which the functions used are not periodic.
- To develop Z- transform techniques in solving difference equations.

UNIT I ORDINARY DIFFERENTIAL EQUATIONS 9+3

Homogeneous linear ordinary differential equations of second order -superposition principle - general solution- Particular integral - Operator method - Solution by variation of parameters - Method of undetermined coefficients - Homogeneous equations of Euler–Cauchy and Legendre's type – System of simultaneous linear differential equations with constant coefficients.

UNIT II LAPLACE TRANSFORMS 9+3

Existence theorem - Transform of standard functions – Transform of Unit step function and Dirac delta function – Basic properties - Shifting theorems - Transforms of derivatives and integrals – Transform of periodic functions - Initial and Final value theorem - Inverse Laplace transforms- Convolution theorem (without proof) – Solving Initial value problems by using Laplace Transform techniques.

UNIT III FOURIER SERIES 9+3

Dirichlet's conditions – General Fourier series – Odd and even functions – Half-range Sine and Cosine series – Complex form of Fourier series – Parseval's identity – Computation of harmonics.

UNIT IV FOURIER TRANSFORMS 9+3

Fourier integral theorem – Fourier transform pair - Fourier sine and cosine transforms – Properties – Transform of elementary functions – Inverse Fourier Transforms - Convolution theorem (without proof) – Parsevals's identity.

UNIT V Z – TRANSFORM AND DIFFERENCE EQUATIONS 9+3

Z-transform – Properties of Z-transform – Inverse Z-transform – Convolution theorem – Evaluation of Inverse Z transform using partial fraction method and convolution theorem - Initial and final value theorems – Formation of difference equations – Solution of difference equations using Z - transform.

TOTAL: 60 PERIODS

Laboratory based exercises / assignments / assessments will be given to students from the content of the course wherever applicable.

Branch specific / General Engineering applications based on the content of each units will be introduced to students wherever possible.

Suggested Laboratory based exercises / assignments / assessments :

Ordinary differential equations

1. Symbolic computation of linear ordinary differential equations
2. Solving System of simultaneous linear differential equations using ODE SOLVER

Laplace transforms

1. Symbolic computation of Laplace transform and Inverse Laplace transform
2. Plotting Laplace transforms

Fourier Series

1. Symbolic computation of Fourier Coefficients
2. Computation of harmonics
3. Plotting truncated Fourier Series

Fourier Transform

1. Symbolic computation of Fourier Transforms
2. Plotting truncated Fourier Transforms

Z – transform

1. Symbolic computation of Z-Transforms

OUTCOMES:

CO1 :Solve higher order ordinary differential equations which arise in engineering applications.
CO2 :Apply Laplace transform techniques in solving linear differential equations.
CO3 :Apply Fourier series techniques in engineering applications.
CO4 :Understand the Fourier transforms techniques in solving engineering problems.
CO5 :Understand the Z-transforms techniques in solving difference equations.

TEXT BOOKS:

1. Grewal B.S., “Higher Engineering Mathematics”, Khanna Publishers, 45th Edition, New Delhi, 2020.
2. Erwin Kreyszig, "Advanced Engineering Mathematics", 10th Edition, Wiley India Pvt Ltd., New Delhi, 2018.

REFERENCES:

1. N.P. Bali and Manish Goyal, A text book of Engineering Mathematics, Laxmi Publications, Reprint, 2008
2. Greenberg M.D., “Advanced Engineering Mathematics”, Pearson Education2nd Edition, 5th Reprint, Delhi, 2009.
3. Jain R.K. and Iyengar S.R.K., “Advanced Engineering Mathematics”,Narosa Publications, 5 th Edition, New Delhi, 2017.
4. Peter V.O’Neil, “Advanced Engineering Mathematics”, Cengage Learning India Pvt., Ltd, 7 th Edition, New Delhi , 2012.
5. Ramana B.V., “Higher Engineering Mathematics”, Tata McGraw Hill Co. Ltd., 11th Reprint, New Delhi, 2010.

CO – PO Mapping:

Course Outcomes	PROGRAMME OUTCOMES											
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**P10**	**P11**	**P12**
CO 1 :	3	3	2	3	1	2	1	1	1	1	1	3
CO 2 :	3	3	2	3	1	2	1	1	1	1	1	3
CO 3 :	3	3	2	3	1	2	1	1	1	1	1	3
CO 4 :	3	3	2	3	1	2	1	1	1	1	1	3
CO 5 :	3	3	2	3	1	2	1	1	1	1	1	3

CY23C01 ENGINEERING CHEMISTRY L T P C
3 0 2 4

UNIT I WATER TECHNOLOGY

Water – sources and impurities – water quality parameters: colour, odour, pH, hardness, alkalinity, TDS, COD, BOD, and heavy metals. Boiler feed water – requirement – troubles (scale & sludge, caustic embrittlement, boiler corrosion and priming & foaming. Internal conditioning – phosphate, Calgon, and carbonate treatment. External conditioning – demineralization. Municipal water treatment (screening, sedimentation, coagulation, filtration, disinfection-ozonolysis, UV treatment, chlorination), Reverse Osmosis – desalination.

PRACTICAL:

- Estimation of HCl using Na_2CO_3 as the primary standard
- Determination of alkalinity in the water sample.
- Determination of hardness of water by EDTA method.
- Determination of DO content of water sample by Winkler's method.

UNIT II NANOCHEMISTRY

Basics-distinction between molecules, nanomaterials and bulk materials; size-dependent properties (optical, electrical, mechanical, magnetic and catalytic). Types –nanoparticle, nanocluster, nanorod, nanowire and nanotube. Preparation of nanomaterials: sol-gel, solvothermal, laser ablation, chemical vapour deposition, electrochemical deposition and electro-spinning. Characterization - Scanning Electron Microscope and Transmission Electron Microscope - Principle and instrumentation (block diagram). Applications of nanomaterials – medicine including AYUSH, automobiles, electronics, and cosmetics.

PRACTICAL:

- Preparation of nanoparticles by Sol-Gel method/sonication method.
- Preparation of nanowire by Electrospinning.
- Study of morphology of nanomaterials by scanning electron microscopy

UNIT III CORROSION SCIENCE

Introduction to corrosion – chemical and electrochemical corrosions – mechanism of electrochemical and galvanic corrosions – concentration cell corrosion-soil, pitting, inter-granular, water line, stress and microbiological corrosions-galvanic series-factors influencing corrosion-measurement of corrosion rate. Electrochemical protection – sacrificial anodic protection and impressed current cathodic protection. Protective coatings-metallic coatings (galvanizing, tinning), organic coatings (paints). Paints: Constituents and functions.

PRACTICAL:

- Corrosion experiment-weight loss method.
- Salt spray test for corrosion study.
- Corrosion prevention by electroplating.
- Estimation of corroded Iron by Potentiometry/UV-visible spectrophotometer

UNIT IV ENERGY SOURCES

Electrochemical cell, redox reaction, electrode potential – oxidation and reduction potential. Batteries – Characteristics; types of batteries; primary battery (dry cell), secondary battery (lead

acid, lithium-ion battery) and their applications. Emerging energy sources – metal hydride battery, hydrogen energy, Fuel cells – H_2-O_2 fuel cell. Supercapacitors –Types and Applications, Renewable Energy: solar heating and solar cells. Recycling and disposal of batteries.

PRACTICAL:

- Study of components of Lead acid battery.
- Measurement of voltage in a photovoltaic cell.
- Working of $H_2 – O_2$ fuel cell

UNIT V POLYMER CHEMISTRY

Introduction: Functionality-degree of polymerization. Classification of polymers (Source, Structure, Synthesis and Intermolecular forces). Mechanism of free radical addition polymerization. Properties of polymers: Tg, tacticity, molecular weight-number average, weight average, viscosity average and polydispersity index (Problems). Techniques of polymerization: Bulk, emulsion, solution and suspension. Compounding and Fabrication Techniques: Injection, Extrusion, Blow and Calendaring. Polyamides, Polycarbonates and Polyurethanes – structure and applications. Recycling of polymers.

PRACTICAL:

- Determination of molecular weight of a polymer using Ostwald viscometer.
- Preparation of a polymer.
- Determination of molecular weight by Gel Permeation Chromatography.

TOTAL: 75 PERIODS

COURSE OUTCOMES:

CO1: To demonstrate knowledge of water quality in various industries and develop skills in analyzing water quality parameters for both domestic and industrial purposes.

CO2: To identify and apply fundamental concepts of nanoscience and nanotechnology for engineering and technology applications, and to develop skills in synthesizing nanomaterials and studying their morphology.

CO3: To apply fundamental knowledge of corrosion protection techniques and develop skills to conduct experiments for measuring and preventing corrosion.

CO4: To study the fundamentals of energy storage devices and develop skills in constructing and experimenting with batteries.

CO5: To recognize and apply basic knowledge of different types of polymeric materials and develop skills in preparing and determining their applications for futuristic material fabrication needs.

TEXT BOOKS:

1. Jain P. C. & Monica Jain., “Engineering Chemistry”, 17th Edition, Dhanpat Rai Publishing Company (P) Ltd, New Delhi, 2015.
2. Sivasankar B., “Engineering Chemistry”, Tata McGraw-Hill Publishing Company Ltd, New Delhi, 2012.

3. Dara S.S., “A Textbook of Engineering Chemistry”, Chand Publications, 2004.
4. Laboratory Manual - Department of Chemistry, CEGC, Anna University (2023).

REFERENCES:

1. Schdeva M.V., “Basics of Nano Chemistry”, Anmol Publications Pvt Ltd, 2011.
2. Friedrich Emich, “Engineering Chemistry”, Medtech, 2014.
3. Gowariker V.R., Viswanathan N.V. and Jayadev Sreedhar, “Polymer Science” New AGE International Publishers, 2009.
4. Vogel’s Textbook of Quantitative Chemical Analysis (8th edition, 2014).

CO - PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	-	-	-	-	3	-	-	-	-	-
CO2	3	-	2	-	2	-	3	-	-	-	-	-
CO3	3	3	2	-	2	-	3	-	-	-	-	-
CO4	3	3	-	-	-	-	3	-	-	-	-	-
CO5	3	-	-	-	-	-	3	-	-	-	-	-
Avg	3	3	-	-	-	-	3	-	-	-	-	-

1’ = Low; ‘2’ = Medium; ‘3’ = High

CS23C02 COMPUTER PROGRAMMING IN PYTHON

L	T	P	C
3	0	2	4

COURSE OBJECTIVES:

- To understand fundamental structural programming concepts and problem-solving process.
- To solve problems using modular programming and decomposition techniques.
- To solve problems using data structures and abstraction techniques.
- To create programming solutions using libraries and packages.
- To design solutions to domain problems using programming problem-solving techniques.

UNIT I – STRUCTURED PROGRAMMING 9+6

Problem-Solving Strategies. Basic Problem-Solving Tools: Flowcharts, Pseudocode. Introduction to Programming Languages and Development Environments. Programming. Basic Concepts and Syntax: Variables, Identifiers, Data Types: Primitive Types and Strings, Statements, Operators, Expressions and its evaluation, Operator Precedence, Basic Arithmetic Operations. Principles of Structured Programming – Control Structures: Sequence, Selection, Iteration and Branching.

PRACTICALS:

- Design algorithms for simple computational problems
- Create Pseudo-code and Flow charts for simple computational problems
- Create Python programs using simple and nested selective control statements
- Create Python programs using simple and nested sequence & iterative control statements
- Create Python programs to generate series/patterns using control statements

UNIT II – MODULARITY AND DECOMPOSITION 9+6

Principles of Modular and Decomposition. Functions: Defining functions –Argument types – Function Name-spaces – Scoping: Global and Non-local. Principles of Recursion: Base case and Recursive cases – Develop and Analyze Recursive functions: Factorial, Fibonacci. Principles of First-Class and Higher-Order functions: Lambda functions – Functions as arguments.

PRACTICALS:

- Create Python programs using functions
- Create python program using recursion
- Create Python programs using lambda functions
- Create Python programs using first-class functions
- Create Python programs using higher-order functions

UNIT III – DATA STRUCTURES AND ABSTRACTIONS 9+6

Principles of Data Structures and Abstractions. String Methods and Manipulations,.Lists: List Operations and Methods, List comprehensions, Nested List comprehensions, Matrix

operations using Lists. Tuples and sequences. Sets and Operations. Dictionaries: Dictionary operations, Dictionary comprehensions, Nested Dictionary comprehensions. Comparing Data Structures. Search and Sort Data Structures. Principle of Functional Programming and Tools : map, filter, and reduce.

PRACTICALS:

- Create Python programs for strings manipulations.
- Design Python programs using Lists, Nested Lists and Lists comprehensions
- Create Python programs using Tuples, Nested Tuples, and Tuple comprehensions
- Create Python programs creating Sets and performing set operations
- Create Python programs using Dictionary, Nested Dictionary and comprehensions
- Create Python programs by applying functional programming concepts

UNIT IV – LIBRARIES AND MODULES **9+6**

Exceptions: Syntax errors, Exceptions, Exception types, Handling exceptions, Raising exceptions. Files: File Path, Type of files, opening modes, Reading and Writing text files, Handling other format Data files. Modules: Creating Modules, import and from statements, Executing modules as scripts, Standard modules. Packages and Importing from packages

PRACTICALS:

- Design Python programs to handle errors and exceptions
- Create, import, and use pre-defined modules and packages
- Create, import, and use user-defined modules and packages
- Create Python programs to perform various operations on text files
- Create Python programs to perform various operations on other data file formats.

UNIT V – SIMPLE PROBLEM SOLVING TECHNIQUES IN PROGRAMMING **9+6**

Data Structures for Problem Solving: Stack, Queue. Principles of Divide and Conquer: Binary Search. Principles of Greedy Algorithms: Minimum Coin Change Problem. Case studies on programming application of problem-solving techniques in different fields of engineering.

PRACTICALS:

- Create python programs to implement stack and queue.
- Create python programs to implement binary search.
- Create python programs to solve minimum coin change problem.
- Case study on developing python solution to a domain specific problems.

TOTAL = 45 + 30 = 75 PERIODS

Course Outcomes

1. Understand fundamental structural programming concepts and problem-solving process.
2. Solve problems using modular programming and decomposition techniques.
3. Solve problems using data structures and abstraction techniques.
4. Create programming solutions using libraries and packages.
5. Design solutions to domain problems using programming problem-solving techniques.

TEXT BOOKS

1. Reema Thareja, Python Programming using Problem Solving Approach, Oxford University Press, First Edition, 2017.
2. S. Sridhar, J. Indumathi, V. M. Hariharan, Python Programming, Pearson Education, First Edition, 2023

REFERENCE BOOKS

1. Paul Deitel, Harvey Deitel, Python for Programmers, Pearson Education, 2020.
2. John V Guttag. Introduction to Computation and Programming Using Python, With Application to Computational Modeling and Understanding Data. Third Edition, The MIT Press, 2021
3. Mark Lutz, Learning Python, 5th Edition, O'Reilly Media, Inc.
4. Python official documentation and tutorial, https://docs.python.org/3/
5. Numerical Python official documentation and tutorial, https://numpy.org/

CO's-PO's & PSO's MAPPING

CO	PO1	PO2	PO3	PO4	POS	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	2		2		1								1	1	
2	2		2		1								1	1	
3	2	1	2		1								1	1	
4	2	1	2	1	1								1	1	
5	2	1	2	1	1								1	1	
Avg	2	1	2	1	1								1	1	

1 - low, 2 - medium, 3 - high, '-' - no correlation

ME23C03	ENGINEERING MECHANICS	L T P C
		3 1 0 4

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students for:
Determining the resultant forces acting on a particle in 2D and 3D and for applying methods of equilibrium on a particle in 2D and 3D.

Evaluating the reaction forces for bodies under equilibrium, for determining the moment of a force, moment of a couple, for resolving force into a force-couple system and for analyzing trusses

Assessing the centroids of 2D sections / center of gravity of volumes and for calculating area moments of inertia for the sections and mass moment of inertia of solids.

Evaluating the frictional forces acting at the contact surfaces of various engineering systems and for applying the work-energy principles on a particle.

Determining kinetic and kinematic parameters of the rigid bodies subjected to concurrent coplanar forces.

UNIT I STATICS OF PARTICLES 9+3

Fundamental Concepts and Principles, Systems of Units, Method of Problem Solutions, Statics of Particles -Forces in a Plane, Resultant of Forces, Resolution of a Force into Components, Rectangular Components of a Force, Unit Vectors. Equilibrium of a Particle- Newton's First Law of Motion, Space and Free-Body Diagrams, Forces in Space, Equilibrium of a Particle in Space.

UNIT II EQUILIBRIUM OF RIGID BODIES AND TRUSSES 9+3

Principle of Transmissibility, Equivalent Forces, Vector Product of Two Vectors, Moment of a Force about a Point, Varignon's Theorem, Rectangular Components of the Moment of a Force, Scalar Product of Two Vectors, Mixed Triple Product of Three Vectors, Moment of a Force about an Axis, Couple - Moment of a Couple, Equivalent Couples, Addition of Couples, Resolution of a Given Force into a Force -Couple system, Further Reduction of a System of Forces, Equilibrium in Two and Three Dimensions - Reactions at Supports and Connections – Analysis of Trusses – Method of Joints and Method of Sections.

UNIT III DISTRIBUTED FORCES 9+3

Centroids of lines and areas – symmetrical and unsymmetrical shapes, Determination of Centroids by Integration, Theorems of Pappus-Guldinus, Distributed Loads on Beams, Centre of Gravity of a Three-Dimensional Body, Centroid of a Volume, Composite Bodies, Determination of Centroids of Volumes by Integration.

Moments of Inertia of Areas and Mass - Determination of the Moment of Inertia of an Area by Integration , Polar Moment of Inertia , Radius of Gyration of an Area , Parallel-Axis Theorem , Moments of Inertia of Composite Areas, Moments of Inertia of a Mass - Moments of Inertia of Thin Plates , Determination of the Moment of Inertia of a Three-Dimensional Body by Integration.

UNIT IV FRICTION AND WORK PRINCIPLES 9+3

The Laws of Dry Friction. Coefficients of Friction, Angles of Friction, Wedges, Wheel Friction. Rolling Resistance, Ladder friction. Work of a Force, Kinetic Energy of a Particle, Principle of Work and Energy, Principle of Impulse and Momentum, Impact, Method of Virtual Work - Work of a Force, Potential Energy, Potential Energy and Equilibrium.

UNIT V DYNAMICS OF PARTICLES AND RIGID BODIES 9+3

Kinematics - Rectilinear Motion and Curvilinear Motion of Particles. Kinetics- Newton's Second Law of Motion -Equations of Motions, Dynamic Equilibrium, Energy and Momentum Methods – Kinematics of Rigid Bodies and Plane Kinetics.

TOTAL : 60 Periods

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

1. To determine the resultant forces acting on a particle in 2D and 3D and to apply methods of equilibrium on a particle in 2D and 3D.
2. Evaluate the reaction forces for bodies under equilibrium, to determine moment of a force, moment of a couple, to resolve force into a force-couple system and to analyze trusses
3. Assess the centroids of 2D sections / center of gravity of volumes and to calculate area moments of inertia for the sections and mass moment of inertia of solids.
4. Evaluate the frictional forces acting at the contact surfaces of various engineering systems and apply the work-energy principles on a particle. evaluate the kinetic and kinematic parameters of a particle.
5. Determine kinetic and kinematic parameters of the rigid bodies subjected to concurrent coplanar forces.

TEXT BOOKS:

1. Beer Ferdinand P, Russel Johnston Jr., David F Mazurek, Philip J Cornwell, Sanjeev Sanghi, Vector Mechanics for Engineers: Statics and Dynamics, McGraw Higher Education., 12th Edition, 2019.
2. Vela Murali, "Engineering Mechanics-Statics and Dynamics", Oxford University Press, 2018.

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	3	3	2	3									3		
2	3	3	2	3									3		
3	3	3	2	3									3		
4	3	3	2	3									3		
5	3	3	2	3									3		
Avg	3	3	2	3									3		

ME23C04	MAKERSPACE	L	T	P	C
		1	0	4	3

COURSE OBJECTIVES:

1. To practice the usage of various tools towards assembly and dis-assembly of different items / equipment.
2. To make simple part / component using welding processes.
3. To train on the basic wiring practices of boards, machines, etc.
4. To provide a hands-on experience on the use of electronic components, equipment, sensors and actuators.
5. To expose to modern computer tools and advanced manufacturing / fabrication processes.

LIST OF ACTIVITIES **1L,4P**

(A). Dis-assembly & Assembly Practices

i. Tools and its handling techniques.

ii. Dis-assembly and assembly of home appliances – Grinder Mixer Grinder, Ceiling Fan, Table Fan & Washing Machine.

iii. Dis-assembly and assembly of Air-Conditioners & Refrigerators.

iv. Dis-assembly and assembly of a Bicycle.

(B). Welding Practices

i. Welding Procedure, Selection & Safety Measures.

ii. Power source of Arc Welding – Gas Metal Arc Welding & Gas Tungsten Arc Welding processes.

iii. Hands-on session of preparing base material & Joint groove for welding.

iv. Hands-on session of MAW, GMAW, GTAW, on Carbon Steel & Stainless Stell plates / pipes, for fabrication of a simple part.

(C). Electrical Wiring Practices

i. Electrical Installation tools, equipment & safety measures.

ii. Hands-on session of basic electrical connections for Fuses, Miniature Circuit Breakers and Distribution Box,

iii. Hands-on session of electrical connections for Lightings, Fans, Calling Bells.

iv. Hands-on session of electrical connections for Motors & Uninterruptible Power Supply.

(D). Electronics Components / Equipment Practices

i. Electronic components, equipment & safety measures.

ii. Dis-assembly and assembly of Computers.

iii. Hands-on session of Soldering Practices in a Printed Circuit Breaker.

iv. Hands-on session of Bridge Rectifier, Op-Amp and Transimpedance amplifier.

v. Hands-on session of integration of sensors and actuators with a Microcontroller.

vi. Demonstration of Programmable Logic Control Circuit.

(E). Contemporary Systems

i. Demonstration of Solid Modelling of components.

ii. Demonstration of Assembly Modelling of components.

iii. Fabrication of simple components / parts using 3D Printers.

iv. Demonstration of cutting of wood / metal in different complex shapes using Laser Cutting Machine.

TOTAL: 75 Periods (15 Lecture + 60 Practical)

COURSE OUTCOMES:

Upon the successful completion of the course, students will be able to:

CO1: Assemble and dis-assemble various items / equipment.
CO2: Make simple parts using suitable welding processes.
CO3: Setup wiring of distribution boards, machines, etc.
CO4: Utilise the electronic components to fabricate a simple equipment, aided with sensors and actuators.
CO5: Take advantage of modern manufacturing practices.

REFERENCES:

1. Stephen Christena, Learn to Weld: Beginning MIG Welding and Metal Fabrication Basics, Crestline Books, 2014.

2. H. Lipson, Fabricated - The New World of 3D Printing, Wiley, 1st edition, 2013.
3. Code of Practice for Electrical Wiring Installations (IS 732:2019)
4. A.S. Sedra and K.C. Smith, Microelectronic Circuits, Oxford University Press, 7th ed. (Indian edition), 2017.
5. Mazidi, Naimi, Naimi, AVR Microcontroller and Embedded Systems: Using Assembly and C, Pearson India, 1st edition 2013.
6. Visualization, Modeling, and Graphics for Engineering Design, D.K. Lieu, S.A. Sorby, Cengage Learning; 2nd edition.

CE23C03	BASIC CIVIL ENGINEERING	L T P C 2 0 0 2

UNIT I CIVIL ENGINEERING MATERIALS **6**

Traditional materials - Stone, timber, brick, lime, cement - Mortars - Concrete - Metals - Bitumen - Paints - Tiles.

UNIT II BUILDING CONSTRUCTION **6**

Building elements - Planning - Types of buildings - Super structure - Substructure - Damp proofing.

UNIT III SURVEYING **6**

Principles of surveying - Classification of surveying - Chain surveying - Compass surveying - Levelling - Theodolite - Total station - GIS - Remote sensing.

UNIT IV WATER SUPPLY AND SANITATION **6**

Water supply engineering: Sources of water - Quality of water - Treatment.
Sanitary Engineering: Sewage - Sewage disposal - Septic tank - Treatment - Solid waste management.

UNIT V DISASTER MANAGEMENT **6**

Types of disaster - Earthquake - Wind - Cyclone - Flood - Fire - Precautions to be taken - Disaster management and planning.

TOTAL: 30 PERIODS

COURSE OUTCOMES:

On completion of this course, the student is expected to be able to:

CO1	Identify the civil engineering materials for construction
CO2	Gain knowledge on construction of buildings
CO3	Acquire basic knowledge on various types of surveying
CO4	Get familiarized with the importance of water supply and sanitary engineering
CO5	Gain awareness on various natural disasters and their mitigation

TEXTBOOKS:

1. Bhavikatti S. S., “Basic Civil Engineering”, New Age International Publishers, New Delhi, 2010.
2. Punmia B. C., Ashok K. Jain, Arun K. Jain, “Basic Civil Engineering”, Laxmi Publications (P) Ltd., New Delhi, 2004.

REFERENCES:

1. Varghese P. C., “Building Materials”, Prentice Hall of India Learning Pvt. Ltd., New Delhi, 2015.

2. Arora S. P. and Bindra S. P., “The Textbook of Building Construction”, Dhanpat Rai Publishing Co. Pvt. Ltd., 2019.
3. Kanetkar T. P. and Kulkarni S. V., “Surveying and Levelling”, Pune Vidyarthi Griha Prakashan Publications, Pune, 2015.
4. Santosh Kumar Garg, “Environmental Engineering Volumes I and II”, Khanna Publishers, New Delhi, 2010.
5. Subramanian R., “Disaster Management", Vikas Publishing House, New Delhi, 2018.

CO-PO-PSO MAPPING: BASIC CIVIL ENGINEERING

CO	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	3	2	3	2	3	3	3	3	2	2	3	3	3	3	3
2	3	2	3	2	3	3	3	3	3	3	2	3	3	3	3
3	3	3	3	3	3	2	2	3	2	2	3	3	3	3	3
4	2	2	2	2	3	2	1	1	1	1	1	1	3	3	3
5	2	2	3	2	2	3	3	2	3	2	2	3	3	3	3
Avg.	**3**	**2**	**3**	**2**	**3**	**3**	**2**	**2**	**2**	**2**	**2**	**3**	**3**	**3**	**3**

UC23H02 **தமிழரும் தொழில்நுட்பமும்** **L T P C**
1 0 0 1

அலகு I **நெசவு மற்றும் பானைத் தொழில்நுட்பம்**: **3**

சங்க காலத்தில் நெசவுத் தொழில் – பானைத் தொழில்நுட்பம் – கருப்பு சிவப்பு பாண்டங்கள் – பாண்டங்களில் கீறல் குறியீடுகள்.

அலகு II **வடிவமைப்பு மற்றும் கட்டிடத் தொழில்நுட்பம்**: **3**

சங்க காலத்தில் வடிவமைப்பு மற்றும் கட்டுமானங்கள் & சங்க காலத்தில் வீட்டுப் பொருட்களில் வடிவமைப்பு- சங்க காலத்தில் கட்டுமான பொருட்களும் நடுகல்லும் – சிலப்பதிகாரத்தில் மேடை அமைப்பு பற்றிய விவரங்கள் – மாமல்லபுரச் சிற்பங்களும், கோவில்களும் – சோழர் காலத்துப் பெருங்கோயில்கள் மற்றும் பிற வழிபாட்டுத் தலங்கள் – நாயக்கர் காலக் கோயில்கள் - மாதிரி கட்டமைப்புகள் பற்றி அறிதல், மதுரை மீனாட்சி அம்மன் ஆலயம் மற்றும் திருமலை நாயக்கர் மஹால் – செட்டிநாட்டு வீடுகள் – பிரிட்டிஷ் காலத்தில் சென்னையில் இந்தோ-சாரோசெனிக் கட்டிடக் கலை.

அலகு III **உற்பத்தித் தொழில் நுட்பம்**: **3**

கப்பல் கட்டும் கலை – உலோகவியல் – இரும்புத் தொழிற்சாலை – இரும்பை உருக்குதல், எஃகு – வரலாற்றுச் சான்றுகளாக செம்பு மற்றும் தங்க நாணயங்கள் – நாணயங்கள் அச்சடித்தல் – மணி உருவாக்கும் தொழிற்சாலைகள் – கல்மணிகள், கண்ணாடி மணிகள் – சுடுமண் மணிகள் – சங்கு மணிகள் – எலும்புத்துண்டுகள் – தொல்லியல் சான்றுகள் – சிலப்பதிகாரத்தில் மணிகளின் வகைகள்.

அலகு IV **வேளாண்மை மற்றும் நீர்ப்பாசனத் தொழில் நுட்பம்**: **3**

அணை, ஏரி, குளங்கள், மதகு – சோழர்காலக் குமுழித் தூம்பின் முக்கியத்துவம் – கால்நடை பராமரிப்பு – கால்நடைகளுக்காக வடிவமைக்கப்பட்ட கிணறுகள் – வேளாண்மை மற்றும் வேளாண்மைச் சார்ந்த செயல்பாடுகள் – கடல்சார் அறிவு – மீன்வளம் – முத்து மற்றும் முத்துக்குளித்தல் – பெருங்கடல் குறித்த பண்டைய அறிவு – அறிவுசார் சமூகம்.

அலகு V **அறிவியல் தமிழ் மற்றும் கணித்தமிழ்**: **3**

அறிவியல் தமிழின் வளர்ச்சி –கணித்தமிழ் வளர்ச்சி – தமிழ் நூல்களை மின்பதிப்பு செய்தல் – தமிழ் மென்பொருட்கள் உருவாக்கம் – தமிழ் இணையக் கல்விக்கழகம் – தமிழ் மின் நூலகம் – இணையத்தில் தமிழ் அகராதிகள் – சொற்குவைத் திட்டம்.

TOTAL : 15 PERIODS

TEXT-CUM-REFERENCE BOOKS

1. தமிழக வரலாறு – மக்களும் பண்பாடும் – கே.கே. பிள்ளை (வெளியீடு: தமிழ்நாடு பாடநூல் மற்றும்
   கல்வியியல் பணிகள் கழகம்).
2. கணினித் தமிழ் – முனைவர் இல. சுந்தரம். (விகடன் பிரசுரம்).

3. கீழடி – வைகை நதிக்கரையில் சங்ககால நகர நாகரிகம் (தொல்லியல் துறை வெளியீடு)
4. பொருநை – ஆற்றங்கரை நாகரிகம். (தொல்லியல் துறை வெளியீடு)
5. Social Life of Tamils (Dr.K.K.Pillay) A joint publication of TNTB & ESC and RMRL – (in print)
6. Social Life of the Tamils – The Classical Period (Dr.S.Singaravelu) (Published by: International Institute of Tamil Studies.
7. Historical Heritage of the Tamils (Dr.S.V.Subatamanian, Dr.K.D. Thirunavukkarasu) (Published by: International Institute of Tamil Studies).
8. The Contributions of the Tamils to Indian Culture (Dr.M.Valarmathi) (Published by: International Institute of Tamil Studies.)
9. Keeladi – 'Sangam City C ivilization on the banks of river Vaigai' (Jointly Published by: Department ofArchaeology & Tamil Nadu Text Book and Educational Services Corporation, Tamil Nadu)
10. Studies in the History of India with Special Reference to Tamil Nadu (Dr.K.K.Pillay) (Publishedby: The Author)
11. Porunai Civilization (Jointly Published by: Department of Archaeology & Tamil Nadu Text Bookand Educational Services Corporation, Tamil Nadu)
12. Journey of Civilization Indus to Vaigai (R.Balakrishnan) (Published by: RMRL) – Reference Book.

UC23H02 TAMILS AND TECHNOLOGY L T P C
1 0 0 1

UNIT I WEAVING AND CERAMIC TECHNOLOGY 3

Weaving Industry during Sangam Age – Ceramic technology – Black and Red Ware Potteries (BRW) – Graffiti on Potteries.

UNIT II DESIGN AND CONSTRUCTION TECHNOLOGY 3

Designing and Structural construction House & Designs in household materials during Sangam Age -Building materials and Hero stones of Sangam age – Details of Stage Constructions in Silappathikaram - Sculptures and Temples of Mamallapuram - Great Temples of Cholas and other worship places - Temples of Nayaka Period -Type study (Madurai Meenakshi Temple)-Thirumalai NayakarMahal -ChettiNadu Houses, Indo-Saracenic architecture at Madras during British Period.

UNIT III MANUFACTURING TECHNOLOGY 3

Art of Ship Building - Metallurgical studies -Iron industry - Iron smelting, steel -Copper and gold-Coins as source of history - Minting of Coins – Beads making-industries Stonebeads -Glass beads - Terracotta beads -Shell beads/ bone beats - Archeological evidences - Gem stone types described in Silappathikaram.

UNIT IV AGRICULTURE ANDIRRIGATION TECHNOLOGY 3

Dam, Tank, ponds, Sluice, Significance of KumizhiThoompuof Chola Period,Animal Husbandry - Wells designed for cattle use - Agriculture and Agro Processing -KnowledgeofSea -Fisheries – Pearl - Conche diving - Ancient Knowledge ofOcean -KnowledgeSpecificSociety.

UNIT V SCIENTIFIC TAMIL & TAMIL COMPUTING 3

Development of Scientific Tamil - Tamil computing – Digitalization of Tamil Books – Development of Tamil Software – Tamil Virtual Academy – Tamil Digital Library – Online Tamil Dictionaries – Sorkuvai Project.

TOTAL : 15 PERIODS

TEXT-CUM-REFERENCEBOOKS

1. தமிழக வரலாறு – மக்களும் பண்பாடும் – கே.கே. பிள்ளை (வெளியீடு: தமிழ்நாடு பாடநூல் மற்றும் கல்வியியல் பணிகள் கழகம்).
2. கணினித் தமிழ் – முனைவர் இல. சுந்தரம். (விகடன் பிரசுரம்).
3. கீழடி – வைகை நதிக்கரையில் சங்ககால நகர நாகரிகம் (தொல்லியல் துறை வெளியீடு)
4. பொருநை – ஆற்றங்கரை நாகரிகம். (தொல்லியல் துறை வெளியீடு)
5. Social Life of Tamils (Dr.K.K.Pillay) A joint publication of TNTB & ESC and RMRL – (in print)
6. Social Life of the Tamils – The Classical Period (Dr.S.Singaravelu) (Published by: International Institute of Tamil Studies.
7. Historical Heritage of the Tamils (Dr.S.V.Subatamanian, Dr.K.D. Thirunavukkarasu) (Published by: International Institute of Tamil Studies).
8. The Contributions of the Tamils to Indian Culture (Dr.M.Valarmathi) (Published by: International Institute of Tamil Studies.)
9. Keeladi – 'Sangam City C ivilization on the banks of river Vaigai' (Jointly Published by: Department ofArchaeology & Tamil Nadu Text Book and Educational Services Corporation, Tamil Nadu)
10. Studies in the History of India with Special Reference to Tamil Nadu (Dr.K.K.Pillay) (Publishedby: The Author)
11. Porunai Civilization (Jointly Published by: Department of Archaeology & Tamil Nadu Text Bookand Educational Services Corporation, Tamil Nadu)
12. Journey of Civilization Indus to Vaigai (R.Balakrishnan) (Published by: RMRL) – Reference Book.

MA23C05	PROBABILITY AND STATISTICS	L	T	P	C
		3	1	0	4

OBJECTIVES:

- To understand the basics of random variables with emphasis on the standard discrete and continuous distributions.
- To understand the basic probability concepts with respect to two dimensional random variables along with the relationship between the random variables and the significance of the Central Limit theorem.
- To understand the basic concepts of sampling distributions and statistical properties of point and interval estimators.
- To apply the small/ large sample tests through Tests of hypothesis.
- To understand the concept of analysis of variance and use it to investigate factorial dependence.

UNIT I ONE-DIMENSIONAL RANDOM VARIABLES 9+3

Discrete and continuous random variables – Moments – Moment generating functions – Binomial, Poisson, Geometric, Uniform, Exponential, Gamma and Normal distributions – Functions of a random variable.

UNIT II TWO-DIMENSIONAL RANDOM VARIABLES 9+3

Joint distributions – Marginal and conditional distributions – Covariance – Correlation and Linear regression – Transformation of random variables – Central limit theorem (for independent and identically distributed random variables).

UNIT III ESTIMATION THEORY 9+3

Sampling distributions – Characteristics of good estimators – Method of Moments – Maximum Likelihood Estimation – Interval estimates for mean, variance and proportions.

UNIT IV TESTS OF SIGNIFICANCE 9+3

Type I and Type II errors – Tests for single mean, proportion, Difference of means (large and small samples) – Tests for single variance and equality of variances –χ^2 test for goodness of fit – Independence of attributes.

UNIT V DESIGN OF EXPERIMENTS 9+3

Completely Randomized Design – Randomized Block Design – Latin Square Design – 2^2 factorial design.

TOTAL: 60 PERIODS

Laboratory based exercises / assignments / assessments will be given to students from the content of the course wherever applicable.

Branch specific / General Engineering applications based on the content of each units will be introduced to students wherever possible.

SUGGESTED LAB EXERCISES

1. Data exploration using R
2. Visualizing Probability distributions graphically
3. Evaluation of correlation coefficient
4. Creating a Linear regression model in R
5. Maximum Likelihood Estimation in R
6. Hypothesis testing in R programming
7. Chi square goodness of fit test in R
8. Design and Analysis of experiments with R

OUTCOMES:

CO1: Can analyze the performance in terms of probabilities and distributions achieved by the determined solutions.

CO2: Will be familiar with some of the commonly encountered two dimensional random variables and be equipped for a possible extension to multivariate analysis.

CO3: Provides an estimate or a range of values for the population parameter from random samples of population.

CO4: Helps to evaluate the strength of the claim/assumption on a sample data using hypothesis testing.

CO5: Equips to study the influence of several input variables on the key output variable.

TEXT BOOKS:

1. Irwin Miller and Marylees Miller, "John E. Freund's Mathematical Statistics with applications", Pearson India Education, Asia, 8th Edition, 2014.
2. Walpole, R.E., Myers R.H., Myres S.L., and Ye, K. "Probability and Statistics for Engineers and Scientists", Pearson Education, Asia, 9th Edition, 2024.

REFERENCES:

1. Richard A. Johnson, Irwin Miller, John Freund "Miller & Freund's Probability and Statistics for Engineers", Person Education, 8th Edition, 2015.
2. Ross, S.M. "Introduction to Probability and Statistics for Engineers and Scientists", Elsevier,
   New Delhi, 5th Edition, 2014.
3. Spiegel, M.R., Schiller, J., Srinivasan, R.A. and Goswami, D. "Schaum's Outline of Theory and Problems for Probability and Statistics", McGraw Hill Education, 3rd Edition, Reprint, 2017.
4. Devore, J.L. "Probability and Statistics for Engineering and the Sciences", Cengage Learning, 9th Edition, 2016.

CO – PO Mapping:

COURSE OUTCOMES	PROGRAMME OUTCOMES											
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**P10**	**P11**	**P12**
CO1 :	3	3	2	3	1	2	1	1	1	1	1	3
CO2 :	3	3	2	3	1	2	1	1	1	1	1	3
CO3 :	3	3	2	3	1	2	1	1	1	1	1	3
CO4 :	3	3	2	3	1	2	1	1	1	1	1	3
CO5 :	3	3	2	3	1	2	1	1	1	1	1	3

CT23301	PHYSICAL FOUNDATION OF MATERIAL SCIENCE	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

1. To provide with a comprehensive understanding of the fundamental principles governing the structure, properties and behavior of materials
2. To equip with the skills necessary to apply materials science principles to solve real world engineering problems

UNIT I STRUCTURE OF SOLIDS 9

Introduction, Bohr Rutherford atomic model, wave mechanical model of the atom -uncertainty principle, the Schrodinger wave equation, quantum numbers from wave mechanical model, atomic orbitals, charge cloud representation of orbitals, four quantum number system, electronic configuration of atoms; Interatomic and intermolecular forces – ionic bonding – ionization potential, electron affinity, energetics of ionic bond formation, equilibrium spacing; covalent bonding – directional nature of covalent bonds, covalent radii, bond energies; transitional type bonds, metallic bonds, secondary bonds – permanent dipole attractions, induced dipole attractions, fluctuating dipole attraction; states of matter, structure of solids, crystallization, polymorphism, formation of amorphous solids, colloidal states of matter, liquid crystals, plasma state of matter.

UNIT II ATOMIC ARRANGEMENTS IN CRYSTALLINE SOLIDS 9

Introduction, Space lattice and unit cell, crystal system and lattice coordinates, crystal planes and directions – atomic density, interplanar spacings, crystal cleavage; Packing of atoms in crystals – BCC, FCC, HCP, stacking of close packed layers, atomic packing and deformability; indexing crystallographic planes and directions; representation of orientations – stereographic projections; types of crystal structures - molecular structures; crystal structures of compounds – interstitial sites, AX type compounds, AX_2 type compounds, A_2X_3 type compounds, AB_mX_m type compounds, spinel structure; influence of radius ratio on structure; experimental crystallographic methods – Bragg's Law, x-ray methods, electron microscopy, crystallographic textures.

UNIT III IMPERFECTIONS 9

Point – vacancies, interstitials, point imperfections in molecular crystals, mobility of point imperfections, physical effects of defect structures; Line imperfections – types, energy of a dislocation, dislocations characteristics, slip systems, dislocation mechanism of slip, role of dislocation, interaction between dislocations; Planar defects stacking faults, twinning, grain boundaries, grain size, tilt boundary, phase boundaries – classification, phenomenological characteristics of phase boundaries; Volume defects; Experimental technique for identification of defects- optical metallography, SEM, TEM, HRTEM, Scanning probe microscopes and atomic resolution;

UNIT IV DIFFUSION 9

Importance of diffusion, Types of diffusion – self diffusion, inter diffusion, surface diffusion, grain boundary diffusion, volume diffusion; atomic mechanism of diffusion – random walk theory, vacancy and interstitial mechanism, diffusion in crystalline solids – substitutional and interstitial diffusion mechanisms, diffusion in metals, ceramics and polymers; factors affecting diffusion – temperature, crystal structure, defects and impurities; mathematical description of diffusion – Fick's Laws, solution to diffusion equations, diffusion co-efficient – definition, Arrhenius relationship; experimental techniques – tracer diffusion methods, interdiffusion methods, other techniques; diffusion in nanostructured materials ; diffusion in non-crystalline materials; simulation and modelling of diffusion.

UNIT V MATERIAL SELECTION, MODELLING AND SIMULATION 9

Introduction, multiscale modelling approach – quantum, atomistic, mesoscale, continuum; quantum mechanical methods – fundamentals of quantum mechanics relevant to materials science, DFT principles and applications, introduction to setting up a DFT calculation; Atomistic simulation models – molecular dynamics simulations principles an algorithms, interatomic potentials and force fields, software tools; Mesoscale and continuum methods – introduction to mesoscale modelling techniques, Monte Carlo simulations principles and applications, software tools; FEM principles and applications, multiscale modelling; machine learning in materials science – introduction, applications of machine learning in materials discovery and design.

TOTAL: 45 PERIODS

COURSE OUTCOMES

On completion of the course, the students will be able to

CO1 Understand how and why the properties of materials are controlled by structure and bonding at the atomic scale and by the features at the microstructural and macroscopic levels.

CO2 Gain a comprehensive understanding of the structure of crystalline solids, equipping them with the knowledge and skills necessary for advanced studies and careers in materials science and engineering.

CO3 Analyze the types. formation and effects of imperfections in materials and utilize this knowledge to predict and improve material properties and performance

CO4 Apply diffusion concepts to solve practical engineering problems and optimize material properties for various applications

CO5 Gain a solid foundation in computational materials science equipped with the knowledge and skills

TEXT BOOKS

1. Balasubramaniam, R. "Callister's Materials Science and Engineering", Wiley India Pvt. Ltd., 2014.
2. William F. Smith, "Foundations of Materials Science and Engineering", McGraw Hill Publisher, Fifth Edition, 2010.

REFERENCES

1. Michael F Ashby, Materials Selection in Mechanical Design, Butterworth and Heinemann,2011.
2. Donald Askeland, “Materials Science and Engineering”, Cengage Learning India Pvt. Ltd, 2011.
3. Richard LeSar, Introduction to Computational Materials Science, Cambridge University Press, 2016.
4. Raghavan V., Materials Science and Engineering: A First Course, Fifth Edition, PHI Learning Pvt. Ltd., 2011
5. Khurmi R.S., Sedha R.S., “Materials Science”, S.Chand and Company Limited, 2018
6. Charles Kittel, Introduction to Solid State Physics – 8th Edition, Wiley, 2005.

COURSE ARTICULATION MATRIX

CO	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	1	1	1	1	1	1	2	-	2	2	2	3	2	1	-
2	2	2	2	2	1	1	1	-	2	2	2	3	-	-	2
3	3	3	1	2	1	1	1	-	2	2	2	3	-	-	1
4	3	2	3	2	2	1	1	-	2	2	2	3	-	2	-
5	1	1	3	1	1	2	2	-	2	2	2	3	-	2	-
Avg	**2**	**1.8**	**2**	**1.6**	**1.2**	**1.2**	**1.4**	**-**	**2**	**2**	**2**	**3**	**2**	**1.7**	**1.5**

Correlation Levels: 1 — low, 2 — medium, 3 — high, - — no correlation

CT23302	CERAMIC RAW MATERIALS	L	T	P	C
		3	0	2	4

COURSE OBJECTIVES

1. To introduce the basics of rock formation, its types, and mineral formation and its physical andoptical properties.
2. To impart knowledge about various natural and synthetic ceramic raw materials.
3. To enable students to analyze the given ceramic raw material for its chemical composition and estimate its physical properties

UNIT I GENERAL GEOLOGY AND MINEROLOGY 9+6

Minerals — formation, relation of mineral deposit to igneous activity; chemical and physical properties like composition, color, streak, luster, fracture, cleavage, hardness, density, and tenacity; radioactive properties and optical properties, rocks — formation, characteristics, classification into igneous, sedimentary and metamorphic. Some important rocks – granite, sandstone, marble - availability, quality and industries demand.

PRACTICALS **1.** Identification of minerals based on physical and optical properties

UNIT II FLUX AND PLASTIC RAW MATERIALS 9+6

Occurrence, properties, industrial importance of fluxes, uses of natural fluxes — feldspar group, nepheline syenite, Cornish stone. clay minerals. clay structures — kaolinite and montmorillonite groups. occurrence of clay deposits. classification of clays – China clay, ball clay, fire clay, building clay etc. beneficiation of clays. Clay properties — charged nature, cation exchange capacity, flow behavior, plasticity, effect of heating. Mica, talc, pyrophyllite and sillimanite group – physical and chemical properties, applications - availability, industries and Demand.

PRACTICALS **1.** Identification of clays based on physical properties

2. Determination of Loss on Drying and Loss on Ignition

UNIT III NATURAL RAW MATERIALS 9+6

Alumina — natural raw materials. Preparation, properties and applications of synthetic alumina raw materials – calcined alumina, fused alumina, tabular alumina, reactive alumina, bubble alumina Silica – occurrence, structure, polymorphic transformation. Silicate minerals – quartz, quartzite – properties and uses. Availability, Industries and Demand. Occurrence, properties, industrial importance of Wollastonite, Magnesite, dolomite, chromite,limestone, rutile, zircon, beryllia, gypsum minerals.

PRACTICALS **1.** Determination of CaO and MgO by complexometry

UNIT IV SYNTHETIC RAW MATERIALS 9+6

Occurrence, properties, industrial importance of Lithium containing minerals, U_2O, ThO_2, PuO_2 Bone ash, cullet, slag, Fly ash. Preparation / Occurrence, properties and uses of Silicon carbide, Tungsten carbide, Silicon nitride, Aluminium nitride, Boron nitride, Borides silicides and SiAlON.

PRACTICALS **1.** Determination of Na, K and Li by flame photometry

UNIT V PROPERTIES AND TESTING OF RAW MATERIALS 9+6

Loss on drying and loss on ignition, theory and procedure for chemical estimation of silica, alumina, alkali and alkaline earth oxides in a given ceramic raw material, Chemical characterization by X-ray fluorescence (XRF), potentiometry, coulometry and atomic absorption spectrometry (AAS), determination of light elements (lithium, fluorine and boron) by ICP-AES/AAS, potentiometry

PRACTICALS **1.** Determination of elements by ICP method

TOTAL (T45+P30) = 75 PERIODS

EQUIPMENTS REQUIRED:

1.Flame Photometer
2.Hot Plate
3.Hot Air Oven
4.Electronic Balance
5.Furnace
6.ICP

COURSE OUTCOMES

On completion of the course, the students will be able to

CO1 Recognize different rocks and minerals
CO2 Identify the different types of flux and clay raw materials
CO3 Understand the various types of natural ceramic minerals and their properties
CO4 Describe the properties and applications of synthetic ceramic minerals
CO5 Study the important properties and testing of various ceramic raw materials

TEXT BOOKS

1. Parbin Singh, Engineering and General Geology, S.K.Kataria and Sons, NewDelhi,2001
2. Christopher W.Sinton, Raw Materials for Glass and Ceramics: Sources, Processes and Quality Control, John Wiley and Sons, Inc., 2006

REFERENCES

1. Venkat Reddy D, Engineering Geology, Vikas Publishing House Pvt. Ltd., New Delhi,2010.
2. Norton F.H, Fine Ceramics: Technology and Applications, McGraw-Hill Co., NY,1978
3. Deer W.A, Howie R.A and ZussmanJ, Rock Forming Minerals, Longmans, London,1967
4. Worrall W.E, Ceramic Raw Materials, Pergamon Press, NY,1992.
5. Deer W.A, Howie R.A and Zussman J, Rock Forming Minerals, Longmans, London,1967

COURSE ARTICULATION MATRIX

CO	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	2	1	2	1	1	3	2	-	2	2	1	3	2	-	2
2	2	2	2	2	1	3	2	-	2	2	1	3	2	-	3
3	2	2	2	2	1	3	3	-	2	2	1	3	2	-	3
4	2	2	2	2	1	3	3		2	2	1	3	2	-	2
5	2	2	2	2	3	3	2	-	2	2	2	3	1	-	2
Avg	**2**	**1.9**	**2**	**1.9**	**1.2**	**3**	**2.4**	**-**	**2**	**2**	**1.2**	**3**	**1.8**	**2**	**2.3**

Correlation Levels: 1 — low, 2 — medium, 3 — high, - — no correlation

CT23303	PROCESSING OF CERAMIC RAW MATERIALS	L	T	P	C
		3	0	2	4

COURSE OBJECTIVES

1 To introduce the students to the various steps involved in obtaining natural ceramic raw materials in their usable form, right from extraction of raw material.

2 To familiarize the various equipment / methods involved in size reduction, size separation, mixing, storage and conveying.

UNIT I QUARRYING 9 + 6

Winning of clays – china clay and Kaolin; Clay purification methods – Dorr bowl classifier, continuous centrifuge, electro-osmosis and mechanical air separator; Sedimentary clay – British ball clay and fire clay; Weathering of clay; quarrying of non plastic materials; Beneficiation of non plastic materials; machinery used in clay winning.

PRACTICALS – 1. Non-plastic Raw material purification by froth flotation
2. Separation of solids by sedimentation method

UNIT II SIZE REDUCTION 9 + 6

Laws of size reduction; mechanism of size reduction; principle and working of different crushers and grinders – jaw crusher, gyratory crusher, hammer mill, different types of tumbling mill, jet mill, attrition mill, vibro-energy mill; Closed circuit and open circuit grinding.

PRACTICALS – 1. Size reduction by Jaw Crusher with various materials and find the efficiency
2. Size reduction in ball milling with respect to speed & grinding media size

UNIT III MECHANICAL SEPARATION 9 + 6

Introduction; types of separation; Screening – dry and wet screening, equipments, effectiveness of screen; test sieves - ASTM, BSS, BIS, IS; Filtration – theory of filtration, batch and continuous filters, principles of cake filtration; Separation based on movement through a fluid – sedimentation, cyclone separation, air classification; Magnetic separation; Applications - requirements and market scenario; Industries.

PRACTICALS – 1. Separation of solid from liquid by filter press and PoP mould Drying
2. Separating magnetic particles by magnetic separator

UNIT IV MIXING AND CONVEYING 9 + 6

Mixing – mechanism of mixing; batch and continuous solid mixers – pan mixer, shaft mixer, U mixer, muller mixer, 3D mixer and other mixers; liquid mixers – mechanism, blungers, agitators; Conveying – solid conveying, types of conveyors, criteria for selecting a conveyor; liquid conveying- condition for liquid conveying, different types of pumps.

PRACTICALS – 1. Solid mixing by pan mixer and evaluate the mixing efficiency
2. Liquid mixing by agitators with varied solid content & viscosity measurement

UNIT V STORAGE OF MATERIALS AND TESTING 9 + 6

Storage methods for different ceramic powders; Problems in bin storage; Coning and quartering of sample; sampling on delivery; measurement of moisture content by IR moisture balance, speedy moisture test; particle size analysis – sieve test, sedimentation method, Stokes, Andreasen Pipette, sedigraph, image analysis; Determination of surface area by permeametry, adsorption.

PRACTICALS – 1. Determination of particle size by Hydrometer

2. Determination of particle size by Andreasen Pipette method
3. Determination of particle size by image analysis

TOTAL (T45+P30) = 75 PERIODS

EQUIPMENTS REQUIRED:

1. Blunger
2. Froth flotation equipment
3. Jaw Crusher
4. Ball mill
5. Sieve set
6. Sieve shaker
7. Magnetic separator
8. Filter press
9. Pan mixer
10. Agitator

COURSE OUTCOMES

On completion of the course, the students will be able to

CO1 understand and apply the different quarrying methods to extract clay and non clay materials and its purification process

CO2 associate and analyze proper size reduction method for the given input size and for the expected final size

CO3 distinguish and analyze different size separation methods

CO4 comprehend and evaluate suitable method of mixing of raw materials, and conveying for the given material.

CO5 relate different storage methods and categorize fundamental properties of the powdered materials

TEXT BOOKS

1. Warren L.McCabe, Julian C.Smith and Peter Harriott, Unit Operations of Chemical Engineering, 7thEdn., McGraw Hill International Edition,2013.
2. Charles Burroughs Gill, Materials Beneficiation, Springer Verlag, 1991

REFERENCES

1. Ryan W and Redford C, Whitewares: Production, Testing and Quality Control, Pergamon Press, NY, 1987.
2. Vincenzini P, Fundamentals of Ceramic Engineering, Elsevier Applied Science, London, 1991.
3. Singer F.and Singer S., Industrial Ceramics, Oxford and IBH Publishing Co. 1991.
4. Mohamed N.Rahaman, Ceramic Processing, CRC Press, 2th Edn.,2017.
5. Paul De Garmo E, Black J.J and Ronald A.Kohser, Materials and Processes in Keishi Gotoh, Powder Technology Handbook, Marcel Dekker Inc.,1997.

COURSE ARTICULATION MATRIX

CO	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	3	3	3	2	1	1	3	-	3	2	3	2	3	2	-
2	2	3	3	3	2	1	1	-	3	2	3	2	3	3	-
3	2	2	2	2	2	1	1	-	3	2	3	2	3	3	-
4	2	3	3	2	2	1	1	-	3	2	3	2	3	3	-
5	2	3	3	2	2	1	1	-	3	2	3	2	3	2	-
Avg	**2.2**	**2.8**	**2.8**	**2.2**	**1.8**	**1**	**1.4**	**-**	**3**	**2**	**3**	**2**	**3**	**2.6**	**-**

Correlation Levels: 1 — low, 2 — medium, 3 — high, - — no correlation

CT23304	CERAMIC FABRICATION PROCESSES	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

1. Enable the students to have a thorough knowledge about the different ceramic fabrication process and the other final operations involved after the fabrication of the product
2. Enable students to prepare casting slip and analyze its various properties
3. Prepare articles through different shaping methods

UNIT I INTRODUCTION **9**

Characteristics of Ceramic Materials - Particles, Powders, Colloids, and Agglomerates, Raw-Material Specifications, Particle Size and Shape, Density, Pore Structure, and Specific Surface Area, Particle Packing, Consistency, and Batch Calculations, Batch Consistency and Formulation, General Ceramic Forming Principles

UNIT II COLLOIDAL FORMING PROCESS **9**

Plaster of Paris — chemical reaction and physical properties-shrinkage, POP‘s life; Mould preparation — Design, Tools, process for making; slip casting - Drain Casting, solid casting and other slip casting techniques; Theories of Slip Casting, Mechanism of cast formation – role of additives, Slip preparation and properties, Aging, Zeta potential, Casting Defects, Casting control, particle size, shape and surface effects, Finishing. Advanced shaping processes - tape casting, gel casting, freeze casting, centrifugal casting, robocasting, direct ink jet printing, stereolithography

UNIT III PLASTIC FORMING PROCESS **9**

Plastic mass preparation — pug mill, pugging defects, testing - Phefferkorn, Atterberg test; Shaping methods — extrusion, jiggering, roller machine, compression molding, injection molding, additive manufacturing; Hand Molding –The Potter‘s Wheel, layer form; Tools; Defects and Remedies, finishing.

UNIT IV DRY FORMING PROCESS **9**

Pressing- Uniaxial pressing –Compaction behavior, role of additives and effect of particle size, Die wall effects on compaction, control of defects in compacts, stress distribution on green body – defects and remedies, vibration compaction, isostatic pressing — advantages — defects and remedies, finishing

UNIT V DRYING AND FIRING **9**

Drying shaped ware prepared by different methods – dryers-unheated dryers, heated dryers. Batch dryers, continuous dryers; drying defects; Dryer efficiencies. Finishing – cutting and trimming – sponging, fettling and towing — scumming. Kiln and Types of Kilns. Processing. Design of firing schedule, Firing of ceramic ware, water smoking period, oxidation and decomposition reactions, Maturing of the body, rate of shrinkage, role of kiln atmosphere (oxygen level and pressure) during firing, energy calculations in firing ceramic bodies, defects in fired ware.

TOTAL : 45 PERIODS

COURSE OUTCOMES

On completion of the course, the students will be able to

CO1 Understand the characteristics of various raw materials and tailor the properties for different shaping techniques

CO2 Recognise the steps involved and understand the effect of various factors in shaping by colloidal processing techniques

CO3 Acquaint the process of plastic mass preparation and comprehend various plastic forming processes

CO4 Discuss the factors involved in dry process shaping of ceramics and understand the defect control parameters

CO5 Recognize the methods to dry / fire the articles prepared by different forming techniques, understand the defects and design of firing schedule

TEXT BOOKS

1. F. Singer and S. Singer, Industrial Ceramics, Oxford and IBH Publishing Co., 2013.
2. David W. Richerson and William E.Lee, Modern Ceramic Engineering: Properties, Processing and Use in Design, 4th Edn., CRC Press, 2018.

REFERENCES

1. Mohamed N.Rahaman, Ceramic Processing, Taylor and Francis, 2017.
2. Alan G. King, Ceramic Technology and Processing, Noyes Publication, USA, 2002.
3. Roy W.Rice, Ceramic Fabrication Technology, Marcel Dekker Inc., 2002.
4. James S. Reed, Principles of Ceramic Processing, 2nd Edn, John Wiley and Sons, NY, 1995.
5. Sasha Wardell, Slip casting, University of Pennsylvania press, 2007.

COURSE ARTICULATION MATRIX

CO	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	3	3	2	2	2	1	3	-	2	3	3	2	3	3	3
2	3	3	2	2	2	1	3	-	2	3	3	2	2	3	2
3	3	3	2	2	2	1	3	-	2	3	3	2	2	3	2
4	3	3	2	2	2	1	3	-	2	3	2	2	2	3	2
5	3	3	2	2	2	1	3	-	2	3	2	2	3	3	3
Avg	**3**	**3**	**2.4**	**2.4**	**2**	**1**	**3**	**-**	**2**	**3**	**2.6**	**2**	**2.4**	**3**	**2.4**

Correlation Levels: 1 — low, 2 — medium, 3 — high, - — no correlation

CT23305	UNIT OPERATIONS IN CERAMIC INDUSTRIES	L	T	P	C
		3	0	2	4

COURSE OBJECTIVES

1 To acquaint the students with the unit operations that are prevalent in ceramic industries and to build their perspective in a wholesome manner

UNIT I INTRODUCTION 9

Unit operations; unit systems - physical quantities, SI units, CGS units, gas constant, conversion of units, units and equations; dimensional analysis; basic concepts - equations of state of gases, material balances, energy balances.

UNIT II MECHANICAL OPERATIONS 9 + 7

Size reduction - computer simulation of milling operations, laws of size reduction, energy requirement for size reduction / Equipment for size reduction. Screening - screening efficiency, screening equipment. Filtration - cake filters, centrifugal filters and filter media, membrane filters, mechanism selection of filtration technique. Sedimentation - gravity sedimentation process, centrifugal sedimentation process, law of settling, designing sedimentation vessel.

PRACTICALS – 1. Size separation by Sieves and Calculating screen effectiveness of sieves
2. Settling study on particles

UNIT III FLUID MECHANICS 9 + 7

Fluid statics – hydrostatic equilibrium, applications of fluid statics – manometer, gravity decanter; Fluid flow phenomena – laminar flow, rheological properties of fluids, turbulence; Fluid flow equation – Mass balance in a flowing fluid, mechanical energy equation for flowing fluid; Flow past immersed solids – drag and drag coefficient, flow through a bed of solids, motion of particles through fluids.

PRACTICALS – 1. Estimating pressure drop using manometer.
2. Analysing fluid flow past immersed solids.

UNIT IV HEAT TRANSFER 9 + 8

Heat transfer by conduction - Basic law of conduction, Steady and Unsteady - State conduction; Convective heat transfer; Radiation Heat Transfer - Emission of Radiation, Absorption of radiation by opaque solids, Radiation between surfaces; Heat Exchange equipment - Concentric heat exchanger, shell and tube heat exchangers, plate type exchangers.

PRACTICALS – 1. Estimation of thermal conductivity of composite material.
2. Estimation of overall heat transfer coefficient of concentric tube heat exchanger

UNIT V MASS TRANSFER 9 + 8

Diffusion – definition, prediction of diffusivities; Humidification operation – definition, humidity chart, wet bulb temperature; Drying of solids – classification of dryers, solids handling in dryer, principles of drying, cross circulation drying, through circulation drying, freeze drying, drying equipments for solids, pastes, solutions and slurries; Crystallization – crystal geometry, super saturation, mechanism of crystallization.

PRACTICALS – 1. Calculation of relative humidity using wet bulb thermometer.
2. Drying rate estimation during drying of a solid.
3. Effect of cooling rate on the crystallization

TOTAL (L45+P30) = 75 PERIODS

EQUIPMENTS REQUIRED:

1. Manometer
2. Sieve shaker and sieves
3. Concentric tube heat exchanger
4. Thermal conductivity equipment
5. Thermometer
6. IR moisture analyzer
7. Hot air oven
8. Crystallization vessel

COURSE OUTCOMES

On completion of the course, the students will be able to

CO1 Understand the basic concepts of mass and energy balances and unit operations
CO2 Analyze the basic techniques of mechanical operations in ceramic technology.
CO3 Understand the concepts of fluid mechanics and applying the fluid statics in ceramics.
CO4 Calculate the heat transfer through conduction, convection and radiation.
CO5 Apply the knowledge about mass transfer operations involved in ceramic technology.

TEXT BOOKS

1. Warren L.McCabe, Julian C.Smith and Peter Harriott, Unit Operations of Chemical Engineering, 7th Edition, McGraw Hill International Edition,2013
2. SalilK.Ghosal, ShyamalK.Sanyal and Siddhartha Datta, Introduction to Chemical Engineering, Tata McGraw-Hill Publishing Co. Ltd., New Delhi,2011.

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1. Perry R.H and Green D (eds), Perry's Chemical Engineers' Handbook, 6th Edn.,McGraw-Hill, New York,1984.
2. Walas S.M, Chemical Process Equipment, Butterworths,1988.
3. Treybal R.E, Mass Transfer Operations, 3rd Edn., McGraw-Hill, New York,1980.
4. David Shallcross, Chemical Engineering Explained: Basic Concepts for Novices, CPI Group, UK, 2013
5. David M.H, James B. Riggs,Basic Principles and Calculations in Chemical Engineering, 8th edition, Prentice Hall,2012.

COURSE ARTICULATION MATRIX

CO	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	3	3	2	1	2	1	1	-	1	1	2	2	3	2	1
2	3	3	3	3	2	1	1	-	3	2	1	2	3	2	1
3	3	3	3	3	2	1	1	-	3	2	2	2	3	2	1
4	3	3	3	3	2	1	1	-	3	2	3	2	3	2	3
5	3	3	3	3	2	1	1	-	3	2	3	2	3	2	2
Avg	**3**	**3**	**3**	**2.6**	**2**	**1**	**1**	**-**	**2.4**	**1.6**	**2.2**	**2**	**3**	**2**	**1.6**

CorrelationLevels:1—low,2—medium, 3—high, -—no correlation

CT23401	THERMODYNAMICS FOR CERAMIC ENGINEERS	L	T	P	C
		2	1	0	3

COURSE OBJECTIVES

1. To provide a comprehensive understanding of the basic concepts and principles of thermodynamics with a specific focus on their applications to ceramic materials

UNIT I INTRODUCTION TO THERMODYNAMICS 9

Fundamental concepts – definition and scope of thermodynamics in ceramics, system, surroundings and boundaries in ceramic processes, state, properties and state functions; Thermodynamics properties – intensive and extensive properties, equilibrium states, zeroth law of thermodynamics and temperature measurements; Development of thermodynamics and its application.

UNIT II FIRST LAW OF THERMODYNAMICS AND ENERGY BALANCES 9

Energy and work – forms of energy relevant to ceramics, internal energy, enthalpy, work and heat transfer in ceramic processes; First Law of Thermodynamics – Application to closed systems, open systems, steady flow energy equation and its relevance to ceramic manufacturing; Applications in ceramics – energy balances in ceramic kiln operations, thermal processes in ceramic manufacturing.

UNIT III SECOND LAW OF THERMODYNAMICS AND ENTROPY 9

Second law of thermodynamics – Kelvin Planck and Clausius statements, concept of entropy and Carnot theorem and Carnot cycle, reversible and irreversible processes in ceramics; Entropy changes – entropy changes in reversible and irreversible process, T-s diagrams, H-s diagrams, entropy changes in ceramic reactions and processes, entropy generation and minimization in ceramic manufacturing; Applications in ceramics – analysis of entropy in ceramic sintering, impact of entropy on ceramic material properties

UNIT IV THERMODYNAMIC PROPERTIES OF MATERIALS 9

Thermodynamic potentials – Helmholtz and Gibb's free energies, chemical potential and its application to ceramics; State functions and equation of state; PVT behaviour of pure substances and mixtures; Heat capacities and its importance in ceramic materials; property data for ceramics – use of thermodynamic tables and charts, estimation of thermodynamic properties for ceramic materials.

UNIT V APPLICATIONS IN CERAMICS 9

Thermodynamics of surfaces, interfaces and microstructures – surface energy and thermodynamics of interfaces in ceramics, grain boundary thermodynamics and its effect on microstructure, thermodynamics of sintering – driving forces, mechanisms and models; wetting,

adhesion and capillarity in ceramic systems; thermodynamics of advanced ceramic processing techniques.

TOTAL: 45 PERIODS

COURSE OUTCOMES

On completion of the course, the students will be able to

CO1 Comprehend the foundational concepts of thermodynamics
CO2 Utilize the first law of thermodynamics to analyze energy balances in ceramic processes
CO3 Employ the second law of thermodynamics to evaluate the entropy changes and efficiencies in ceramic manufacturing
CO4 Assess the thermodynamic properties of materials using appropriate data and tools
CO5 Apply the thermodynamic concepts to ceramic processing and manufacturing techniques

TEXT BOOKS

1. David R. Gaskell and David E. Laughlin, Introduction to the Thermodynamics of Materials, 6th edition, CRC Press, 2018.
2. Robert DeHoff, Thermodynamics in Materials 2nd ed., CRC Press, 2016.

REFERENCES

1. Zeemansky W. and Dittman H., Heat and thermodynamics, 8th edition, McGraw-Hill companies, 2017.
2. Narayanan K. V., A textbook of Chemical engineering thermodynamics, PHI learning Private Limited, 2013.
3. Nag P.K, Engineering Thermodynamics, Third Edition, Tata McGraw Hill Publishing Company Ltd., 2006.
4. David Halliday, Robert Resnick, Jearl Walker, Fundamentals of Physics Extended, 10th Edition, Wiley 2013.
5. John H S Lee, “Thermodynamics of Materials”,

COURSE ARTICULATION MATRIX

CO	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	3	3	1	3	1	2	2	-	2	2	1	2	3	1	3
2	3	3	1	3	1	2	2	-	2	2	1	2	3	1	3
3	3	3	1	3	1	2	2	-	2	2	1	2	3	1	3
4	3	3	1	3	2	2	2	-	2	2	1	2	3	1	3
5	3	3	1	3	1	2	2	-	2	2	1	2	3	1	3
Avg	**3**	**3**	**1**	**3**	**1.2**	**2**	**2**	**-**	**2**	**2**	**1**	**2**	**3**	**1**	**3**

Correlation Levels: 1 — low, 2 — medium, 3 — high, - — no correlation

CT23402	PHASE DIAGRAMS AND PHASE TRANSFORMATIONS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

1 Equip students with the essential skills to effectively apply the principles and concepts of phase equilibria, enabling them to evaluate multi component systems.

UNIT I THERMODYNAMICS OF SOLUTIONS 9

Introduction, thermodynamic aspects of phase formation and phase equilibrium, mixing of atoms; Raoult‘s law and Henry‘s law; Gibbs free energy of formation of a solution, properties of ideal solutions, non-ideal solutions; criteria of phase equilibrium, criterion of stability, phase equilibria in single and multi-component system; binary solutions — constant pressure system, constant temperature system, partially miscible and immiscible system, liquid-liquid; System, phases and components, equilibrium, phase rule.

UNIT II UNARY AND BINARY SYSTEMS 9

One component systems - Le Chatelier Principle, Water system, hypothetical system, silica system, silica system, titania and zirconia system, carbon system; two component system – binary eutectic, intermediate compounds, solid solutions, liquid immiscibility, structural considerations of liquid immiscibility, Al_2O_3 – SiO_2 system, CaO – SiO_2 system, iron carbon diagram, hypothetical binary systems, phase diagram analysis.

UNIT III TERNARY SYSTEMS 9

Methods of determining composition, isoplethal studies in ternary systems, Alkemade lines, composition triangles, isothermal sections, systems with a binary compound melting congruently, peritectic and eutectic reactions during cooling, composition on an Alkemade line, decomposition of a binary compound having a phase filed in the ternary system, intermediate ternary compounds, complex cooling paths, ternary solid Solutions, ternary system with two solid solution phases, MgO-FeO-SiO_2 system, liquid immiscibility, MgO-Al_2O_3-SiO_2 system, Na_2O-CaO-SiO_2, reactions during heating, suppression of an intermediate compound, glass formation and transformation curve, metastable immiscibility, solid solutions.

UNIT IV PHASE TRANSFORMATIONS 9

Definition and significance of phase transformation, types of phase transformations – diffusional and diffusion less; thermodynamic principles – Gibbs free energy and phase stability, driving force for phase transformation; nucleation theory – classical nucleation theory, critical nucleus size and nucleation rate, energy barriers to nucleation; heterogenous nucleation – role of surfaces, interfaces and impurities, comparison with homogenous nucleation; growth mechanisms – diffusion controlled growth, interface controlled growth, coarsening; diffusional transformations – precipitation from solid solution, eutectoid and peritectoid reactions, order – disorder

transformations; diffusion less transformations – martensitic transformation, bainite transformation; spinoidal decomposition – thermodynamics and kinetics.

UNIT V CONSTRUCTION AND DETERMINATION OF PHASE DIAGRAMS 9

Construction of phase diagrams – construction from thermal analysis data, solid liquid and solid solid transitions; binary systems – lever rule and tie line method, isomorphous, eutectic and peritectic systems, solid solution phases and intermediate phases; ternary systems – representation of ternary phase diagrams, triangular co-ordinates and Gibbs triangles; Determination of phase diagrams – thermal analysis – DSC, DTA, TGA; Microscopy and Microanalysis – Optical microscopy, SEM, EDS; X-ray techniques – XRD, Rietveld refinement; other techniques – dilatometry, NMR, atom probe tomography; computational methods for phase diagram prediction – CALPHAD, software tools.

TOTAL: 45 PERIODS

COURSE OUTCOMES

On completion of the course, the students will be able to

CO1 Describe the relation between thermodynamics and phase equilibria.

CO2 Interpret the phase diagrams, and examine the phase stability diagrams in unary, and binary phase diagrams.

CO3 Discuss the types of ternary phase and its types

CO4 Demonstrate the phase transformation and microstructural development.

CO5 Construct and evaluate phase diagrams

TEXT BOOKS

1. F. A. Hummel, Introduction to Phase Equilibria in Ceramic Systems, MarcelDekker,1984
2. A. M. Alper, Phase Diagrams: Materials Science and Technology, Vol. I, II and III, Academic Press.

REFERENCES

1. Kingery W.D, Bowen H.K and Uhlmann D.R, —Introduction to Ceramics, 2ndEdn. John Wiley and Sons,2004.
2. Zhao J C, Methods for Phase Diagram Determination, Elsevier, 2007
3. Allen M. Alper, Phase diagrams in Advanced Ceramics, Academic Press Inc.,1995
4. West D R F, N Saunders, Ternary Phase Diagrams in Material Science,Wood head Publishing, 2006P.
5. Gordon, Principles of Phase Diagrams in Materials Science by McGraw HillBook Co., NY, 1968.
6. D A Porter, K E Easterling, “Phase Transformations in Metals and Alloys”
7. Robert E Reed Hill and Reza Abbaschian, “Physical Metallurgy Principles”

COURSE ARTICULATION MATRIX

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	2	2	2	2	2	1	1	-	2	2	1	3	3	2	3
2	3	3	3	2	2	1	1	-	2	2	1	3	3	2	3
3	2	2	2	2	2	1	1	-	2	2	1	3	3	2	3

4	3	2	2	2	2	1	1	-	2	2	1	3	3	3	3
5	3	3	3	3	2	1	1	-	2	2	1	3	3	3	3
Avg	**2.6**	**2.4**	**2.4**	**2.2**	**2**	**1**	**1**	**-**	**2**	**2**	**1**	**3**	**3**	**2.4**	**3**

Correlation Levels: 1 — low, 2 — medium, 3 — high, - — no correlation

CT23403 **PROPERTIES OF CERAMICS** **L T P C**
3 0 2 4

COURSE OBJECTIVES:

This course is aimed to

1 Discuss and explain the basics of materials science with the objective of rationalizing, predicting modifying and describing the mechanical, thermal, physical, optical, electrical and magnetic behavior of materials.
2 Correlate between structure-property-performance of materials.
3 Practice the students to experiment and correlate the properties with the structure.

UNIT I MECHANICAL PROPERTIES **9 + 9**

Stress strain behaviour – elastic deformation – linear elastic behaviour, Young's modulus, Poisson's ratio, shear modulus; plastic deformation – limited plasticity in ceramics, dislocation motion and its constraints; brittle fracture – nature of brittle fracture in ceramics, Griffith's theory of brittle fracture; Mechanical Testing – hardness testing – Vickers, Knoop's and Mohs hardness tests, interpretation of results; toughness testing – fracture toughness, methods – single notch bend and chevron bend; strength testing – flexural strength, compressive and tensile strength test; strengthening mechanisms – grain size reduction – Hall Petch relationship, effect of fine grains on strength and toughness; solid solution strengthening – mechanism; secondary phase dispersion – role of secondary phases, toughening mechanism; creep mechanism and testing; fatigue behaviour and testing; applications of mechanical properties.

PRACTICALS :
1. Tensile and Compressive Testing
2. Hardness Testing
3. Impact Testing

UNIT II THERMAL PROPERTIES **9 + 9**

Thermal conductivity and expansion – mechanism of heat conduction – phonon conduction in ceramics, factors affecting thermal conductivity, comparison of thermal conductivity of different materials; thermal expansion – linear thermal expansion co-efficient, anisotropic thermal expansion in ceramics, thermal expansion behaviour of common ceramics; thermal shock resistance – definition and significance in ceramic applications, factors influencing TSR, examples of ceramics with high TSR; Heat capacity – definition and importance in thermal analysis, heat capacity at constant pressure and volume, Debye model and its application to ceramics; thermal diffusivity – relationship between Tc, specific heat and density, measurement and practical implications in thermal management; Thermal stress and fracture – generation, mathematical analysis and case studies; thermal fracture – mechanism, testing methods and prevention strategies; high temperature ceramics – materials and applications; high temperature stability –

materials and applications; thermal insulation materials – low conductivity ceramics, porous ceramics

PRACTICALS :
1. Thermal conductivity
2. Thermal expansion
3. Role of pore formers on thermal conductivity

UNIT III PHYSICAL AND OPTICAL PROPERTIES 9+3

Density and porosity – definition, methods for measuring density and porosity, effect of porosity properties; specific gravity and bulk density – importance in material selection, applications where it is critical; optical properties – refractive index and transparency; absorption and transmission – mechanism, spectral response, applications; luminescence – mechanism, materials and applications, photonic and optoelectronic ceramics – photonic crystals and their properties, integration of ceramics in optoelectronic devices, examples and applications; non linear optical materials – materials exhibiting non linear optical properties, applications.

PRACTICALS :
1. Density and Porosity measurements
2. Reflectivity

UNIT IV ELECTRICAL AND ELECTRONIC PROPERTIES 9+6

Electrical conductivity – intrinsic and extrinsic conduction – mechanism, conducting ceramics – types and applications, factors affecting electrical conductivity; dielectric properties – polarization mechanism, dielectric constant and dielectric loss, applications in capacitors, insulators and dielectric resonators; Ferroelectric and piezoelectric ceramics – ferroelectric behaviour – ferroelectric phase transitions, hysteresis loop and polarization switching, examples of ferroelectric ceramics; piezoelectric effect – direct and inverse, piezoelectric co-efficient and materials selection, applications in sensors, actuators and energy harvesting devices; pyroelectric ceramics – pyroelectric effects and materials, applications in IR sensors and thermal imaging; Ionic conductors – mechanism – defect chemistry and ionic transport, types, applications – SOFC, electrolytes for batteries and sensors; proton conductors – mechanism and application in fuel cells and hydrogen sensors; superconducting ceramics – mechanism, characteristics and applications, challenges and future directions; advanced applications – varistors, thermistors.

PRACTICALS : 1. Band Gap

2. Electrical Resistivity

UNIT V MAGNETIC PROPERTIES 9+3

Basic concepts of magnetism, types of magnetism, ferrites – structure – spinel, hexagonal, garnet; properties – saturation magnetization, coercivity and remanence, magnetic anisotropy; synthesis and processing, hysteresis loop, magnetic losses – hysteresis loss, eddy current loss, relaxation loss; measurement techniques – vibrating sample magnetometry, superconducting quantum interference device magnetometry; applications – soft magnetic materials, hard magnetic materials; microwave and radio frequency applications, magnetic storage, multiferroic materials – coupling between magnetic and electric properties, examples and applications; magnetoelectric

effects – direct and inverse, measurement techniques and applications; nanostructures magnetic ceramics – synthesis and properties, applications in biomedicine.

PRACTICALS : 1. B-H Curve

TOTAL (L45+P30) = 75 PERIODS

LIST OF EQUIPMENTS

1. Universal Testing Machine
2. Hardness Testing Machine [Vicker's, Brinell, Rockwell]
3. Impact Testing Machine
4. Dilatometer
5. Band Gap Apparatus
6. B-H Curve Apparatus
7. Emissivity

COURSE OUTCOMES :

On completion of the course the students will be able to

CO1 Analyse and evaluate the mechanical properties of ceramic materials, including their stress-strain behaviour, hardness, toughness, and resistance to creep and fatigue, and apply this knowledge to design and select appropriate ceramics for various engineering applications.

CO2 Evaluate and analyze the thermal properties of ceramic materials, including thermal conductivity, thermal expansion, specific heat, and thermal shock resistance, and apply this knowledge to select and design ceramics for high-temperature and thermal insulation applications.

CO3 Assess and interpret the physical and optical properties of ceramic materials, including density, porosity, refractive index, transparency, and luminescence, and apply this knowledge to innovate and optimize ceramics for various industrial and technological applications.

CO4 Analyze and apply the electrical and electronic properties of ceramic materials, including electrical conductivity, dielectric behavior, ferroelectricity, and piezoelectricity, to design and optimize ceramics for advanced technological applications such as sensors, actuators, and energy devices.

CO5 Evaluate and apply the magnetic properties of ceramic materials, including their structure, magnetic hysteresis, and loss mechanisms, to design and optimize magnetic ceramics for various technological applications such as data storage, electronic devices, and magnetic sensors..

TEXTBOOKS:

1. William D Callister, "Materials Science and Engineering – An Introduction", Willey, 10th Edition, 2018.

2. William F. Smith “Foundations of Materials Science and Engineering”, McGraw Hill Publisher, 7th Edition, 2022.

REFERENCES:

1. Kingery W.D, Bowen H.K and Uhlmann D.R, Introduction to Ceramics, John Wiley & Sons, 1991.
2. Rajput R.K., “A Textbook of Material Science and Engineering” S.K. Kataria and Sons.
3. Upadhyaya G.S., Anish Upadhaya, “Materials Science and Engineering”, Viva Books Private Limited, 2006.
4. Khurmi R.S., Sedha R.S., “Materials Science”, S. Chand and Company Limited, 2018.
5. Allen S.M., and Thomas E.L. “The Structure of Materials” New York, J. Wiley and Sons, 1999.
6. Rohrer, G. “Structure and Bonding in Crystalline Materials” New York, Cambridge University Press, 2001.
7. Raghavan V., Materials Science and Engineering: A First Course, Fifth Edition, PHI Learning Pvt. Ltd., 2011
8. John Mark P Mccall, “ Optical Properties of Materials”
9. B D Cullity, C D Graham, “Introduction to Magnetic Ceramics”
10. R C Pullar, “ Magnetic Ceramics”
11. Nicola A Spaldin, “Magnetic materials : Fundamentals and Device Application

COURSE ARTICULATION MATRIX:

CO	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	3	3	2	3	1	1	2	1	2	1	2	3	3	-	2
2	3	3	2	3	1	1	2	1	2	1	2	3	3	-	2
3	3	3	2	3	1	1	2	1	2	1	2	3	3	-	2
4	3	3	2	3	1	1	2	1	2	1	2	3	3	-	2
5	3	3	2	3	1	1	2	1	2	1	2	3	3	-	2
Average	**3**	**3**	**2**	**3**	**1**	**1**	**2**	**1**	**2**	**1**	**2**	**3**	**3**	**-**	**2**

Correlation Levels: 1 — low, 2 — medium, 3 — high, - — no correlation

CT23404	CERAMIC WHITEWARES	L	T	P	C
		3	0	2	4

COURSE OBJECTIVES

1. To provide an understanding of the basic principles of ceramic science and engineering as they apply to whitewares
2. To familiarize and understand the role of each component in the formulation of ceramic bodies and the influence of processing parameters on the final properties of the products

UNIT I BODY RAW MATERIALS AND CERAMIC BODIES 9

Classification of traditional bodies; raw materials – Plastic and non-plastic; additives - Binders, electrolytes, plasticizers; body composition – porcelain, earthenware, bone china, sanitary ware, hotel china, terracotta, steatite bodies, cordierite bodies; recipe preparation - mixing, screening, magnetic separation, storage system of slip; Market Scenario - Demand.

UNIT II WHITEWARE PRODUCTS AND FABRICATIONS 9+7

Manufacturing process and properties – tableware, floor tile, wall tiles, sanitary ware, dental porcelains, bone china, chemical stone wares, chemical porcelains, electrical porcelains — insulators; heavy clayware - face bricks, paving bricks, hollow bricks, roofing tiles, sewer pipes, stoneware pipes.

PRACTICALS

1. Determination of isoelectric point of slip
2. Determination of green and fired shrinkage of body

UNIT III PROPERTIES AND TESTING OF CERAMIC BODIES 9+7

Tests on unfired body — bulk density, green MOR, Shrinkage; tests on fired body - strength, density, porosity, moisture absorption, abrasion resistance, chemical durability, thermal expansion, thermal shock resistance and electrical properties - dielectric strength, dielectric constant.

PRACTICALS

1. Determination of bulk density, apparent porosity and water absorption of body

UNIT IV GLAZE RAW MATERIALS AND PROCESSING 9+8

Body-glaze relationship; glaze raw materials; frit preparation; engobe; classification of glazes;role of individual raw materials - colouring agents - stains - glaze additives; surface treatments and

modifications; Glazing techniques - dipping, pouring, spraying, brushing, painting and other techniques; decoration methods;

PRACTICALS

1. Determination of glaze viscosity and density
2. Measurement of uniformity and thickness of glaze on application over ware by spraying, dipping and pouring

UNIT V SPECIAL GLAZES AND TESTING 9+8

Special glazes - matt glazes, snake skin glazes, crackled glazes, salt glazes and other glazes; processing and application of glaze; glaze defects and remedies - crazing, peeling, crawling, rolling, blisters, pin holes, dunting; testing of glazes - particle size distribution, slip density, viscosity, fluidity, coherence parameter, glaze pick up, solubility of lead frits, glaze fit, thermal expansion, chemical durability, colour measurement, thermal shock measurement

PRACTICALS

1. Determination of glaze maturity by Glost firing at various temperatures
2. Determination of glaze fit by varying raw materials in glaze formulation
3. Glaze crazing test using autoclave

TOTAL(T45+L30) = 75 PERIODS

EQUIPMENTS REQUIRED

1. Sieve Shaker
2. Hot Plate
3. Hot Air Oven
4. Furnace
5. Electronic balance
6. Autoclave
7. Pneumatic Spray gun

COURSE OUTCOMES

On completion of the course, the students will be able to

CO1 Understand the basic classification, raw materials and body formulation of traditional whitewares.

CO2 Be capable of understanding the properties and choice of appropriate fabrication methodology for whiteware products

CO3 Property evaluation for unfired ceramic bodies and finished products using suitable test methods

CO4 Recognise various glaze formulations and glazing techniques and understand the factors influencing the glaze.

CO5 Understand the types of glazes, implement the testing methods for glaze, and analyse the properties of glazed articles

TEXT BOOKS

1. Ryan W.and Radford C., “Whitewares Production, Testing and Quality Control, ,Pergamon Press, NY, 1987.
2. Tailor J.R and Bull A.C, “Ceramics Glaze Technology”, Pergamon Press, NY, 1986.

REFERENCES

1. Rexford Newcomb Jr, “Ceramic Whitewares : History, Technology and Applications ǁ,Pitman Publishing Corporation, 1947.
2. Singer F.and Singer S, “Industrial Ceramics”, Oxford and IBH Publishing Co, 1991.
3. Kenneth Shaw, “Ceramic Glazes”, Elsevier Publishing Co., NY, 1971.
4. Emmanuel Cooper, “The Potter Book of Glaze Recipes”, B.T.Batsford Ltd.,London,1986
5. Sudhir Sen, “Ceramic Whitewares : Production, Testing and Quality Control, Pergamon Press, 1987.

COURSE ARTICULATION MATRIX

CO	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	2	1	1	1	1	2	2	1	-	-	-	-	-	3	-
2	2	2	2	2	3	2	2	2	3	3	3	3	2	3	2
3	2	2	2	2	2	2	2	3	3	3	2	3	2	3	2
4	2	1	1	1	3	2	2	1	3	3	3	3	2	3	2
5	2	2	2	2	2	2	2	3	3	3	3	3	2	3	2
Avg	**2**	**1.6**	**1.6**	**1.6**	**2**	**2**	**2**	**2**	**2.4**	**2.4**	**2.2**	**2.4**	**1.6**	**3**	**1.6**

Correlation Levels: 1 — low, 2 — medium, 3 — high, - — no correlation

CT23405	SINTERING OF CERAMICS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

1. Describe the fundamental mechanisms and stages of the sintering process, including the roles of particle diffusion, pore reduction, and grain growth.
2. Explain the mechanisms that influence the microstructure and properties of sintered ceramics.
3. To design and optimize sintering protocols for various ceramic materials which includes selecting appropriate temperature profiles, atmosphere conditions, and time durations to achieve desired material properties, such as density, strength, and dimensional stability.

UNIT I INTRODUCTION 9

Introduction to Sintering Techniques; measurement – dilatometry, heating schedule, multistage, sintering atmosphere; driving force; defect chemistry, diffusion in crystalline solids; mechanisms of sintering; Chemical potential; Diffusional Flux equations: Vapour pressure over a curved surface; Scaling Laws; Effect of dopants; construction of heating schedule of sintering.

UNIT II MICROSTRUCTURE CONTROL 9

Introduction; general features of grain growth – grain growth and coarsening, occurrence of grain growth, driving force, normal and abnormal grain growth, importance of controlling grain growth; Ostwald Ripening – LSW theory and its modification, time dependent Ostwald ripening; topological and interfacial tension; Controlled microstructure; Normal grain growth in dense solids; Pore evolution; Grain growth in thin films; mechanisms controlling boundary mobility – simultaneous densification and grain growth.

UNIT III SOLID PHASE AND VISCOUS SINTERING 9

Mechanisms of sintering in Polycrystalline and Amorphous solid; Scaling Laws; Analytical Models – Stages of sintering, kinetic equations and limitations; Geometric models; diffusion mechanisms; viscous flow; hot pressing models and mechanisms; stress intensification factor; sintering of mixed powders – glass, cordierite, ZnO-SiC, Al_2O_3- SiC, Cr_2O_3-Al_2O_3; applications of solid phase and viscous sintering.

UNIT IV LIQUID PHASE SINTERING 9

Driving force for densification; stages in liquid phase sintering; thermodynamic and kinetic factors – phase diagram concepts, interfacial energy, wetting angle, dihedral Angle, Solubility, Capillary forces, effect of gravity; grain boundary films; mechanisms of liquid phase sintering – rearrangement and liquid redistribution, solution precipitation, pore filling, coarsening; hot

Pressing with a liquid phase; phase diagrams in liquid phase sintering; activated sintering; vitrification; applications of liquid phase sintering

UNIT V ADVANCED SINTERING TECHNIQUES 9

Sintering of ceramic composites; constrained sintering – thin films, multilayers; effect of additives – role of MgO in Al_2O_3; reaction sintering – process variables, applications; viscous sintering with crystallization – process variables; pressure assisted sintering; extrusion; shockwave consolidation; densification maps; induction sintering; LASER sintering; microwave sintering; spark plasma sintering; hot pressing; sinter forging; hot isostatic pressing (HIP); flash sintering; applications and Case studies.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

On completion of the course, the students are expected to

CO1. Comprehend the driving force for sintering.
CO2. Design a microstructure by understanding the factors that control the same.
CO3. Understand the mechanism of solid state and viscous sintering
CO4. Appraise the mechanism of liquid phase sintering.
CO5. Evaluate advanced sintering techniques and suggest a suitable technique for an intended application

TEXT BOOKS:

1. Rahaman M.N., Sintering of Ceramics, CRC Press, 2007
2. Rahaman M.N., Ceramic Processing and Sintering, Taylor and Francis, Second Edition, 2016.

REFERENCES:

1. Randall M.German et al, Sintering Technology, Marcel Dekker, Inc., 1996
2. David W. Richerson, Modern Ceramic Engineering, CRC Press, 4thEdn., 2018
3. Hayne Palmour, Sintering'85, Plenum Press, 1987
4. Suk-Joong L. Kang, Sintering: Densification, Grain Growth and Microstructure, Elsevier Publications, 2005
5. Randall M.German, Sintering Theory and Practice, John Wiley and Sons, Inc., 1996.

COURSE ARTICULATION MATRIX

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	2	3	3	3	3	1	1	-	2	2	1	2	1	3	3
2	3	3	3	2	3	1	2	-	2	2	1	2	1	3	3
3	2	3	3	2	3	1	1	-	2	2	1	2	1	3	3
4	3	3	3	3	3	1	2	-	2	2	1	3	2	3	3

5	2	3	3	3	3	1	1	-	2	2	1	2	1	3	3
Avg	**2**	**3**	**3**	**2.6**	**3**	**1**	**1.4**	**-**	**2**	**2**	**1**	**2.2**	**1.2**	**3**	**3**

Correlation Levels: 1 — low, 2 — medium, 3 — high, '-' — no correlation

CT23U01 STANDARDS – CERAMIC TECHNOLOGY

L	T	P	C
1	0	0	1

COURSE OBJECTIVES

1 To provide the key Indian Standards for Ceramics, learn the methodologies and testing procedures as per IS Standards

2 To provide skills to ensure quality control and compliance in ceramic industries

MODULE 1 OVERVIEW OF INDIAN STANDARDS **6**

Basic concepts of standardization; Purpose of Standardization, marking and certification of articles and processes; Importance of standards to industry, policy makers, trade, sustainability and innovation. Objectives, roles and functions of BIS, Bureau of Indian Standards Act, ISO/IEC Directives; WTO Good Practices for Standardization. Important Indian and International Standards.

MODULE 2 STANDARDS FOR CERAMIC TECHNOLOGY **9**

1. **CLASSIFICATION AND NOMENCLATURE OF CERAMICS**
    a. IS1597 – Classification of Ceramic Materials, Nomenclature and terminology
2. **RAW MATERIALS AND TESTING**
    a. IS4589 – Methods of sampling and testing of raw materials
    b. Standards for raw materials such as clay, feldspar, silica
3. **PHYSICAL AND CHEMICAL PROPERTIES**
    a. IS13630 – Standards for physical properties of ceramics
    b. IS14411 – Chemical Analysis Requirements
4. **MECHANICAL PROPERTIES**
    a. IS1528 – Methods of determining mechanical properties
    b. Impact of mechanical properties on applications
5. **THERMAL PROPERTIES**
    a. IS14147 – Standards on thermal properties

b. Importance of thermal properties in high temperature applications

6. ELECTRICAL PROPERTIES

a. IS3347 – Standards for electrical properties

b. Applications of ceramics with specific electrical properties

7. CERAMICS FOR SPECIFIC APPLICATIONS

a. IS4860 – Standards for ceramic tiles

b. IS5749 – Standards for sanitary ceramics

c. IS2712 – Standards for refractory ceramics

8. QUALITY CONTROL AND ASSURANCE

a. IS9000 – Quality Management systems for ceramics

b. Implementation of quality control measures

c. Case studies on quality assurance in ceramic manufacturing

9. ENVIRONMENTAL AND SAFETY STANDARDS

a. IS15358 – Environmental impact and safety standards

b. Compliance with environmental regulations

TOTAL : 15 PERIODS

COURSE OUTCOMES

On completion of the course, the students will be able to

CO1 Understand and articulate the essential Indian Standards relevant to ceramic industry

CO2 Interpret and implement effective quality control measures in ceramic manufacturing ensuring compliance with IS standards

COURSE ARTICULATION MATRIX

CO	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	1	1	1	1	1	3	3	2	1	3	2	3	2	1	1
2	2	2	2	2	2	3	3	2	2	3	2	3	2	3	2
Avg	**1.5**	**1.5**	**1.5**	**1.5**	**1.5**	**3**	**3**	**2**	**1.5**	**3**	**2**	**3**	**2**	**2**	**1.5**

Correlation Levels: 1 – low, 2 – medium, 3 – high, _-_ – no correlation

UC23U01 **UNIVERSAL HUMAN VALUES** **L T P C**

1 0 2 2

COURSE OBJECTIVE:

The objective of the course is four-fold:

1. Development of a holistic perspective based on self-exploration about themselves (human being), family, society and nature/existence.
2. Understanding (or developing clarity) of the harmony in the human being, family, society and nature/existence
3. Strengthening of self-reflection.
4. Development of commitment and courage to act.

Module I: Introduction **(3L,6P)**

Purpose and motivation for the course, recapitulation from Universal Human Values-I, Self-Exploration– Its content and process; 'Natural acceptance' and Experiential Validation- as the process for self-exploration Continuous Happiness and Prosperity- A look at basic Human Aspirations Right understanding, Relationship and Physical Facility- the basic requirements for fulfilment of aspirations of every human being with their correct priority Understanding Happiness and Prosperity correctly- A critical appraisal of the current scenario, Method to fulfil the above human aspirations: understanding and living in harmony at various levels.

Practical Session: *Include sessions to discuss natural acceptance in human being as the innate acceptance for living with responsibility (living in relationship, harmony and co-existence) rather than as arbitrariness in choice based on liking-disliking*

Module II: Harmony in the Human Being **(3L,6P)**

Understanding human being as a co-existence of the sentient 'I' and the material 'Body', Understanding the needs of Self ('I') and 'Body' - happiness and physical facility, Understanding the Body as an instrument of 'I' (I being the doer, seer and enjoyer), Understanding the characteristics and activities of 'I' and harmony in 'I', Understanding the harmony of I with the Body: Sanyam and Health; correct appraisal of Physical needs, meaning of Prosperity in detail, Programs to ensure Sanyam and Health.

Practical Session: *Include sessions to discuss the role others have played in making material goods available to me. Identifying from one's own life. Differentiate between prosperity and accumulation. Discuss program for ensuring health vs dealing with disease.*

Module III: Harmony in the Family and Society **(3L,6P)**

Understanding values in human-human relationship; meaning of Justice (nine universal values in relationships) and program for its fulfilment to ensure mutual

happiness; Trust and Respect as the foundational values of relationship, Understanding the meaning of Trust; Difference between intention and competence, Understanding the meaning of Respect, Difference between respect and differentiation; the other salient values in relationship, Understanding the harmony in the society (society being an extension of family): Resolution, Prosperity, fearlessness (trust) and co-existence as comprehensive Human Goals, Visualizing a universal harmonious order in society- Undivided Society, Universal Order- from family to world family.

Practical Session*: Include sessions to reflect on relationships in family, hostel and institute as extended family, real life examples, teacher-student relationship, goal of education etc. Gratitude as a universal value in relationships. Discuss with scenarios. Elicit examples from students' lives*

Module IV: Harmony in the Nature and Existence (3L,6P)

Understanding the harmony in the Nature, Interconnectedness and mutual fulfilment among the four orders of nature- recyclability and self regulation in nature, Understanding Existence as Co-existence of mutually interacting units in all- pervasive space, Holistic perception of harmony at all levels of existence.

Practical Session: *Include sessions to discuss human being as cause of imbalance in nature (film "Home" can be used), pollution, depletion of resources and role of technology etc.*

Module V: Implications of Harmony on Professional Ethics (3L,6P)

Natural acceptance of human values, Definitiveness of Ethical Human Conduct, Basis for Humanistic Education, Humanistic Constitution and Humanistic Universal Order, Competence in professional ethics: a. Ability to utilize the professional competence for augmenting universal human order b. Ability to identify the scope and characteristics of people friendly and eco-friendly production systems, c. Ability to identify and develop appropriate technologies and management patterns for above production systems. Case studies of typical holistic technologies, management models and production systems, Strategy for transition from the present state to Universal Human Order: a. At the level of individual: as socially and ecologically responsible engineers, technologists and managers b. At the level of society: as mutually enriching institutions and organizations, Sum up.

Practical Session: *Include Exercises and Case Studies will be taken up in Sessions E.g. To discuss the conduct as an engineer or scientist etc.*

TOTAL: 45 (15 Lectures + 30 Practicals) PERIODS

COURSE OUTCOME:

By the end of the course, the students will be able to:

1. Become more aware of themselves, and their surroundings (family, society, nature);
2. Have more responsible in life, and in handling problems with sustainable solutions, while keeping human relationships and human nature in mind.
3. Have better critical ability.
4. Become sensitive to their commitment towards what they have understood (human values, human relationship and human society).
5. Apply what they have learnt to their own self in different day-to-day settings in real life, at least a beginning would be made in this direction.

REFERENCES:

1. Human Values and Professional Ethics by R R Gaur, R Sangal, G P Bagaria, Excel Books, New Delhi, 3rd revised edition, 2023.
2. Jeevan Vidya: Ek Parichaya, A Nagaraj, Jeevan Vidya Prakashan, Amarkantak, 1999.
3. Human Values, A.N. Tripathi, New Age Intl. Publishers, New Delhi, 2004.
4. The Story of Stuff (Book).
5. The Story of My Experiments with Truth - by Mohandas Karamchand Gandhi
6. Small is Beautiful - E. F Schumacher.
7. Slow is Beautiful - Cecile Andrews.
8. Economy of Permanence - J C Kumarappa
9. Bharat Mein Angreji Raj - PanditSunderlal
10. Rediscovering India - by Dharampal
11. Hind Swaraj or Indian Home Rule - by Mohandas K. Gandhi
12. India Wins Freedom - Maulana Abdul Kalam Azad
13. Vivekananda - Romain Rolland (English)
14. Gandhi - Romain Rolland (English)

Web URLs:

1. Class preparations: https://fdp-si.aicte-india.org/UHV-II%20Class%20Note.php
2. Lecture presentations: https://fdp-si.aicte-india.org/UHV-II_Lectures_PPTs.php
3. Practice and Tutorial Sessions: https://fdp-si.aicte-india.org/UHV-II%20Practice%20Sessions.php

Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1						1	1	1	3			3
CO2						1	1	1	3			3
CO3						3	3	2	3		1	3
CO4						3	3	2	3		1	3
CO5						3	3	3	3		2	3

CT23501	MECHANICAL BEHAVIOR OF CERAMIC MATERIALS	L	T	P	C
		3	0	2	4

COURSE OBJECTIVES

1. To provide a comprehensive understanding of the basic principles of mechanical behavior in ceramics, including stress-strain behavior, elastic and plastic deformation, and fracture mechanics.
2. To apply theoretical and practical knowledge of mechanical properties to design and select ceramic materials for various engineering applications, including structural components, wear-resistant materials, and composites.

UNIT I ELASTIC BEHAVIOUR 9 + 6

Elastic constants – elastic deformation of isotropic and crystalline materials - effect of lattice constant, Grain size and Temperature- Theoretical strength – Yield criteria - stress – strain relationship - Stiffness measurement – static and dynamic methods – Critical resolved shear stress - Hardness measurement

PRACTICALS – 1. Measurement of Elastic Constant
2. Hardness test - Vickers, Brinell, Rockwell

UNIT II FRACTURE MECHANICS 9 + 6

Types of fracture - ductile and brittle fracture - Linear elastic fracture mechanics, Stress concentration, Griffith theory, stress at crack tip – - Critical stress intensity factor measurement – single edge notched, Chevron notched beam, indentation method – Statistical treatment.

PRACTICALS – 1. Measurement of Fracture Toughness - Three point bending, Vickers
2. Compressive strength measurement

UNIT III STRENGTH 9 + 4

Strength reducing mechanisms – subcritical crack propagation, failure under constant stress. Stable crack propagation – R curve, measurement. Fatigue of Ceramics – Testing method, paris theory, Life time prediction, cylindrical Pressure vessel - design of beam and columns.

PRACTICALS – 1. Fatigue test - Rotary bending

UNIT IV THERMAL BEHAVIOUR 9 + 10

Thermal stress, Eshellby method-Thermal shock resistance, Thermal cycle – measurement, micro cracking of ceramics, thermal tempering. Thermal conductivity – measurement, Creep of Ceramics – mechanisms, measurement types – Diffusion, dislocation, Construction of Deformation Map- safe life design.

PRACTICALS – 1. Thermal conductivity measurement – Guarded hot plate
2. Measurement of Thermal shock resistance.
3. Measurement of creep – Metallic wire
4. Use open source software tools to measure deflection, Thermal conductivity of composite walls.

UNIT V TOUGHENING AND MECHANICAL PROPERTIES OF CERAMICS 9 + 4

Toughening mechanisms – crack deflection, crack bowing, crack branching, crack tip shielding by process zone and bridging effect, transformation toughening, wear testing, Mechanical properties of Alumina, Silicon Nitride, Silicon Carbide and Porous ceramics, Selection of Ceramic materials.

PRACTICALS – 1. Measurement of wear – Pin on Disc

TOTAL (L45 + P30) = 75 PERIODS

EQUIPMENTS REQUIRED:

1. Three-point bending Machine
2. Sonic measurement device
3. Micro Vickers Hardness tester,
4. Brinell hardness testing machine
5. Rockwell hardness testing machine
6. Fatigue testing machine
7. Hot press
8. Micro wave furnace,
9. Thermal conductivity measuring instrument,
10. Furnace (Max 1400^{o}C)
11. Pin on disc
12. Optical Microscope
13. Universal testing machine.

COURSE OUTCOMES

On completion of the course, the students will be able to

CO1 Analyze and predict the elastic behavior of ceramic materials, including the calculation of stress-strain relationships and the determination of elastic constants, to effectively design and select ceramics for applications requiring high stiffness and minimal deformation.

CO2 Apply principles of fracture mechanics to evaluate the fracture behavior of ceramic materials, including understanding crack initiation and propagation, and use this knowledge to design ceramics with improved fracture resistance for critical applications.

CO3 Evaluate and enhance the strength of ceramic materials through understanding and applying principles such as grain size control, phase transformation, and composite reinforcement, to design ceramics with superior mechanical performance for structural and engineering applications.

CO4 Evaluate and apply the principles of thermal behavior in ceramic materials, including thermal conductivity, thermal expansion, and thermal shock resistance, to design and optimize ceramics for high-temperature and thermally demanding applications.

CO5 Analyze and implement various toughening mechanisms in ceramic materials, such as transformation toughening, crack deflection, and fiber reinforcement, to enhance their fracture toughness and reliability for advanced engineering applications.

TEXT BOOKS

1. Joshua Pelleg, “Mechanical Properties of Ceramics”, Springer Link, 2014.
2. John B.Watchman, Mechanical Properties of Ceramics, John Wiley and Sons Inc., NY, 2nd edition, 2009.

REFERENCES

1. Jonathan Salem et al, “Mechanical Properties and Performance of Engineering Ceramics and Composites VII”,Wiley,2012, Volume 33, Issue 2
2. Barsoum. M.W, Fundamentals of Ceramics, 1 st edition, Taylor & Francis, 2003.
3. R C Bradt et al, “Fracture mechanics of ceramics Volume 8: Microstructure, Methods, Design, and Fatigue” 2013.
4. R C Bradt, D P H Hasselman, “Fracture Mechanics of Ceramics, Composites, R-Curve Behavior, and Fatigue”, Springer, 2012.
5. SastriV.S and Edward Ghalai, Corrosion-prevention and protection, John Willey and Sons, 2007.

COURSE ARTICULATION MATRIX

CO	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	3	2	2	2	2	1	1	3	3	3	1	3	3	-	3
2	3	2	2	2	2	1	1	3	3	3	1	3	3	-	3
3	3	3	3	3	3	1	1	3	3	3	1	3	3	3	3
4	2	3	3	3	3	1	1	2	3	3	1	3	3	-	3
5	1	3	3	3	3	1	1	1	1	1	1	1	1	3	3
Avg	2.4	2.6	2.6	2.6	2.6	1	1	2.4	2.6	2.6	1	2.6	2.6	1.2	3

Correlation Levels: 1 — low, 2 — medium, 3 — high

CT23502	CERAMIC CHARACTERIZATION TECHNIQUES	L	T	P	C
		3	0	2	4

COURSE OBJECTIVES

1 To enable students to be thorough in different materials characterizations techniques which are dependent on their composition, phase, crystal, particulate and microstructure properties and applications.

2 To enable students to characterize ceramic powders and products for various properties

UNIT I THERMAL ANALYSIS 9

Principles of Differential thermal analysis (DTA), Thermogravimetric analysis (TGA) and Differential scanning calorimetry (DSC), Derivative Thermogram (DTG), Dilatometer - their applications in processing and Characterization of ceramics, glasses, and glass Ceramics. Thermal data for ceramic materials and its interpretation.

PRACTICALS **1.** Thermal Analysis of ceramic and glass materials by TGA, DTA, DSC.

UNIT II X – RAY DIFFRACTION 9+6

Characteristics X — rays, Fundamental principles of X-ray diffraction (XRD); Bragg‘s Law, Determination of Crystal Structure and particle size from XRD, powder XRD. Single crystal and powder diffraction. Interpretation of data for ceramic materials.

PRACTICALS **2.** Indexing the X ray diffraction pattern of ceramic system.

UNIT III SPECTROSCOPY 9+6

Basic laws of spectrophotometry and its application in elemental analysis in UV/ Visible range, Construction and working principle of spectrophotometer, Beer-Lambert's law- limitations, deviations. Additive rule of absorbance in multiple analysis of materials. General aspects of IR spectroscopy and its application in structural analysis of ceramic systems. Optical systems and operation of FTIR spectrophotometers. FTIR for ceramic materials. Raman spectroscopy.

PRACTICALS 3. Analyzing FTIR of some ceramic samples

UNIT IV SURFACE CHARACTERIZATIONS 9+8

Construction and operation of optical microscope; Principle of electron microscopy: electrostatic and magnetic lens systems; Generation of electron beam (Electron gun); Interaction of electron beam with material. Construction and operation of Transmission Electron Microscope and Scanning, Electron Microscope. Mechanism of image formation in SEM and its processing. Electron microprobe analysis (EDAX and WDS). Preparation of ceramic samples for TEM and SEM electron microscopic studies. Characteristics of microstructure; Quantitative microstructure and phase analysis: Study of the morphology, size and aggregation of ceramic materials. BET, Atomic force microscopy, OES, ICP, XRF, mass spectroscopy.

PRACTICALS **4.** Study the surface morphology of ceramic systems by microscopy techniques Optical Microscopy and SEM.

UNIT V ELECTRICAL, MAGNETIC CHARACTERIZATIONS 9+10

Nondestructive testing - ultrasonic and radiographic technology, electrical resistivity in bulk and films (2-probe method and 4-probe method), Hall effect, Impedance spectroscopy, Vibrating sample magnetometer (VSM), Magnetic PE loop.

PRACTICALS

1. Temperature and frequency dependence of dielectric constant of ferroelectric material by impedance spectroscopy.
2. Determination of dielectric constant of unknown ceramic system by parallelplate capacitor method.
3. Determination of Energy Band Gap of semiconducting materials by 4 probe method.
4. Construction of B-H loop of ferromagnetic materials.

TOTAL (T45+P30) = 75 PERIODS

EQUIPMENTS REQUIRED

1. Flame photometer
2. Thermo gravimetric analyzer
3. Brookfield viscometer
4. Laser particle size analyser
5. Optical microscope
6. Scanning electron microscope
7. Nano Indenter
8. Pin on disc wear tester
9. Dilatometer
10. Impedence spectroscopy
11. LCR meter
12. XRF analyser
13. B-H Loop equipment
14. X-ray diffractometer
15. Band gap apparatus – 4 probe method

COURSE OUTCOMES

On completion of the course, the students will be able to

CO1 Evaluate various thermal properties of ceramic products
CO2 Analyse XRD data of ceramic samples
CO3 Evaluate spectroscopic techniques for sample characterization
CO4 Select suitable surface characterization technique
CO5 Interpret the electrical and magnetic characterizations

TEXT BOOKS

1. Antony R. West, Solid State Chemistry and its applications, Second edition, John Wiley and Sons, 2014.
2. Zhang S, Li L. and Ashok Kumar, Materials Characterization Techniques, CRC Press, 2008.

REFERENCES

1. Cullity B. D., Elements of X-ray diffraction, Second edition, Addition-Wesley publication, 2001.
2. Yoshio Wase da, Kozo Shinoda, Eiichiro Matsubara, X-Ray Diffraction Crystallography: Introduction, Examples and Solved Problems, Springer, 2011.
3. Characterization of materials (Materials Science and Technology: A comprehensive treatment, Vol 2A and 2B, VCH (1992)

COURSE ARTICULATION MATRIX

CO	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	3	3	3	2	3	2	1	3	3	2	3	3	3	2	3
2	2	3	3	3	2	2	1	3	3	2	3	3	3	2	3
3	3	3	3	2	2	2	1	3	3	2	3	3	3	2	3
4	2	3	3	3	2	2	1	3	3	2	3	3	3	2	3
5	2	3	3	2	2	2	1	3	3	2	3	3	3	2	3
Avg	**2.4**	**3**	**3**	**2.4**	**2.2**	**2**	**1**	**3**	**3**	**2**	**3**	**3**	**3**	**2**	**3**

Correlation Levels: 1 — low, 2 — medium, 3 — high, - — no correlation

CT23503	GLASS AND GLASS CERAMICS	L	T	P	C
		3	0	2	4

COURSE OBJECTIVES

1 To describe the principle behind glass formation, raw materials for glass making, glass ceramics and structures of different glasses.
2 To compare different furnaces used for glass melting, their design and operation
3 To enable students to prepare different glass compositions, products and estimate glass properties

UNIT I GLASS FORMATION 9

Definition; Glass Formation – atomistic hypothesis of glass formation, kinetic approach to glass Formation; Structures of glasses – fundamental laws, elements of structural models for glasses, structural models for silicate glasses; Phase diagrams of glass forming oxide systems – $CaOAl_2O_3$- SiO_2, Na_2O-CaO-SiO_2.

UNIT II RAW MATERIALS AND BATCH PREPARATION 9+6

Raw materials – Network former, network modifier, intermediate glass former, minor additives, cullet; Handling and storage, problems and remedies; Briquetting and Pelletizing; Glass and glass ceramic compositions, Glass Batch Calculation; Major reactions and physiochemical changes during glass melting.

PRACTICALS **1.** Preparation of Soda Lime Glass with varying Cullet Percentage and Amber Glass

UNIT III GLASS MELTING FURNACES 9+9

Construction and operation of pot furnace and day tank furnace; Tank furnace – types, design and construction, Heat recovery systems; Refractories used; Electric tank furnace – design and operation, electrodes used, electric boosting in tank furnace; Forehearth & Feeder

PRACTICALS **1.** Determination of Density, Thermal Expansion, and Chemical Durability of glass
2. Determination of Refractive Index and dielectric properties of glass
3. Case study – Defects in sheet glass, bottle glass and glaze

UNIT IV FORMING AND TREATMENT 9+15

Hand operations; Flatware – patterned glass, sheet glass, float glass; Hollow ware – press & blow, blow & blow, IS machine, tube making. Annealing – Importance, Strain release, and annealing cycle; coated glasses, laminated glass, tempered glass, micro porous glass, sealing glass, and glass fibers.

PRACTICALS

1. Glass fusion and shaping
2. Preparation and testing of laminated glass
3. Determination of hardness of a toughened glass
4. Effect of different chemicals and thermal treatment on glass tempering
5. Effect of different chemicals and thermal treatment on gloziness of glaze

UNIT V GLASS CERAMICS 9

Glass ceramic materials – characteristics; phase equilibria in glass forming system; glass crystallization kinetics. melting, forming, heat treatment; Alkali and alkaline earth silicates – SiO_2-Li_2O; Aluminosilicates - SiO_2-Al_2O_3-Li_2O, Flurosilicates - SiO_2-Al_2O_3-MgO-CaO-ZrO_2- F; Silicophosphates - SiO_2-CaO-Na_2O-P_2O_5; applications - Industries - Market Demand

TOTAL (L45+P30) = 75 PERIODS

EQUIPMENTS REQUIRED:

1. Sieve Shaker
2. Hot Plate
3. Hot Air Oven
4. Furnace
5. Electronic balance
6. Dilatometer
7. Spectrometer
8. Optical microscope
9. Vicker's hardness tester
10. Three point bending test apparatus

COURSE OUTCOMES

On completion of the course, the students will be able to

- **CO1** Have thoroughly understood the science behind glass formation
- **CO2** understand the various raw materials used for glass preparation and the purpose of its usage and apply the batch composition formulation of glass compositions
- **CO3** different glass melting furnace and explain the operation of different furnaces with the means to control its operation
- **CO4** Understand the different fabrication processes of glass and recognize the importance of annealing a glass ware
- **CO5** Know fundamentals and preparation and property evaluation of glass ceramics

TEXT BOOKS

1. James E.Shelby, Introduction to Glass Science and Technology, The Royal Society of Chemistry, 1997.
2. Z. Strnad, Glass Ceramics materials, Glass Science and Technology 8, Elsevier 1986

REFERENCES

1. Tooley F.V, Handbook of Glass Manufacture, VollandII, Ogden Publishing Co., NY, 1960
2. Chapman & Hall, Schott Guide to Glass Second Edition,1996
3. Wolfgang Trier, Glass Furnaces-Design, Construction and Operation, Society of Glass Technology, 2000.
4. Wolfram Holand and George H. Beall, Glass – Ceramic Technology, second edition,2012.
5. Charles A Harper, Handbook of Ceramic Glasses and Diamonds, McGraw Hill,2001

COURSE ARTICULATION MATRIX

CO	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	2	2	2	2	-	2	2	2	-	-	-	-	3	3	-
2	2	3	3	2	3	3	3	3	3	3	3	3	2	3	3
3	2	3	3	2	2	3	3	3	3	3	2	3	2	-	2
4	2	3	3	2	3	3	3	3	3	3	3	3	3	-	2
5	2	3	3	2	-	3	3	3	-	-	-	-	-	3	3
Avg	2.0	2.8	2.8	2.0	1.6	2.8	2.8	2.8	1.8	1.8	1.6	1.8	2.0	1.8	2.0

Correlation Levels: 1 — low, 2 — medium, 3 — high, - — no correlation

CT23504	REFRACTORIES	L	T	P	C
		3	0	2	4

COURSE OBJECTIVES

1 Outline the basics about refractories and its need in high temperature process industries

2 Impart knowledge about various refractory materials and their significance

UNIT I INTRODUCTION 9 + 4

Definition; demand and growth of refractories in India; layout of a refractory plant; general classification of refractory; factors for refractory selection – thermal, mechanical and chemical factors, and their analysis.

PRACTICALS – 1. Microstructure study of various refractory materials

UNIT II RAW MATERIAL SELECTION 9 + 10

Overview of raw material selection; Types and effect of impurity of silica, alumino-silicates, alumina, magnesia, dolomite, carbon & graphite, special raw materials; other raw materials like antioxidants, resins, pitches and binders.

PRACTICALS – 1. Effect of mineralizer on phase transformation in silica refractories

2. Effect of grog content on the physical and mechanical properties of fireclay Refractories
3. Influence of alumina percentage on the high temperature properties of high alumina refractories

UNIT III REFRACTORY PREPARATION 9 + 6

Shaped refractories – manufacturing sequence of dense bricks, fused cast bricks and insulating bricks, brick shapes; unshaped refractories – overview on types; fibers and fiber products.

PRACTICALS – 1. Preparation of insulating refractories by different techniques and its property evaluation

UNIT IV INSTALLATION OF REFRACTORY 9

Installation of shaped refractories, unshaped refractories, boards and blankets; refractory dry out and anchoring systems.

UNIT V REFRACTORY TESTING 9 + 10

Refractory texture; testing methods to analyze physical, thermal, mechanical, chemical properties of refractory; overview of technical datasheet.

PRACTICALS – 1. Thermal expansion behavior of various refractory materials

2. Corrosion studies on different refractories

TOTAL (L45+P30) = 90 PERIODS

EQUIPMENTS REQUIRED

1. Sieve shaker
2. Planetary mixer
3. Weighing balance
4. Extruder
5. Uniaxial press
6. Dryer
7. Furnace
8. Flexural strength tester
9. Thermal cycling tester
10. Dilatometer
11. Thermal conductivity equipment

COURSE OUTCOMES:

On completion of the course, the students are expected to

CO1 Comprehend different refractory properties, their inter relations and significance
CO2 Appraise the criteria to be considered for raw material selection.
CO3 Analyze the steps involved in preparation various refractory product types.
CO4 Relate the installation methods of different refractory products
CO5 Assess a suitable testing method to test the refractory properties.

TEXT BOOKS:

1. Thomas Vert, Refractory Material Selection for Steelmaking, John Wiley & Sons, 2016.
2. Charles A. Schacht, Refractories Handbook, Marcel Dekker Inc., 2004.

REFERENCES:

1. Ritwik Sarkar, Refractory Technology: Fundamentals and Applications, CRC Press, 2017
2. Surendranathan A. O., An Introduction to Ceramics and Refractories, CRC Press,2014.
3. Nandi D.N., Handbook of Refractories, Tata McGraw Hill Publishing Co, New Delhi,1991.
4. Chesters J.H, Refractories: Production and Properties, Iron and Steel Institute, London,1973.
5. Coope B.M. and Dickson E.M., Raw Materials for the Refractories Industries, An Industrial Minerals Consumer Survey, 1981.
6. Shaw K, Refractories and Their Uses, App, Science Publishers, UK,1972.

COURSE ARTICULATION MATRIX

CO	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	2	1	3	3	3	1	2	-	3	3	3	3	3	-	3
2	2	1	3	2	3	1	2	-	3	3	3	3	-	3	3
3	2	1	3	2	3	1	2	-	3	3	3	3	-	3	3
4	2	1	3	2	3	1	2	-	-	-	-	-	3	-	-
5	2	3	3	3	3	1	2	-	3	3	3	3	-	3	3
Avg	**2**	**1.4**	**3**	**2.4**	**3**	**1**	**2**	**-**	**2.4**	**2.4**	**2.4**	**2.4**	**1.2**	**1.8**	**2.4**

Correlation Levels: 1 — low, 2 — medium, 3 — high, - — no correlation

CT23U02	SUSTAINABILITY COURSE – CERAMIC TECHNOLOGY	L	T	P	C
		2	0	2	3

COURSE OBJECTIVES

1 To expose the students to various sustainability concepts and the best available techniques followed in ceramic industries

UNIT I INTRODUCTION 6

Principles & Historical perspectives, Importance and need for sustainability in engineering and technology, impact and implications. United Nations Sustainability Development Goals (SDG), UN summit – Rio & outcome, Sustainability and development indicators.

UNIT II ENVIRONMENTAL SUSTAINABILITY 6

Climate change, Biodiversity loss, Pollution and waste management, Renewable vs. non-renewable resources, Water and energy conservation, Sustainable agriculture and forestry. National and international policies, Environmental regulations and compliance, Ecological Footprint Analysis

UNIT III SOCIAL & ECONOMIC SUSTAINABILITY 9

Equity and justice, Community development, Smart cities and sustainable infrastructure, Cultural heritage and sustainability, Ethical considerations in sustainable development.

Triple bottom line approach, Sustainable economic growth, Corporate social responsibility (CSR), Green marketing and sustainable product design, Circular economy and waste minimization, Green accounting and sustainability reporting.

UNIT IV SUSTAINABILITY IN CERAMIC INDUSTRIES 9

Determination of Best Available Techniques (BAT) for ceramic manufacturing – description, achieved environmental benefits, cross-media effects, operational data, applicability economics, driving force for implementation, examples; Sector specific BAT – bricks & roof tiles, vitrified clay pipes, refractory products, expanded clay aggregates, wall & floor tiles, household ceramics, sanitaryware, technical ceramics, inorganic bonded abrasives, glass; emerging techniques for ceramic manufacturing – radiant tube burners, microwave assisted drying and firing, new drying systems for refractory products, integrated glaze recovery, lead free glazing.

UNIT V SUSTAINABILITY PRACTICES 30

Suggested Practices not limited to

- Energy efficiency – how to save energy (energy efficient equipment, energy saving behaviours).
- Raw material use and storage - the choice of raw materials being procured, the safe disposal of leftover raw materials, the impact of raw materials on the environment and long-term health impacts on humans.
- Recycling of raw materials and prodcuts

- Green building, green building materials, green building certification and rating: green rating for integrated habitat assessment (GRIHA), leadership in energy and environmental design (LEED)
- Tools for Sustainability - Environmental Management System (EMS), ISO14000, life cycle assessment (LCA)
- Ecological footprint assessment using the Global Footprint Network spreadsheet calculator
- National/Sub national Status of Sustainable Development Goals

TOTAL: 60 PERIODS

COURSE OUTCOMES

On completion of the course, the students will be able to

CO1	Understand the importance of sustainability and the goals of sustainability
CO2	Appreciate the significance of environmental sustainability
CO3	Recognize various social and economic sustainability factors.
CO4	Apply a suitable BAT for a specific ceramic industry
CO5	Analyse various sustainability practices

TEXT BOOKS:

1. Allen, D., & Shonnard, D. R. (2011). Sustainable engineering: Concepts, design and case studies. Prentice Hall.
2. Reference document on Best Available Techniques in Ceramic Industry, European Commission, 2007.

REFERENCES:

1. Esa Salminen, Johan Mjoberg and Juhani Anhava, Nordic Ceramic Industry-Best Available Technique (BAT) , TemaNord, 2019.
2. Munier, N. (2005). Introduction to sustainability (pp. 3558-6). Amsterdam, The Netherlands: Springer.
3. Blackburn, W. R. (2012). The sustainability handbook: The complete management guide to achieving social, economic and environmental responsibility. Routledge.
4. Clini, C., Musu, I., & Gullino, M. L. (2008). Sustainable development and environmental management. Published by Springer, PO Box, 17, 3300.
5. Bennett, M., James, P., & Klinkers, L. (Eds.). (2017). Sustainable measures: Evaluation and reporting of environmental and social performance. Routledge.
6. Seliger, G. (2012). Sustainable manufacturing for global value creation (pp. 3-8). Springer Berlin Heidelberg.
7. Stark, R., Seliger, G., & Bonvoisin, J. (2017). Sustainable manufacturing: Challenges, solutions and implementation perspectives. Springer Nature.
8. Davim, J. P. (Ed.). (2013). Sustainable manufacturing. John Wiley & Sons.

COURSE ARTICULATION MATRIX

CO	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	3	3	3	3	2	3	3	1	3	2	2	3	3	2	1
2	3	3	3	3	2	3	3	1	3	2	2	3	3	2	1
3	3	3	3	3	2	3	3	1	3	2	2	3	3	2	1
4	3	3	3	3	2	3	3	1	3	2	2	3	3	2	1
5	3	3	3	3	2	3	3	1	3	2	2	3	3	2	1
Avg	**3**	**3**	**3**	**3**	**2**	**3**	**3**	**1**	**3**	**2**	**2**	**3**	**3**	**2**	**1**

Correlation Levels: 1 — low, 2 — medium, 3 — high, - — no correlation

CT23S01	CERAMIC DESIGNING AND SIMULATION TOOLS	L	T	P	C
		0	0	4	2

COURSE OBJECTIVES

1 Hands on experience in design, modelling, assembly, analysis and simulation

EXPERIMENTS:

1. Design and Modelling of ceramic crucible
2. Design and modelling of closet, Insulators, IR heaters
3. Design, modelling and assembling of mortar & pestle, bolt & nut.
4. Design and modelling of furnace.
5. Design, modelling and analysis of 1D, 2D & 3D structures.
6. Design, modelling and analysis of beams for three-point bending.
7. Design, modelling and analysis of beams for four-point bending.
8. Design, modelling and thermal analysis of composite wall.
9. Heat and temperature loss of a liquid metal container
10. Fire protect simulation
11. Transient simulation of kiln car
12. Steady state heat flow
13. Transient Heat flow simulation
14. Simulation of fire concrete drying
15. Heat transport mechanism in static and ventilated air-gaps.

TOTAL: 60 PERIODS

Software's required:

1. CATIA
2. Abacus
3. SIMUTHERM

COURSE OUTCOMES:

On completion of the course, the students are expected to

CO1 Design and model a given product, estimate the required amount of material and properties.

CO2 Analyze different beams and the acting loads.

CO3 examine and inspect different heat transports and mechanisms over different layered materials.

COURSE ARTICULATION MATRIX

CO	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	2	1	3	3	3	3	3	1	3	3	3	3	3	-	3
2	2	1	3	2	3	3	3	1	3	3	3	3	-	3	3
3	2	1	3	2	3	3	3	1	3	3	3	3	-	3	3
4	2	1	3	2	3	3	3	1	-	-	-	-	3	-	-
5	2	3	3	3	3	3	3	1	3	3	3	3	-	3	3
Avg	**2**	**1.4**	**3**	**2.4**	**3**	**3**	**3**	**1**	**2.4**	**2.4**	**2.4**	**2.4**	**1.2**	**1.8**	**2.4**

CT23601	CREATIVE AND INNOVATIVE PROJECT	L	T	P	C
		0	0	4	2

COURSE OBJECTIVES:

1. To help students to identify innovative projects that promotes and imbibe creativity.
2. enable students to be familiar with current thinking in their field, and able to apply the concepts to relevant research problems or practical applications related to Ceramic Technology

Each batch comprising of a maximum of 3 students will choose problem related to research or industrial task that has been difficult for them to “solve.” Batch is expected to solve the task by fabricating or developing suitable working model / process / product. At the end of the semester, each student or group of students have to submit a report for evaluation.

COURSE OUTCOMES

On completion of the course, the students are expected to

CO1 learn concepts, models, frameworks, and tools that a Ceramic Engineer need in a world where creativity and innovation is fast becoming a pre- condition for competitive advantage.

CO2 develop a working model using the knowledge they have gained theoretically

COURSE ARTICULATION MATRIX

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Avg	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**

Correlation Levels: 1 — low, 2 — medium, 3 — high, - — no correlation

UC23E01 ENGINEERING ENTREPRENEURSHIP DEVELOPMENT

L	T	P	C
2	0	2	3

COURSE OBJECTIVES:

1. Learn basic concepts in entrepreneurship, develop mind-set and skills necessary to explore entrepreneurship
2. Apply process of problem - opportunity identification and validation through human centred approach to design thinking in building solutions as part of engineering projects
3. Analyse market types, conduct market estimation, identify customers, create customer persona, develop the skills to create a compelling value proposition and build a Minimum Viable Product
4. Explore business models, create business plan, conduct financial analysis and feasibility analysis to assess the financial viability of a venture ideas & solutions built with domain expertise
5. Prepare and present an investible pitch deck of their practice venture to attract stakeholders

MODULE – I: ENTREPRENEURIAL MINDSET **4L,8P**

Introduction to Entrepreneurship: Definition – Types of Entrepreneurs – Emerging Economies – Developing and Understanding an Entrepreneurial Mindset – Importance of Technology Entrepreneurship – Benefits to the Society.

Case Analysis: Study cases of successful & failed engineering entrepreneurs - Foster Creative Thinking: Engage in a series of Problem-Identification and Problem-Solving tasks

MODULE – II: OPPORTUNITIES **4L,8P**

Problems and Opportunities – Ideas and Opportunities – Identifying problems in society – Creation of opportunities – Exploring Market Types – Estimating the Market Size, - Knowing the Customer and Consumer - Customer Segmentation - Identifying niche markets – Customer discovery and validation; Market research techniques, tools for validation of ideas and opportunities

Activity Session: Identify emerging sectors / potential opportunities in existing markets - Customer Interviews: Conduct preliminary interviews with potential customers for Opportunity Validation - Analyse feedback to refine the opportunity.

MODULE – III: PROTOTYPING & ITERATION **4L,8P**

Prototyping – Importance in entrepreneurial process – Types of Prototypes - Different methods – Tools & Techniques.

Hands-on sessions on prototyping tools (3D printing, electronics, software), Develop a prototype based on identified opportunities; Receive feedback and iterate on the prototypes.

MODULE – IV: BUSINESS MODELS & PITCHING **4L,8P**

Business Model and Types - Lean Approach - 9 block Lean Canvas Model - Riskiest Assumptions in Business Model Design – Using Business Model Canvas as a Tool – Pitching Techniques: Importance of pitching - Types of pitches - crafting a compelling pitch – pitch presentation skills - using storytelling to gain investor/customer attention.

Activity Session: Develop a business model canvas for the prototype; present and receive feedback from peers and mentors - Prepare and practice pitching the business ideas- Participate in a Pitching Competition and present to a panel of judges - receive & reflect feedback

MODULE – V: ENTREPRENEURIAL ECOSYSTEM **4L,8P**

Understanding the Entrepreneurial Ecosystem – Components: Angels, Venture Capitalists, Maker Spaces, Incubators, Accelerators, Investors. Financing models – equity, debt, crowdfunding, etc, Support from the government and corporates. Navigating Ecosystem Support: Searching & Identifying the Right Ecosystem Partner – Leveraging the Ecosystem - Building the right stakeholder network

Activity Session: Arrangement of Guest Speaker Sessions by successful entrepreneurs and entrepreneurial ecosystem leaders (incubation managers; angels; etc), Visit one or two entrepreneurial ecosystem players (Travel and visit a research park or incubator or makerspace or interact with startup founders).

TOTAL: 60 PERIODS

COURSE OUTCOMES:

Upon the successful completion of the course, students will be able to:

CO1: Develop an Entrepreneurial Mind-set and Understand the Entrepreneurial Ecosystem Components and Funding types

CO2: Comprehend the process of opportunity identification through design thinking, identify market potential and customers

CO3: Generate and develop creative ideas through ideation techniques

CO4: Create prototypes to materialize design concepts and conduct testing to gather feedback and refine prototypes to build a validated MVP

CO5: Analyse and refine business models to ensure sustainability and profitability Prepare and deliver an investible pitch deck of their practice venture to attract stakeholders

REFERENCES:

1 Robert D. Hisrich, Michael P. Peters, Dean A. Shepherd, Sabyasachi Sinha (2020). Entrepreneurship, McGrawHill, 11th Edition

2. Bill Aulet (2024). Disciplined Entrepreneurship: 24 Steps to a Successful Startup. John Wiley & Sons.

3. Bill Aulet (2017). Disciplined Entrepreneurship Workbook. John Wiley & Sons.

4. Ries, E. (2011). The Lean Startup: How Today's Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses. Crown Business

5. Blank, S. G., & Dorf, B. (2012). The Startup Owner's Manual: The Step-by-Step Guide for Building a Great Company. K&S Ranch

6. Osterwalder, A., & Pigneur, Y. (2010). Business Model Generation: A Handbook for Visionaries, Game Changers, and Challengers. John Wiley & Sons

7. Marc Gruber & Sharon Tal (2019). Where to Play: 3 Steps for Discovering Your Most Valuable Market Opportunities. Pearson.

CT23701	ABRASIVES AND CUTTING TOOLS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

1. To introduce raw materials used as abrasives and various abrasive products.
2. To explain the principle, working, applications of grinding and cutting tools.

UNIT I ABRASIVE RAW MATERIALS AND COATED ABRASIVES 10

Abrasives – definition, classification, applications. Abrasive grains – classification, characteristics like hardness, toughness, bulk density etc. Backings; Binders- temporary and permanent. Selection of abrasives for various processes; Lifecycle and sustainability Manufacturers.

Coated Abrasives - Raw material selection and preliminary treatments, maker coating, abrasive coating, conversions – slitting, belt making, sheet cutting, disc cutting. Individual disc coating process; Applications. Quality control and testing- Manufacturers.

UNIT II BACKUPS 8

Contact wheels – cloth contact wheels, rubber contact wheels, hardness, face serrations, shape, wheel diameter, speed, belt tension, dressing and protection of contact wheels – their characteristics.

Drum, rolls, pads and platens – types, characteristics, choice and uses. Working principle of coated abrasive products.

UNIT III BONDED ABRASIVES 9

Abrasive grain type and characteristics required for bonded abrasives. Types of bonds – vitrified, silicate, resinoid, shellac, rubber and oxychloride. Bonded wheel manufacture - different bonds, Reaction at temperatures, characteristics. Shapes and sizes of wheels, Applications.

Factors determining grinding action – characteristics of abrasive grain, bond type, structure. Wheel losses- cracks, pin holes, boils. Other types of wheels – Diamond wheels, reinforced wheels, mounted wheels. Selection of appropriate abrasive wheels for grinding metals and non-metals – Industries

UNIT IV BASICS OF GRINDING AND POLISHING 9

Grinding wheel – definition, Nomenclature, grinding chips, G ratio, chemical reactions, grade selection, wheel wear and chemical grinding aids. Safe grinding practices.

Grinding fluids – properties, types and purpose. Types of grinding – cylindrical grinding, center less grinding, surface grinding, internal grinding. Polishing – definition, types.

UNIT V CUTTING TOOLS 9

Introduction, types -Ceramic cutting tools - Oxide ceramics. Whiskered ceramics. Silicon nitrides, carbides. SiAlON –Properties, Parameters.

Drilling cutters, milling cutters, tool inserts, coatings on cutting tools; selection of tool & tool life calculations, cost analysis. Lifecycle and sustainability of abrasive tools.

TOTAL: 45 PERIODS

COURSE OUTCOMES

On completion of the course, the students will be able to

CO1 Identify a suitable abrasive for a given process.
CO2 Illustrate the need / selection for a contact wheel, its storage and protection.
CO3 Recognize an appropriate bonded abrasive product for a given application.
CO4 Apply a suitable grinding/polishing/cutting tool for a selected material to be grinded.
CO5 Evaluate the tool life and cost analysis for cutting tool & inserts.

TEXT BOOKS

1. Alfred Broadhead Searle **, (**2010 **) "**The Manufacture and Uses of Abrasive Materials: A Concise Treatment of the Nature and Preparation of Raw Materials, and the Manufacture of Abrasive Blocks, Wheels, Papers, Cloths, Polishes", sir I. Pitman & Sons, Limited, 1922.
2. Ioan.D.Marinescu et al, "Handbook of machining with grinding wheels" CRC Press, 2016**.**

REFERENCES

1. Barbara Linke, "Lifecycle and sustainability of abrasive tools" Springer, 2016.
2. Stephen Malkin, "Grinding technology, Theory and applications of machining with abrasives", Industrial press, 2008.
3. Standards Australia Ltd., Staffs, "Bonded Abrasive Products, Permissible Unbalances of Grinding Wheels as Delivered: Static Testing" Standards Australia & New Zealand publishers 2006.
4. Mark J Jackson, J Paulo Davim, "Machining with abrasives" Springer, 2011.
5. Mark J. Jackson, Michael P. Hitchiner, "High Performance Grinding and Advanced Cutting Tools", Springer, 2012.

COURSE ARTICULATION MATRIX

CO	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	2	3	2	2	3	1	1	-	2	2	1	2	-	3	3
2	2	2	2	2	2	1	1	-	2	2	1	2	-	3	-
3	2	2	3	3	3	1	1	-	2	2	1	2	-	3	-
4	2	3	2	3	2	1	1	-	2	2	1	2	2	3	2
5	2	3	3	3	3	1	1	-	2	2	1	2	2	3	-
Avg	**2**	**2.6**	**2.4**	**2.6**	**2.6**	**1**	**1**	**-**	**2**	**2**	**1**	**2**	**2**	**3**	**2.5**

Correlation Levels: 1 — low, 2 — medium, 3 — high, - — no correlation

CT23702	PROCESS MONITORING AND CONTROL IN CERAMIC INDUSTRIES	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

1 To enable the students to have a basic knowledge about the control instruments and its applications in various fields.

UNIT I INTRODUCTION 9

Principles of measurement and classification of process control instruments; temperature, pressure fluid flow, liquid level, velocity, fluid density, viscosity, conductivity, pH, TDS, TSS etc., instrument scaling; sensors; transmitters and control valves; instrumentation symbols and labels.

UNIT II PROCESS AUTOMATION 9

Basic Concepts; terminology and techniques for process control; control modes; tuning process controllers.

UNIT III ADVANCED CONTROL 9

Advanced control techniques, feed forward and ratio control; controller design; adaptive control system; statistical process control; expert system; multivariable control techniques; supervisory control.

UNIT IV DIGITAL CONTROL 9

Digital control techniques; z transforms; sampling and filtering; response of discrete time systems; sampled data control systems; design of digital controllers, modal predictive control.

UNIT V OPTIMAL CONTROL 9

Optimization and simulation; optimization techniques; single and multivariable constrained optimization; dynamic simulation of distillation columns and reactors.

TOTAL: 45 PERIODS

COURSE OUTCOMES

On completion of the course, the students will be able to

CO1 Understand the principle and classification of process control equipment
CO2 Comprehend the basic concepts on process control.
CO3 Analyse about advanced control instruments.
CO4 Understand the concepts of digital control
CO5 Evaluate the optimal control processes

TEXT BOOKS

1. Nakara, B.C & Choudary K.K., Instrumentation and Analysis, Tata McGraw Hill, New Delhi, Eighth Reprint, 1993.
2. Stephanopoulos G., Chemical Process Control, Tata McGraw Hill, New Delhi, 1993.

REFERENCES

1. Karl J.Astrom & Bjorn Willermans; Computer Controlled Systems, Prentice Hall of India Pvt.Ltd. 1994.

2. Chemical Engineering Refreshers series on Process Automation, McGraw Hill Publications, New York, 1991.

CO	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	3	3	2	2	3	1	1	-	1	2	2	2	3	3	3
2	2	2	2	2	2	1	1	-	1	2	2	2	3	3	-
3	2	2	3	3	3	1	1	-	1	2	2	2	3	3	-
4	2	3	2	3	2	1	1	-	1	2	2	2	2	3	2
5	2	3	3	3	3	1	1	-	1	2	2	2	2	3	-
Avg	**2.2**	**2.6**	**2.4**	**2.6**	**2.6**	**1**	**1**	**-**	**1**	**2**	**2**	**2**	**2.6**	**3**	**2.5**

Correlation Levels: 1 — low, 2 — medium, 3 — high, - — no correlation

CT23703	INDUSTRIAL TRAINING / INTERNSHIP	L	T	P	C
	(4 weeks during Summer)	0	0	0	2

COURSE OBJECTIVES:

1. Give practical exposure to students in industries or in research institute
2. Enable students to relate their theoretical knowledge to practical situation
3. Train students to the industry / research environment

All the students have to undergo practical industrial training / internship of minimum four week (total) duration in recognized establishments during vacations in their third year (vacation during V semester and / or VI Semester), at the end of which they have to submit a report

COURSE OUTCOMES

On completion of the course, the students are expected to

CO1 Employ their theoretical skills

CO2 Be clarified with the components and working of industry / research institute.

CO3 Be trained in the different divisions of the industry / institute

CO4 Face the real life situation in industry / institute with ease on placement.

COURSE ARTICULATION MATRIX

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
4	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Avg	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3

Correlation Levels: 1 – low, 2 – medium, 3 – high, _-_ – no correlation

CT23801	PROJECT WORK / INTERNSHIP CUM PROJECT WORK	L	T	P	C
		0	0	16	8

COURSE OBJECTIVES:

1. To train the students on systematic analysis of a problem
2. To enable students to bring out a solution to the problem

Each student / batch with a maximum of 3 students are required to use concepts of ceramic engineering and technology to develop a pilot model or to suggest a suitable process to solve industrial and/or societal related problems. At the end of the course, they have to submit a report on the project assigned to him/her by the department. The report should be based on the literature collected from the many sources, the actual analysis and the development done by the student on the given project.

TOTAL: 240 PERIODS

COURSE OUTCOMES

On completion of the course, the students are expected to

CO1 Adapt and analyse a given problem systematically
CO2 compile knowledge gained at various stages of the degree course to bring out solution to the problem
CO3 formulate a methodical approach to problem solving

COURSE ARTICULATION MATRIX

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Avg	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**

Correlation Levels: 1 — low, 2 — medium, 3 — high, - — no correlation

CT23001	MONOLITHIC REFRACTORY	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1 To discuss the various types of monolithic materials and their characteristics and applications

2 To compare the installation methods of different monolithic materials

3 To deliberate the wear mechanisms of the installed materials and their testing methods

UNIT I CASTABLES 9

Introduction, raw materials, binders and other additives - types of castables based on CaO and their composition, characteristics and applications. Other castables - dense, insulating and pumpable castables and their compositions and characteristics – Applications of castables.

UNIT II PLASTIC REFRACTORIES, RAMMING AND GUNNING MIXES 9

Plastic refractories –types - alumina and alumina based, silicon carbide, carbon and phosphate bonded plastic masses and their compositions, characteristics and applications. Ramming mix – characteristics, binder systems and their characteristics, properties, installation and uses of ramming mixes. Gunning mixes – introduction, binder system, alumina-based spinel gunning mix, characteristics and applications in rotary kiln lining, power plant lining and ladle repair.

UNIT III MORTARS, COATINGS AND DRY VIBRATABLES 9

Mortars – Introduction, types – silica, alumina, alumina-spinel and basic mortars and their characteristics and applications. Coatings – introduction, applications in refractory lining and foundry, method of coatings- brushing, spraying, dipping and sputtering. Dry vibratables – Introduction, principle and applications in mini steel and iron foundry, steel and alloy foundry and BF cast house.

UNIT IV MONOLITHIC INSTALLATION 9

Methods of installations of castables, plastic refractories, ramming mix and gunning mix. Drying and heating up of installed monolithic lining. Application designs – blast furnace tap hole, blast furnace trough design, trough lining, impact pad and form design, tundish, steel ladle, electric arc furnace. Linings in installation – application of anchors in rotary kiln and direct reduction iron and power plant.

UNIT V WEAR MECHANISMS AND TESTING 9

Tests done on unshaped refractories – chemical analysis – physical properties - density, porosity and workability. Thermal properties – permanent linear change, reheat permanent linear change, linear thermal expansion, thermal conductivity, thermal shock resistance, thermo-mechanical properties – refractoriness under load, creep and hot MOR. Cold crushing strength, modulus of rupture, CO disintegration test. Wear mechanism of refractory lining – corrosion, abrasion, penetration and erosion.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

On completion of the course the students will be able to

CO1 Discuss the types of unshaped / monolithic refractory materials, their composition and Characteristics

CO2 Comprehend the types of various plastic refractories, ramming and ramming mixes and their compositions, properties and applications

CO3 Have studied the various mortars, coating and dry vibratable refractories and prepare monolithic materials with appropriate bond systems.

CO4 Discern the methods of installing different monolithic materials, the application design and the lining materials used while laying monolithic.

CO5 Assess the wear mechanisms that cause failure in a monolithic lining and the methods to test a monolithic.

TEXT BOOKS:

1. Subrata Banerjee, “Monolithic Refractories”, World Scientific Publishing Co. Pt. Ltd.,1998.
2. Taikabutsu Overseas, Recent Progress in Castable Refractories, Techno Japan, Vol.9 No.1, Fuji Marketing Research Co. Ltd., Japan,1995.

REFERENCES:

1. Charles A. Schacht, Refractories Handbook, Marcel Dekker Inc, New York,2004.
2. Norton F.H, Refractories, 4thEdn., McGraw Hill Book Co.,1968.
3. Nandi D.N, Handbook of Refractories, Tata McGraw-Hill Publishing Co., New Delhi,1991.
4. Akira Nishikawa, Technology of Monolithic Refractories, Plibrico, Japan Co. Ltd., Tokyo,1984.
5. Surendranathan A. O., An Introduction to Ceramics and Refractories, CRC Press, NY, 2015.

COURSE ARTICULATION MATRIX:

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	3	3	2	2	1	1	1	1	1	1	1	1	3	3	2
2	3	3	2	2	1	1	1	1	1	1	1	1	3	3	2
3	3	3	2	2	1	1	1	1	1	1	1	1	3	3	2
4	3	3	2	2	1	1	1	1	1	1	1	1	3	3	2
5	3	3	2	2	1	1	1	1	1	1	1	1	3	3	2
Average	**3**	**3**	**2**	**2**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**3**	**3**	2

Correlation Levels: 1 — low, 2 — medium, 3 — high, - no correlation

CT23002	PROCESS METALLURGY	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

1. Introduce various metal types and metallurgical operations to extract the same from their ores.
2. Make the students identify a suitable extraction process for a particular mineral type.

UNIT I INTRODUCTION 9

Economic classification of metals – ferrous and nonferrous metals; metal production – logarithmic law, production patterns, process; recycling of metals; byproduct metals; introduction to types of extractive metallurgical operations.

Ore dressing for metal extraction – beneficiation, ore concentration by physical and chemical methods.

UNIT II PHYSICOCHEMICAL FUNDAMENTALS OF EXTRACTION METALLURGY 9

Chemical Equilibrium; Ellingham-Richardson diagrams for oxides, sulphides, chlorides and carbides; phase diagrams and activities of representative liquid alloys, mattes and slags;

UNIT III PYROMETALLURGICAL PROCESSES 9

Process of and furnaces used for calcining, roasting, sintering/agglomeration, smelting of different metals & significance of slag, types of refining

UNIT IV HYDROMETALLURGICAL PROCESSES 9

Overview; leaching processes; precipitation processes; solvent extraction; hydrometallurgical processing routes of ores, concentrates and residues.

UNIT V ELECTROMETALLURGICAL PROCESSES 9

Basics of electrolysis and aqueous electrolysis; electrowinning – copper, zinc; electrorefining – copper, zinc, lead, tin.

TOTAL : 45 PERIODS

COURSE OUTCOMES

On completion of the course, the students will be able to

CO1 Recognize the different types of metals and understand the steps involved in ore dressing for metal extraction

CO2 Relate the physicochemical concepts involved in metal extraction from ores

CO3 Comprehend the various pyrometallurgical processes involved in metal extraction

CO4 Articulate the metal extraction processes by hydrometallurgy

CO5 Relate different electrometallurgical processes for metal extraction

TEXT BOOKS

1. Alain Vignes, Extractive Metallurgy 2 – Metallurgical Reaction Processes, ISTE Ltd and John Wiley & Sons, 2011.

2. Fathi Habashi, Handbook of Extractive Metallurgy – Vol I, Wiley-VCH, 1997.

REFERENCES

1. Alain Vignes, Extractive Metallurgy 1 – Basic Thermodynamics and Kinetics, ISTE Ltd and John Wiley & Sons, 2011.
2. Alain Vignes, Extractive Metallurgy 3 – Processing Operations and Routes, ISTE Ltd and John Wiley & Sons, 2011.
3. Ahindra Ghosh and Amit Chatterjee, Iron Making and Steel Making – Theory and Practice, PHI Learning Pvt. Ltd., 2008.
4. S.Seetharaman, Fundamentals of Metallurgy, Woodhead Publishing Ltd., 2005.
5. Fathi Habashi, Handbook of Extractive Metallurgy – Vol I, Wiley-VCH, 1997.

COURSE ARTICULATION MATRIX

CO	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	2	1	3	3	3	1	1	-	2	2	2	2	3	-	3
2	2	1	3	2	3	1	1	-	2	2	2	2	-	3	3
3	2	1	3	2	3	1	1	-	2	2	2	2	-	3	3
4	2	1	3	2	3	1	1	-	2	2	2	2	3	-	-
5	2	3	3	3	3	1	1	-	2	2	2	2	-	3	3
Avg	**2**	**1.4**	**3**	**2.4**	**3**	**1**	**1**	**-**	**2**	**2**	**2**	**2**	**1.2**	**1.8**	**2.4**

CorrelationLevels:1—low,2—medium, 3—high, - —nocorrelation

CT23003	REFRACTORY DESIGN AND INSTALLATION	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

1. Impart knowledge on various refractories used in iron and steel industry.
2. Enlighten about the refractory usage in process equipment in non-ferrous metallic industries.
3. Give awareness on various metal-refractory interactions leading to refractory failure.

UNIT I MATERIALS USED IN FURNACE CONSTRUCTION 9

Shaped dense materials – different compositions; shaped insulating materials – bricks, other shapes; unshaped refractories – classification based on materials and installation methods; ceramic fiber materials – classification, forms on delivery; metals – types, classification according to resistance, selection criteria; anchors; surface protection – metallic surface, ceramic surface; other materials – miscellaneous bricks, cements, burnout materials, filler materials, separation layers, mixing water.

UNIT II INSTALLATION WITH SHAPED REFRACTORY 9

Brick shapes and sizes – standard and special; joints; courses and bonds; furnace construction – foundation, wall, hearth; arch – types, geometry, construction calculation, skewback design; design with shaped insulating brick – shapes, anchoring, joints, examples.

UNIT III INSTALLATION WITH UNSHAPED REFRACTORY 9

Introduction; refractory concrete – casting, pumping and extruding, dry packing, trowel placing, pneumatic gun casting, finishing; construction with refractory concrete – support structure, forms, anchors, rebar and metal embedment, joints; plastic refractories – support structure, storage and preparation, forms, anchors, ramming installation, gunning installation, vibratory installation, hand packing, trimming, venting, joints; application examples.

UNIT IV CURING, DRYING AND FIRING 9

Curing; drying and firing – processes during drying, firing schedule, modes, general considerations; drying/firing of different materials – refractory concretes, plastics & ramming mixes, special cases – cement plant with preheater, circulating fluidized bed, thermal refuse incinerator, aluminum melting furnace.

UNIT V INSPECTION AND ASSESSMENT OF REFRACTORY 9

Inspection – introduction, shaped refractory materials, unshaped refractory materials, installation; inspection and assessment of damaged lining – inspection methods, remaining life calculation and exploratory removal, sampling & testing; refractory lining defects and damage mechanisms – castables, bricks, anchors, fiber, special components, multi-component lining systems.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

On completion of the course, the students are expected to

CO1 Select suitable materials for construction of a furnace for specific application.
CO2 Exhibit understanding on installation of shaped refractory material.
CO3 Profess knowledge on unshaped refractory material installation
CO4 Understand the curing, drying and firing processes after refractory installation.
CO5 Inspect and assess the refractory linings for proper installation / failure.

TEXT BOOKS:

1. Sukumar Dr.Laik, Refractory `Engineering: Materials-Design-Construction, 2nd Edn, 2006.
2. Harbison-Walker Brick Installation Guide, Harbison-Walker Refractories Company, USA, 2008.

REFERENCES:

1. ACI 547.1R-89, Refractory Plastics and Ramming Mixes, ACI Committee, 1997
2. API STANDARD 980, Monolithic Refractories: Installation and Dryout, First Edn, 2018
3. API STANDARD 982, Inspection and Assessment of Refractory Linings, First Edn, 2022
4. Stephen Caniglia , Gordon L. Barna, Handbook of Industrial Refractories Technology: Principles, Types, Properties and Applications, Noyes Publications,1992
5. Margaret Rasmussen (Ed), Glass Melting Technology: A Technical and Economic Assessment, Glass Manufacturing Industry Council, USA, 2004.

COURSE ARTICULATION MATRIX

CO	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	1	3	3	3	3	1	2	-	1	2	2	2	1	3	-
2	1	3	3	2	3	1	2	-	1	2	2	2	1	3	-
3	1	3	3	2	3	1	2	-	1	2	2	2	1	3	-
4	1	3	3	3	3	1	2	-	1	2	2	2	1	3	-
5	1	3	3	3	3	1	2	-	1	2	2	2	1	3	3
Avg	**1**	**3**	**3**	**2.6**	**3**	**1**	**2**	**-**	**1**	**2**	**2**	**2**	**1**	**3**	**3**

Correlation Levels: 1 — low, 2 — medium, 3 — high, - — no correlation

CT23004	REFRACTORIES FOR IRON AND STEEL INDUSTRY	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

1. Impart knowledge on various refractories used in iron and steel industry.
2. Give awareness on various metal-refractory interactions leading to refractory failure

UNIT I INTRODUCTION **9**

Occurrence – native metal, other mineral forms; iron ores – deposits, important iron-producing countries, beneficiation of ore, agglomeration; reduction of iron oxide – chemical and technical aspects, raw materials and products; overall iron and steel making process sequence; Present status of World steel industry and Indian Scenario; Environmental pollution and control.

UNIT II IRON MAKING **9**

Coke oven – construction, working, refractories used; blast furnace overview - construction, reactions taking place; refractories in blast furnace – usage in different areas, maintenance practice, methods to prolong blast furnace campaign; cast house refractory – tap hole, hot metal trough, iron runner, wear mechanism, modern refractory practice; hot stove – design, refractory lining, refractory failure and repair methodology.

UNIT III STEEL MAKING **9**

Hot metal transport – torpedo ladle car, desulphurization; hot metal ladle – design and construction; basic oxygen furnace – operating conditions, refractory lining, zonal lining concept, refractory maintenance, methods to prolong refractory life; electric arc furnace – features, lining concepts, slag-refractory interaction, state-of-the-art operating practices.

UNIT V SECONDARY STEEL MAKING **9**

Steel ladles – construction, refractory design; ladle refractory lining – silicon-killed steel, Al-killed steel and Ca treated steel; ladle under vacuum – refractory used, wear mechanism; refractory for flow control – stopper rod, slide plate; refractory for purging systems; refractory for casting – ingot casting, continuous casting, black refractory; modern refractory practice for clean steel.

UNIT V REFRACTORY CORROSION **9**

Introduction; thermodynamic perception; effect of temperature and water vapour; slag-refractory interactions – diffusion in solid, oxidation, infiltration, dissolution, crystalline alteration, Endell, Fehling and Kley model; Phenomenological Approach and Slag Design – refractory solubility, slag composition and volume optimization; specific interactions of metals with refractories.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

On completion of the course, the students are expected to

CO1 Understand the ores and minerals of iron, and the steel industry scenario in India and World

CO2 Comprehend the process of iron making in blast furnace and the various accessories involved in the process

CO3 Explore the various furnaces used for steel making and analyse the reason for specific refractory usage in each furnace

CO4 Evaluate the refractory usage in different stages of secondary steel making process

CO5 Appraise the mechanism behind refractory corrosion and understand refractory failure due to metal interactions.

TEXT BOOKS:

1. Subir Biswas and Debasish Sarkar, Introduction to Refractories for Iron and Steel Making, Springer Nature Switzerland, 2020.
2. Thomas Vert, Refractory Material Selection for Steelmaking, John Wiley&Sons, 2016.

REFERENCES:

1. Ahindra Ghosh and Amit Chatterjee, Iron Making and Steel Making – Theory and Practice, PHI Learning Pvt. Ltd., 2008.
2. Debashish Sarkar, Fundamental Design of Steel Making Refractories, Wiley, USA, 2023.
3. Chesters J.H, Steel Plant Refractories, 2nd Edn, United Steel Company Limited, UK,1973
4. Stephen Caniglia , Gordon L. Barna, Handbook of Industrial Refractories Technology: Principles, Types, Properties and Applications, Noyes Publications,1992
5. Ritwik Sarkar, Refractory Technology: Fundamentals and Applications, CRC Press, 2017

COURSE ARTICULATION MATRIX

CO	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	2	2	2	2	2	2	2	-	3	3	3	3	2	2	3
2	2	3	3	3	3	2	2	-	3	3	3	3	2	2	3
3	2	3	3	3	3	2	2	-	3	3	3	3	2	2	3
4	2	3	3	3	3	2	2	-	3	3	3	3	2	2	3
5	3	3	3	3	3	2	2	-	3	3	3	3	3	-	3
Avg	**2.2**	**3**	**3**	**3**	**3**	**2**	**2**	**-**	**3**	**3**	**3**	**3**	**2.2**	**3**	**3**

Correlation Levels: 1 — low, 2 — medium, 3 — high, - — no correlation

CT23005	REFRACTORIES FOR NON-FERROUS METALLIC AND CHEMICAL INDUSTRIES	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

1. Explain the various non-ferrous metallic industries and chemical industries that makes use of refractories.
2. Educate about the significance of specific refractory usage in a process equipment.

UNIT I NON-FERROUS METALS **9**

Aluminum – calcining, reduction cell design; lining of aluminum reduction cell – carbon cathode bottom, side lining, barrier materials, insulation materials; cast house – refractory materials, lining design in melting furnace, holding furnace, induction furnace, ladles, launders, casting equipment; refractories for anode baking furnace. Copper – overview of copper extraction from ore; construction, working and refractories used in copper extraction processes – roasting, smelting, converting, refining, electrolytic refining. Other non-ferrous metal extraction – lead, zinc.

UNIT II CEMENT INDUSTRY AND LIME CALCINATION **9**

Cement – raw materials, composition, manufacturing process; refractories used in different equipment in cement manufacture – cyclones, ducts, calciner, coolers, smoke chamber, kiln; coating and burnability of clinker; lime calcination – process, shaft kilns, rotary kiln, refractories used in kilns; brick shapes for rotary kiln lining.

UNIT III HYDROCARBON INDUSTRY **9**

Refractories used in petroleum refinery – introduction, process heaters, fluid catalytic cracking unit, sulfur recovery unit; carbon black – manufacturing process, reactor design, refractory selection. Coal gasification – introduction, process, gasifier design, refractories used in different regions, refractory corrosion; syngas – introduction, different processes, refractories used, case study

UNIT IV BOILER AND WASTE HEAT RECOVERY **9**

Boiler – components, refractories used; waste heat recovery – refractories used in preheaters, design and material used in recuperator, design and refractories used in regenerators.

UNIT V REFRACTORY PERFORMANCE AND FAILURE **9**

Physical and chemical interaction of non-ferrous metals with refractories; Performance of rotary kiln refractories – thermo-chemical effect, thermal load, thermo-mechanical load; refractory failure – lining tightness, failure due to anchor; analysis of refractory lining failure.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

On completion of the course, the students are expected to

CO1. Relate the various furnaces used in different stages of non-ferrous metal extraction process

CO2. Compare different equipment used in cement manufacturing and judge selection of proper refractory for an application.

CO3. Interpret the reason for the usage of specific refractory in a particular equipment used in various hydrocarbon industries

CO4. Assess the various methods of waste heat recovery and select proper refractory usage for the same.

CO5. Weigh the various failure mechanisms and design a refractory to meet the required performance.

TEXT BOOKS:

1. Prasunjit Sengupta, Refractories for the Chemical Industries, Springer, Switzerland, 2020.
2. Andrey Yurkov, Refractories for Aluminium – Electrolysis and the Cast House, Springer International Publishing Switzerland, 2015

REFERENCES:

1. Prasunjit Sengupta, Refractories for the Cement Industries, Springer, Switzerland, 2020.
2. Stephen Caniglia, Gordon L. Barna, Handbook of Industrial Refractories Technology: Principles, Types, Properties and Applications, Noyes Publications,1992
3. Peter Mullinger and Barrie Jenkins, Industrial and Process Furnaces, Butterworth-Heinemann, 2008.
4. Trinks W., Mawhinney M.H., Shannon R.A., Reed R.J. and Garvey J.R., Industrial Furnaces, Sixth Edn., John Wiley & Sons., 2004.
5. API STANDARD 982, Inspection and Assessment of Refractory Linings, ANSI, 2022

COURSE ARTICULATION MATRIX

CO	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	-	3	3	3	3	1	-	-	2	2	1	2	2	3	3
2	-	3	3	2	3	1	-	-	2	2	1	2	2	3	3
3	-	3	3	2	3	1	-	-	2	2	1	2	2	3	3
4	-	3	3	3	3	1	-	-	2	2	1	2	2	3	3
5	-	3	3	3	3	1	-	-	2	2	1	2	2	3	3
Avg	**-**	**3**	**3**	**2.6**	**3**	**1**	**-**	**-**	**2**	**2**	**1**	**2**	**2**	**3**	**3**

Correlation Levels: 1 – low, 2 – medium, 3 – high, '-' – no correlation

CT23006	REFRACTORIES FOR GLASS AND CERAMIC INDUSTRIES	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

1. Impart knowledge on various furnaces / kilns used in glass and ceramic industry.
2. Educate about the approach in refractory usage in the furnaces and kilns.
3. Expose the causes for refractory failure during usage.

UNIT I GLASS MELTING FURNACES 9

Introduction to glass melting; furnaces classification; design and working of furnaces – pot furnace, day tank furnace, tank furnace; classification of tank furnace – based on fuel used, based on heat recovery system; electric melting of glass; innovations in glass melting – segmented melting, plasma melting, accelerated melting; energy conservation in furnaces – Sankey diagram, efforts for energy conservation.

UNIT II REFRACTORIES USED IN GLASS MELTING FURNACES 9

Pot furnace – refractories used in different regions and in pots; refractory practices in crown, superstructure, sidewall and basin of tank furnace; refractories used in ports, throat and forehearth of tank furnace; refractory considerations in electric melting glass furnace.

UNIT III REFRACTORY CORROSION IN GLASS MELTING FURNACES 9

Introduction; corrosion mechanisms – diffusion, convection, interfacial and surface tension; corrosion in different regions of glass melting furnace; counter measures – chemistry adjustments in glass, refractory protection; case studies.

UNIT IV KILNS FOR CERAMIC INDUSTRIES 9

Classification – based on operation, based on firing; batch kilns – clamp kiln, up draught kiln, down draught kiln; continuous kilns – Hoffmann kiln, Bull's trench kiln, tunnel kiln, roller hearth kiln, pusher slab kiln; refractories used in different regions of kilns; temperature measurement in kilns; energy consumption in kilns; fast firing technology; low thermal mass concept; case studies.

UNIT V KILN ACCESSORIES 9

Introduction; kiln cars – construction, current trends; saggars and kiln furniture – materials used, types; setting of wares in kiln – tableware, wall tiles, bricks, sanitary ware, electrical porcelain, electronic components; .

TOTAL : 45 PERIODS

COURSE OUTCOMES:

On completion of the course, the students are expected to

CO1 Distinguish the different types of furnaces used for glass melting and their characteristics

CO2 Interpret the reason for the usage of specific refractory in a particular region of the glass melting furnace

CO3 Relate the various corrosion mechanisms in glass tank refractories and execute methods to overcome the same

CO4 Classify various kilns used in ceramic industries and judge the best one to use for a particular application

CO5 Compare the different kiln furniture / accessories available and select a proper for firing a specific product.

TEXT BOOKS:

1. Margaret Rasmussen (Ed), Glass Melting Technology: A Technical and Economic Assessment, Glass Manufacturing Industry Council, USA, 2004.
2. Felix Singer and Sonja S.Singer, Industrial Ceramics, Springer, 1963.

REFERENCES:

1. Prasunjit Sengupta, Refractories for the Chemical Industries, Springer, Switzerland, 2020.
2. Stephen Caniglia , Gordon L. Barna, Handbook of Industrial Refractories Technology: Principles, Types, Properties and Applications, Noyes Publications,1992
3. Trinks W., Mawhinney M.H., Shannon R.A., Reed R.J. and Garvey J.R., Industrial Furnaces, Sixth Edn., John Wiley & Sons., 2004.
4. Fay Tooley, Handbook of Glass Manufacture – Vol 1 & 2, Glass Industry, 1984.
5. Peter Mullinger and Barrie Jenkins, Industrial and Process Furnaces, Butterworth-Heinemann, 2008.

COURSE ARTICULATION MATRIX

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	2	3	3	2	3	1	2	-	1	2	1	3	2	2	-
2	2	2	2	2	3	1	2	-	1	2	1	3	2	3	2
3	2	3	3	2	3	1	2	-	1	2	1	3	2	3	-
4	2	3	3	3	3	1	2	-	1	2	1	3	2	3	2
5	2	3	3	3	3	1	2	-	1	2	1	3	2	3	2
Avg	**2**	**2.8**	**2.8**	**2.4**	**3**	**1**	**2**	**-**	**1**	**2**	**1**	**3**	**2**	**2.8**	**2**

Correlation Levels: 1 – low, 2 – medium, 3 – high, '-' – no correlation

CT23007	ELECTRONIC CERAMICS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

1. To introduce the use of ceramic materials as insulators and capacitors and their properties.
2. To describe the processing, properties and various applications of ferroelectric and magnetic ceramics and its applications.
3. To provide basic knowledge about the manufacture, characteristics and properties of varistors and fuel cells.

UNIT I CERAMIC INSULATORS 9

Insulators, insulator materials, triaxial and non-triaxial insulators –composition, properties and uses. Dielectric properties -dielectric strength, dielectric breakdown mechanisms, factors affecting dielectric strength, dielectric constant and loss - different types of polarization –electronic, ionic, dipolar, effect of frequency and temperature, conduction – electronic and ionic.

UNIT II CERAMIC CAPACITORS 9

Introduction – classification – Capacitance - effect of solid solutions – additives – film capacitors, single layer discrete capacitors – multilayer capacitors – basic principles and fabrication processes, properties. Preparation and characterization of ceramic material for capacitor application.

UNIT III FERROELECTRIC CERAMICS 9

Origin of ferroelectricity in ceramic system, Classification – Ferroelectricity, Anti-ferroelectricity, relaxor ferroelectrics, multiferroics and lead free ferroelectrics: $BaTiO_3$, PZ-PT(PZT), PLZT, PMN and KNN; General characteristics of piezoelectric materials using examples, morphotropic phase boundary and Phase diagram of PZT – Dielectric and elctromechanical properties of PZT, Piezoelectric based sensor/actuators, Thermoelectric and electro-optic materials, Processing and fabrication of ferroelectric material –mixed oxide and chemical precipitation processes. Preparation and characterization of ferroelectric ceramic for energy storage/other applications.

UNIT IV MAGNETIC CERAMICS 9

Origin of magnetism, Classification of magnetic materials – Ferromagnetic, Antiferromagnetic, Ferrimagnetic – Mechanisms of ferro and antiferromagnetic ordering, superexchange, domain theory – Bloch wall – M-H loop – selected examples of magnetic materials - α-Fe and MnO, Spinel ferrites – structure, types of ferrites – manganese, zinc ferrites – hexagonal ferrites – garnets, Magneto resistance -GMR-CMR. Preparation and characterization of magnetic ceramics, VSM

UNIT V VARISTORS AND FUEL CELLS 9

Basics of semiconductors and fuel cells, Introduction ZnO varistors – PN junction diode–electrical characteristics, fabrication of ZnO varistor behaviour – microstructure; fuel cells –types, working principle, solid oxide fuel cells – applications.

TOTAL : 45 PERIODS

COURSE OUTCOMES

On completion of the course, the students will be able to

CO1 Recall the science of Insulators, dielectrics, capacitors and their properties
CO2 Have a basic knowledge about ceramic capacitors and its preparations.
CO3 Have learnt the processing, properties and various applications of ceramic Ferroelectric, piezoelectric and thermoelectric materials.
CO4 Recall the basics of magnetism and learnt the preparations and characteristics magnetic ceramics.
CO5 Have a basic knowledge about the semiconductors, characteristics and properties of varistors and fuel cells.

TEXT BOOKS

1. Hench L.L and J.K.West, Principles of Electronic Ceramics, WILEY, New York,1990.
2. Moulson AJ and HM Herbert, Electroceramics, 2nd ed., WILEY, 2003.

REFERENCES

1. Pillai S. O., Solid State Physics. New age International Publishers, India, 2018.
2. Electrical Engineering Materials by A J Dekkar, Prentice-Hall, 1959
3. Setter N and Colla SL, Ferroelectric Ceramics, Birkhauser Ver Lag, 1993.
4. Buchanan RC, Ceramic Materials for Electronics, Marcel Dekker Inc., NY, 1991.
5. Michel Barsoum, Fundamentals of Ceramics, CRC Press, 2019.

COURSE ARTICULATION MATRIX

CO	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	3	3	1	2	2	3	2	-	2	2	1	2	3	-	1
2	3	3	1	2	2	3	2	-	2	2	1	2	3	1	2
3	3	3	1	2	2	3	2	-	2	2	1	2	3	2	2
4	3	3	1	2	2	3	2	-	2	2	1	2	3	1	1
5	3	3	1	2	2	3	2	-	2	2	1	2	3	1	1
Avg	**3**	**3**	**1**	**2**	**2**	**3**	**2**		**2**	**2**	**1**	**2**	**3**	**1**	**1.4**

Correlation Levels: 1 — low, 2 — medium, 3 — high, -- — no correlation

CT23008	ADVANCED GLASS AND GLASS-CERAMICS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

1. To introduce the types of Building, automotive, medical and pharmaceutical applications
2. To describes the insulating, textile and optical communication fiber materials and other important applications of special glasses
3. To discuss the electrical and electronic applications of glasses, photo sensitive glasses

UNIT I CONSTRUCTION AND AUTOMOTIVE APPLICATIONS 9

Introduction; over view of sheet glass making process; surface treatment – thermally toughened glass, chemically toughened glass, applications; sound insulation; safety and security – Bullet resistance glazing, blast resistance glazing, fire protection glasses, thermal insulation and solar control; Automobiles glasses – windshields, defogger glass, laminated glass, glass antennae for rear light, solar control UV cut glass, acoustic windshield.

UNIT II ELECTRO TECHNOLOGY AND ELECTRONICS 9

Sealing glasses – Introduction, solder glass types, physical form and application methods, firing cycle stages, common problems, solder glass technology, health and safety issues and suppliers; glass in electronic processing; energy devices – electron tube, micro channel plate, data storage reading head, resister glasses, glass capacitors, cathode-ray tube; properties of TV glasses; displays – rigid panels and flexible panels; Energy applications.

UNIT III MEDICAL APPLICATIONS 9

Introduction; dental glass in composite resin materials; glass in dental cements; glass and glass ceramic crown and bridge materials; glass ceramic prosthetics formed by casting process; glass implant materials; porous and foam glass; pharmaceutical glasses, CERABONE; CERAVITAL;

UNIT IV FIBER GLASSES 9

Principles of glass fiber formation – generic fiber forming processes, fibers from strong melt and solutions, fibers from fragile melts; structure of melt and fibers – from glass melt to fiber, melt structure Vs liquids, fiber structure Vs modulus, fiber structure Vs strength; ultra pure silica fiber – down drawing from strong viscous melt, commercial manufacturing process of silicate glass fibers; borosilicate E-glass fibers – specification, properties and applications; insulating glass fibers – products and applications; Textile fibers – types of glasses used, different products; Glass fiber optics – fiber light guides and image guides- manufacturing, uses of optical fibers.

UNIT V PHOTOSENSITIVE AND OTHER APPLICATIONS 9

Photosensitive glass – introduction; photo sensitizers – mechanism, electron and hole trapping; photosensitive glass composition – noble metal based, copper based, photosensitive colors; glass ceramics – noble metal nucleation, fota-lite, polychromic glasses, processes – first and second exposure and thermal treatment; Aerospace and Military – Mirrors for space, spacecraft windows, missile nose cones, infrared glasses; glasses in lamps – Incandescent lamps, halogen Incandescent lamps, fluorescent lamps, low pressure sodium lamps, high pressure mercury lamps;

TOTAL : 45 PERIODS

COURSE OUTCOMES

On completion of the course, the students will be able to

CO1 Understand and apply the different glasses made for building and automotive glasses

CO2 Understand, apply and analyze Selection of composition to prepare various pharmaceutical and medical glasses

CO3 Understand and apply and analyze different glasses used for electronic and sealing applications

CO4 Compare, apply and analyze suitable materials for fiber making process and their applications in various fields

CO5 Understand, apply and analyze different advanced applications of glasses including photosensitive glasses

TEXT BOOKS

1. Bernhard Weller, Cristina Harth, Silke Tasche, and Stefan unnewehr, glass in building principle applications and examples, 1st edition 2009.
2. Frederic T. Wallenberger, Paul A. Bingham, Fiber glass and glass technology, energy friendly composition and applications, Springer, 2010

REFERENCES

1. Chapman & Hall, Schott Guide to Glass Second Edition,1996
2. Nicholas F Borrelli, Photosensitive glass and glass-ceramics, CRC Press, 2017
3. Samuel J Schueider Jr, Engineering materials handbook, volume 4, ceramics and glasses, ASM International, the materials information society. 2000
4. Tooley F.V, Handbook of Glass Manufacture, Vol I and II, Ogden Publishing Co., NY, 1960
5. James E.Shelby, Introduction to Glass Science and Technology, The Royal Society of Chemistry, 1997.

COURSE ARTICULATION MATRIX

CO	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	2	2	2	2	3	2	2	2	2	2	2	3	3	3	3
2	2	3	3	2	2	3	3	3	2	2	2	3	3	3	3
3	2	3	3	2	2	3	3	3	2	2	2	3	3	3	3
4	2	3	3	2	2	3	3	3	2	2	2	3	3	3	3
5	2	3	3	2	2	3	3	3	2	2	2	3	3	3	3
Avg	**2**	**2.8**	**2.8**	**2**	**2.2**	**2.8**	**2.8**	**2.8**	**2**	**2**	**2**	**3**	**3**	**3**	**3**

CT23009	BIO-CERAMICS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

1. Introduce various materials used as implants and the importance of ceramics
2. Describe various compositions of ceramics used as implants and their processing
3. Describe various Properties and Characterization of Biomaterials

UNIT I BIO IMPLANT MATERIALS 9

Introduction; metallic implant materials –stainless steels, co-based alloys, Ti and Ti based alloys, dental metals, corrosion of metallic implant; polymer implant materials –polymerization, polyamides, polyethylene, polypropylene, polyacrylates, fluorocarbon polymer, rubbers, deterioration of polymers; ceramic implant materials-Bioactive, bioresorbable and bioinert; composites as biomaterials – structure and mechanics of composites; tissue response to implants.

UNIT II BIO CERAMICS MATERIALS 9

Aluminum oxide; Zirconium dioxide (ZrO_2) and PSZ; Preparation, properties, Structure, microstructure and biological performance of tri calcium phosphate, tetra calcium phosphate, hydroxyapatite and other phosphates; Calcium phosphate bone cements– Mechanism, preparation, setting behaviour. Bioactive glass and glass-ceramics.

UNIT III BIO CERAMIC PROCESSING 9

Fabrication and Mechanical Properties of Porous Bioceramics; Coating of Bioceramic Thick Films on Bio-Inert Porous Substrates; Coating on Dense Substrates; Hydroxyapatite Coatings for Non-Hard Tissue Applications; Scaffold Designing - Essential Requirements for Bone Tissue Engineering Scaffolds, Scaffold Processing Techniques- Foam, Rapid Prototyping, Electrospinning.

UNIT IV PROPERTIES AND CHARACTERIZATION OF BIOMATERIALS 9

Cell-Materials interaction; Bioactive Properties and Hard Tissue Prosthetics - Bone Biology, Critical Issues on Interfaces Between the Hard Tissue and Biomaterials, Factors that Influence Bioreactivity, Bone Implant, Bonding Mechanisms, In vitro Behavior of Hydroxyapatite; Measurements of Growth and Dissolution of Hydroxyapatite Ceramics; Mechanical Properties.

UNIT V BIOMATERIALS TESTING 9

Biocompatibility; Materials for Medical Devices; In Vitro Tests for Biocompatibility; In Vivo Tests for Biocompatibility; Inflammation, Wound Healing, and the Foreign-Body Response; Hemocompatibility; Immune Responses.

TOTAL : 45 PERIODS

COURSE OUTCOMES

On completion of the course, the students will be able to

CO1	State various implant materials
CO2	Know the fabrication, application and biological response of ceramics and cements.
CO3	Recognize the usage of ceramics in implant as coatings, and scaffolds
CO4	Appraise the importance of Properties and Characterization of Biomaterials
CO5	Examine the usage of Biomaterials scaffolds

TEXT BOOKS

1. JoonPark :Bioceramics Properties, Characterization and Application, Springer,1995.
2. Maria valet regi: Bioceramic with Clinical Applications, Wiley,2010.

REFERENCES

1. Saad B. H. Farid: Bioceramics: For Materials Science and Engineering, Woodhead Publishing Series in Biomaterials, 2019
2. Heimo O.Ylanen: Bioactive Glasses Materials, Properties and Applications, Woodhead Publishing in materials2011.
3. Bikramjit Basu, Kantesh Balani, Advanced Structural Ceramics, A John Wiley & Sons, Inc., Publication, 2011.
4. Donglu Shi, Introduction to Biomaterials, World Scientific Publishing Co. Pte. Ltd., 2006.

COURSE ARTICULATION MATRIX

CO	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	2	3	2	2	2	3	3	-	2	2	1	3	1	3	3
2	2	3	2	2	2	3	3	-	2	2	1	3	1	3	3
3	2	3	2	2	2	3	3	-	2	2	1	3	1	3	3
4	2	3	2	2	2	3	3	-	2	2	1	3	1	3	3
5	2	3	2	2	2	3	3	-	2	2	1	3	1	3	3
Avg	**2**	**3**	**2**	**2**	**2**	**3**	**3**	**-**	**2**	**2**	**1**	**3**	**1**	**3**	**3**

Correlation Levels: 1 — low, 2 — medium, 3 — high, - — no correlation

CT23010	FUEL CELLS AND SENSORS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

1. Enable the students to have a fundamental knowledge about the various types of fuel cells and their characterization
2. Get detailed idea about the ceramic fuel cells
3. Describe the different sensors and their applications.

UNIT I FUEL CELLS 9

Introduction; A simple fuel cell; Fuel cell components; Basic fuel cell operation - fuel cell performance, advantages and disadvantages; Types of fuel cells - Phosphoric acid fuel cell (PAFC), Polymer electrolyte fuel cell (PEMFC), Alkaline Fuel cell (AFC), Molten carbonate fuel cell (MCFC), and Solid-oxide fuel cell (SOFC).

UNIT II REACTION KINETICS 9

Electrode kinetics; Activation energy Vs charge transfer reaction; Reaction rate - Calculating net rate of reaction, rate of reaction at equilibrium; Potential of reaction at equilibrium. Butler –Volmer equation; Improvement of kinetic performance; Tafel equation; Different kinetics in different fuel cells; Catalyst – electrode design

UNIT III CERAMIC FUEL CELLS 9

Introduction, Schematic design of conventional SOFC, Tubular SOFC, Planar SOFC; Sealings, bipolar plates, Stresses in planar SOFCs, Monolithic SOFCs; Varieties of SOFCs – single chamber SOFCs, direct flame SOFCs, Ammonia SOFCs; Types of solid electrolytes – Zirconia and Ceria electrolytes; Materials for electrodes – Anode and cathode materials; Factors influencing the life time of SOFCs; Manufacturers; Demand.

UNIT IV CHARACTERIZATION 9

Ex situ characterizations – Porosity determination, surface area measurements, gas permeability, structure determination, chemical determination; In situ characterizations (electrochemical) - current-voltage measurement, current-interrupt measurement, electrochemical impedance spectroscopy, cyclic voltammetry.

UNIT V SENSORS 9

Introduction; Types – gas sensors, Auto exhaust and Oxygen sensors; Humidity sensors; Vibration sensors; fiber optic sensors as chemical sensors and biosensors; IR sensors; some sensor materials – ZrO_2 , PZT, perovskite materials, and SiC, 2D materials etc.. Manufacturers.

TOTAL : 45 PERIODS

COURSE OUTCOMES

On completion of the course, the students will be able to

CO1 Understand fundamentals of fuel cells and apply the concepts for comparison.
CO2 Understand fuel cell kinetic mechanisms and thermodynamic concepts.
CO3 Understand, apply and analyse their sound knowledge about solid oxide fuel cells.
CO4 Analyse and evaluate the Fuel cells characters by various techniques
CO5 Understand fundamentals of various basic sensors and their applications.

TEXT BOOKS

1. Viladimir S. Bagotsky, “Fuel cells problems and solutions” second edition, Wiley, John Wiley and Sons, inc., Publication. 2012.
2. Ryan O’Hayre, “fuel cell fundamentals” third edition, Wiley, John Wiley and Sons, inc., Publication. 2016.

REFERENCES

1. Buchanan RC, Ceramic Materials for Electronics, Marcel Dekker Inc., NY, 1991.
2. San Ping jiang, “materials for high temperature fuel cells” wiley – VCH, 2013
3. Duncan W. Bruce., “Energy materials”, Wiley, John Wiley and Sons, UK. 2011.
4. Jacob Fraden, Handbook of Modern Sensors: Physics, Design and Applications, Fifth Edition, Springer, 2016.
5. Subhas C Mukhopadhyay and Joe-Air Jiang, Wireless Sensor Networks and Ecological Monitoring, Springer, NY, 2013

COURSE ARTICULATION MATRIX

CO	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	2	2	2	2	3	2	2	2	2	2	1	2	2	2	3
2	2	2	2	2	3	2	2	2	2	2	1	2	3	3	3
3	2	3	3	2	3	3	3	3	2	2	1	2	3	3	3
4	2	3	3	2	3	3	3	3	2	2	1	2	3	3	3
5	2	2	2	2	3	2	2	2	2	2	1	2	2	2	3
Avg	**2**	**2.4**	**2.4**	**2**	**3**	**2.4**	**2.4**	**2.4**	**2**	**2**	**1**	**2**	**2.8**	**2.8**	**3**

Correlation Levels: 1 — low, 2 — medium, 3 — high, -- — no correlation

CT23011	CARBON TECHNOLOGY	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

1. Impart knowledge about various carbon materials, their properties and applications.
2. Empower the students with knowledge on carbon and graphite manufacturing and related technologies.
3. Provide basic knowledge about carbon fibre and carbon composites

UNIT I INDUSTRIAL CARBON 9

Structure, properties and applications, charcoal, activated carbon, coal, pitches, graphite, Polymer - derived carbon. Structure and characterization: Small angle, wide angle X-ray diffraction methods, Electron microscopy, Optical Scanning microscopy, TEM etc.,

UNIT II PROCESSING OF CARBON & GRAPHITE MANUFACTURING 9

Raw Materials, production process – Flow diagram, Milling & sizing, Mixing, shaping, Sintering – liquid phase - solid phase- gas phase, Graphitization – Mechanism – factor affecting- Impregnation liquid phase - pitch & resin- Gas phase

UNIT III MODERN CARBON MATERIALS 9

Vitreous carbon – precursor – processing, types – foam- solid, Pyrolytic carbon – process – properties – structure. Graphite – Metal processing Industry- Semiconductor and related Industry- Electrical application- Mechanical – Chemical- Nuclear – Pyro graphite - Vitreous carbon- Carbon fibre - Carbon composite- Battery, Testing- standards- density – Hardness- Porosity – Electrical Resistivity – Flexural strength – compressive strength – tensile strength – thermal expansion – modulus of elasticity – ash content – moisture content

UNIT IV CARBON AND GRAPHITE FIBRES 9

Carbon fibres: history and development, salient features – Classifications - Raw materials- Rayon/cellulose, Pitch, and Poly acrylo nitrile - Tensile properties: Low modulus, Standard modulus, Intermediate modulus, High modulus, and Ultra high modulus - Functional carbon fibre: Compressive strength, Thermal conductivity, and Electrical conductivity, Low-cost carbon fibres and Niche grade carbon fibres - Carbon fibre manufacturing processes (PAN based- Rayan based- Pitch based), precursors and their characteristics, typical carbon fibre properties

UNIT V CARBON COMPOSITES 9

Textile preforms – classification, woven, multi-directional reinforced preforms. Structural geometry of 2D and 3D fabrics; Carbon matrix precursors - Thermosetting resin matrix precursors, Thermoplastic matrix precursor; Fabrication methods of Cf/C composites - Liquid phase infiltration

(atmospheric and high pressure), Gas phase infiltration techniques (CVI and Film boiling CVI); Properties of Cf/C composites – Microstructures, Interface in Carbon-Carbon. Mechanical & Thermal properties (RT/High temperature), Electromagnetic properties, Application of Cf/C composites.

TOTAL: 45 PERIODS

COURSE OUTCOMES

On completion of the course, the students will be able to

CO1 Learn about the carbon structure and relate characterizations
CO2 Know about carbon and graphite manufacturing technologies
CO3 Gain the knowledge about the various modern carbon materials
CO4 Learn about carbon fibre productions and its characteristics
CO5 Acquire the knowledge on various carbon based composites and its applications.

TEXT BOOKS

1. A Kelly, Carl H Zweben, “Comprehensive Carbon Materials”, Elsevier Publishing, 1st Edition, 2000.
2. Deborah D. L. Chung, Carbon Materials: Science and Applications, World Scientific Publishing, 2019.

REFERENCES

1. Michio Inagaki, Feiyu Kang**,** Materials Science and Engineering of Carbon: Fundamentals, 2nd ed., ELESVIER, 2014.
2. Shukla, S. K. Tiwari, Ashutosh, Advanced Carbon Materials and Technology, Wiley-Scrivener, 2014.
3. M Balasubramaniam, “Composite Materials and Processing”, CRC Press, 1st Edition, 2013.
4. Pierre Delhaes, Carbon Science and Technology: From Energy to Materials, Wiley-ISTE, 2012.
5. K K Chawla, “Composite Materials”, Springer Verlag Publisher, 3rd Edition, 2014.

COURSE ARTICULATION MATRIX

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	3	3	2	1	1	3	3	-	2	1	2	2	3	2	3
2	3	3	2	1	1	3	3	-	1	1	2	2	3	2	-
3	3	3	2	1	1	3	3	-	1	1	2	2	3	2	-
4	3	3	2	1	1	3	3	-	1	1	2	2	3	2	-

5	3	3	2	1	1	3	3	-	1	1	2	2	3	2	-
Avg	**3**	**3**	**2**	**1**	**1**	**3**	**3**	**-**	**1.2**	**1**	**2**	**2**	**3**	**2**	**0.6**

Correlation Levels: 1 — low, 2 — medium, 3 — high, - — no correlation

CT23012	CERAMIC COATINGS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

1 Discuss the fundamentals of advanced ceramic coatings.
2 Elaborate on various advanced ceramic coating techniques
3 List the different properties and applications of ceramic coatings

UNIT I SURFACE PREPARATION AND PROPERTIES FOR COATING DEPOSITION 9

Surface cleaning techniques - chemical methods, mechanical methods, modified methods, unconventional techniques; surface monitoring and characterization techniques - wettability, contact angle measurements, SEM, EDX, AES, XPS

UNIT II SOL-GEL METHODS FOR OXIDE COATINGS 9

Introduction; coating solutions - chemistry of alkoxides, alkoxide-based, colloidal; coating deposition and drying - coating deposition methods, structural development; thermal treatment - structural evolution in the amorphous state, development of a crystalline microstructure, stress and cracking; selected applications.

UNIT III THERMAL BARRIER COATINGS: POWDER SPRAY PROCESS AND COATING TECHNOLOGY 9

Induction; requirements for coating control system; ceramic coatings - gas turbine, diesel engines applications; the microstructure of zirconia; plasma spray technology - air plasma spraying, electric arc wire, HVOF, Detonation gun (D-Gun); introduction of requirements for production of thermally sprayed coatings - powders for plasma spraying - evaluation of the system powder spray process; advanced powder qualities; bond coatings; a new generation of thick thermal barrier coatings - tailored to meet distinct service conditions.

UNIT IV COATED SURFACE CHARACTERIZATION METHODS 9

Glancing incidence x-ray diffraction (GIXRD); High resolution scanning electron microscopy (HRSEM); auger electron spectroscopy (AES), secondary ion mass spectroscopy (SIMS); photoelectron spectroscopy (PES).

UNIT V PROPERTIES AND APPLICATIONS 9

Thermal; mechanical; Optical and chemical properties; hardness; wear and erosion resistance; high temperature properties; applications; defects and remedies.

TOTAL : 45 PERIODS

COURSE OUTCOMES

On completion of the course, the students will be able to

CO1 Understand the fundamentals of coatings, substrate selection and preparation.
CO2 Understand the knowledge about the sol gel coatings their properties.
CO3 Analyze the thermal barrier coatings and their properties and applications.
CO4 Analyze the coated and uncoated surfaces.
CO5 Calculate the properties of coated and uncoated surfaces

TEXT BOOKS

1. Narendra B. Dahotre, T. S, Sudarshan, 'Intermetallic and Ceramic Coatings", marcel dekker, Inc., New York, 1999
2. Hocking M.G.Vasantasree V Sidky PS, Metallic and Ceramic coatings, Longman, 1989.

REFERENCES

1. Hocking M.G.Vasantasree V Sidky PS, Metallic and Ceramic coatings, Longman, 1989.
2. Krishna Seshan, Thin Film deposition, processes and technologies, second edition, Noyes publications, William Andrew Publishing, Norwich, New York, U.S.A.
3. Lisa C Klien(Ed),Sol Gel Technique for Thin Films, Fibres, Performs, Electronics and Specialty Shapes, Noyes publications, New Jersy, 1988.
4. Boriosenko Al, High Temperature Protective Coatings, American Publishing Co., New Delhi, 1986.
5. Orlando Auciello and Rainer Waser, Science and Technology of Electro ceramic Thin film, NATO ASI series- Kluwer Academic publishers, 1995.

COURSE ARTICULATION MATRIX

CO	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	3	3	3	3	1	2	2	-	2	2	1	3	3	2	3
2	3	3	3	3	1	2	2	-	2	2	1	3	3	2	3
3	3	3	3	3	1	2	2	-	2	2	1	3	3	2	3
4	3	3	3	3	1	2	2	-	2	2	1	3	3	2	3
5	3	3	3	3	1	2	2	-	2	2	1	3	3	2	3
Avg	**3**	**3**	**3**	**3**	**1**	**2**	**2**	**-**	**2**	**2**	**1**	**3**	**3**	**2**	**3**

CorrelationLevels:1—low,2—medium, 3—high, -—no correlation

CT23013	RAW MATERIALS AND STRUCTURE FORMATION OF GLASS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

1. Describe about the raw materials for glass making and raw materials batch calculations.
2. Elucidate the structure formation of glass

UNIT I MAJOR RAW MATERIALS 9

Glass forming oxides - silica, soda ash, lime stone, dolomite, boron oxide, soda feldspar, lead oxide - sources, glass properties, advantages and disadvantages, uses; Glass modifiers - zirconia, lithium, sodium, potassium, and calcium - sources, glass properties, advantages and disadvantages, uses; Intermediates – titanium, aluminum, and zinc - sources, glass properties, advantages and disadvantages, uses; effects of glass modifiers and intermediates.

UNIT II MINOR RAW MATERIALS 9

Coloring agents - cadmium sulphate, chromium oxide, cobalt oxide, copper oxide, gold, manganese oxide, neodymium, Nickel oxide, selenium, rare earth oxides, silver, uranium oxide; decoloring agents - cerium oxide, antimony oxide. Refining agents - barium oxide, arsenic oxide, sodium chloride, sodium sulfate - sources, glass properties, advantages and disadvantages, uses; reducing agents - iron, carbon, tin, anthracite, sulphide sulphur from beneficiated slag - sources, glass properties, advantages and disadvantages, uses; recycled materials – cullet, slag etc.

UNIT III GLASS RAW MATERIALS BATCH CALCULATION 9

Glass batch calculation - Arithmetical approximation method, method of simultaneous equation, computerized batch calculation; role in the raw materials procurement - batch formation, provision of basis of evaluating raw materials, final evaluation of raw materials, introducing new or modified batches into operation.

UNIT IV PRINCIPLES OF GLASS FORMATION AND GLASS STRUCTURE 9

Crystallization and glass formation; formation of glasses from simple organic liquids; glass formation in oxides; glass formation and material properties; classical theories of glass formation - goldschmidt, Zachariasen's random network, smekal's mixed bonding hypothesis, sun's bond-strength; kinetic theories of glass formation - nucleation, crystal growth; Range of structural orders; experimental methods; specific systems - vitreous silica, multi-component silicate glasses, Borate glasses, phosphate glasses, other oxide glasses, metallic glasses.

UNIT V PHASE SEPARATION AND CRYSTALLIZATION 9

Phase separation - Phase diagrams, theories of immiscibility, nucleation, growth; morphology and spinodal decomposition, property changes and applications related to phase separation; crystallization - nucleation, experimental measurements of nucleation and growth rates, nucleating agents, morphology, growth, fluoride glasses.

TOTAL : 45 PERIODS

COURSE OUTCOMES

On completion of the course, the students will be able to

CO1 Gather idea on types and sources of major raw materials of glass
CO2 Understand the various minor ingredients added during glass preparation and their role in glass
CO3 Calculate batch composition for a glass of particular composition
CO4 Relate the various theories of glass formation and the structures of glass.
CO5 Understand phase separation and crystallization in glass and its significance

TEXT BOOKS

1. Christopher W. Sinton, "Raw materials for Glass and Ceramics - Sources, process and Quality control', John Wiley & Sons, Inc., 2006
2. Robert H. Doremus, "Glass Science (Second Edition), A Wiley-Intersciene publication

REFERENCES

1. J. E. Shelby, "Introduction to glass science and Technology", 2nd Edition, The Royal Society of Chemistry, 1997.
2. Fundamentals of Glass Manufacturing Process 1991, Proceedings of the First Conference of the European Society of Glass Science and Technology, Society of Glass Technology,1991.
3. Tooley F.V, Handbook of Glass Manufacture, Vol I and II, Ogden Publishing Co., NY, 1960.
4. Charles A Harper, Handbook of Ceramic Glasses and Diamonds, McGraw Hill,2001.
5. Narottam P Bansal, R.H.Doremus, Handbook of Glass Properties, Academic Press, Inc,1986.

COURSE ARTICULATION MATRIX

CO	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	3	3	3	3	3	1	2	-	2	2	1	3	3	3	-
2	3	3	3	3	3	1	2	-	2	2	1	3	3	3	-
3	3	3	3	3	3	1	2	-	2	2	1	3	3	3	-
4	3	3	3	3	3	1	2	-	2	2	1	3	3	3	-
5	3	3	3	3	3	1	2	-	2	2	1	3	3	3	-
Avg	**3**	**3**	**3**	**3**	**3**	**1**	**2**	**-**	**2**	**2**	**1**	**3**	**3**	**3**	**-**

CT23014	PROPERTIES AND TESTING METHODS OF GLASS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

1 To describe about the physical, thermal, mechanical, electrical, optical and other properties of glass.

UNIT I VISCOSITY AND GLASS TRANSITION 9

Introduction; theories; viscoelasticity; measurement techniques; temperature dependence of viscosity; compositional dependence of viscosity; effect of thermal history, phase separation and crystallization on viscosity; glass transition - structural and strain relaxation.

UNIT II DENSITY AND THERMAL PROPERTIES 9

Introduction, measurement techniques - density, thermal expansion coefficients; density and molar volume - compositional effects, thermal history effects, effect of phase separation and crystallization, radiation effects, pressure compaction; thermal expansion behaviour - fundamentals of thermal expansion behaviour, compositional effects on thermal expansion coefficients of homogenous glasses, phase separated glasses, thermal history effects, effect of crystallization; thermal conductivity - compositional effects.

UNIT III TRANSPORT PROPERTIES 9

Introduction; fundamentals of diffusion; ionic diffusion; ion exchange; ionic conductivity - compositional effects, activation energy for electrical conductivity, effect of phase separation, thermal and crystallization on electrical conductivity; chemical durability; weathering; gas permeation and diffusion; diffusion controlled reactions; reaction with gases.

UNIT IV MECHANICAL PROPERTIES 9

Introduction; elastic modulus; hardness; fracture strength - theoretical strength of glasses, practical strengths of glasses, flaw sources and removal, strengthening of glass, statistical nature of fracture of glass; fatigue of glasses; thermal shock; annealing of thermal stresses.

UNIT V OPTICAL PROPERTIES 9

Introduction; bulk optical properties - refractive index, molar and ionic refractivity, dispersion; ultraviolet absorption; visible absorption - ligand filed coloration of glasses, amber glass, colloidal metal colors, colloidal semi-conductors colors, radiation-induced colors, solarization; infrared absorption - bound hydrogen species, dissolved gases; other optical properties of glasses - photosensitive and photochromic glasses, opal glasses, faraday rotation.

TOTAL : 45 PERIODS

COURSE OUTCOMES

On completion of the course, the students will be able to

CO1 Comprehend measurement of and factors influencing viscosity of glass
CO2 Analyse the physical and thermal properties of various glasses.
CO3 Understand the transport properties of various glasses and its significance.
CO4 Calculate the strength, hardness and fracture toughness of various glasses.
CO5 Reflect on the different optical properties of glass.

TEXT BOOKS

1. J. E. Shelby, "Introduction to glass science and Technology", 2nd Edition, The Royal Society of Chemistry, 1997.
2. Robert H. Doremus, "Glass Science (Second Edition), A Wiley-Intersciene publication

REFERENCES

1. Fundamentals of Glass Manufacturing Process 1991, Proceedings of the First Conference of the European Society of Glass Science and Technology, Society of Glass Technology,1991.
2. Tooley F.V, Handbook of Glass Manufacture, VollandII, Ogden Publishing Co., NY, 1960.
3. Charles A Harper, Handbook of Ceramic Glasses and Diamonds, McGraw Hill,2001.
4. Glass Furnaces-Design, Construction and Operation, Wolfgang Trier, Society of Glass Technology, 2000.
5. Narottam P Banral, R.H.Doremus, Handbook of Glass Properties, Academic Press, Inc,1986.

COURSE ARTICULATION MATRIX

CO	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	3	3	2	3	1	1	1	-	1	1	1	2	1	2	3
2	3	3	2	3	1	1	2	-	1	1	1	2	1	2	3
3	3	3	2	3	1	1	1	-	1	1	1	2	1	2	3
4	3	3	2	3	1	1	2	-	1	1	1	2	1	2	3
5	3	3	2	3	1	1	1	-	1	1	1	2	1	2	3
Avg	**3**	**3**	**2**	**3**	**1**	**1**	**1.4**	**-**	**1**	**1**	**1**	**2**	**1**	**2**	**3**

CorrelationLevels:1—low,2—medium, 3—high, -—nocorrelation

CT23015	GLASS CERAMICS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

1 Introduce the fundamental science of glass-ceramics formation.
2 Describe raw materials, melting process of glass ceramic material.
3 Discuss about various composition system for glass ceramics

UNIT I INTRODUCTION 9

Glass ceramic materials – characteristics; phase equilibria in glass forming system; Glass formation; Glass crystallization – Homogeneous, and heterogeneous nucleation, Photo-nucleation and crystal growth in glass, overall glass crystallization kinetics; effect of nucleating agent and meta-stable liquid phase separation on crystallization.

UNIT II PREPARATION OF GLASS CERAMIC MATERIALS 9

Raw materials; preparation of the glass batch; melting; forming; heat treatment; special methods for preparing glass ceramic materials – Strengthening of glass ceramics, sintered glass ceramics, coloured glass ceramics, anisotropic glass ceramics, fotoceram, preparation of glass ceramics by sol-gel method.

UNIT III VARIOUS COMPOSITION SYSTEMS FOR GLASS CERAMICS 9

Alkali and alkaline earth silicates – SiO_2-Li_2O; Aluminosilicates - SiO_2-Al_2O_3, SiO_2-Al_2O_3-Li_2O,SiO_2-Al_2O_3-Na_2O, SiO_2-Al_2O_3-CaO; Flurosilicates - SiO_2-Al_2O_3-MgO-CaO-ZrO_2-F;Silicophosphates - SiO_2-CaO-Na_2O-P_2O_5; Iron silicates - SiO_2-Fe_2O_3-CaO; Phosphates – P_2O_5-Al_2O_3-CaO.

UNIT IV PROPERTIES OF GLASS CERAMIC MATERIALS 9

Density; mechanical properties – strength and elasticity, hardness and abrasion resistance; thermal properties – coefficient of thermal expansion, resistance to thermal shock, specific heat, Thermal conductivity; electrical property – electrical resistivity, dielectric constant dielectric losses and dielectric strength.

UNIT V APPLICATIONS 9

Medical – CERABONE, CERAVITAL, BIOVERIT and dental applications; electrical and electronic applications – insulator, electronic packaging; energy applications – components for lithium batteries joining materials for solid oxide fuel cell components; consumer and technical applications - Industries - Market Demand.

TOTAL : 45 PERIODS

COURSE OUTCOMES

On completion of the course, the students will be able to

CO1 Understand the fundamentals of phase equilibria in glass forming system, nucleation, crystal growth and overall glass crystallization kinetics.

CO2 Recognize the process involved in the preparation of glass ceramic materials.

CO3 Understand, apply and analyze various composition systems for glass ceramics.

CO4 Evaluate and understand the properties of glass ceramic materials.

CO5 Identify and compare the application of glass ceramics in various fields.

TEXT BOOKS

1. Z. Strnad, Glass Ceramics materials, Glass Science and Technology 8, Elsevier 1986
2. Wolfram Holand and George H. Beall, Glass – Ceramic Technology, second edition,2012.

REFERENCES

1. Bach.Krause (Eds), Low Thermal Expjansion Glass Ceramics, Second edition, Springer 2005
2. BasudebKarmaker, Functional Glasses and Glass-Ceramics: Processing, Properties and Applications, Butterworth-Heinemann, 2017.
3. Wolfram Holand and George H. Beall, Nucleation and Crystallisation of Glasses and Glass-Ceramics, Frontiers in Materials, 2017.
4. NIIR Board of Consultants and Engineers,The Complete Book on Glass and Ceramics Technology, Asian Pacific Business Press, 2005.
5. James E Shelby, Introduction to Glass Science and Technology, 2TH Edition, TJ International LTD, UK, 2005.

COURSE ARTICULATION MATRIX

CO	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	2	2	2	2	1	2	2	2	2	2	1	2	3	3	-
2	2	3	3	2	1	3	3	3	2	2	1	2	3	2	-
3	2	2	2	2	1	2	2	2	2	2	1	2	2	3	3
4	2	3	3	2	1	3	3	3	2	2	1	2	-	-	-
5	2	3	3	2	1	3	3	3	2	2	1	2	3	3	2
Avg	**2**	**2.6**	**2.6**	**2**	**1**	**2.6**	**2.6**	**2.6**	**2**	**2**	**1**	**2**	**3**	**3**	**2.5**

Correlation Levels: 1 — low, 2 — medium, 3 — high, - — no correlation

CT23016	GLASSES FOR SPECIAL APPLICATIONS – I	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

1. To introduce the types of special glasses
2. To describe the various glasses used in medical and pharmaceutical applications
3. To discuss the electrical and electronic applications of glasses

UNIT I FUSED SILICA AND BOROSILICATE GLASSES 9

Introduction; Quartz glass- preparation, properties; physical and chemical properties of Duran glass; Borosilicate glass – fundamentals, laboratory equipments, glass process plant.

UNIT II MEDICAL GLASSES 9

Introduction; pharmaceutical glasses and optical glasses - properties and classifications; Transmission of radiation, color filters, special optical glasses for nuclear technology and radiation research, manufacture of optical glasses.

UNIT III GLASSES FOR ELECTRO TECHNOLOGY AND ELECTRONICS 9

Introduction; sealing glasses – Tungsten, Molybdenum, Kovar and Lead glasses; glass for television; glass for x-ray tubes; transmitting and image intensifying tube; glasses for soldering and passivation; sintered glass parts; glass for high voltage insulations; ultrasonic delay lines; electron conductive glasses and lamp glasses.

UNIT IV FIBER GLASSES 9

Introduction; insulating glass fibers – products and applications; Textile fibers – types of glasses used, glass silk, glass threads, glass staple fibers, different products. Glass fiber optics – fiber light guides and image guides- manufacturing, uses of optical fibers

UNIT V OTHER APPLICATIONS 9

Aerospace and Military – Mirrors for space, spacecraft windows, missile nose cones, solar cell covers, infrared glasses, frangible glasses; glasses in lamps – Incandescent lamps, halogen Incandescent lamps, fluorescent lamps, low pressure sodium lamps, high pressure mercury and sodium lamps, metal halide lamps; direct view cathode-ray tubes.

TOTAL : 45 PERIODS

COURSE OUTCOMES

On completion of the course, the students will be able to

CO1 Understand and apply the different glasses made from pure silica and borosilicate

glasses

CO2 Understand, apply and analyze Selection of composition to prepare various pharmaceutical and medical glasses

CO3 Understand and apply different glasses used for electronic and sealing applications

CO4 Understand and apply suitable materials for textile and optical communication purposes

CO5 Understand, apply and analyze different advanced applications of glasses

TEXT BOOKS:

1. Chapman & Hall, Schott Guide to Glass Second Edition,1996
2. Charles A Harper, Handbook of Ceramic Glasses and Diamonds, McGraw Hill,2001

REFERENCES:

1. Frederic T. Wallenberger, Paul A. Bingham, Fiber glass and glass technology, energy friendly composition and applications, Springer, 2010
2. Tooley F.V, Handbook of Glass Manufacture, VollandII, Ogden Publishing Co., NY, 1960
3. Wolfgang Trier, Glass Furnaces-Design, Construction and Operation, Society of Glass Technology, 2000.
4. James E.Shelby, Introduction to Glass Science and Technology, The Royal Society of Chemistry, 1997.
5. Z. Strnad, Glass Ceramics materials, Glass Science and Technology 8, Elsevier 1986

COURSE ARTICULATION MATRIX

CO	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	2	2	2	2	2	2	2	2	2	1	1	3	3	3	-
2	2	3	3	2	2	3	3	3	2	1	1	3	3	2	-
3	2	3	3	3	2	3	3	3	2	1	1	3	2	3	3
4	2	3	3	2	2	3	3	3	2	1	1	3	-	-	-
5	2	2	3	2	2	2	2	2	2	1	1	3	3	3	2
Avg	**2**	**2.6**	**2.8**	**2.2**	**2**	**2.6**	**2.6**	**2.6**	**2**	**1**	**1**	**3**	**2.75**	**2.75**	**2.5**

Correlation Levels: 1 — low, 2 — medium, 3 — high, - — no correlation

CT23017	GLASSES FOR SPECIAL APPLICATIONS – II	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

1 Explain the process and significance of surface coated glass

UNIT I INTRODUCTION **9**

Introduction; nature of glass surface – characterization, production of surface; surface preparation – cleaning procedures, control and maintenance of clean surface; correlation between glass and thin films; adhesion between substrate and film – methods of measurement, causes for adhesion, parameters influencing adhesion, practical aspects of adhesion measurement; Introduction to subtractive and additive methods of coating formation.

UNIT II COATING BY CHEMICAL PROCESSES **9**

Chemical film formation processes – deposition of metal films & oxide films from solution; dip coating; spin coating; chemical vapour deposition (CVD) – principle, atmospheric pressure CVD, low pressure CVD.

UNIT III COATING BY PHYSICAL VAPOUR DEPOSITION **9**

Vacuum technology, film deposition by evaporation and condensation in high vacuum, film deposition by cathode sputtering, film deposition by ion plating, reactive deposition processes, plasma polymerization.

UNIT IV FILM THICKNESS AND PROPERTIES OF THIN FILMS **9**

Film thickness – general methods of measurement, methods applicable to PVD films, current trends; Properties - Structure, microstructure, chemical composition, mechanical properties, chemical & environmental stability, optical properties, relation between density, stress and optical film properties, electro-optical materials and their properties.

UNIT V APPLICATIONS OF COATINGS ON GLASS **9**

Anti-reflective coatings, rear surface mirror, surface mirrors and beam splitter mirrors, separation of light by filters, absorptive coatings, transparent conductive coatings, energy related coatings, solderable coatings, scientific applications.

TOTAL : 45 PERIODS

COURSE OUTCOMES

On completion of the course, the students will be able to

CO1 understand the steps involved in coating surface preparation and factors causing adhesion of coating

CO2 appreciate different chemical film forming processes
CO3 apply different physical vapour deposition processes for glass coating
CO4 understand and analyse different properties of thin films
CO5 recognize the applications of thin films on glass

TEXT BOOKS:

1. H.K.Pulker, Coatings on Glass, Elsevier, 1999.
2. Chapman & Hall, Schott Guide to Glass Second Edition,1996

REFERENCES:

1. Charles A Harper, Handbook of Ceramic Glasses and Diamonds, McGraw Hill,2001
2. Tooley F.V, Handbook of Glass Manufacture, Vol I, Ogden Publishing Co., NY, 1960
3. Tooley F.V, Handbook of Glass Manufacture, Vol II, Ogden Publishing Co., NY, 1960
4. Wolfgang Trier ,Glass Furnaces-Design, Construction and Operation, Society of Glass Technology, 2000.
5. James E.Shelby, Introduction to Glass Science and Technology, The Royal Society of Chemistry, 1997.

COURSE ARTICULATION MATRIX

CO	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	2	2	2	2	3	2	2	2	2	2	1	3	3	3	-
2	2	3	3	2	3	3	3	3	2	2	1	3	3	2	-
3	2	3	3	3	3	3	3	3	2	2	1	3	2	3	3
4	2	3	3	2	3	3	3	3	2	2	1	3	-	-	-
5	2	2	3	2	3	2	2	2	2	2	1	3	3	3	2
Avg	**2**	**2.6**	**2.8**	**2.2**	**3**	**2.6**	**2.6**	**2.6**	**2**	**2**	**1**	**3**	**2.75**	**2.75**	**2.5**

Correlation Levels: 1 — low, 2 — medium, 3 — high, - — no correlation

CT23018	PHOTOSENSITIVE GLASS AND GLASS CERAMICS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

1 Introduce the Photosensitive glasses and their applications
2 Describe the various photorefractive and photochromic glasses
3 Discuss the solarization and polarizing glass properties and applications

UNIT I PHOTOSENSITIVITY OF GLASS 9

Photosensitive glass – introduction; photo sensitizers – mechanism, electron and hole trapping; photosensitive glass composition – noble metal based, copper based, photosensitive colors; Optical absorption from Nanoparticles – computed dielectric functions, comparison of the experimental results.

UNIT II PHOTOREFRACTIVE AND PHOTOCHROMIC GLASSES 9

photorefractive glasses – introduction and background; photorefractive effect in NaF-based glasses – exposure and thermal treatment, characterization of the photorefractive effect; photorefractive effect in Ag halide containing glasses – experimental results; femtosecond laser-induced index change – exposure, mechanism; photochromic glasses – introduction and background; Cu halide photochromic glasses – photochromic behavior, experimental data, exciton feature.

UNIT III SOLARIZATION 9

Background and possible origins of color centers in glass; experimental results; impurity induced solarization – Ti^{4+} impurity, other impurity ions; inherent color centers – alkali aluminosilicates, alkali borosilicates; quantitative mechanisms; thermal annealing; x-ray induced solarization; light induced defects – experimental results, mechanism.

UNIT IV POLARIZING GLASSES 9

Introduction – history and background; novel process development – practical methods, theory, performance and applications; stretched Ag-coating glasses – Pt doped Ag containing glasses, Pt initiated nucleating mechanism, process, polarized glass results; method of high temperature redraw.

UNIT V PHOTOSENSITIVITY OF GLASS CERAMICS 9

Glass ceramics – noble metal nucleation, fota-lite, polychromic glasses, processes – first and second exposure and thermal treatment, Microstructure and mechanisms, coloring fota-light;

fotoform – chemical machinability, lens arrays, controlled CTE fotoform; second stage nucleation

TOTAL : 45 PERIODS

COURSE OUTCOMES

On completion of the course, the students will be able to

CO1 Understand and apply mechanism and different compositions of photorefractive glasses

CO2 Understand, apply and analyze the properties and preparation of the photorefractive and potochromic glasses

CO3 Understand, apply and analyze solarization process done in glass

CO4 Understand, apply and analyze the composition process and applications of polarizing glasses

CO5 Understand, apply and analyze the composition process and applications of photosensitive glasses ceramics

TEXT BOOKS

1. Nicholas F Borrelli, Photosensitive glass and glass-ceramics, CRC Press, 2017
2. Chapman & Hall, Schott Guide to Glass Second Edition,1996

REFERENCES

1. Samuel J Schueider Jr, Engineering materials handbook, volume 4, ceramics and glasses, ASM International, the materials information society.
2. Tooley F.V, Handbook of Glass Manufacture, Vol I and II, Ogden Publishing Co., NY, 1960
3. James E.Shelby, Introduction to Glass Science and Technology, The Royal Society of Chemistry, 1997.
4. Bernhard Weller, Cristina Harth, Silke Tasche, and Stefan unnewehr, glass in building principle applications and examples, 1st edition 2009.
5. Frederic T. Wallenberger, Paul A. Bingham, Fiber glass and glass technology, energy friendly composition and applications, Springer, 2010

COURSE ARTICULATION MATRIX

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	2	2	2	2	3	2	2	2	2	2	1	3	3	3	2
2	2	3	3	2	3	3	3	3	2	2	1	3	3	2	2
3	2	3	3	3	3	3	3	3	2	2	1	3	2	3	2
4	2	3	3	2	3	3	3	3	2	2	1	3	-	-	2
5	2	3	3	2	3	3	3	3	2	2	1	3	3	3	2

Avg	**2**	**2.8**	**2.8**	**2.2**	**3**	**2.8**	**2.8**	**2.8**	**2**	**2**	**1**	**3**	**2.75**	**2.75**	**2**

Correlation Levels: 1 — low, 2 — medium, 3 — high, - — no correlation

CT23019	**MATERIAL SELECTION AND DESIGN**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES

1. To provide the students a thorough systematic approach to the selection of materials required for mechanical design
2. To familiarize the students with material properties and material fabrication processes and an approach for selecting a process capable of producing a component possessing the size, shape, properties and cost dictated by the design

UNIT I INTRODUCTION TO MATERIAL SELECTION 9

Introduction – importance of materials selection in engineering, review of material classes and properties; Materials properties and performance – mechanical properties, thermal properties, electrical, magnetic and optical properties; material selection criteria – performance indices, cost considerations, environmental and sustainability factors; material selection charts and tools; case studies in material selection, examples of successful and failed materials selection.

UNIT II MATERIALS SELECTION FOR SPECIFIC APPLICATIONS 9

Design with metals – properties and applications of metals, metal alloys and their selection criteria; Design with polymers - properties and applications of polymers, selection criteria for polymeric materials; Design with ceramics and glasses – properties and applications of ceramics and glasses, selection criteria for ceramic materials; Design with composites - properties and applications of composite materials, selection criteria for composites, emerging trends in materials selection and design.

UNIT III ADVANCED MATERIALS AND PROCESSING TECHNIQUES 9

Smart and functional materials – introduction to smart materials, applications and design considerations; Nanomaterials and their applications – properties, applications, design challenges and opportunities; Material processing and design – influence of processing on material properties, selection of processing methods; Sustainable materials design – environmental impact on material production and design, strategies for sustainable materials design

UNIT IV FAILURE ANALYSIS AND RELAIBILITY 9

Failure modes and analysis – common modes of material failure, failure analysis techniques; Designing for reliability and durability – principles of reliability engineering, designing materials components for long term performance; Life cycle assessment – techniques for life cycle assessment, case studies of different materials; Economic Analysis in materials selection – cost benefit analysis, life cycle costing.

UNIT V DESIGNING MATERIALS FOR SPECIFIC APPLICATIONS 9

Thermal, Electrical, Magnetic and Optical materials – Charts, drilling down the origin and manipulation of properties, design using the properties, case studies; Introduction to hybrid materials – holes in the material property space – method – composites – sandwich structures – cellular structures – segmented structures; case studies of hybrids

TOTAL: 45 PERIODS

COURSE OUTCOMES

On completion of the course, the students will be able to

- **CO1** Explain the fundamental properties of various classes of materials and their implications for engineering applications
- **CO2** Evaluate and select materials for specific applications considering properties, processing and performance requirements of metals, polymers, ceramics and composites.
- **CO3** Utilize material selection charts and databases to identify suitable materials for engineering design
- **CO4** Apply criteria such as performance, cost and sustainability to select appropriate materials for specific engineering applications
- **CO5** Use the methodologies for designing new materials and conceiving hybrid solutions

TEXT BOOKS

1. Michael F Ashby, Materials Selection in Mechanical Design, Butterworth and Heinemann,2011.
2. William F. Smith, “Foundations of Materials Science and Engineering”, McGraw Hill Publisher, Fifth Edition, 2010.

REFERENCES

1. Donald Askeland, “Materials Science and Engineering”, Cengage Learning India Pvt. Ltd, 2011.
2. Kenneth G Budinski, “Engineering Materials : Properties and Selection”, Prentice Hall 1996
3. George E Dieter, “Engineering Design: A Materials and Processing Approach”, McGraw Hill, 1991
4. Raghavan V., Materials Science and Engineering: A First Course, Fifth Edition, PHI Learning Pvt. Ltd., 2011
5. Khurmi R.S., Sedha R.S., “Materials Science”, S.Chand and Company Limited, 2018

COURSE ARTICULATION MATRIX

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	1	1	1	1	3	2	2	-	1	2	1	3	2	2	-

2	2	2	2	2	3	2	2	-	1	2	1	3	2	2	2
3	3	3	1	2	3	2	2	-	1	2	1	3	2	2	1
4	3	2	3	2	2	2	2	-	1	2	1	3	2	2	-
5	1	1	3	1	1	2	2	-	1	2	1	3	2	2	-
Avg	**2**	**1.8**	**2**	**1.6**	**2.4**	**2**	**2**	**-**	**1**	**2**	**1**	**3**	**2**	**2**	**1.5**

Correlation Levels: 1 — low, 2 — medium, 3 — high, - — no correlation

CT23020 FRACTURE MECHANICS AND FAILURE ANALYSIS

L	T	P	C
3	0	0	3

COURSE OBJECTIVES

1. Impart an understanding on the fracture mechanisms and method for characterizing fracture in metals, polymers, ceramics and composites
2. Develop insights and detailed understanding on the concepts of fracture mechanics through case studies
3. Analyse the causes for engineering failures and relate with the consequences and mechanisms to overcome it.

UNIT I FRACTURE: BASIC CONCEPTS AND OVERVIEW 9

Introduction to fracture-elastic deformation, plastic and elasto-plastic deformation, theoretical cohesive strength, defect population in solids, stress-concentration factor, notch strengthening, variables affecting fracture, characterizing fracture process, microscopic mechanisms and macroscopic fracture characteristics in metals, polymers, glass and ceramics, engineering composites

UNIT II ELEMENTS OF FRACTURE MECHANICS 9

Elements of fracture mechanics - Griffith crack theory, charpy impact fracture testing, polymer fracture test methods, stress analysis of cracks; failure analysis case study – relationship between energy rate and stress field, crack tip plastic zone size determination, analysis of crack development during structural fatigue test, plane- stress fracture toughness testing, elastic-plastic analysis with the J-integral, determination of JIC, other fracture models, fracture mechanics and adhesion measurements

UNIT III FRACTURE TOUGHNESS 9

Toughness and strength, intrinsic toughness, extrinsic toughening, toughening of metals and alloys through microstructural anisotropy, toughness of ceramics, glass, ceramic matrix composites, polymers, particle toughened polymers, fiber reinforced polymer composites, natural and biomimetic materials

UNIT IV FATIGUE AND CRACK PROPAGATION 9

Macro-fractography of fatigue failures, cyclic stress-controlled fatigue, cyclic strain controlled fatigue, fatigue life estimations for notched components, crack initiation mechanics, prevention of fatigue damage, stress and crack length correlation with with FCP, macroscopic fracture modes in fatigue, failure analysis case study – stress intensity factor, estimation based on fatigue growth bands, crack growth behaviour at ΔK extremes, load interactions, corrosion fatigue, Fatigue crack propagation in engineering plastics, ceramics and composites

UNIT V ANALYSIS OF ENGINEERING FAILURES AND CONSEQUENCES 9

Environment assisted cracking – in plastics, ceramics and glasses, embrittlement models, variables affecting cracking, life and crack length calculations; typical defects, macroscopic fracture surface examinations, metallographic and fractographic examinations, component failure analysis data, case study; consequences of product failure – product liability and history, regulatory requirements and considerations

TOTAL: 45 PERIODS

COURSE OUTCOMES

On completion of the course, the students will be able to

CO1 Understand the fracture mechanisms and characterize fracture in metals, polymers, glass and ceramics, engineering composites

CO2 Describe the elements of fracture mechanics and correlate the inter-relations using case study

CO3 Understand the fracture toughness in metals, polymers, glass and ceramics, engineering composites

CO4 Relate fatigue crack propagation and factors influencing failure

CO5 Analyse engineering failure and relate with the consequences

TEXT BOOKS

1. Hertz berg R W, “Deformation and fracture mechanics of Engineering materials” second edition John Wiley sons inc, New York 1983.
2. Knott. J.F, “Fundamentals of Fracture Mechanics” Butterworth London, 1973.

REFERENCES

1. Campbel J E, Underwood J H, and Gerberich W W., “Applications of Fracture Mechanics for the selection of Materials “, American Society for Metals, Metals Park Ohio, 1982.
2. Evalds H L and RJH Warnhil,” Fracture Mechanics”, Edward Arnold Ltd, Baltimore,1984.
3. Fracture Mechanics Metals Handbook, ninth edition, vol. 8 437-491, American Society of Metals Metal Park ohio, 1985
4. Kare Hellan, “Introduction of Fracture Mechanics”, McGraw-Hill Book Company, 1985.
5. Prashant Kumar, “Elements of Fracture Mechanics”, Wheeler Publishing,1999.

COURSE ARTICULATION MATRIX

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	2	1	1	2	1	2	2	-	1	2	1	3	2	2	1
2	2	1	1	2	1	2	2	-	1	2	1	3	1	2	2
3	2	1	1	2	1	2	2	-	1	2	1	3	3	2	1
4	3	2	1	3	1	2	2	-	1	2	1	3	3	2	2

5	3	3	2	1	2	3	2	-	1	2	1	3	1	2	2
Avg	**2.4**	**1.6**	**1.2**	**2.0**	**1.6**	**2.2**	**2**	**-**	**1**	**2**	**1**	**3**	**2**	**2**	**1.6**

Correlation Levels: 1 — low, 2 — medium, 3 — high, - — no correlation

CT23021 SMART CERAMICS

L	T	P	C
3	0	0	3

COURSE OBJECTIVES

1. To impart knowledge on the importance of smart materials used in varied applications
2. To enable the students to have knowledge on the various smart materials, its advantages, limitations and applications
3. To enable the student to choose the right choice of materials based on the emerging demands.

UNIT I INTRODUCTION AND SHAPE MEMORY MATERIALS 9

Introduction - Intelligent / Smart materials – Functional materials – Polyfunctional materials – Structural materials, Electrical materials, bio-compatible materials; Shape memory alloys – historical background, fabrication process, shape memory effect, types and potential application, shape memory polymers, ceramics and hybrids – applications, advantages and disadvantages.

UNIT II CHROMOGENIC MATERIALS 9

Chromogenic materials – history, concepts, classification; Electrochromic, photochromic, thermochromic, thermotropic, gasochromic, chemochromic, biochromic, magnetochromic materials – mechanism, materials used, advanatges and disadvantages, applications.

UNIT III SMART FLUIDS 9

Electro-rheological and magneto-rheological fluids – materials used, preparation, strengthening mechanisms, microstructure and properties, applications, advantages and disadvantages; ferro fluid – mechanism, preparation and applications.

UNIT IV BULK METALLIC GLASS 9

Bulk metallic glass – introduction, history, mechanism and dynamics of formation, classification, processing, fundamental characteristics, metallic glass foams, coatings and applications

UNIT V ULTRALIGHT MATERIALS 9

Ultralight materials – aerogel, grapheme, aerographene, graphite, carbyne – synthesis, properties and applications; micro-lattice material of metal, polymer and ceramic – properties and application; Metallic, polymer and ceramic foams – synthesis, properties and applications

TOTAL: 45 PERIODS

COURSE OUTCOMES

On completion of the course, the students will be able to

CO1 Understand the basic concepts and the application of shape memory materials

CO2 Understand various mechanism of chromism and interpret the categorization of the chromogenic system

CO3 Imbibe the fundamental characteristics of smart fluids and recognise the effective application of various rheological materials.

CO4 Interpret the dynamics and mechanism of formation with the knowledge on the fundamental characteristics of bulk metallic glass and realize the applications

CO5 Recognise the importance of ultralight materials in dynamic systems and learn the applications based on properties

TEXT BOOKS

1. Ajit Behera, “Advanced Materials: An Introduction to Modern Materials Science”, Springer Cham, 1st edition Switzerland AG, 2022
2. M. V. Gandhi and B. S. Thompson, “Smart Materials and Structures”, Chapman and Hall, London, First Edition, 1992.

REFERENCES

1. Mel Schwartz (Ed), Encyclopaedia of Smart Materials” Volume –I and II, John Wiley & Sons, Inc.2002
2. Duerig,T. W., Melton, K. N, Stockel, D. and Wayman, C.M., “Engineering aspects of Shapememory Alloys”, Butterworth – Heinemann, 1990
3. Peter L. Reece, “Smart materials and Structures: New Research”, Nova Science Publishers, New York, 2006
4. Marinella Ferrara, Murat Bengisu, “Materials that Change Color - Smart Materials, Intelligent Design”, Springer International Publishing, 2013
5. C. Suryanarayana, A. Inoue’ “Bulk Metallic Glasses”, CRC Press, 2017.

COURSE ARTICULATION MATRIX

CO	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	2	1	1	1	2	1	1	-	1	2	1	3	1	-	1
2	1	1	2	-	2	1	1	-	1	2	1	3	2	2	-
3	1	1	2	-	2	1	1	-	1	2	1	3	1	1	2
4	2	1	2	1	2	1	1	-	1	2	1	3	3	-	1
5	1	1	2	-	2	1	1	-	1	2	1	3	3	1	2
Avg	**1.4**	**1**	**1.8**	**1**	**2**	**1**	**1**	**-**	**1**	**2**	**1**	**3**	**2**	**1.3**	**1.5**

Correlation Levels: 1 — low, 2 — medium, 3 — high, - — no correlation

CT23022	NON-DESTRUCTIVE MATERIAL TESTING AND EVALUATION	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

1 To impart knowledge on the importance of NDT on quality assurance
2 To enable the students to have knowledge on principles of various NDT techniques, its applications and limitations.
3 To develop the ability in students in selecting the right choice of NDT technique.

UNIT I INTRODUCTION 9

Non-destructive test and evaluation technology – an overview, materials, manufacturing process and non-destructive testing methods, designs and industrial applications – railways, nuclear, non-nuclear, chemical industries, automotive industries.

UNIT II RADIOGRAPHIC TESTING 9

Sources of x-ray and gamma rays, their interaction with matter, equipment, general radiographic procedure, technique and acceptance standard, special radiographic techniques and safety aspects of industrial radiography.

UNIT III ULTRASONIC TESTING 9

Principles of wave propagation, reflection, refraction, diffraction, mode conversion and attenuation, sound field, piezoelectric effect, ultrasonic transducers and their characteristics, ultrasonic equipment, scan presentation of test indications and interpretations, effective applications and limitations of ultrasonic testing.

UNIT IV EDDY CURRENT TESTING 9

Introduction- principle, eddy current test system, eddy current sensing elements, probes, instrumentation, applications, advantages and limitation, interpretation of results and case study.

UNIT V OTHER METHODS 9

Liquid penetrant test - basic concepts, system, test procedure, effective applications and limitations; magnetic particle test – magnetic materials, principle, equipment, procedure, interpretation and evaluation, effective applications and limitations; other methods – thermal infrared testing, acoustic emission.

TOTAL: 45 PERIODS

COURSE OUTCOMES

On completion of the course, the students will be able to

CO1 Understand the basic concepts and the importance of NDT in quality assurance

CO2 Recognize the importance of radiographic testing with the understanding on the safety aspects

CO3 Understand the effective application of ultrasonic testing and interpretation of test results.

CO4 To understand the principles and effectiveness of eddy current testing

CO5 To explain various other test methods of NDT and awareness on recent advancements

TEXT BOOKS

1. Paul E Mix, “Introduction to Non-Destructive Testing: A Training Guide”, Wiley, 2nd edition New Jersey, 2005
2. McGonnagle, W.J, Non-Destructing Testing Methods, McGraw Hill Co., NY, 1961.

REFERENCES

1. Metals Handbook, Volume 2, 8th Edn, ASTM, Metals Park, Ohio.
2. Dainty, Laser Speckle and Related Phenomena, Springer – Verlag, New York, 1984.
3. PrasadJ and C G K Nair, Non Destructive Test and Evaluation of Materials, TATA McGraw Hill, New Delhi, 2008.
4. Dos Reis H, Non-Destructive Testing And Evaluation For Manufacturing And Construction, Hemisphere Publishing Corporation, US, 1990.
5. Baldev Raj, T. Jayakumar and M. Thavasimuthu, Practical Non-destructive Testing, Narosa Publishing House, New Delhi, 2002.

COURSE ARTICULATION MATRIX

CO	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	1	2	1	1	3	3	3	-	2	2	1	3	2	-	1
2	1	2	1	2	3	3	3	-	2	2	1	3	2	1	1
3	1	2	1	2	3	3	3	-	2	2	1	3	2	-	1
4	1	2	1	2	3	3	3	-	2	2	1	3	2	-	1
5	2	2	1	2	1	3	3	-	2	2	1	3	2	2	1
Avg	**1.2**	**2**	**1**	**1.8**	**2.6**	**3**	**3**	**-**	**2**	**2**	**1**	**3**	**1.8**	**2**	**1**

Correlation Levels: 1 — low, 2 — medium, 3 — high, - — no correlation

CT23023	SURFACE ENGINEERING FOR CERAMICS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

1. Familiarize various process of modifying the surface of materials
2. Impart knowledge on the principles of various methods and the factors affecting the surface modification
3. Conceptual understanding on the methods used for imparting functionality in materials and surfaces

UNIT I MACHINING **9**

Abrasive process – materials, tribosystem properties and interrelations of elements, basic analysis of surface grinding, design and specification - micromilling, aspect ratio, contact length, grain penetration depth, grain shape, density, spacing and wear; abrasive topography – definition and measurement techniques, grinding wheels, process fluids for abrasive polishing.

UNIT II TEXTURING **9**

Principles of laser and laser – basics, modes of laser operation, surface interactions, modifications of surface properties; surface nano-structuring, surface optical non-linearity, nano ripple - formation on surface, characteristics and analysis; laser engraving and marking – principle, materials, analysis of laser induced ablation.

UNIT III FUNCTIONALIZATION **9**

Surface treatments- anodic oxidation, ion implantation, ion beam mixing, thermochemical treatment, transformation hardening, mechanical treatment, ion - implantation; powder surface modification techniques – plasma surface treatments - properties and characterization

UNIT IV COATING **9**

Surface coating technologies – chemical, electrodeposition, vacuum deposition, arc welding, thermal spraying, magnetron coating, smart coatings for material protection, self-healing – principle, mechanism, materials used, design, case study

UNIT V WEAR AND CORROSION **9**

Surface degradation, wear and corrosion, types of wear, adhesive, abrasive, oxidative, corrosive, interphase tribology, erosive and fretting wear, roles of friction and lubrication; corrosion - principles, types, coatings and corrosion prevention, testing.

TOTAL: 45 PERIODS

COURSE OUTCOMES

On completion of the course, the students will be able to

CO1 Interpret the design and specifications of the abrasive process in surface engineering

CO2 Understand the principles and mechanisms to analyse surface textures

CO3 Relate surface treatment approaches in imparting various functionalities

CO4 Understand and analyse various surface coating methodologies

CO5 Explain the concepts on wear and corrosion and get familiarized on thetesting and preventive approaches

TEXT BOOKS

1. Jamal Takadoum, “Materials and Surface Engineering in Tribology”, Wiley Publishing, NJ, 2007.
2. Ken N. Strafford, “Surface Engineering: Processes and Applications”, CRC press, 2018.

REFERENCS

1. Ram Kossowsky, Subhash Singhal, “Surface Engineering: Surface Modification of Materials”, William Andrew Publishing, 2004
2. Rashid A. Ganeev, “Laser—Surface Interactions”, Springer, New York, 2014
3. Marinescu, W. Brian Rowe, Boris Dimitrov, Ichiro Inasaki, “Tribology of Abrasive Machining Processes”, (2005), William Andrew publishing, 2004
4. Dheerendra Kumar Dwivedi, “Surface Engineering: Enhancing Life of Tribological Components”, Springer India, 2018
5. J Paulo Davim, “Materials and Surface Engineering: Research and Development”, Elsevier Science, 2012.

COURSE ARTICULATION MATRIX

CO	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	3	2	1	1	3	1	1	-	1	2	1	3	-	2	1
2	2	1	2	1	3	1	1	-	1	2	1	3	-	2	-
3	3	1	3	2	3	1	1	-	1	2	1	3	1	3	-
4	2	1	2	1	3	1	1	-	1	2	1	3	-	2	1
5	2	2	3	1	3	1	1	-	1	2	1	3	1	-	2
Avg	**2.4**	**1.4**	**2.2**	**1.2**	**3**	**1**	**1**	**-**	**1**	**2**	**1**	**3**	**1**	**2.3**	**1.3**

Correlation Levels: 1 — low, 2 — medium, 3 — high, - — no correlation

CT23024	RECYCLING OF MATERIALS AND SUSTAINABILITY	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

1. Develop an intuitive understanding on the eco-attribute of materials and design process
2. Improve the understanding of material selection and processes for sustainable future
3. Enable to apply the sustainability principles in development of techno-commercial process and products

UNIT I INTRODUCTION 9

Material dependence- non-renewable materials, material consumption and dependence, life cycle assessment, recycling materials, carbon footprint, eco attributes of materials, energy selection strategies, material selection for environment, renewable resources

UNIT II ENGINEERING DESIGN AND SUSTAINABILITY 9

Engineering design process, selection of materials, machining process, design review, product design, considerations on sustainable product design; environmental legislations – introduction, examples; design for disassembly, assembly, and maintenance – definition, types, framework and guidelines.

UNIT III REUSE AND RECYCLE 9

Product reuse, modularization for ease of reuse; recycling, types, components of recycling system, design, criteria for individual components, sub-assemblies, product and logistics, assessing recyclability; material separation – design guidelines, case study.

UNIT IV REMANUFACTURING 9

Products and comparison with reuse and recycle processes, considerations and guidelines, types of remanufacturers, design stages to assess feasibility, metrics for assessing re-manufacturability, factors affecting, benefits, case study

UNIT V SUSTAINABLE PRODUCT DESIGN – COST EXERCISE 9

Types of cost – direct and indirect, recycling, remanufacturing, refurbishing, mathematical models to predict developmental cost, case study.

TOTAL: 45 PERIODS

COURSE OUTCOMES

On completion of the course, the students will be able to

CO1 Understand eco attributes of materials and selection strategies
CO2 Relate engineering design process to sustainability
CO3 Gauge criteria and assess modularization viability to reuse and recycle products
CO4 Identify critical stages and evaluate the design feasibility in remanufacturing products
CO5 Articulate sustainable product design and evaluate cost involved in the development

TEXT BOOKS

1. M. F. Ashby, “Materials and the Environment Eco-Informed Material Choice”, Elsevier Science, 2012
2. Anoop Desai and Anil Mittal, “Sustainable Product Design and Development”, CRC press, Taylor & Francis, 2021

REFERENCES

1. Yves Grohens, Kishor Kumar Sadasivuni, Abderrahim Boudenne, “Recycling and Reuse of Materials and their Products”, Advances in Materials Science Volume 3, Apple Academic Press, NJ, 2013
2. Waseem S. Khan, Eylem Asmatulu, Md. Nizam Uddin, Ramazan Asmatulu, “Recycling and Reusing of Engineering Materials: Recycling for Sustainable Developments”, Elsevier, 2022
3. Alan Richardson, Alan Richardson, “Reuse of Materials and Byproducts in Construction: Waste Minimization and Recycling”, Springer-Verlag London, 2013
4. D S Ginley, Davịd Kahen, “Fundamentals of materials for energy and environmental sustainability, Cambridge University Press, 2012
5. Subramanian Senthil kannan Muthu, “Environmental Implications of Recycling and Recycled Products”, Springer Nature Singapore, 2015

COURSE ARTICULATION MATRIX

CO	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	1	2	1	1	-	2	2	-	2	2	1	3	1	2	2
2	2	1	2	1	1	2	3	-	2	2	1	3	2	3	2
3	1	1	3	2	2	3	3	-	2	2	1	3	1	3	2
4	1	1	3	2	2	3	3	-	2	2	1	3	1	3	3
5	2	1	2	3	3	3	3	-	2	2	1	3	2	3	3

Avg	**1.4**	**1.2**	**2.2**	**1.8**	**2**	**2.6**	**2.8**	**-**	**2**	**2**	**1**	**3**	**1**	**3**	**2.4**

Correlation Levels: 1 — low, 2 — medium, 3 — high, - — no correlation

CT23025	**STATISTICAL PROCESS CONTROL AND SIMULATION IN CERAMIC PROCESSING**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES

1 Impart knowledge on design and implement statistical process control in ceramic industry.
2 Study the process and machine capability and applications of various charts.
3 Developing the basic concepts of quality control procedures.

UNIT I INTRODUCTION TO STATISTICAL PROCESS CONTROL (SPC) 9

Introduction - Statistical Basics (DMAIC) and Statistical Distributions - statistical methods for design, control and improvement of quality - Statistical Process and Quality Control (SPC & SQC) -State of control and process out of control identification in charts, pattern study and process capability studies. Regression and Correlation Analysis. Acceptance Sampling.

UNIT II ANOVA 9

One factor experiments – Mathematical model for one factor experiments- Two Factor Experiments - Mathematical model for two factor experiments- Applications to production problems.
Seven SPC tools; Process Improvement - Design of Experiments- conventional and software's; Six Sigma process capability, Response optimization.

UNIT III SPC IN CERAMIC FABRICATION 9

Raw Materials -Batching - Material Preparation - Forming Operations - Drying –Firing; Glass Processing - Machining - Finished Ware Inspection - Following Ware through the Production Process - Continual Improvement

UNIT IV SPC IN CERAMIC INDUSTRIES 9

Case studies in various ceramic industries – Glass manufacturing, tile making, sanitary ware manufacturing, abrasives industries, refractory industries, etc., - use of open source software tools.

UNIT V SIMULATION IN CERAMIC PROCESSING 9

Introduction – simulation techniques – merits and demerits, selection of suitable technique. Finite-element simulation of ceramic drying processes- archaeological pottery analysis - Discrete

Element Simulation of Ceramic Powder Processing- Monte Carlo simulation of ceramic grain growth during laser ablation processing - Digital Simulation and Optimization of Ceramic Technology Based on Genetic Algorithm - Neural network speeds up identification of piezoelectric properties - Glass discovery and design: challenges in artificial intelligence and machine learning for glass science

TOTAL : 45 PERIODS

COURSE OUTCOMES

On completion of the course, the students will be able to

- **CO1** Understand the basics principles and importance of SPC & SQC.
- **CO2** Evaluate the quality of processes using control charts and DOE in ceramic industries.
- **CO3** Implement SPC in ceramic processing.
- **CO4** Analyse and apply SPC in various ceramic industries.
- **CO5** Apply simulation in ceramic processing.

TEXT BOOKS

1. Besterfield D.H., “Quality Control”, 8th edition, Prentice Hall, 2009.
2. Does R J M M et al, “Statistical process control in industry”, Kluwer academic publishers, 1996.

REFERENCES

1. Richard Barrett elements, “Handbook of Statistical Methods in Manufacturing”, PH, 1991.
2. J.S. Crompton, K.C. Koppenhoefer, S.P. Yushanov, "Simulation of Manufacturing Process of Ceramics Matrix Composites, "Ceram. Trans., Vol. 220, 37-46 (2010).
3. Monohar Mahajan, “Statistical Quality Control”, Dhanpat Rai & Sons 2016.
4. C.L. Alves et al, “Integrated process simulation of porcelain stoneware manufacturing using flowsheet simulation”, CIRP Journal of Manufacturing Science and Technology.
5. https://ceramics.org/category/ceramic-tech-today/modeling-simulation

COURSE ARTICULATION MATRIX

CO	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	1	2	2	2	2	2	2	-	1	2	1	3	3	2	3
2	1	3	3	3	3	2	2	-	1	2	1	3	3	2	3
3	3	2	2	2	2	2	2	-	1	2	1	3	3	2	3
4	3	3	3	2	3	2	2	-	1	2	1	3	3	2	3
5	3	2	2	2	3	2	2	-	1	2	1	3	3	2	3
Avg	**2.2**	**3**	**3**	**3**	**3**	**2**	**2**	**-**	**1**	**2**	**1**	**3**	**3**	**2**	**3**

CT23026	ADVANCED SINTERING TECHNIQUES	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

1. Impart knowledge on the mechanisms of solid state and liquid phase sintering, and crystal growth during sintering.
2. Enlighten the advanced sintering processes and their mechanisms

UNIT I NEW SINTERING TECHNIQUES 9

Principles, practice and applications of sintering: Hot Pressing and Hot Isostatic Pressing; Isothermal sintering; Two step sintering; Explosive Shock Consolidation; sinter forging; Spark plasma sintering, Field assisted sintering; microwave sintering; Laser sintering; Electron beam sintering.

UNIT II ADVANCED SINTERING OF NANOSTRUCTURED POWDERS, MECHANICAL ACTIVATION AND OXIDE SYSTEMS 9

Physical-Chemical Characteristics of the Materials by Mechanical Activation; Mechanically Activated $BaCO_3$-AlP_3-SiO_2 Mixture as an Additive for Liquid Phase Sintering of Si_3N_4; Sintering of Nanocrystalline Zirconia-Based Ceramics, Sintering of Diamond-WC-Co; Sinterability of Uranium Dioxide Powder through Surface Adsorption; Isothermal Sintering of CdO-Bi_2O_3 System; Vacuum Sintering of Zirconia Based Ceramics, Oxide Ceramic Functional Thin Layer Processing by Thermal and Laser Sintering of Green Layers

UNIT III ADVANCED SINTERING OF ELECTRONIC CERAMICS 9

Microwave sintering in thermistor ceramics, microwave sintering of NTC thermistor and insulator; A few case studies: Sintering of lithium Ferrite and MnZn ferrite, Bulk-Sintered and Thick Film MnCoFe-Oxide Thermistors, PZT ceramics, $BaTiO_3$ ceramics and its composites, ZnO Doped SnO_2 , and advances in sintered electronic materials.

UNIT IV ADVANCED SINTERING OF SOFC AND SUPPORTED OXYGEN SEPARATION MEMBRANE 9

Introduction, Synthesis of the SOFC material, samples preparation for sintering, sintering of cathode, anode and other parts of SOFC; Few case studies in sintering parameters influencing the performance of cathode and anode material

UNIT V ADVANCED SINTERING OF BIO CERAMIC 9

Introduction, synthesis of biomaterial, sample preparation for sintering, problems occurring during the sintering of bio materials: Zirconia toughened Alumina; porous structure of bioactive ceramics; new challenges during the sintering of HA/ZrO_2 composites, remedies to overcome the sintering problems in composites. A few case studies of sintering process

TOTAL : 45 PERIODS

COURSE OUTCOMES

On completion of the course, the students will be able to

CO1 Knowledge on the types of advanced sintering techniques.
CO2 Comprehend advanced sintering of nanostructured powders and oxides
CO3 Elate advanced sintering techniques for electronic ceramics
CO4 Understand new techniques to sinter SOFC and support membranes
CO5 Analyse problems in sintering of bioceramics and appreciate the role of advanced sintering techniques to overcome the same

TEXT BOOKS

1. Biljana D. Stojanovic, Valery V. Skorokhod and Maria Vesna Nikolic, Advanced science and Technology of Sintering, Springer Science Business Media, LLC,1999
2. Arunachalam Lakshman, Sintering of ceramic new emerging techniques, Intech Open, 2012

REFERENCES

1. Rahaman.M.N, Ceramic Processing and Sintering‖, Taylor and Francis, Second Edition, 2016.
2. Randall M.German et al, —Sintering Technology‖, Marcel Dekker, Inc., 1996
3. David W. Richerson, —Modern Ceramic Engineering‖, CRC Press, 4thEdn., 2018
4. Narottam. P. Bansal and Jacques Lamon, ‖ Ceramic Matrix Composites, Materials Modelling and Technology‖, Wiley, The American Ceramic Society, 2015
5. Hayne Palmour, —Sintering‖85‖, Plenum Press, 1987
6. Suk-Joong L. Kang, —Sintering: Densification, Grain Growth and Microstructure‖, Elsevier Publications, 2005

COURSE ARTICULATION MATRIX

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	2	2	2	2	3	2	1	-	2	2	1	3	2	2	3
2	2	2	3	3	3	1	1	-	2	2	1	3	2	2	3
3	2	2	2	3	3	1	1	-	2	2	1	3	2	2	3
4	2	2	3	2	3	1	1	-	2	2	1	3	2	2	2

5	2	2	2	2	3	1	1	-	2	2	1	3	2	2	2
Avg	**2**	**2**	**2**	**2**	**3**	**1**	**1**	**-**	**2**	**2**	**1**	**3**	**2**	**2**	**3**

Correlation Levels: 1 – low, 2 – medium, 3 – high, _-_ – no correlation

CT23027 COLLOIDAL CERAMIC PROCESSING

L	T	P	C
3	0	0	3

COURSE OBJECTIVES

1 To introduce the various parameters influencing sol gel process
2 To describe the chemistry of precursor solution
3 To impart knowledge on different types of gels and processing from gel

UNIT I COLLOIDAL PROCESSING 9

Introduction to colloidal processing -Types of Colloidal Systems with Some Common Examples-Lyophilic -lyophobic-Attractive surface forces-van der Waals forces between atoms and molecules-Van der Waals forces between macroscopic bodies- determination of Hamaker constant- Effect of the intervening medium.

UNIT II STABILIZATION OF COLLOIDAL SUSPENSION 9

Colloidal stabilization -reason for stabilizing the colloid -steps to carry out before stabilizing the colloids-Purification-DLVO theory -Method of stabilization-Electrostatic, steric, hybrid, advantages, disadvantages-Factors influencing the stabilization of colloids

UNIT III SOL GEL PROCESS 9

Introduction to sol, gel. Gel formation, various parameters involved in sol gel process, hydrolysis, condensation, gelation, pH, aging, drying, densification, processing. Types of gel - aero gel,xerogel,cryo gel.

UNIT IV APPROACHES IN PARTICULATE AND POLYMERIC GEL 9

Particulate gel- Single component system- steps involved; multi component systems-steps involved; polymeric gel- approaches in polymeric gel.

UNIT V PREPARATION OF MATERIAL 9

Silica, Alumina, Zirconia, Mullite, Hydroxyapatite preparation- Applications -coating and thin film, fibers. Sol-gel catalysts- techniques - Manufacturers.

TOTAL : 45 PERIODS

COURSE OUTCOMES

On completion of the course, the students will be able to

CO1 Identify science of interaction between colloidal state of powders

CO2 Interpret the parameters influencing sol gel process & state the chemistry of precursor solution

CO3 Interpret the gel formation, its types and properties

CO4 Prepare different materials through sol gel process

CO5 Identify suitable application areas for sol gel process

TEXT BOOKS

1. Rahman, Ceramic processing and sintering second edition 2016
2. Jeffrey and C., George W.Scherer -sol-gel science The physics and chemistry of Sol-gel processing, Academic press inc 1990

REFERENCES

1. Alain C.Pierre ,llIntroduction to solgel processing –springer1990
2. John D.Wright, Nico A.J.M Sommerdijk, Sol-Gel Materials: Chemistry and Applications, CRC Press, 2001
3. SumioSakka, Handbook of Sol-Gel Science and Technology: Processing, Characterization and Applications, Kluwer Academic Publishers, 2004.
4. Ajay Kumar Mishra, Sol-Gel Based Nano Ceramic Materials, Springer, 2017.
5. Sumio Sakka, Sol-Gel Science and Technology: Topics in Fundamental Research and Applications, Springer, US, 2011.

COURSE ARTICULATION MATRIX

CO	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	3	**3**	**2**	**2**	**3**	1	1	**-**	1	1	1	1	1	2	3
2	3	**2**	**2**	**1**	**2**	1	1	**-**	1	1	1	1	1	2	3
3	3	**3**	**1**	**1**	**2**	1	1	**-**	1	1	1	1	1	2	3
4	3	**2**	**2**	**2**	**2**	1	1	**-**	1	1	1	1	1	2	3
5	3	**3**	**2**	**2**	**2**	1	1	**-**	1	1	1	1	1	2	3
Avg	**3**	**3**	**2**	**2**	**3**	**1**	**1**	**-**	**1**	**1**	**1**	**1**	**1**	**2**	**3**

Correlation Levels: 1 — low, 2 — medium, 3 — high, - — no correlation

CT23028	CERAMIC MATRIX COMPOSITES	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

1	To introduce the different types of composites, reinforcement and matrix
2	To describe the different types of reinforcement, its manufacturing techniques and properties.
3	To empower the students with the skills needed for the design, manufacture and analysis of composite materials.

UNIT I INTRODUCTION TO COMPOSITES 9

Introduction on composites; Classification and characteristics of Composite materials - Fibre reinforced composites, Particulate composites, Hybrid composites; Advantages and application of composites - Matrix and its properties – metal, ceramic, polymer; Reinforcement – fibres, whiskers, particles; Implications of fibre properties - continuous reinforcements, discontinuous reinforcements; Elastic behaviour under longitudinal loading and transverse loading, Functional requirements of reinforcement and matrix - Effect of reinforcement (size, shape, distribution, volume fraction) on overall composite performance. Application of ceramic matrix composite(CMC) – four applications.

UNIT II CERAMIC MATRIX AND REINFORCEMENT 9

Common crystal structures in ceramics; Glass ceramics, Processing and properties of ceramic matrix materials – Glass ceramics, Alumina, Silica, Mullite, Silicon carbide, Boron carbide, Silicon nitride, Boron nitride; Fracture and creep in ceramics; Ceramic reinforcement- Introduction, fibre flexibility; Glass fibre, Boron fibre, Carbon fibre, Alumina fibre, SiC fibre-preparation and its properties; Whiskers- preparation and its properties; Effect of temperature on ceramic fibre; Comparison of fibres.

UNIT III PROCESSING OF CMC 9

Particle based processes – cold compaction, slurry infiltration and hot pressing, Infiltration –Liquid infiltration, LANXIDE process; reaction bonding process Chemical reaction technique – CVD and CVI, Sol-Gel; Polymer infiltration and Pyrolysis (PIP)

UNIT IV INTERFACE 9

Introduction; Interfacial area in composites; Crystallographic nature of the interface; wettability; Bonding at the interface; Role of interface in CMC; Tests for measuring interface bonf strength – Bend test, single fibre pull out tests, curved neck specimen test, instrumented indentation tests, Laser spallation technique.

UNIT IV EVALUATION OF COMPOSITES 9

Introduction – Mechanical Properties – elastic, strength, creep, creep rupture, fatigue, notch sensitivity, impact resistance, interfacial shear properties, Thermal shock resistance, Thermal conductivity, Density, Electrical properties – Resistivity, Dielectric properties.

TOTAL: 45 PERIODS

COURSE OUTCOMES

On completion of the course, the students will be able to

CO1 Learn about various composite materials and its applications.
CO2 Recall different matrix and reinforcements
CO3 Acquire the knowledge on prepare of CMC by various methods
CO4 Gain knowledge on application of CMCs
CO5 Compare/evaluate the relative merits of using alternatives for important engineering and other applications.

TEXT BOOKS

1. Ceramic Matrix Composites, K K Chawla, 2nd edition, 2003.
2. Composite Materials- Science and Engineering 4th edition, Krishnan K Chawla, 2019

REFERENCES

1. Composite Materials and Processing, M Balasubramaniam, 1st edition, 2013.
2. I M Low, Advances in Ceramic Matrix Composites, Woodhead Publishing, SecondmEdition, 2018.
3. Richard Warren, Ceramic-Matrix Composites, 1992, Blackie, Glasglow.
4. Hull D and Clyne T.W, An Introduction to Composite Materials, 2nd Edn.,Cambridge University Press, 1996.
5. Bunsell A.R and Renard J, Fundamentals of Fine Fibre Reinforced Composite Materials, IOP Publishing Ltd., 2005.

COURSE ARTICULATION MATRIX

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	3	3	-	-	-	3	-	-	-	-	-	2	3	2	-
2	3	3	-	-	-	3	-	-	-	-	-	2	3	2	-
3	3	3	-	-	2	3	-	-	-	-	-	2	3	2	-
4	3	3	-	-	2	3	-	-	-	-	-	2	3	2	-

5	3	3	-	-	2	3	-	-	-	-	-	2	3	2	3
Avg	3	3	-	-	-	3	-	-	-	-	-	2	3	2	-

Correlation Levels: 1 — low, 2 — medium, 3 — high, - — no correlation

CT23029	MACHINING AND JOINING OF CERAMICS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

1 To acquire knowledge on the concepts of ceramic machining and joining technology
2 To apply them for the advanced manufacturing processing suitable for various structural engineering applications.
3 To explain the principle, applications of different polishing techniques.

UNIT I BASIC MACHINING METHODS 9

Basic machining requirements of ceramics - Ductile grinding – material removal mechanisms. Diamond wheels, Electrolytic In- Process Dressing Grinding of Ceramic materials – Mechanism, Ultrasonic machining, Abrasive water jet machining

UNIT II ADVANCED MACHINING 9

LASER beam machining - LASER assisted Grinding, Ion Beam machining, Electron Beam machining–chemical– Electrochemical –Electrical discharge machining of ceramic materials.

UNIT III SURFACE FINISHING 9

Magneto rheological abrasive flow finishing – principle, applications, Polycrystalline Diamond lapping of ceramics, Flame polishing–Annealing–Healing of surface cracks–Gaseous etching, Ionic polishing of optical surfaces–Ceramic surface texture by reflective replica technique.

UNIT IV JOINING METHODS 9

Classification – Engineering requirements – Mechanics of Joining – Contact area, testing methods and Bond strength of Metal ceramic joints – Thermo-elastic mismatch and material anisotropy – Transient liquid phase bonding – Glass-metal seals – Diffusion bonding – Reactive brazing, Alumina-metal seals, Ceramic-ceramic joints, Liquid silicon infiltration, Nano-powder infiltration – Adhesive joints – Testing of joints.

UNIT V ADVANCED JOINING METHODS 9

Laser transient joining – Microwave and spark plasma assisted joining – Solid state Ti-Si-C reaction joints – Applications – Vacuum seals, Feed through, Microelectronic packaging – Electronic insulation - Thermo-electric modules – Thermal protection systems – Case studies.

TOTAL:45 PERIODS

COURSE OUTCOMES

On completion of the course, the students will be able to

CO1 Evaluate materials problems associated with basic machining and joining technology
CO2 Analyze a suitable process for machining of ceramic materials.
CO3 Understand the concepts and working behind different polishing techniques
CO4 Apply engineering structures with the dissimilar materials
CO5 Implementing the low cost manufacturing possibilities by appropriate selection of the joining process

TEXT BOOKS

1. Kapil Gupta, “Advanced Manufacturing technologies, modern machining, advanced joining, sustainable manufacturing” Springer, 2017.
2. Charles A Lewinsohn et al, “Advances in joining of ceramics”, Proceedings of the joining of ceramics symposium, 104th annual meeting, The American Ceramic Society, 2003.

REFERENCES

1. Narottam P.Bansal and Jacques Lamon, “Ceramic Matrix Composites-Materials, Modeling and Technology”, 2015, John Wiley & Sons, Inc., Hoboken, New Jersey.
2. V.K.Jain,”Introduction to Micromachining”, 2010,Alpha Science International Ltd.
3. El-Hofy, H., Advanced Machining Processes-Non-traditional and Hybrid Machining Processes, McGraw-Hill, NewYork.
4. Pandey P. C., Modern Machining Processes, TMH Publication.
5. McGough J. A., Advanced Methods of Machining, Chapman and Hall Ltd., London.

COURSE ARTICULATION MATRIX

CO	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	1	3	3	3	3	3	1	-	2	2	1	3	3	3	3
2	1	3	3	2	3	3	1	-	2	2	1	3	3	3	3
3	1	2	2	2	3	3	1	-	2	2	1	3	3	3	3
4	1	2	2	2	3	3	1	-	2	2	1	3	3	3	3
5	1	2	2	2	3	3	1	-	2	2	1	3	3	3	3
Avg	**1**	**2.4**	**2.4**	**2.2**	**3**	**3**	**1**	**-**	**2**	**2**	**1**	**3**	**3**	**3**	**3**

Correlation Levels: 1 — low, 2 — medium, 3 — high, - — no correlation

CT23030	CERAMIC ADDITIVE MANUFACTURING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

1. Provide an in depth understanding of the principles, techniques and applications of additive manufacturing in ceramics
2. Familiarize with the material properties, design considerations, process technologies and real-world applications of ceramic additive manufacturing

UNIT I INTRODUCTION **9**

Definition and classification, historical development of AM, general benefits and challenges of AM; Ceramics in additive manufacturing – introduction to ceramics and its properties, advantages of using ceramics in AM, applications of ceramic AM in various industries; Comparison with traditional manufacturing – differences between additive and traditional ceramic manufacturing methods, case studies showcasing the benefits of ceramic AM; Basic terminology and concepts – key terms and definitions in ceramic AM, understanding the digital workflow from CAD to final product.

UNIT II MATERIALS AND DESIGN FOR CERAMIC AM **9**

Ceramic materials for AM – types of ceramics used in AM, properties and characteristics of ceramic powders and slurries, material selection criteria for specific applications; Design considerations – design for additive manufacturing principles, design constraints and opportunities specific to ceramics, case studies of successful ceramic AM designs; Digital tools and software – overview of CAD software for ceramic AM, simulation and optimization tools, hands on session with a popular CAD software

UNIT III CERAMIC AM TECHNOLOGIES AND PROCESSES **9**

Overview of ceramic AM technologies – binder jetting, stereolithography, fused deposition modeling, direct ink writing, selective laser sintering; Process parameters and optimization – key process parameters for each technology, effect of parameters on final product properties, methods for optimizing AM processes; Post processing techniques – de-binding and sintering, surface finishing techniques, quality control and testing methods

UNIT IV APPLICATIONS **9**

Industrial applications of ceramic AM – aerospace and defence, medical and dental, electronics and energy, automotive and industrial tooling; case studies – detailed analysis of successful

ceramic AM applications, challenges and solutions in each case; Research and Development in ceramic additive manufacturing

UNIT V FUTURE PERSPECTIVES AND ETHICAL CONSIDERATIONS 9

Emerging trends and future directions – advancements in materials and technologies, integration with other advanced manufacturing techniques, potential impact on various industries; Sustainability and environmental impact – environmental benefits and concerns of ceramic AM, strategies for sustainable manufacturing; Ethical and social considerations – ethical implications of ceramic AM, impact on workforce and society, regulatory and safety issues**.**

TOTAL: 45 PERIODS

COURSE OUTCOMES

On completion of the course, the students will be able to

CO1 Describe the fundamental principles and differentiate between ceramic AM and traditional manufacturing methods.

CO2 Identify and select appropriate ceramic materials for specific AM applications based on their properties and performance characteristics

CO3 Apply design principles to create efficient and innovative ceramic components

CO4 Demonstrate knowledge of carious ceramic AM technologies and their respective process parameters

CO5 Predict future trends and potential advancements in ceramic AM technologies and materials.

TEXT BOOKS

1. Ian Gibson, David W Rosen, Brent Stucker, “Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping and Direct Digital Manufacturing”
2. Akira Kawasaki, Yutaka Kagawa, “Additive Manufacturing of Ceramics: Stereolithography, Binder Jetting and Direct Ink Writing**”**

REFERENCES

1. Chee Kai Chua, Kah Fai Leong, “3D Printing and Additive Manufacturing: Principles and Applications”, World Scientific Publishing Company Ltd, 5th Edition 2017
2. Igor Shishkovsky, “Additive Manufacturing of High Performance Metallic and Ceramic Materials”, Intech Open, 2018
3. Martin Leary, “Design for Additive Manufacturing: Concepts and Applications”, Elsevier, 2020
4. Jing Zhang, Yeon Gil Jung, “Additive Manufacturing: Materials, Processes, Quantifications and Applications”, Butterworth Heinmann, 2018
5. Ralf Riedel, “Handbook of Ceramic Hard Materials”, Wiley 2000

COURSE ARTICULATION MATRIX

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	1	3	3	3	3	3	1	-	2	2	1	3	3	3	3

2	1	3	3	2	3	3	1	-	2	2	1	3	3	3	3
3	1	2	2	2	3	3	1	-	2	2	1	3	3	3	3
4	1	2	2	2	3	3	1	-	2	2	1	3	3	3	3
5	1	2	2	2	3	3	1	-	2	2	1	3	3	3	3
Avg	**1**	**2.4**	**2.4**	**2.2**	**3**	**3**	**1**	**-**	**2**	**2**	**1**	**3**	**3**	**3**	**3**

Correlation Levels: 1 — low, 2 — medium, 3 — high, - — no correlation

CT23E01 SEMICONDUCTOR TECHNOLOGY

L	T	P	C
3	0	0	3

COURSE OBJECTIVES

1 To provide the students with a comprehensive understanding of the fundamental principles of semiconductor materials, devices and technology

2 To explore the operational principles of various semiconductor devices, processes involved in the fabrication, apply their knowledge in designing and analyzing basic semiconductor circuits and systems.

UNIT I INTRODUCTION TO SEMICONDUCTOR MATERIALS 9

Definition and types, comparison with conductors and insulators; bonding and structure - crystal structure (diamond, zinc blende), covalent bonding in semiconductors; energy bands – energy band theory, conduction and valence bands, bandgap and its significance; carrier statistics – electrons and holes, effective mass, fermi level and its significance.

UNIT II SEMICONDUCTOR DEVICES AND THEIR OPERATION 9

P-N junction – formation and properties, depletion region, forward and reverse bias characteristics; diodes – types and applications; bipolar junction transistors – structure and operation, current gain, common configurations; Field effect transistor – JFETs and MOSFETs, threshold voltage and I-V characteristics, applications.

UNIT III FABRICATION TECHNIQUES 9

Crystal growth and wafer preparation – czochralski process, wafer slicing and polishing; oxidation – thermal oxidation process, properties of silicon dioxide; photolithography – photoresist application, exposure and development; etching and doping – wet and dry etching techniques, diffusion and ion implantation; thin film deposition – chemical vapor deposition and physical vapor deposition; fabrication for ceramic components – tape casting, sintering, machining , challenges in processing ceramic materials, integration with semiconductor fabrication process.

UNIT IV CHARACTERIZATION AND TESTING OF SEMICONDUCTORS 9

Electrical characteristics – I-V and C-V measurements, carrier lifetime and mobility; Optical characterization – photoluminescence and Raman spectroscopy, absorption and reflection measurements; structural characterization – x-ray diffraction, SEM, TEM; Reliability and Failure analysis – stress testing, common failure mechanisms, techniques for failure analysis; characterization of ceramic materials – mechanical testing, thermal properties, electrical

properties

UNIT V CERAMICS IN SEMICONDUCTOR TECHNOLOGY 9

Overview of applications in semiconductor devices and fabrication processes, comparison with other materials used in semiconductors; ceramic substrates – types of substrates, properties and advantages of ceramic substrates, applications in power electronics, RF components and high frequency devices; ceramic packaging – importance of packaging in semiconductor devices, types of ceramic packaging, advantages, thermal management and reliability; ceramic s in MEMs – role of ceramics in MEMs, common materials and applications; ceramic dielectrics – types of ceramic dielectric materials, properties and applications, role of high k dielectrics for advanced semiconductor devices.

TOTAL: 45 PERIODS

COURSE OUTCOMES

On completion of the course, the students will be able to

CO1 Explain the fundamental concepts of semiconductor physics
CO2 Demonstrate the ability to analyze and describe the operation of various semiconductor devices
CO3 Acquire knowledge of the key processes in semiconductor device fabrication
CO4 Use the various characterization and testing techniques to evaluate the properties and performance of semiconductor materials and devices
CO5 Aware of the current trends and future directions in the use of ceramics in semiconductor technology including advancements in materials and fabrication techniques

TEXT BOOKS

1. Peter Y Yu, Manuel Cardona, “Fundamentals of Semiconductors: Physics and Material Properties”, Springer, 2013
2. Dieter K Schroder, “Semiconductor Material and Device Characterization” , Wiley Publications, 2006

REFERENCES

1. Donald A Neamen, “Semiconductor Physics and Devices”, 2017
2. Adel S Sedra, Kenneth C Smith, “Microelectronic Circuits”, Oxford University, 2017
3. Ben G Streetman, Sanjay Banerjee, “Solid State Electronic Devices”, Oxford University 2009
4. Stephen A Campbell, “The Science and Engineering of Microelectronic Fabrication”, Oxford University, 2001
5. Hong Xiao, “Introduction to Semiconductor Manufacturing Technology”, Pearson, 2000
6. C Barry Carter, M Grant Norton, “ Ceramic Materials: Science and Engineering”, Springer Verlog, New York, 2013

COURSE ARTICULATION MATRIX

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	1	1	1	1	1	1	2	-	2	2	1	3	2	1	1

2	2	2	2	2	1	1	2	-	2	2	1	3	1	1	2
3	3	3	1	2	1	1	2	-	2	2	1	3	1	1	1
4	3	2	3	2	2	1	2	-	2	2	1	3	1	2	1
5	1	1	3	1	1	1	2	-	2	2	1	3	1	2	1
Avg	**2**	**1.8**	**2**	**1.6**	**1.2**	**1**	**2**	**-**	**2**	**2**	**1**	**3**	**1.2**	**1.4**	**1.2**

Correlation Levels: 1 — low, 2 — medium, 3 — high, - — no correlation

CT23E02 ULTRA-HIGH TEMPERATURE MATERIALS

L	T	P	C
3	**0**	**0**	**3**

COURSE OBJECTIVES

1. To provide students with a thorough understanding of the fundamental principles, properties, and classifications of ultra-high temperature materials (UHTMs).
2. To familiarize students with various industrial applications of UHTMs, supported by detailed case studies, and to analyze the challenges and solutions encountered in real-world applications.

UNIT I INTRODUCTION **9**

Definition and classification of UHTMs, applications in aerospace, defense, energy and other industries; Properties of UHTMs – Thermal properties, mechanical properties, chemical properties; Types of UHTMs – carbides, nitrides, borides, oxides; design and prediction of UHTM properties using computational methods.

UNIT II PROCESSING AND FABRICATION TECHNIQUES **9**

Powder metallurgy – powder production methods. Compaction and sintering processes, hot isostatic pressing; Chemical vapor deposition and Physical vapor deposition – principles, applications and advantages of each technique, case studies; Additive manufacturing – techniques for UHTMs, advantages and challenges, case studies; Composites and coatings – fabrication, surface coatings for enhanced performance, case studies; Novel processing techniques – SPS, field assisted sintering technique, advanced AM methods, impact of nove; processing techniques on microstructure and properties.

UNIT III CHARACTERIZATION **9**

Microstructural characterization – optical microscopy, SEM, TEM, XRD; Mechanical testing – Hardness, tensile and compressive testing, fracture toughness testing; Chemical and thermal testing – thermal analysis, oxidation and corrosion testing, thermal shock and thermal fatigue testing; Non destructive evaluation – ultrasonic testing, radiographic testing, acoustic emission testing.

UNIT IV APPLICATIONS **9**

Aerospace – UHTMs in rocket propulsion and hypersonic vehicles, case studies of UHTM components in aerospace; Defense - UHTMs in armor and missile systems, case studies of

UHTM applications in defense; Energy sector – UHTMs in nuclear reactors and thermal protection systems, case studies of UHTM application in energy; Emerging applications – UHTMs in space exploration and advanced manufacturing, future potential applications and research directions.

UNIT V FUTURE PERSPECTIVES 9

Emerging trends and innovations – advances in UHTM materials and processing technologies, integration with other advanced materials and technologies, potential impact on various industries; Sustainability and environmental impact – environmental benefits and concerns of UHTMs, strategies for sustainable development and recycling, ethical and social considerations.

TOTAL: 45 PERIODS

COURSE OUTCOMES

On completion of the course, the students will be able to

- **CO1** Demonstrate a comprehensive understanding of the fundamental principles, properties, and classification of UHTMs.
- **CO2** Describe and apply the various processing and fabrication techniques for UHTMs
- **CO3** Identify the different characterization techniques and analyze the impact of processing techniques.
- **CO4** Analyze and discuss various industrial applications of UHTMs and evaluate the challenges and solutions encountered in real world applications
- **CO5** Investigate interdisciplinary approaches integrating UHTMs with other advanced materials and technologies.

TEXT BOOKS

1. Igor L Shabalin, “Ultra high temperature Materials I: Carbon and Refractory Metals, Springer, 2014
2. Willain G Fahrenholtz, Eric J Wuchina, William E Lee, Yutai Katoh, “Ultra High Temperature Ceramics: Materials for Extreme Environment Applications”, Wiley, 2014

REFERENCES

1. Yoseph Bar Cohen, “High Temperature Materials and Mechanisms”
2. Eugene Olevsky, Arne Molinari, “Field Assisted Sintering: Science and Applications”
3. David John Young, “High Temperature Oxidation and Corrosion of Metals”
4. Robert C TuckerJr, G Bruce Gradwell, Paul E Hodge, “High Temperature Materials and Coatings for Gas Turbines”

COURSE ARTICULATION MATRIX

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	1	1	1	1	2	-	1	-	1	1	-	2	2	1	-
2	2	2	2	2	2	-	1	-	1	1	-	2	-	-	2
3	3	3	1	2	1	-	1	-	1	1	-	2	-	-	1

4	3	2	3	2	2	-	1	-	1	1	-	2	-	2	-
5	1	1	3	1	1	-	1	-	1	1	-	2	-	2	-
Avg	2	1.8	2	1.6	1.6	-	1	-	1	1	-	2	2	1.7	1.5

Correlation Levels: 1 — low, 2 — medium, 3 — high, - — no correlation

CT23901	CERAMIC MATERIALS FOR ENGINEERING APPLICATIONS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

1. To provide insights on the application of ceramic materials in engineering, emphasizing their use in structural, electronic, biomedical, environmental, and energy applications.
2. To explore the properties, processing techniques, and design considerations that make ceramics suitable for specific engineering purposes.

UNIT I INTRODUCTION TO CERAMIC MATERIALS IN ENGINEERING 9

Overview of ceramic materials – definition and classification, key properties relevant to engineering, evolution of ceramics in engineering, structural, electronic, biomedical, environmental and energy applications

UNIT II MATERIALS FOR SCTRUCTURAL APPLICATIONS 9

Construction and building materials – bricks, tiles and cement, refractories – aerospace and automotive applications; thermal protection systems, wear resistant components – mechanical properties for structural use; strength and toughness, creep and fatigue resistance – design and performance considerations, reliability and safety factors

UNIT III MATERIALS FOR ELECTRICAL AND ELECTRONIC APPLICATIONS 9

Dielectric and ferroelectric ceramics – semiconducting and conductive ceramics; varistors and thermistors, ionic conductors – magnetic ceramics; ferrite and applications in magnetic storage – advanced electronic applications; piezoelectric ceramics in sensors and actuators, superconducting ceramics.

UNIT IV MATERIALS FOR BIOMEDICAL APPLICATIONS 9

Bio inert Vs bioactive ceramics – dental applications, crowns, bridges and implants – orthopedic implants, bone grafts and joint replacements – advanced biomedical uses, drug delivery systems, tissue engineering scaffolds.

UNIT V MATERIALS FOR ENVIRONMENTAL AND ENERGY APPLICATIONS 9

Environmental applications – catalyst for pollution control, filtration and separation membranes; energy generation and storage - fuel cells and solid oxide electrolytes; batteries and supercapacitors – thermal management; thermal barrier coatings; heat exchangers, recycling and waste management, green manufacturing processes.

TOTAL : 45 PERIODS

COURSE OUTCOMES

On completion of the course, the students will be able to

CO1 Analyse the use of ceramics in structural, electronic, biomedical, environmental, and energy applications and explore the current and future trends in the application of ceramics in engineering.

CO2 Evaluate the performance and design considerations for ceramic materials in various engineering contexts.

CO3 Explore the different ceramic materials used for electrical and electronic applications

CO4 Prioritize the ceramic materials for biomedical applications

CO5 Appraise the ceramic materials for energy and environmental applications

TEXT BOOKS

1. Phillippe Boch, Jean-Claude Niepce, “Ceramic Materials — Processes, Properties and Applications”, Hermes Science Publications, 2001
2. Carter C Barry, Norton M Grant, “Ceramic Materials – Science and Engineering”, 2007

REFERENCES

1. Bikramjit Basu and Kantesh Balani, “Advanced Structural Ceramics”, Wiley Publications, 2011
2. Wolfram Holand and George Beall, “Glass Ceramic Technology”, The American Ceramic Society, 2002

COURSE ARTICULATION MATRIX

CO	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	1	3	3	3	3	3	1	-	2	2	1	3	3	3	3
2	1	3	3	2	3	3	1	-	2	2	1	3	3	3	3
3	1	2	2	2	3	3	1	-	2	2	1	3	3	3	3
4	1	2	2	2	3	3	1	-	2	2	1	3	3	3	3
5	1	2	2	2	3	3	1	-	2	2	1	3	3	3	3
Avg	**1**	**2.4**	**2.4**	**2.2**	**3**	**3**	**1**	**-**	**2**	**2**	**1**	**3**	**3**	**3**	**3**

Correlation Levels: 1 — low, 2 — medium, 3 — high, - — no correlation

CT23902	CERAMIC PROCESSING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

1. To provide an in-depth study of the processing techniques used to manufacture ceramic materials.
2. It familiarize with the entire processing cycle, from raw material preparation to final product fabrication, with an emphasis on understanding the underlying principles and their practical applications

UNIT I INTRODUCTION TO CERAMIC PROCESSING 9

Overview of ceramic materials – definition and classification, key properties and applications of ceramic processing, basic concepts of traditional Vs modern techniques, steps in ceramic processing, importance of microstructure control, challenges in ceramic processing, processing defects.

UNIT II RAW MATERIALS AND POWDER PREPARATION 9

Types of raw materials – natural Vs synthetic, powder synthesis of primary and secondary raw materials, solid state synthesis, sol gel process, CVD, particle size and distribution, surface area and porosity, ball milling, spray drying agglomeration and dispersion, flocculation and deflocculation, role of additives and binders

UNIT III SHAPING AND FORMING METHODS 9

Drying and semidry pressing – uniaxial and isostatic pressing, equipment and process parameters; casting techniques – slip casting, tape casting; plastic forming methods – extrusion, injection molding; additive manufacturing – 3D printing technologies and applications in ceramics; forming defects and its prevention, common defects, quality control measures

UNIT IV SINTERING AND DENSIFICATION 9

Principles of sintering – solid state and liquid phase sintering, sintering mechanism; sintering techniques – conventional sintering, microwave and spark plasma sintering; densification behavior – role of additives, grain growth and control; sintering atmospheres in sintering – inert, reducing and oxidizing atmospheres; post sintering processes – hot isostatic pressing, surface treatments.

UNIT V ADVANCED PROCESSING TECHNIQUES 9

Advanced powder processing – nano-powders and their processing, sol gel derived materials; coating techniques – thermal spraying, PVD and CVD; Composite ceramics – types, processing methods; fabrications of multifunctional ceramics – functionally graded materials, smart ceramics; case studies and applications – high performance ceramics in aerospace, biomedical ceramics, energy related applications

TOTAL : 45 PERIODS

COURSE OUTCOMES

On completion of the course, the students will be able to

CO1 Understand the principles and techniques involved in the processing of ceramic materials.

CO2 Apply knowledge of ceramic processing to solve practical engineering problems.

CO3 Analyze the properties and behavior of ceramic powders and formed bodies.

CO4 Evaluate the effects of processing parameters on the microstructure and properties of ceramics.

CO5 Develop skills in advanced ceramic processing techniques and their applications.

TEXT BOOKS

1. Mohamed N.Rahaman, Ceramic Processing, Taylor & Francis, 2007.
2. Loan D. Marinescu, Handbook of Advanced Ceramic Machining, CRC press, 2007.

REFERENCES

1. Alan G.King, Ceramic Technology and Processing, Noyes Publication, USA, 2001.
2. James S. Reed, Principle of Ceramic Processing, John Willey and Sons, NY, 1988.
3. David W. Richerson, Modern Ceramic Engineering, 3rd Edn., Taylor & Francis, 2005.
4. Paul De Garmo E, Black J.J and Ronald A.Kohser, Materials and Processes in Manufacturing, 8th Edn, Prentice - Hall India Pvt. Ltd., New Delhi, 1997.
5. Reed J.S, Introduction to the Principles of Ceramic Processing, Willey, New York, 1988.
6. John G.P.Binner (Ed), Advanced Ceramics Processing and Technology, Noyes Publications, New Jersey, 1990.
7. Burtrand Lee and Sridhar Komarnei (Eds.), Chemical Processing of Ceramics, 2nd Edn., Taylor & Francis, 2005.

COURSE ARTICULATION MATRIX

CO	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	1	3	3	3	3	3	1	-	2	2	1	3	3	3	3
2	1	3	3	2	3	3	1	-	2	2	1	3	3	3	3
3	1	2	2	2	3	3	1	-	2	2	1	3	3	3	3

4	1	2	2	2	3	3	1	-	2	2	1	3	3	3	3
5	1	2	2	2	3	3	1	-	2	2	1	3	3	3	3
Avg	**1**	**2.4**	**2.4**	**2.2**	**3**	**3**	**1**	**-**	**2**	**2**	**1**	**3**	**3**	**3**	**3**

Correlation Levels: 1 — low, 2 — medium, 3 — high, - — no correlation