DEPARTMENT OF CERAMIC TECHNOLOGY

ANNA UNIVERSITY, CHENNAI

VISION:

Short Term Goal

- To develop infrastructure facilities for establishing ceramic laboratory with specialization on Traditional Ceramics, Structural Ceramics, Bio-Ceramics and Electronic Ceramics.
- To concentrate on development of research activities and generate funds through R&D projects.
- To serve as nodal centre for testing and quality analysis for catering the needs of Ceramic and Allied Industries in and around Tamilnadu.

Long Term Goal

- To develop processing and testing Centre for Excellence similar to that of CERAM, UK in the area of ceramics and cater the needs of Ceramic and Allied Industries.

MISSION:

- To serve as a resource centre for Ceramic Science and Technology.
- To stimulate R&D activities in the technological and commercial development of new products and processes useful for the Ceramic and Allied Industries.
- To contribute to education in Ceramic Science and Technology.
- To conduct basic and applied programmes at the forefront of Ceramic Science and Technology which is relevant to the Indian Industry.

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

ANNA UNIVERSITY, CHENNAI:600 025

UNIVERSITY DEPARTMENTS

REGULATIONS – 2019

M.TECH. CERAMIC TECHNOLOGY

CHOICE BASED CREDIT SYSTEM

1. **PROGRAMME EDUCATIONAL OBJECTIVES (PEOs):**

1. To gain progress in manufacturing and Technology sector.
2. To have a vertical growth in managerial position and a competitive lead in an organization.
3. To provide a platform for educational advancement in career.
4. To become a preferable consultant and a sorter to solve the practical problems of any organization.
5. To be an enterprising entrepreneur in the supply chain or a well established executive.

2. **PROGRAMME OUTCOMES (POs):**

After going through the four years of study, our Ceramic Technology Graduates will exhibit ability in:

PO	Graduate Attribute	Programme Outcome
1.	Engineering knowledge	Enhance the knowledge in mathematics, basic science and engineering science.
2.	Problem analysis	Capable of Identifying engineering problems and formulating tools to solve the same.
3.	Design/development of solutions	Design a system or process to improve its performance within the constraints
4.	Conduct investigations of complex problems	Ability to conduct experiments and collecting data, analyzing and drawing inferences.
5.	Usage of Modern tools	Use modern tools and techniques to improve the efficiency of the system.
6.	The Engineer and society	Ability to have Professional excellence and strive for societies up liftment
7.	Environment and sustainability	Design to be environment conscious and growth oriented
8.	Ethics	To boost the industry, business and society in a professional and ethical manner.
9.	Individual and team work	Composition of an integrated team.
10.	Communication	Proficiency in oral and written Communication.
11.	Project management and finance	To be innovatively progressive within resources
12.	Life-long learning	Continue professional development and learning as a life-long activity.

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

3. MAPPING OF PROGRAMME EDUCATIONAL OBJECTIVE WITH PROGRAMME OUTCOMES

PROGRAMME EDUCATIONAL	PROGRAMME OUTCOMES											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
1.	✓	✓	✓	✓	✓	✓						✓
2.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
3.	✓	✓	✓	✓		✓						✓
4.						✓		✓		✓	✓	✓
5.						✓	✓	✓	✓	✓	✓	✓

4. MAPPING OF COURSE OUTCOMES AND PROGRAMME OUTCOMES

		Course Name	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
YEAR 1	Semester1	Synthesis Techniques for Ceramic Raw Materials	1	2	3	2								3
		Microstructure Development during Ceramic Processing	2	3	3	3	3							3
		Mechanical and Thermal Behavior of Ceramics	3	3	3	3	3							3
		Densification of Ceramics	1	3	3	3	3							3
		Professional Elective I	1	2	2	3	3	3						3
		Research Methodology and IPR		3	3	3	3							3
		Audit Course I	3						2	3				3
		Mechanical and Thermal Testing Laboratory	1	3	3	3	3							3
		Advanced Processing of Ceramics Laboratory	1	3	3	3	3							3

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

		Ceramic White wares	1	2	3	2	2							3
		Strategic Applications of Ceramics	1	3	3	3	3	2						3
		Advanced Characterization Techniques	1	3	3	3	3							3
		Professional Elective II	1	2	2	3	3	3						3
		Professional Elective III	1	2	2	3	3	3						3
		Open Elective	1	2	2	3	3	3						3
		Audit Course II	3						2	3				3
		White ware Laboratory	1	3	3	3	3							3
		Advanced Characterization Laboratory	1	3	3	3	3							3
		Mini Project and Seminar	1	3	3	3	3	2			3	3		3
	Semester2	Internship/ Training during (2Weeks)	1	2	1	3	2	2	2	3	3	3	3	3
YEAR 2		Professional Elective IV	1	2	2	3	3	3						3
		Professional Elective V	1	2	2	3	3	3						3
		Project Work Phase I	1	3	3	3	3	3	2	3	3	3	3	3
	Semester3	Internship /Training during (2Weeks)	1	2	1	3	2	2	2	3	3	3	3	3
	Semester4	Project Work Phase II	1	3	3	3	3	3	2	3	3	3	3	3

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

ANNA UNIVERSITY, CHENNAI

UNIVERSITY DEPARTMENTS

REGULATIONS – 2019

M.TECH. CERAMIC TECHNOLOGY

CHOICE BASED CREDIT SYSTEM

CURRICULA AND SYLLLABI FOR I TO IV SEMESTER

SEMESTER I

S. NO.	CODE NO.	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	CR5101	Synthesis Techniques for Ceramic Raw Materials	PCC	3	0	0	3	3
2.	CR5102	Microstructure Development during Ceramic Processing	PCC	3	0	0	3	3
3.	CR5103	Mechanical and Thermal Behavior of Ceramics	PCC	3	1	0	4	4
4.	CR5104	Densification of Ceramics	PCC	3	0	0	3	3
5.		Professional Elective I	PEC	3	0	0	3	3
6.	RM5151	Research Methodology and IPR	RMC	2	0	0	2	2
7.		Audit Course I*	AC	2	0	0	2	0
PRACTICALS								
8.	CR5111	Mechanical and Thermal Testing Laboratory	PCC	0	0	4	4	2
9.	CR5112	Advanced Processing of Ceramics Laboratory	PCC	0	0	4	4	2
			TOTAL	19	1	8	28	22

*Audit Course is Optional

SEMESTER II

S. NO.	CODE NO.	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	CR5201	Ceramic White wares	PCC	3	0	0	3	3
2.	CR5202	Strategic Applications of Ceramics	PCC	3	0	0	3	3
3.	CR5203	Advanced Characterization Techniques	PCC	3	1	0	4	4
4.		Professional Elective II	PEC	3	0	0	3	3
5.		Professional Elective III	PEC	3	0	0	3	3
6.		Open Elective	OEC	3	0	0	3	3
7.		Audit Course II*	AC	2	0	0	2	0
PRACTICALS								
8.	CR5211	White ware Laboratory	PCC	0	0	4	4	2
9.	CR5212	Advanced Characterization Laboratory	PCC	0	0	4	4	2
10.	CR5213	Mini Project and Seminar	EEC	0	0	2	2	1
11.	CR5312	Internship / Training** (Minimum 2 Weeks)	EEC	-	-	-	-	-
			TOTAL	20	1	10	31	24

*Audit Course is Optional

**Students have to undergo Internship / Training for a period of 2 weeks during summer and assessments will be done during III semester.

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

SEMESTER III

S. NO.	CODE NO.	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.		Professional Elective IV	PEC	3	0	0	3	3
2.		Professional Elective V	PEC	3	0	0	3	3
PRACTICALS								
3.	CR5311	Project Phase I	EEC	0	0	12	12	6
4.	CR5312	Internship / Training (Minimum 2 Weeks)	EEC	0	0	0	0	1
			TOTAL	6	0	12	18	13

SEMESTER IV

S. NO.	CODE NO.	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
PRACTICALS								
1.	CR5411	Project Phase II	EEC	0	0	24	24	12
			TOTAL	0	0	24	24	12

Total Credits = 71

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

Programme Core Courses (PCC)

S. No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1	CR5101	Synthesis Techniques for Ceramic Raw Materials	PCC	3	3	0	0	3
2	CR5102	Microstructure Development during Ceramic Processing	PCC	3	3	0	0	3
3	CR5103	Mechanical and Thermal Behavior of Ceramics	PCC	4	3	1	0	4
4	CR5104	Densification of Ceramics	PCC	3	3	0	0	3
5	CR5111	Mechanical and Thermal Testing Laboratory	PCC	4	0	0	4	2
6	CR5112	Advanced Processing of Ceramics Laboratory	PCC	4	0	0	4	2
7	CR5201	Ceramic White wares	PCC	3	3	0	0	3
8	CR5202	Strategic Applications of Ceramics	PCC	3	3	0	0	3
9	CR5203	Advanced Characterization Techniques	PCC	4	3	1	0	4
10	CR5211	White ware Laboratory	PCC	4	0	0	4	2
11	CR5212	Advanced Characterization Laboratory	PCC	4	0	0	4	2

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

PROFESSIONAL ELECTIVE COURSES (PEC)

S. NO.	CODE NO.	COURSETITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	CR5001	Additive Manufacturing	PEC	3	0	0	3	3
2.	CR5002	Advanced Carbon Materials	PEC	3	0	0	3	3
3.	CR5003	Bioceramic Materials And Their Applications	PEC	3	0	0	3	3
4.	CR5004	Ceramic Coatings	PEC	3	0	0	3	3
5.	CR5005	Ceramic Fuel Cells	PEC	3	0	0	3	3
6.	CR5006	Ceramic Machining & Joining	PEC	3	0	0	3	3
7.	CR5007	Ceramic Matrix Composites	PEC	3	0	0	3	3
8.	CR5008	Design and Selection of Abrasives	PEC	3	0	0	3	3
9.	CR5009	Functional Glasses	PEC	3	0	0	3	3
10.	CR5010	Glass Science And Technology	PEC	3	0	0	3	3
11.	CR5011	Industrial Hazards and Safety	PEC	3	0	0	3	3
12.	CR5012	Leadership Skills	PEC	3	0	0	3	3
13.	CR5013	Management Concepts in Engineering	PEC	3	0	0	3	3
14.	CR5014	Non Destructive Evaluation	PEC	3	0	0	3	3
15.	CR5015	Phase Equilibria in Ceramics	PEC	3	0	0	3	3
16.	CR5016	Product Design, Development and Sustainability	PEC	3	0	0	3	3
17.	CR5017	Refractory Engineering	PEC	3	0	0	3	3
18.	CR5018	Science of Materials	PEC	3	0	0	3	3
19.	CR5019	Synthesis and Consolidation of Nanomaterials	PEC	3	0	0	3	3

RESEARCH METHODOLOGY AND IPR COURSES (RMC)

Sl. No	Code No.	Course Title	Periods Per Week			Credits	Semester
			L	T	P		
1	RM5151	Research Methodology and IPR	2	0	0	2	1

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

OPEN ELECTIVE COURSES [OEC]*

*(Out of 6 Courses one Course must be selected)

S.NO.	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			Lecture	Tutorial	Practical		
1.	OE5091	Business Data Analytics	3	0	0	3	3
2.	OE5092	Industrial Safety	3	0	0	3	3
3.	OE5093	Operations Research	3	0	0	3	3
4.	OE5094	Cost Management of Engineering Projects	3	0	0	3	3
5.	OE5095	Composite Materials	3	0	0	3	3
6.	OE5096	Waste to Energy	3	0	0	3	3

AUDIT COURSES (AC)

Registration for any of these courses is optional to students

S. NO.	COURSE CODE	COURSETITLE	PERIODSPERWEEK			CREDITS	SEMESTER
			Lectur	Tutorial	Practical		
1.	AX5091	English for Research Paper Writing	2	0	0	0	1/2
2.	AX5092	Disaster Management	2	0	0	0	
3.	AX5093	Sanskrit for Technical Knowledge	2	0	0	0	
4.	AX5094	Value Education	2	0	0	0	
5.	AX5095	Constitution of India	2	0	0	0	
6.	AX5096	Pedagogy Studies	2	0	0	0	
7.	AX5097	Stress Management by Yoga	2	0	0	0	
8.	AX5098	Personality Development Through Life Enlightenment Skills	2	0	0	0	
9.	AX5099	Unnat Bharat Abhiyan	2	0	0	0	

EMPLOYABILITY ENHANCEMENT COURSES (EEC)

S. No.	Code No.	Course Title	Periods Per Week			Credits	Semester
			L	T	P		
1	EV5213	Mini Project with Seminar	0	0	2	1	2
2	EV5311	Project Phase I	0	0	12	6	3
3	EV5411	Project Phase II	0	0	24	12	4

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

SUMMARY:

S.NO.	Subject Area	Credits per Semester				Credits Total
		I	II	III	IV	
1	PCC	17	14	-	-	31
2	PEC	3	6	6	-	15
3	OEC	-	-	3	-	3
4	EEC	-	1	7	12	20
5	RMC	2	-	-	-	2
	Total	22	21	16	12	**71**
	Audit courses (Non Credit)	*	*			

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

SYLLABI
SEMESTER I

CR5101 SYNTHESIS TECHNIQUES FOR CERAMIC RAW MATERIALS L T P C
3 0 0 3

OBJECTIVE

The course is aimed to

- Impart knowledge on various advanced techniques for synthesis of ceramic raw materials.

UNIT I MECHANICAL AND MECHANOCHEMICAL SYNTHESIS 7

Introduction, Comminution - principle, equipments, mechanism, merits and demerits. Mechano-chemical synthesis - principle, equipment, examples, merits and demerits – experimental principle for the mechano-chemical synthesis methods with an example

UNIT II SOLID-STATE REACTION 9

Introduction, shrinking core and shrinking sphere models. Fluid-solid reactions - thermodynamics and kinetics of decomposition, oxidation, reduction, nitridation, liquid-solid reactions with examples. Solid-solid reactions - reaction mechanisms with examples.

UNIT III PRECIPITATION AND LIQUID EVAPORATION 10

Precipitation - principle, nucleation, growth mechanisms, procedures for precipitation - complex oxides, coated particles and industrial powder preparation by precipitation. Liquid evaporation - principle, working and mechanism of spray drying, spray pyrolysis, freeze drying.

UNIT IV GEL ROUTE 10

Sol-gel process - introduction; particulate gels - mechanism and example for single component and multi component gels; polymeric gels - mechanism and example for single component and multi component gels. Other gel routes - Pechini method, Citrate gel method, Glycine nitrate process.

UNIT V VAPOUR-PHASE SYNTHESIS 9

Reaction between gases - principle of powder formation by CVD technique - electric furnace method, plasma method, laser method. Flame synthesis of nano-scale ceramic powders.

TOTAL :45 PERIODS

OUTCOMES

On completion of the course the students are expected to

CO1. Have learnt about various synthesis techniques of ceramic raw materials.
CO2. Ability to synthesize ceramic raw materials using the appropriate synthesis technique.
CO3. Capable of selecting a suitable synthesis method for preparing a raw material.

TEXT BOOKS

1. Mohamed N.Rahaman, **"Ceramic Processing"**, Taylor & Francis, 2007.
2. David W. Richerson, "**Modern Ceramic Engineering**", 3rd Edition, Taylor & Francis, 2005.

REFERENCES

1. John G.P.Binner (Ed), "**Advanced Ceramics Processing and Technology**", Noyes Publications, New Jersey, 1990.
2. Octave Levenspiel, "**Chemical Reaction Engineering**", John Wiley & Sons, 1999
3. Burtrand Lee and Sridhar Komarnei (Eds.), "**Chemical Processing of Ceramics"**, 2nd Edn., Taylor & Francis, 2005
4. Terry A.Ring, **Fundamentals of Ceramic Powder Processing and Synthesis,** Academic Press, 1979.
5. Alan G. King, **Ceramic Technology and Processing**, Noyes Publications, 2002.

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

Course Articulation Matrix:

Course Outcomes	Statement	Program Outcome														
		PO 1	PO2	PO3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	Have learnt about various synthesis techniques of ceramic raw materials	1	2	3	2	-	–	–	–	–	–	–	3	3	–	3
CO2	Ability to synthesize ceramic raw materials using the appropriate synthesis technique	1	2	3	2	-	–	–	–	–	–	–	3	3	–	3
CO3	Capable of selecting a suitable synthesis method for preparing a raw material	1	2	3	2	-	–	–	–	–	–	–	3	3	–	3
SYNTHESIS TECHNIQUES FOR CERAMIC RAW MATERIALS		1	2	3	2	-	–	–	–	–	–	–	3	3	–	3

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

CR5102 MICROSTRUCTURE DEVELOPMENT DURING CERAMIC PROCESSING L T P C
3 0 0 3

OBJECTIVES

The course is aimed to

- Understand the critical importance of ceramic processing in determining the composition-microstructure-property relationships for ceramic materials.
- Understand the chemical and physical material changes that take place when manufacturing a ceramic, and the resultant effects on microstructure and properties.
- Ability to determine fundamental design aspects and perform calculations relevant to specific forming operations, drying operations, and firing operations used in ceramic processing.
- Understand and design basic processing routes for ceramic materials and components, and undertake practical problem solving.

UNIT I INTRODUCTION 9

Introduction - processing methods - glass ceramic methods, gelation methods, powder methods, densification concepts - Two particle concepts, multiple concepts, minimum energy configurations of particle arrays, stability condition of isolated pores, grain growth and densification, experiments relating grain growth to pore disappearance, colloidal powder processing - Heterogeneities associated with powder processing, colloidal methods for preparing and consolidating powders, consolidating powders consistent with the colloidal method.

UNIT II PROCESS CONTROL IN THE MANUFACTURE OF CERAMICS 9

Introduction – Process control and the need for characterization – Complex processes and the need for statistical process control – overview of ceramic process; powders – grain size and specific surface, chemical composition and moisture content, processing and functional tests, milling; consolidation – compact characterization, pressing, injection molding, extrusion, slip casting, tape casting, comparison of the various consolidation methods; sintering – post sintering operations

UNIT III MICROSTRUCTURAL TARGETS FOR CERAMICS 9

Introduction – controlled porosity – macroporous body, microporous body, mesoporous body; mechanical strength at room temperature – Young's modulus(effect of porosity), size of flaw; fracture energy – resistance to high temperature deformation – resistance to thermal shock – hardness and wear resistance – thermal conductivity – thermal expansion – optical functions – specific electrical functions – magnetic functions – resistance to corrosion - joinability.

UNIT IV GREEN MICROSTRUCTURE AND THEIR CHARACTERIZATION 9

Introduction – structure of green bodies – definition, green bodies in ceramic processing, microstructure, macrostructure and texture, homogenous green material: structure of particle packing – packing of spherical particles of uniform sizes, bimodal stackings of spherical particles, sol gel structures, hierarchical cluster packing, measureable quantities, processing technology in relation to green structures; characterization methods – types of green bodies and usability of characterization techniques.

UNIT V FIRED MICROSTRUCTURE AND THEIR CHARACTERIZATION 9

Introduction – characterization techniques ; defect containing microstructures – processing defects, high temperature defects; tough ceramic microstructures – process zone toughening mechanism, bridging zone toughening mechanism; novel microstructures and processing methods – fibrous monolithic ceramics, duplex bimodal structures; processing techniques involving metallic precursors - reaction bonding, direct metal oxidation, co-continuous ceramic composites; microstructures formed by controlled nucleation – model ceramic microstructures – electronic and optical ceramic microstructures.

TOTAL :45 PERIODS

OUTCOMES

On completion of the course, the students are expected to

CO1. Identify and specify key features pertaining to the design and operation of powder processing equipment and forming equipment used in industrial ceramic processing.
CO2. Design basic processing routes suitable for the forming of specific types of ceramic products, including selection of specific equipment and identification of potential processing problems and their prevention.
CO3. Explain and predict the effect of heat treatment conditions on the high temperature reactions of specific ceramic materials and resultant microstructure and properties.
CO4. Solve problems and to undertake design in the area of ceramic processing.

TEXTBOOKS

1. Jon G P Binner, "**Advanced Ceramic Processing and Technology**", Vol I, Noyes Publications, 1990.
2. R J Brook "**Processing of Ceram**ics", Wiley – VCH Verlag Gmbh & Co, 1996

REFERENCES

1. Mohamed N. Rahaman, **Ceramic Processing,** Taylor & Francis Group, 2003.
2. R.A. Terpstra, P.P.A.C. Pex and A.H. De Vries, **Ceramic Processing**, Springer Science Business media, B.V,1995.
3. Terry A. Ring, **Fundamentals of Ceramic Powder Processing and Synthesis,** Academic Press, 1979.
4. Alan G. King, **Ceramic Technology and Processing**, Noyes Publications, 2002.
5. Robert W. Cahn, R.J. Brook, **Materials Science and Technology**, VCH, 1996.
6. Gary L. Messing, Fred F. Lange, Shin-Ichi-Hirano, **Ceramic Processing Science**, American ceramic society, 1998.

Course Articulation Matrix:

Course Outcomes	Statement	Program Outcome														
		PO1	PO2	PO3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	Identify and specify key features pertaining to the design and operation of powder processing equipment and forming equipment used in industrial ceramic processing.	2	3	3	3	3	–	–	–	–	–	–	3	3	–	3
CO2	Design basic processing routes suitable for the forming of specific types of ceramic products, including selection of specific equipment and identify potential processing problems and their prevention.	2	3	3	3	3	–	–	–	–	–	–	3	3	–	3
CO3	Explain and predict the effect of heat treatment conditions on the high temperature reactions of specific ceramic materials and resultant microstructure.	2	3	3	3	3	–	–	–	–	–	–	3	3	–	3
CO4	Solve problems and to undertake design in the area of processing.	2	3	3	3	3	-	-	-	-	-	-	3	3	-	3
MICROSTRUCTURE DEVELOPMENT DURING CERAMIC PROCESSING		2	3	3	3	3	–	–	–	–	–	–	3	3	–	3

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

CR5103 MECHANICAL AND THERMAL BEHAVIOR OF CERAMICS L T P C
3 1 0 4

OBJECTIVE

The course is aimed to

- give the students a fundamental understanding of the thermal behavior (e.g., thermal stresses) and mechanical behavior (e.g., stress-strain, fatigue and fracture: or materials, and to evaluate the processing-structure-property correlations.

UNIT I FRACTURE MECHANICS 10

Types of fracture - ductile and brittle fracture; Elasticity – definition – elastic constants – elastic deformation of isotropic and crystalline materials – measurement of elastic constants – variation of elastic constant with temperature and porosity; Theoretical strength and stress concentrations; Griffith theory – linear elastic fracture mechanics, microstructural aspects, critical stress intensity factor measurement – indentation method, assessment of residual porosity and flaw populations, grain size influence on load effect, effect of grain size and surface state at different measuring approaches, notch test - fractography

UNIT II STRENGTH 9

Tensile strength – measurement techniques; Factors affecting strength – processing defects & surface defects; Statistical treatment of strength – significance, methods – Gaussian distribution, Weibull distribution. Strength reducing mechanisms – subcritical crack propagation, time dependent strength behavior,SPT diagram.

UNIT III TOUGHENING 8

Toughening mechanisms – crack deflection, crack bowing, crack branching – transformation toughening - crack tip shielding by process zone & bridging effect; Stable crack propagation and R-curve behavior,Mechanical properties of Porous and structural ceramic materials – case studies on toughening

UNIT IV CREEP AND THERMAL SHOCK BEHAVIOUR 9

Introduction to creep, Dislocation creep, diffusion creep, microstructure dependence, multicomponent system techniques, creep deformation maps, creep rupture at high temperatures and safe life design.Thermal stress, thermal shock resistance parameters, thermal stresses and cracking, thermal shock testing techniques, application.

UNIT V FATIGUE AND WEAR 9

Fatigue of ceramics – S-N Curves – stress cycles – effect of cracks – fatigue lifetime – cyclic hardening – load and amplitude effects on crack in fatigue – structural observation in fatigued specimen – notch effect – failure resulting from cyclic deformation – thermal fatigue. Wear of ceramics – types, mechanism, measurement, factors affecting wear.

TOTAL :45 PERIODS

OUTCOMES

On completion of the course, the students are expected to

CO1. Learn fracture behavior of ceramics and able to measure fracture toughness by various methods
CO2. Identify reasons for strength reducing concepts and suggest suitable toughening methods
CO3. Identify thermal and fatigue failures and suggest a suitable recommendation for a safe design
CO4. Learn various wear methods and its prevention.

TEXT BOOKS

1. John B Wachtman, "**Mechanical Properties of Ceramics**", John Wiley and Sons, Inc, 1996
2. Thomas Courtney,"**Mechanical Behavior of Materials**", McGraw Hill Publishing, 2nd Edition, 2000

REFERENCES

1. M.A. Meyers and K.K. Chawla,"**Mechanical Behavior of Materials**", Prentice -Hall, 1999
2. George Dieter, "**Mechanical Metallurgy**", McGraw-Hill Publications
3. William CallisterJr, "**Materials Science and Engineering**", Wiley Publications
4. Michael Ashby and David Jones, "**Engineering Materials 1**", Pergamon Press
5. Richard W Hertzbery, **"Deformation and Fracture Mechanics of Engineering Materials",** 4th Edition, Wiley & Sons, NY, 1996.

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

Course Articulation Matrix:

Course Outcomes	Statement	Program Outcome														
		PO1	PO2	PO3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	Learn fracture behavior of ceramics and able to measure fracture toughness by various methods	3	3	3	3	3	–	–	–	–	–	–	3	-	3	3
CO2	Identify reasons for strength reducing concepts and suggest suitable toughening methods	3	3	3	3	3	–	–	–	–	–	–	3	-	3	3
CO3	Identify thermal and fatigue failures and suggest a suitable recommendation for a safe design	3	3	3	3	3	–	–	–	–	–	–	3	-	3	3
CO4	Learn various wear methods and its prevention.	3	3	3	3	3	-	-	-	-	-	-	3	-	3	3
MECHANICAL AND THERMAL BEHAVIOR OF CERAMICS		3	3	3	3	3	–	–	–	–	–	–	3	-	3	3

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

CR5104	DENSIFICATION OF CERAMICS	L T P C 3 0 0 3

OBJECTIVES

The course is aimed to

- Expose the students to formulate and discuss a variety of approaches to convert fine particulates into useful controlled density and controlled microstructure ceramic components

UNIT I SINTERING SCIENCE 9

Introduction – Categories of sintering – sintering process – characterization, approach to sintering – Driving force for sintering – surface curvature, applied pressure, chemical reaction – Thermodynamics of the interface – surface energy and adsorption, surface tension and surface energy, thermodynamics of curved surfaces – Polycrystalline microstructures – interfacial tension and microstructure, single phase microstructures, multiphase microstructures.

UNIT II SOLID STATE AND VISCOUS SINTERING 9

Introduction – mechanism – effects of grain boundaries – theoretical analysis of sintering – Herring's Scaling Law – derivation, application and limitation –Analytical Models – Stages of sintering, modeling the sintering process, limitations – sintering diagrams – construction. Limitations – stress intensification factor and sintering stress

UNIT III GRAIN GROWTH AND 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, modification to LSW theory, time dependent Ostwald ripening – Topological and interfacial tension – grain growth in thin films – mechanisms controlling boundary mobility –simultaneous densification and grain growth.

UNIT IV LIQUID PHASE SINTERING 9

Introduction – elementary features of liquid phase sintering – stages of liquid phase sintering – thermodynamics and kinetic factors – wetting and spreading of liquid, dihedral angle, effect of solubility, capillary forces, effect of gravity – grain boundary films – activated sintering – vitrification – controlling parameters, vitrification of silicate systems – applications and an analysis of an industrial problem.

UNIT V PROCESS VARIABLES AND SINTERING PRACTICE 9

Introduction – Sintering measurement techniques – furnaces, shrinkage and density, grain size – conventional sintering – particle and green compact effects, anisotropic sintering shrinkage, heating schedule, sintering atmosphere, production of controlled sintering atmospheres – case studies; advanced sintering methods – vaccum sintering, microwave sintering, photonic sintering, field assisted sintering

TOTAL :45 PERIODS

OUTCOMES

On completion of the course, the students are expected to

CO1. Basic understanding of the importance of drying and additive removal as a precursor to firing of ceramics. Factors controlling cracking and warping and strategies for effectively dealing with post-forming additive removal.

CO2. A deeper understanding of the role of the driving force for microstructural evolution and shrinkage during sintering, and the role of the relative rates of densification and coarsening on the overall microstructure that develops.

CO3. An appreciation of how the thermal cycle, powder particle size, atmosphere, pressure, and additives can affect the densification-coarsening competition, and can be used to drive microstructural evolution along desired paths.

CO4. An ability to relate microstructural characteristics of fired ceramics to certain aspects of processing and materials selection, and to troubleshoot failures to produce products with desired microstructural characteristics.

TEXT BOOKS

1. Suk-Joong L.Kang, **"Sintering Densification, Grain Growth, and Microstructure",** Elsevier, 2005.
2. Mohamed N. Rahaman, **"Sintering of Ceramics**", CRC Press, 2007.

REFERENCES

1. R.M. German, "**Liquid Phase Sintering**", Springer, 1985.
2. Mohamed N. Rahaman, "**Ceramic Processing and Sintering**", Taylor & Francis Group, 2003.
3. Zhigang Zak Fang, **"Sintering of Advanced Materials – Fundamentals and Processes"** Woodhead Publications, 2010
4. Randall M German, Gary L Messing, Robert G Cornwall, "**Sintering Technology",** Marcel Dekker, 1996
5. Mohammed N Rahaman, "**Ceramic Processing and Sinter**ing", CRC Press, 2003.

Course Articulation Matrix:

Course Outcomes	Statement	Program Outcome													
		PO1	PO2	PO3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	Basic understanding of the importance of drying and additive. Factors controlling defects for effectively dealing with post-forming additive removal.	1	3	3	3	3	–	–	–	–	–	–	3	3	-	3
CO2	A deeper understanding of the role of the driving force for microstructural evolution and shrinkage during sintering, and the role of the relative rates of densification& coarsening.	1	3	3	3	3	–	–	–	–	–	–	3	3	-	3
CO3	An appreciation of how the thermal cycle, powder particle size, atmosphere, pressure, and additives can affect the densification-coarsening competition, and can be used to drive microstructural	1	3	3	3	3	–	–	–	–	–	–	3	3	-	3

	evolution.															
CO4	An ability to relate microstructure of fired ceramics to certain aspects of processing and materials selection, and to produce products with desired microstructure.	1	3	3	3	3	-	-	-	-	-	-	3	3	-	3
DENSIFICATION OF CERAMICS		1	3	3	3	3	–	–	–	–	–	–	3	3	-	3

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

RM5151 **RESEARCH METHODOLOGY AND IPR** **LT P C**
2 0 0 2

COURSE OBJECTIVES:

To impart knowledge and skills required for research and IPR:

- Problem formulation, analysis and solutions.
- Technical paper writing / presentation without violating professional ethics
- Patent drafting and filing patents.

UNIT I RESEARCH PROBLEM FORMULATION 6

Meaning of research problem- Sources of research problem, criteria characteristics of a good research problem, errors in selecting a research problem, scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, necessary instrumentations

UNIT II LITERATURE REVIEW 6

Effective literature studies approaches, analysis, plagiarism, and research ethics.

UNIT III TECHNICALWRITING /PRESENTATION 6

Effective technical writing, how to write report, paper, developing a research proposal, format of research proposal, a presentation and assessment by a review committee.

UNIT IV INTRODUCTION TO INTELLECTUAL PROPERTY RIGHTS (IPR) 6

Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

UNIT V INTELLECTUAL PROPERTY RIGHTS (IPR) 6

Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications. New Developments in IPR: Administration of Patent System, IPR of Biological Systems, Computer Software etc.

Traditional knowledge Case Studies, IPR and IITs.

TOTAL: 30 PERIODS

COURCE OUTCOMES:

1. Ability to formulate research problem
2. Ability to carry out research analysis
3. Ability to follow research ethics
4. Ability to understand that today's world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity
5. Ability to understand about IPR and filing patents in R & D.

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

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

REFERENCES:

1. Asimov, “Introduction to Design”, Prentice Hall, 1962.
2. Halbert, “Resisting Intellectual Property”, Taylor & Francis Ltd ,2007.
3. Mayall, “Industrial Design”, McGraw Hill, 1992.
4. Niebel, “Product Design”, McGraw Hill, 1974.
5. Ranjit Kumar, 2nd Edition, “Research Methodology: A Step by Step Guide for beginners” 2010

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

CR5111 MECHANICAL AND THERMAL TESTING LABORATORY L T P C
0 0 4 2

OBJECTIVE

The course is aimed to

- Impart hands on experience in testing Ceramic Materials for thermal and Mechanical properties.

EXPERIMENTS

1. Measurement of Elastic Constant
   - (i) Static method
   - (ii) Dynamic methods
2. Hardness test
   - (i) Micro Vickers
   - (ii) Nano Indentation
3. Measurement of Fracture Toughness
   - (i) Three Point bending
   - (ii) Hardness test
4. Compressive strength measurement
   - (i) Dry compact
   - (ii) Hot pressed
   - (iii) Microwave sintered
5. Thermal conductivity measurement
6. Measurement of Thermal shock resistance.
7. Use software tools to measure deflection, Thermal conductivity of composite walls

TOTAL: 60 PERIODS

OUTCOMES

On completion of the course, the students are expected to

CO1. Be trained to test ceramic components and
CO2. analyze its thermal and mechanical properties

EQUIPMENTS REQUIRED

1. Three point bending Machine
2. Sonic measurement device
3. Micro Vickers tester,
4. Nano Indentor
5. Three point bending test
6. Hot press
7. Micro wave furnace,
8. Thermal conductivity measuring instrument, Furnace(Max 1400^{o}C)

Course Articulation Matrix:

Course Outcomes	Statement	Program Outcome														
		PO1	PO2	PO3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	Be trained to test ceramic components	1	3	3	3	3	–	–	–	–	–	–	3	-	3	3
CO2	Analyze its thermal and mechanical properties	1	3	3	3	3	–	–	–	–	–	–	3	-	3	3
MECHANICAL AND THERMAL TESTING LABORATORY		1	3	3	3	3	–	–	–	–	–	–	3	-	3	3

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

CR5112 ADVANCED PROCESSING OF CERAMICS LABORATORY L T P C
0 0 4 2

OBJECTIVES

The course is aimed to

- Impart the capability and knowledge to synthesize ceramics, which incorporate and unify disparate elements, processes and concepts.

EXPERIMENTS

1. Sol Gel Processing
    a. Processing Method
    b. Controlling particle size
    c. Determination of microstructure
2. Solid State Processing
    a. Processing Method
    b. Controlling grain size and porosity
3. Solution Processing
    a. Processing method
    b. Control Parameters
4. Co-precipitation
    a. Processing Method
    b. Control Parameters
5. Hydrothermal Method
    a. Processing Method
    b. Control Parameters
6. Microwave Synthesis
    a. Processing Method
    b. Control Parameters
7. Advanced Ceramic Processing
    a. Preparation of Ceramic Foams
    b. 3D Printing

TOTAL :60 PERIODS

OUTCOMES:

On completion of the course, the student is expected

CO1. To analyze a material related problem, and would be able to come up with a solution by modifying the synthesis.
CO2. Given the discovery of a new or improved material, have an understanding of what is required to come up with a scalable synthesis.
CO3. Predict changes in ceramic materials/structures as a function of composition, temperature, pressure, and time.
CO4. Relate the structure of ceramics to processing required to make them; and, Relate the ceramics of materials to the resultant properties and applications.

EQUIPMENTS REQUIRED

1. Particle Size Analyzer
2. Microwave Furnace
3. Hydrothermal Instrument
4. Kappa 3D Printer
5. High Energy Ball Mill

Course Articulation Matrix:

Course Outcomes	Statement	Program Outcome														
		PO1	PO2	PO3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	To analyze a material related problem, and would be able to come up with a solution by modifying the synthesis.	1	3	3	3	3	–	–	–	–	–	–	3	3	-	3
CO2	Given the discovery of a new or improved material, have an understanding of what is required to come up with a scalable synthesis.	1	3	3	3	3	–	–	–	–	–	–	3	3	-	3
CO3	Predict changes in ceramic materials/structures as a function of composition, temperature, pressure, and time.	1	3	3	3	3	–	–	–	–	–	–	3	3	-	3
CO4	Relate the structure of ceramics to processing required to make them; and, Relate the ceramics of materials to the resultant properties and applications.	1	3	3	3	3	-	-	-	-	-	-	3	3	-	3
ADVANCED PROCESSING OF CERAMICS LABORATORY		1	3	3	3	3	–	–	–	–	–	–	3	3	-	3

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

CR5201 **CERAMIC WHITEWARES** **L T P C**
3 0 0 3

OBJECTIVES

The course is aimed to

- Have basic knowledge of white ware industries. It includes
- Knowledge on the physical and chemical properties of raw materials used in pottery and ceramic whiteware industries.
- Impart detailed information of ceramic bodies with their batch composition.
- Provide knowledge of manufacturing of various whiteware articles along with process of glazing and decoration.

UNIT I RAW MATERIALS 9

Ceramics raw materials – Plastic & non plastic; Clay formation – classification – occurrence and mineralogy – Properties of clay-water mixtures and influencing factors – absorption, cation exchange capacity, plasticity, rheology, electrical double layer theory, zeta potential & its measurement; Non – plastic raw materials – feldspar and quartz – properties and characteristics; additives.

UNIT II THEORY OF PACKING 9

Body composition – packing of two components system – porosity – effect of grain size– unfired porosity – experimental verification – wet to dry contraction - unfired strength – permeability and casting rate – dry to fired contraction – fired strength.

UNIT III FABRICATION PROCESS 9

Triaxial bodies – batch formulations – body formulations – porcelains, stoneware, earthenware, terracotta; pressing – types, process, defects; Plastic forming – types – extrusion, jiggering and jollying, injection molding, defects; casting Plaster mould preparation – slip formation – suspensions/ceramic slurries – stability of slurries, types of stabilization – fluidity and thixotrophy – various casting techniques – defects – case studies

UNIT IV GLAZING 9

Glaze – definition – composition – raw materials; Engobe – definition – raw materials – process; Fritting – definition – fritting rules – manufacturing process; Glaze batch calculation; Glaze application techniques – types; Glaze defects; Glaze properties – fusibility, viscosity, surface tension, thermal and mechanical properties, glaze-body interface layer, opacity and translucency – select and solve an industrial problem on tiles

UNIT V DRYING & FIRING 9

Drying – mechanism of drying – transfer of heat – energy balance calculations – factors that control drying –types of dryers – drying defects; Finishing operations – cutting, trimming, remedies; Effect of heat on clays – the action of heat on ceramic bodies – physical and chemical changes – firing schedules – firing range – liquid phase sintering, vitrification – case studies

TOTAL :45 PERIODS

OUTCOMES

At the end of the course, the studentS are expected to

CO1. Develop a working knowledge of classical ceramics.

CO2. Demonstrate an understanding of the structures and properties of clays, as well as processing of tri-axial porcelain bodies.

CO3. Demonstrate an understanding of adhesion and color in glaze coatings.

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

TEXTBOOKS

1. Sudhir Sen, "**Ceramic Whiteware**", Oxford & IBH Publishing Co., New Delhi, 1992
2. Singer, F and Singer, S.S, "**Industrial Ceramics**", Oxford & IBH Publishing Co., 1991

REFERENCES

1. Worral, W.E, "**Ceramic Raw Materia**ls", Pergamon Press, NY, 1992.
2. W.Ryan, "**Properties of Ceramic Raw Materials**", Pergamon Press, 2nd Edn. 1978
3. M.J.Wilson, "**Clay Mineralogy**", Chapman and Hall, 1995.
4. Allen Dinsdale, "**Pottery Science**", Ellis Horwood Ltd., NY, 1986.
5. Ryan, W and Radford, C, "**Whitewares: Production, Testing and Quality Control**", Pergamon Press, NY, 1987.
6. H.Nosbusch and I.V Mitchell, "**Clay Based Material for the Ceramics Industry"**, 1996, Elsevier Publications.
7. Terry A.Ring, "**Fundamentals of Ceramic Powder Processing and Synthesis**", 1996, Academic press.
8. Rex W.Grimshaw, "**Chemistry and Physics of Clays and Allied Ceramic Materials**", 1971.\

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

Course Articulation Matrix:

Course Outcomes	Statement	Program Outcome														
		PO1	PO2	PO3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	Develop a working knowledge of classical ceramics.	1	2	3	2	2	–	–	–	–	–	–	3	-	3	-
CO2	Demonstrate an understanding of the structures and properties of clays, as well as processing of tri-axial porcelain bodies	1	2	3	2	2	–	–	–	–	–	–	3	-	3	-
CO3	Demonstrate an understanding of adhesion and color in glaze coatings.	1	2	3	2	2	–	–	–	–	–	–	3	-	3	-
CERAMIC WHITEWARES		1	2	3	2	2	–	–	–	–	–	–	3	-	3	-

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

CR5202 **STRATEGIC APPLICATION OF CERAMICS** **L T P C**
3 0 0 3

OBJECTIVE

The course is aimed to

- Familiarize with the full range of ceramic materials, properties, applications, and design requirements necessary for the utilization of high-performance ceramics in modern technological functions.

UNIT I CERAMICS FOR HIGH TEMPERATURE AND HIGH STRENGTH APPLICATIONS 9

Introduction-Silicon based ceramics-fabrication and micro structural control of silicon based monolithic ceramics- mechanical properties of silicon based monolithic ceramics-spontaneous fracture, time dependent deformation and fracture anelasticity, oxidation-toughening of silicon based ceramics by fiber reinforcement-laminated composite structure with enhanced fracture resistance-fabrication-application.

UNIT II CERAMICS FOR POROUS APPLICATIONS 9

Introduction-porous materials- classification, characteristics, fabrication-particle stacking sintering, appending pore forming agent, polymeric sponge impregnation process, foaming process, sol gel method, new processing of porous ceramics, preparation of new types of porous ceramics-hydrophobic porous ceramics, ceramic with gradient pores, fiber porous ceramics, slender porous ceramic tubes, porous ceramics with directionally arrayed pores, porous ceramic powder-preparation of porous ceramic membranes-porous ceramics composites-ceramics honey combs-applications of porous ceramics-filtration in separation, functional chemical engineering, combustion and fire retardant.

UNIT III CERAMICS FOR BIO MEDICAL APPLICATIONS 9

Introduction-ceramics for artificial joints-ceramics for artificial bones-requirements for artificial material to bond to living bone-requirement for artificial material to for apatite-functional groups effective for apatite nucleation-apatite forming metals-apatite polymer composites-apatite forming inorganic-organic hybrids-apatite polymer fiber composites-bioactive cements-cements in-situ radiotherapy of cancer, ceramic for insitu hyper thermotherapy of cancer; Ceramic dental implants – materials and processes.

UNIT IV CERAMICS FOR THERMO PHYSICAL APPLICATIONS 9

Introduction- modeling and design-general approach and design procedure, distribution functions of composites, models, fabrication process- vapor deposition methods, sol phase method, liquid phase method-application-structural materials, function materials.

UNIT V CERAMICS FOR HIGH THERMAL CONDUCTIVE APPLICATIONS 9

Introduction- process flow-material properties-thermal resistance-reliability-LTCC with high thermal expansion coefficient new high thermal expansion co-efficient (TCE) ceramic materials for wire bonded chip assembly type CSP with potting compounds-reliability of new high TCE ceramic materials- LTCC with low permittivity and loss tangent at high frequency for microwave applications -Introduction, characterization, reliability.

TOTAL :45 PERIODS

OUTCOMES

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

CO1. Understand the principles underlying the functional behavior of ceramic materials.

CO2. Articulate the common strategies used to enhance functional performance for various applications in ceramic materials

CO3. Appreciate the real-life performance scenarios for products made from these materials

TEXT BOOKS

1. S Banerjee, A K Tyagi, "**Functional Materials : Preparation, Processing and Applications**", Elsevier Publications, Ist Edition, 2012.
2. Hee-Gweon Woo, Hong Li, "**Advanced Functional Materials**", Springer, 2011.

REFERENCES

1. Ewa Ktobzinska, **"Functional Materials : Properties, Performance and Evaluation**" CRC Press, 2015.
2. Deborah D L Chung, " **Composite Materials: Science and Applications**", Springer, 2003.
3. Ashutosh Tiwari, Lokman Uzun, "**Advanced Functional Materials**" Wiley Publications.
4. Mario Leclerc, Robert Gauvin, **"Functional Materials**".
5. Qingrui Yin, Binghe Zhu, Huarong Zeng, **"Microstructure, Properties and Processing of Functional Ceramics",** Springer, 2003.

Course Articulation Matrix:

Course Outcomes	Statement	Program Outcome													
		PO1	PO2	PO3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	Understand the principles underlying the functional behavior of ceramic materials.	1	3	3	3	3	2	–	–	–	–	–	3	-	3	3
CO2	Articulate the common strategies used to enhance functional performance for various applications in ceramic materials	1	3	3	3	3	2	–	–	–	–	–	3	-	3	3
CO3	Appreciate the real-life performance scenarios for products made from these materials	1	3	3	3	3	2	–	–	–	–	–	3	-	3	3
STRATEGIC APPLICATION OF CERAMICS		1	3	3	3	3	2	–	–	–	–	–	3	-	3	3

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectivel

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

CR5203 **ADVANCED CHARACTERIZATION TECHNIQUES** **L T P C**

3 0 0 3

OBJECTIVES

The course is aimed to

- Provide concepts on the several materials characterization techniques at the morphological, structural and chemical level
- Acquisition of skills in the use and selection of advanced experimental techniques for characterization of materials
- Application of these techniques to solve problems in materials science and engineering.

UNIT I THERMAL ANALYSIS 9

Principles of Thermogravimetric analysis (TGA), Differential thermal analysis (DTA), Differential scanning calorimetry (DSC), Dilatometer - their applications in processing and characterization of ceramics, glasses, and glass ceramics.

UNIT II X – RAY DIFFRACTION 9

Characteristics of X – rays - Fundamental principles of X-ray diffraction (XRD) - Bragg's Law - Determination of crystal Structure and particle size from XRD - Atomic Scattering and geometrical structure factors and their application in intensity calculation - Single crystal and powder diffraction.

UNIT III SPECTROSCOPY 9

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 - Raman spectroscopy, X-ray photoelectron spectroscopy, Atomic emission spectroscopy, Atomic absorption spectroscopy - ICP .

UNIT IV SURFACE CHARACTERIZATION 10

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 – Principle, Instrumentation and applications of Scanning Electron Microscope and Transmission Electron Microscope - Preparation of ceramic samples, electron microscopy studies - Characteristics of microstructure in SEM and TEM; Electron microprobe analysis (EDAX and WDS) ; Quantitative microstructure and phase analysis - Study of morphology, size and aggregation of ceramic materials – BET surface area analysis, Atomic force microscopy (AFM), Piezo-response Force Microscopy(PFM), Magnetic Force Microscopy (MFM).

UNIT V ELECTRICAL, MAGNETIC AND NON-DESTRUCTIVE CHARACTERIZATION 8

Electrical resistivity in bulk and thin films (2-probe method & 4-probe method), - Hall effect - Impedance spectroscopy - Vibrating sample magnetometer (VSM) - Magnetic PE loop; Non destructive characterization – ultrasonic techniques – reflection techniques – back reflection and pulse-echo – thickness measurement by resonance - Acoustic emission techniques- Radiographic testing - thermographic testing.

Attested

TOTAL :45 PERIODS

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

OUTCOMES

On completion of the course, the student are expected to

CO1. To understand the characterization methods used for state of the art materials
CO2. To appreciate the results from characterization methods and their reliability
CO3. To appreciate the multi-scale and multidisciplinary nature of materials

TEXT BOOKS

1. Antony R. West, "**Solid State Chemistry and its Applications**, Second Edition, John Wiley & Sons, 2014.
2. B. D. Cullity, "**Elements of X-ray Diffraction**", Second Edition, Addition-Wesley Publication, 2001.

REFERENCES

1. S Zhang, L. Li and Ashok Kumar, "**Materials Characterization Techniques**", CRC Press, 2008
2. **"Characterization of Materials Science and Technology: A Comprehensive Treatment",** Vol 2A&2B, VCH, 1992
3. Yoshio Waseda, Kozo Shinoda, Eiichiro Matsubara, **"X-Ray Diffraction Crystallography: Introduction, Examples and Solved Problems"**, Springer, 2011.
4. Willard, H.H., L.L.Meritt, J.A.Denn and F.A.Settle, **"Instrumental Methods of Analysis"** CBS Publishers, New Delhi, 1986
5. J B Watchman, Z.H Kalman, **"Characterization of Materials",** Butterworth Heinemann, 1993.
6. Elton N Kaufmann, "**Characterization of Materials**", Wiley Inter-science, 2003

Course Articulation Matrix:

Course Outcomes	Statement	Program Outcome														
		PO1	PO2	PO3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	To understand the characterization methods used for state of the art materials	1	3	3	3	3	–	–	–	–	–	–	3	3	-	3
CO2	To appreciate the results from characterization methods and their reliability	1	3	3	3	3	–	–	–	–	–	–	3	3	-	3
CO3	To appreciate the multi-scale and multidisciplinary nature of materials	1	3	3	3	3	–	–	–	–	–	–	3	3	-	3
ADVANCED CHARACTERIZATION TECHNIQUES		1	3	3	3	3	–	–	–	–	–	–	3	3	-	3

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

CR5211	WHITEWARE LABORATORY	L T P C 0 0 4 2

OBJECTIVES

The course is aimed to

- Impart knowledge and hands on training in processing of traditional ceramic materials and its property evaluation

EXPERIMENTS

1. To study of physical and properties of raw materials
2. To analyze the following properties of Clay: (i) Moisture (ii) Loss on Ignition (iii) Grit content (iv) Water of Plasticity
3. To analyze the following elements in raw materials: (i) Silica Content (ii) Alumina Content (ii) Iron Content
4. Determine the particle size distribution using Hydrometer Method
5. Determine the particle size distribution using Andreson Pipette Method
6. To determine the rheological characteristics of ceramic slip.
7. To fabricate a ceramic body by the following Techniques: (i) Uniaxial Pressing & Hot pressing and (ii) Cold Extrusion (iii) Slip Casting
8. To determine the properties of fired body– Density, Porosity, Water absorption, Shrinkage.
9. To determine the properties of tri-axial bodies: Flexural Strength – 3 point, Compressive Strength.
10. To compare the properties of the ceramic body prepared by various fabrication methods.
11. To prepare a glaze slip and analyze its properties
12. To apply the glaze on a fired body and evaluate the properties of the glazed ware

TOTAL :60 PERIODS

OUTCOMES

On completion of the course, the students are expected to

CO1. Acquire knowledge on the physical properties required for whiteware bodies.
CO2. Acquire knowledge on the chemical analysis of ceramic raw material
CO3. Acquire knowledge on the preparation of the glaze slip and evaluation of its properties

EQUIPMENTS REQUIRED

1. Uniaxial Press
2. Universal Testing Machine
3. Hydrometer
4. Hand Extruder
5. Atterberg Plasticity Tester

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

Course Articulation Matrix:

Course Outcomes	Statement	Program Outcome														
		PO1	PO2	PO3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	Acquire knowledge on the physical properties required for whiteware bodies.	1	3	3	3	3	–	–	–	–	–	–	3	3	3	-
CO2	Acquire knowledge on the chemical analysis of ceramic raw material	1	3	3	3	3	–	–	–	–	–	–	3	3	3	-
CO3	Acquire knowledge on the preparation of the glaze slip and evaluation of its properties	1	3	3	3	3	–	–	–	–	–	–	3	3	3	-
WHITEWARE LABORATORY		1	3	3	3	3	–	–	–	–	–	–	3	3	3	-

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

CR5212 **ADVANCED CHARACTERIZATION LABORATORY** **L T P C**
0 0 4 2

OBJECTIVES

The course is aimed to

- Introduce the basic techniques for materials characterization
- Hands on training on the characterization methods
- Interpretation of the data on a particular characterization.

EXPERIMENTS

1. Determination of Particle Size and Particle size analysis using LASER Diffraction.
2. Determination of Viscosity of liquids using Brookfield Viscometer.
3. Determination of Microstructure using Optical Microscope
4. Determination of forbidden gap using band gap apparatus
5. Determination of hysteresis curve using B-H apparatus
6. Determination of RUL and PCE of refractories
7. Determination of Wear Resistance using Pin on Disc Wear Tester
8. Impedance Analysis using LCR Meter
9. Determination of Surface Roughness using Surface Roughness Tester
10. Determination of crystallite size using XRD
11. Study of surface morphology using AFM
12. Study of surface characteristics using SEM

TOTAL :60 PERIODS

OUTCOMES

On completion of the course, the students are expected to

CO1. Identify suitable techniques for specific materials characterization
CO2. Identify and justify the selection of at least 3 techniques to evaluate a particular sample
CO3. Be given an unknown sample, the student will be able to collect a targeted dataset on it using an instrument

EQUIPMENTS REQUIRED

1. Pin on Disc Apparatus
2. Particle size Analyzer
3. Optical Microscope
4. Brookfield Viscometer
5. Surface Roughness Tester
6. B-H Apparatus
7. LCR Meter
8. Band Gap Apparatus

Course Articulation Matrix:

Course Outcomes	Statement	Program Outcome													
		PO1	PO2	PO3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	Identify suitable techniques for specific materials characterization	1	3	3	3	3	–	–	–	–	–	–	3	3	-	3
CO2	Identify and justify the selection of at least 3 techniques to evaluate a particular sample	1	3	3	3	3	–	–	–	–	–	–	3	3	-	3
CO3	Be given an unknown sample, the student will be able to collect a targeted dataset on it using an instrument	1	3	3	3	3	–	–	–	–	–	–	3	3	-	3
ADVANCED CHARACTERIZATION LABORATORY		1	3	3	3	3	–	–	–	–	–	–	3	3	-	3

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

CR5311 **PROJECT PHASE - I** **L T P C**
0 0 12 6

OBJECTIVES

The course is aimed to

- Offer the opportunity to apply and extend material learned throughout the program.
- Introduces the dimension of workload management into the program to enable completion of a large, relatively unstructured "assignment" over the course of the semester.
- Diversify to a range of topics, including theoretical, simulation and experimental studies, and vary from year to year.
- Emphasize on facilitating student learning in technical, project management and presentation spheres.

This course will be conducted largely as an individual project under the direct supervision of a member of academic staff. The specific project topic undertaken will reflect the common interests and expertise of the student and supervisor. The project work may be carried out in an Industry or a Research Organization. The project work will be evaluated in three reviews.

Students will be required to:

1) Select a real problem in an industry or research
2) Perform a literature search to review current knowledge and developments in the chosen technical area
3) Undertake detailed technical work in the chosen area
4) Produce progress reports or maintain a professional journal to establish work completed, and to schedule additional work within the time frame specified for the project;
5) Deliver a seminar on the general area of work being undertaken and specific contributions to that field
6) Prepare an interim report describing the work undertaken and results obtained so far; and
7) Present the work in a forum involving poster presentations and demonstrations.

TOTALS:: 180 PERIODS

OUTCOMES:

On successful completion of the course, the student are expected to

CO1. Demonstrate a sound technical knowledge of their selected project topic.
CO2. Undertake problem identification, formulation and solution.
CO3. Design engineering solutions to complex problems utilizing a systems approach.
CO4. Conduct an engineering project
CO5. Demonstrate the knowledge, skills and attitudes of a professional engineer.

Course Articulation Matrix:

Course Outcomes	Statement	Program Outcome														
		PO1	PO2	PO3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	Demonstrate a sound technical knowledge of their selected project topic.	1	3	3	3	3	3	2	3	3	3	3	3	3	3	3
CO2	Undertake problem identification, formulation and solution.	1	3	3	3	3	3	2	3	3	3	3	3	3	3	3
CO3	Design engineering solutions to complex problems utilizing a systems approach.	1	3	3	3	3	3	2	3	3	3	3	3	3	3	3
CO4	Conduct an engineering project	1	3	3	3	3	3	2	3	3	3	3	3	3	3	3
CO5	Demonstrate the knowledge, skills and attitudes of a professional engineer.	1	3	3	3	3	3	2	3	3	3	3	3	3	3	3
DENSIFICATION OF CERAMICS		1	3	3	3	3	3	2	3	3	3	3	3	3	3	3

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

CR5312 **INTERNSHIP / TRAINING** **L T P C**
0 0 0 1

OBJECTIVES

The course is aimed to

- Provide comprehensive learning platform to students where they can enhance their employ ability skills and become job ready along with real corporate exposure.
- Enhance students' knowledge in one particular technology.
- To Increase self-confidence of students and helps in finding their own proficiency
- Cultivate student's leadership ability and responsibility to perform or execute the given task.
- Provide learners hands on practice within a real job situation.

Industrial Training is an organized method or activity of enhancing and improving skill set and knowledge of engineering students, which boost their performance and consequently helping them to meet their career objectives. It is crucial for students because it is the best way to acquire as much mastery about their field as possible, which helps in building confidence of the students. Training helps learners to acquire the latest techniques, skills, and methodologies and to build a strong foundation for their career growth. In a nutshell, we can say that it helps in boosting career of students, since by the end of this training; students are turned into professionals in their specialized area. The students are expected to carryout a 2 weeks training during Summer Vacation in an Industry. After completion, the students have to submit a report about the training carried out.

OUTCOMES:

After completion of the training, the student are expected to

CO1. Capable to acquire and apply fundamental principles of engineering.
CO2. Become master in one's specialized technology
CO3. Become updated with all the latest changes in technological world.
CO4. Ability to communicate efficiently.
CO5. Trained to be a multi-skilled engineer with good technical knowledge, management, leadership and entrepreneurship skills.
CO6. Ability to identify, formulate and model problems and find engineering solution based on a systems approach.
CO7. Capability and enthusiasm for self-improvement through continuous professional development and life-long learning
CO8. Awareness of the social, cultural, global and environmental responsibility as an engineer.

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

Course Articulation Matrix:

Course Outcomes	Statement	Program Outcome														
		PO1	PO2	PO3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	Capable to acquire and apply fundamental principles of engineering.	1	2	1	3	2	2	2	3	3	3	3	3	3	-	3
CO2	Become master in one's specialized technology	1	2	1	3	2	2	2	3	3	3	3	3	3	-	3
CO3	Become updated with all the latest changes in technological world.	1	2	1	3	2	2	2	3	3	3	3	3	3	-	3
CO4	Ability to communicate efficiently.	1	2	1	3	2	2	2	3	3	3	3	3	3	-	3
CO5	Trained to be a multi-skilled engineer with good technical knowledge, management, leadership & entrepreneurship skills.	1	2	1	3	2	2	2	3	3	3	3	3	3	-	3
CO6	Ability to identify, formulate model problems and find engineering solution based on a systems approach.	1	2	1	3	2	2	2	3	3	3	3	3	3	-	3
CO7	Capability & enthusiasm for self-improvement through	1	2	1	3	2	2	2	3	3	3	3	3	3	-	3

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

	continuous professional development and life-long learning															
CO8	Awareness of the social, cultural, global and environmental responsibility as engineer	1	2	1	3	2	2	2	3	3	3	3	3	3	-	3
INDUSTRIAL TRAINING DURING SUMMER		1	2	1	3	2	2	2	3	3	3	3	3	3	-	3

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

CR5411	PROJECT PHASE - II	L T P C 0 0 24 12

OBJECTIVES

The course is aimed to

- Offer the opportunity to apply and extend material learned throughout the program.
- Introduces the dimension of workload management into the program to enable completion of a large, relatively unstructured "assignment" over the course of the semester.
- Diversify to a range of topics, including theoretical, simulation and experimental studies, and vary from year to year.
- Emphasize on facilitating student learning in technical, project management and presentation spheres.

This course will be conducted largely as an individual project under the direct supervision of a member of academic staff. The specific project topic undertaken will reflect the common interests and expertise of the student and supervisor. The project work may be carried out in an Industry or a Research Organization. The project work will be evaluated in three reviews.

Students will be required to:

8) Select a real problem in an industry or research
9) Perform a literature search to review current knowledge and developments in the chosen technical area
10) Undertake detailed technical work in the chosen area
11) Produce progress reports or maintain a professional journal to establish work completed, and to schedule additional work within the time frame specified for the project;
12) Deliver a seminar on the general area of work being undertaken and specific contributions to that field
13) Prepare an interim report describing the work undertaken and results obtained so far; and
14) Present the work in a forum involving poster presentations and demonstrations.

TOTALS:: 360 PERIODS

OUTCOMES:

On successful completion of the course, the student are expected to

CO1: Demonstrate a sound technical knowledge of their selected project topic.

CO2: Undertake problem identification, formulation and solution.

CO3: Design engineering solutions to complex problems utilizing a systems approach.

CO4: Conduct an engineering project

CO5: Demonstrate the knowledge, skills and attitudes of a professional engineer.

Course Articulation Matrix:

Course Outcomes	Statement	Program Outcome														
		PO1	PO2	PO3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	Demonstrate a sound technical knowledge of their selected project topic.	1	3	3	3	3	3	2	3	3	3	3	3	3	3	3
CO2	Undertake problem identification, formulation and solution.	1	3	3	3	3	3	2	3	3	3	3	3	3	3	3
CO3	Design engineering solutions to complex problems utilizing a systems approach.	1	3	3	3	3	3	2	3	3	3	3	3	3	3	3
CO4	Conduct an engineering project	1	3	3	3	3	3	2	3	3	3	3	3	3	3	3
CO5	Demonstrate the knowledge, skills and attitudes of a professional engineer.	1	3	3	3	3	3	2	3	3	3	3	3	3	3	3
DENSIFICATION OF CERAMICS		1	3	3	3	3	3	2	3	3	3	3	3	3	3	3

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

CR5001 **ADDITIVE MANUFACTURING** **L T P C**
3 0 0 3

OBJECTIVES

The course is aimed to

- Understand the principle, methods, possibilities and limitations of different Additive Manufacturing technologies.
- Learn the various software tools, processes and techniques to create physical objects that satisfy product development/prototyping requirements, using additive manufacturing processes.
- Familiarize with the business opportunities of the different Additive Manufacturing technologies.

UNIT I INTRODUCTION **9**

Overview – Need - Development of Additive Manufacturing (AM) Technology - Rapid Prototyping- Rapid Tooling – Rapid Manufacturing – Additive Manufacturing. AM Process Chain- Classification – Business Opportunities and Future Directions- Intellectual Property.

UNIT II MATERIAL SCIENCE FOR AM **9**

Multifunctional and graded materials in AM, Role of solidification rate, Evolution of non-equilibrium structure, microstructural studies, Structure property relationship- selection of polymer, Metallic and ceramic materials for AM – Limitations.

UNIT III AM TECHNOLOGIES **9**

Powder-based, droplet based, extrusion based, object stereolithography, Micro- and nano-additive processes. Sheet Lamination Process: Laminated Object Manufacturing (LOM)- Tooling system - Basic Principle- Mechanism: Gluing or Adhesive Bonding – Thermal Bonding

UNIT IV FDM OF CERAMIC 3 D PRINTING **9**

Extrusion Based System: Fused Deposition Modeling (FDM)- Process-Extruder deposition System – Tooling – Product dimensional tolerance - Data Processing - CAD Model Preparation -Part Orientation and Support Structure Generation -Model Slicing - Tool Path Generation- Shaped Deposition Manufacturing and Modular configuration- Selection of Materials – properties - Applications and Limitations – sintering of product – part quality studies - case studies.

UNIT V SLM OF CERAMIC 3D PRINTING **9**

Selective Laser Melting – process – types of Laser – system design – selection of materials, properties. – tolerance design -– CAD model preparation- topology optimization - tooling – sintering methods - Customized Design and Fabrication for Medical Applications- Case Studies

TOTAL: 45 PERIODS

OUTCOMES

On completion of the course, the students are expected to

CO1. Select between a subtractive and an AM process for a particular application. He or she will be able to select a particular AM process.

CO2. Plan a career in research or in advanced manufacturing, the AM being a rapidly evolving area and with wide applications.

CO3. Capable for product development of engineering components and for entrepreneurship.

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

TEXT BOOKS

1. Ian Gibson, David W.Rosen, Brent Stucker "**Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing"** Springer,Second Edition,2015. ISBN-13: 978-1493921126
2. Andreas Gebhardt Jan-Steffen Hötter "**Additive Manufacturing:3D Printing for Prototyping and Manufacturing**",Hanser publications, 2015. ISBN: 978-1-56990-582-1

REFERENCES

1. Liou, L.W. and Liou, F.W., **"Rapid Prototyping and Engineering Applications : A tool box for prototype development"**, CRC Press, 2011. ISBN: 9780849334092
2. Kamrani, A.K. and Nasr, E.A., **"Rapid Prototyping: Theory and Practice",** Springer, 2006. ISBN978-1-4614-9842-1
3. Amit Bandyopadhyay , Susmita Bose **"Additive Manufacturing**",1st Edition, CRC Press,2015. ISBN-13: 978-1482223590
4. Andreas Gebhardt **"Understanding Additive Manufacturing: Rapid Prototyping, Rapid Manufacturing"** Hanser Gardner Publication 2011. ISBN :9783446425521
5. Milan Brandt**,"Laser Additive Manufacturing: Materials, Design, Technologies, and Applications"**, Woodhead Publishing,2016. ISBN: 9780081004333
6. Majumdar J.D. and Manna I., "**Laser-assisted Fabrication of Materials",** Springer Series in Material Science, 2013.
7. Lu L., Fuh F. and. Wong Y. S, "**Laser-induced Materials and Processes for Rapid Prototyping",** Kluwer Academic Press, 2001.
8. Zhiqiang Fan and Frank Liou, "**Numerical Modeling of the Additive Manufacturing (AM) Processes of Titanium Alloy",** InTech, 2012.

Course Articulation Matrix:

Course Outcomes	Statement	Program Outcome													
		PO1	PO2	PO3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	Select between a subtractive and an AM process for a particular application. He or she will be able to select a particular AM process.	1	2	2	3	3	3	–	–	–	–	–	3	3	-	3
CO2	Plan a career in research or in advanced manufacturing, the AM being a rapidly evolving area and with wide applications.	1	2	2	3	3	3	–	–	–	–	–	3	3	-	3
CO3	Capable for product development of engineering components and for entrepreneurship.	1	2	2	3	3	3	–	–	–	–	–	3	3	-	3
ADDITIVE MANUFACTURING		1	2	2	3	3	3	–	–	–	–	–	3	3	-	3

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

CR5002 **ADVANCED CARBON MATERIALS** **L T P C**
3 0 0 3

OBJECTIVE

The course is aimed to

- Impart knowledge about various carbon materials, their properties and applications.

UNIT I INDUSTRIAL CARBON 9

Structure, properties and applications, charcoal, activated carbon, coal, pitches, graphites, 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 AND APPLICATIONS 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 - Applications: Carbon fibre supply chain, as carbon reinforced forms, Continuous filaments, Chops, Mills, Flame resisted Panox fibres,

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 C_f/C composites - Liquid phase infiltration (atmospheric and high pressure), Gas phase infiltration techniques (CVI and Film boiling CVI); Properties of C_f/C composites – Microstructures, Interface in Carbon-Carbon. Mechanical & Thermal properties (RT / High temperature), Electromagnetic properties; Oxidation & Oxidation protection - High temperature coatings on carbon fibres and C_f/C composites; Application of C_f/C composites.

TOTAL :45 PERIODS

OUTCOMES

On completion of the course the students are expected to

CO1. Comprehend the basics of carbon structures
CO2. Have knowledge about the preparation of various carbon related materials like graphite, fibers and foams.
CO3. Have learnt about various carbon composites.
CO4. Acquire familiarity with applications of carbon and graphite
CO5. Understand the testing methods of carbon materials

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

TEXT BOOKS

1. A Kelly, Carl H Zweben, **"Comprehensive Carbon Materials",** Elsevier Publishing, 1st Edition, 2000.
2. M Balasubramaniam, **"Composite Materials and Processing**", CRC Press, 1st Edition, 2013.

REFERENCES

1. Jean Baptsite Donnet, Serge Rebouillat, **"Carbon Fibres",**CRC Press, Third Edition, 1998.
2. E Ditzer, R T K Baker, J L Figueiredo, C A Bernardo, **"Carbon Fibre Filaments and Composites"**, Springer Publishing, 1st Edition, 1990.
3. L H Peebles, **"Carbon Fibres : Formation, Structure and Properties",** 1st Edition, CRC Press, 1995.
4. Peter Morgan, **"Carbon Fibres and their Composites",** 1st Edition, CRC Press, 2005.
5. K K Chawla, **"Composite Materials"**, Springer Verlag Publisher, 3rd Edition, 2014.
6. G Savage, **"Carbon Carbon Composites",** Springer Publishing, 1st Edition, 1993.

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

Course Articulation Matrix:

Course Outcomes	Statement	Program Outcome													
		PO1	PO2	PO3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	Comprehend the basics of carbon structures	1	2	2	3	3	3						3	-	3	3
CO2	Have knowledge about the preparation of various carbon related materials like graphite, fibers and foams.	1	2	2	3	3	3						3	-	3	3
CO3	Have learnt about various carbon composites.	1	2	2	3	3	3						3	-	3	3
CO4	Acquire familiarity with applications of carbon and graphite	1	2	2	3	3	3						3	-	3	3
CO5	Understand the testing methods of carbon materials	1	2	2	3	3	3						3	-	3	3
ADVANCED CARBON MATERIALS		1	2	2	3	3	3						3	-	3	3

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

CR5003 BIOCERAMIC MATERIALS AND THEIR APPLICATIONS L T P C
3 0 0 3

OBJECTIVE

The course is aimed to

- Impart basic knowledge about various bio materials, their properties and applications.

UNIT I INTRODUCTION TO BIOMATERIALS & BIOCERAMICS 9

Introduction – processing of biomaterials – metals, ceramics, polymers, biocomposites, sterilization. Micro/ Nano surface modification. Bioceramics – Types – bio inert, bioactive, bio resorable. Experimental evaluation of biocompatibility

UNIT II CALCIUM PHOSPHATE CERAMICS 9

Preparation, mechanical properties and biological performance of tri calcium phosphate, tetra calcium phosphate and hydroxyapatites. Calcium phosphate bone cements – preparation, properties, setting behavior and bio compatibility, Application – interaction with biological system

UNIT III BIOGLASS AND GLASS CERAMICS 9

Bioactive Glasses – Introduction, processing, compositions, properties, reaction kinetics, Tissue bonding, Clinical applications of bioactive glasses- Maxillofacial repair, orthopaedics. A/W glass ceramic- Processing and properties – Mechanical and surface Chemistry. Ceravital® glass ceramics - interaction with biological system

UNIT IV BIOCERAMIC COATING AND COMPOSITES 9

Hydroxyapatite coating – introduction, processing, plasma spraying, other coating techniques, composites, properties, tissue response, clinical applications; bioactive glass coatings – introduction, enameling; bioceramic coatings for metallic implants; titania based composites, ceramic-polymer composites - interaction with biological system

UNIT V BIO CERAMIC APPLICATIONS 9

Cardiovascular Medical Device, Orthopedic Implants, Maxillofacial implant- Dental Implants, Ear prostheses, Fillers, Drug Delivery ,Tissue Engineering.

TOTAL :45 PERIODS

OUTCOMES

On completion of the course the students are expected to

CO1. Comprehend various materials used for biological applications
CO2. Have an understanding various compositions of calcium phosphate and non calcium phosphate ceramics for biological applications.
CO3. Have learnt about various fabrication techniques and testing

TEXT BOOKS

1. Bikramjit Basu, Dhirendra Katti, and Ashok Kumar, **Advanced Biomaterials: Fundamentals, Processing and Application,** Wiley, 2009.
2. Larry L. Hench, **An introduction to Bioceramics**, ICP, Second Edition, 2013.

REFERENCES

1. Lulian Vasile Antoniac, **Handbook of Bioceramics and Biocomposites**, Springer Reference, 2016.
2. Tadashi Kokubo, **Bioceramics and their Clinical Applications**, CRC, 2008
3. B D Ratner, A S Hoffman, F J Schoen, J E Lemon, **"Biomaterials Science",** Academic Press,ISBN 0-12-582460 – 2.
4. L L Hench, J R Jones**, "Biomaterials, Artificial Organs and Tissue Engineering",** CRC Press, ISBN 10: D-84932577-3
5. Bernhard Palsson, Jerry A Hubbell, Robert Plonsey, Joseph D Bronzino, **"Tissue Engineering",** CRC Press, 2003.

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

Course Articulation Matrix:

Course Outcomes	Statement	Program Outcome														
		PO1	PO2	PO3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	Comprehend various materials used for biological applications	1	2	2	3	3	3	-	-	-	-	-	3	3	3	3
CO2	Have an understanding various compositions of calcium phosphate and non-calcium phosphate ceramics for biological applications.	1	2	2	3	3	3	-	-	-	-	-	3	3	3	3
CO3	Have learnt about various fabrication techniques and testing	1	2	2	3	3	3	-	-	-	-	-	3	3	3	3
BIOCERAMIC MATERIALS AND THEIR APPLICATIONS		1	2	2	3	3	3	-	-	-	-	-	3	3	3	3

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

CR5004 **CERAMIC COATINGS** **L T P C**
3 0 0 3

OBJECTIVE

The course is designed to identify material processing technologies that have the potential to produce ceramic coatings for a specific application cost effectively

UNIT I INTRODUCTION **9**

Introduction – Processing, Characterization and Areas of application in ceramic coatings; recent trends in Ceramic Coatings – Diamond Coatings, High Tc Superconducting ceramic coatings, Ceramic coating on cutting tool, Ceramic coating in Semiconductor integrated circuit, Ceramic coating on Architectural and automotive glass.

UNIT II COATINGS BY CVD **9**

Introduction – TiC Coatings – CVD process condtions for TiC coatings, TiC depositon rate, TiC coatings – Substrate interface - TiN coatings - CVD process condtions for TiN coatings; Al_2O_3 Coatings - CVD process condtions for Al_2O_3 coatings; Multi layer Coatings – TiN – TiC type multi layers, Al_2O_3 type Multi-layer coatings; CVD process condtions for multi layer coatings – Coating thickness optimization - Cutting tool wear modes, influence of thickness upon flank wear resistance, Thickness influence on crater wear resistance and strength, Thickness of multi layer coatings ; Other Coatings – Hafnium and Zirconium based coatings , TiB_2 coatings , Tungsten Carbide coatings.

UNIT III COATINGS BY ENAMELLING **9**

Introduction to Porcelain Enamels – History of Porcelain Enamelling, Reasons for Porcelain Enamelling, General Applications of Porcelain Enamelling; Porcelain Enamelling principles and theories – Porcelain Enamel smelting and fritting, Metals selection and preparation for Porcelain Enamelling, Porcelain Enamel milling, Porcelain enamel applications, Porcelain Enamel bond theories, Covercoat opacity mechanisms, Drying, firing and defects in Porcelain Enamels; Other details on material processing – Applications and improvement methods for Porcelain enamel coatings- Applications and competitive coatings, Porcelain Enamel properties, enhancement of Porcelain Enamel protective properties.

UNIT IV COATINGS BY PLASMA SPRAYING **9**

Introduction – Plasma spraying – Feed stock preparation, Ceramic coating, Special features of plasma sprayed coatings – Alumina based coatings – Thermal barrier coatings – Applications, Materials Properties – Plasma sprayed high Tc superconductors- Spray parameter optimization, Post spray annealing and improving super conducting properties, Texturing: Improving the transport critical current density, Coating/Substrate interdiffusion – Test methodologies – Characterisation of coatings, Properties of coatings .

UNIT V COATINGS BY SOL GEL PROCESS **9**

Introduction – Sol – gel processing – Coating Chemistry, Drying and firing – Coatings via Sol-Gel processing- Special solution requirements, Coating techniques, Unique advantages of Sol-gel Coatings – Application- Electrical applications,Optical applications – Problems faced- Film cracking, Removal of Residual species, Precursor characterisation and aging, Impact of deposition conditions on film properties, Low Temperature Densification of films, Comparison of Thin Film vs Bulk Ceramics, The Nature of sol – gel research.

TOTAL :45 PERIODS

OUTCOMES

At the end of the course, the student is expected to

CO1. Design, build, improve and install ceramic systems or processes which meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability, in accordance with standards

CO2. Develop an inclination towards innovation and technopreneurship which includes utilization and commercialization of ceramic technology in the form of product, service or process

TEXT BOOKS

1. John B Watchman, Richard A Haber**, "Ceramic Films and Coatings,** Noyes Publications, 1993
2. Sam Zhang, Nasar Ali, **"Nanocomposites Thin Films and Coatings : Processing, Properties and Performance,** Imperial College Press, 2007

REFERENCES

1. **Ceramic Fibers and Coatings,** National Academy Press, 1998.
2. Kurt H Stern, **"Metallurgy and Ceramic Protective Coatings",** Champman and Hall Publications, 1996.
3. Sudhangshu Bose**, "High Temperature Coatings",** Butterworth Heinmann, 2nd Edition, 2018.
4. Dongming Zhu, Uwe Schulz, **"Advance Ceramic Coatings and Interface",** John Wiley and Sons, 2007.
5. Narendra B Dahotre, T S Sudharsan**, "Intermetallic and Ceramic Coatings",** Marcel Dekker Publications, 1999.

Course Articulation Matrix:

Course Outcomes	Statement	Program Outcome													
		PO1	PO2	PO3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	Design, build, improve and install ceramic systems or processes which meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability, in accordance with standards	1	2	2	3	3	3	-	-	-	-	-	3	3	3	3
CO2	Develop an inclination towards innovation and technopreneurship which includes utilization and commercialization of ceramic technology in the form of product, service or process	1	2	2	3	3	3	-	-	-	-	-	3	3	3	3
CERAMIC COATINGS		1	2	2	3	3	3	-	-	-	-	-	3	3	3	3

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

CR5005 **CERAMIC FUEL CELLS** **L T P C**
3 0 0 3

OBJECTIVE

The course is aimed to

- Impart understanding and knowledge on the basic electrochemical principles of the ceramic fuel cells, basic fuel cell design concepts and its characterizations**.**

UNIT I CERAMIC FUEL CELLS 9

Introduction. A simple fuel cell. Classification of ceramic fuel cells. Fuel cell components. Basic fuel cell operation. Fuel cell Performance. conduction in electrolyte – defects in fluoride type oxides, perovskite type oxides, conduction process, transference number – Types of fuels and oxidants Advantages and disadvantages. Factors influencing the life time of solid oxide fuel cells.

UNIT II REACTION KINETICS 9

Electrode kinetics. Activation energy Vs charge transfer reaction and 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 ELECTROLYTE AND ELECTRODE MATERIALS 9

Electrolyte materials - Oxygen ion conducting materials-Yttria Stabilized Zirconia, Doped ceria, perovskite oxides, proton conducting perovskites. Electrode / catalyst materials – Ni-YSZ Cermet anode materials, ceria based anode materials, perovskite anode materials. Poisoning of anode materials. Cathode materials – perovskite and double perovskite materials.

UNIT IV INTERCONNECTS AND SEALING MATERIALS 9

Metallic interconnect materials – introduction, basic requirements, oxidation in anode, cathode and dual atmospheres. Compatibility with cell and stack components. Development of new alloys as interconnects. Sealants – Glass and glass-ceramic sealants, properties related to short-term and long-term performance. Mica, metal braze and composite sealants.

UNIT V CHARACTERIZATION OF SOFC MATERIALS & STACK DESIGN 9

Ex situ characterization techniques – 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.Schematic designs performance and technological status of conventional SOFC, Tubular SOFC, Planar SOFC, single chamber SOFCs, direct flame SOFCs and Ammonia SOFCs.

TOTAL:45 PERIODS

OUTCOMES

On completion of the course, the student are expected to

CO1. Develop a basic understanding of the electrochemical, thermodynamic and transport processes governing fuel cell operation.

CO2. Acquire technical competency in fuel cell technology including design, performance assessment, and quantitative analysis related to ceramic fuel cells

CO3. Develop an appreciation for practical aspects of ceramic fuel cells

TEXT BOOKS

1. Ryan O' Hayre, Suk-Won Cha, Whitney G. Colella and Fritz B. Prinz, "**Fuel cell Fundamentals",** Third Edition, John Wiley & Sons,2016.
2. Xianguoli, "**Principles of Fuel Cells**", Taylor & Francs,2005.

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

REFERENCES

1. Gregor Hoogers, "**Fuel Cell Technology Hand Book**", CRC Press, 2003.
2. Suddhasatwa Basu, "**Recent Trends in Fuel Cell Science and Technology",** Springer, 2007.
3. Buchanan RC, **Ceramic Materials for Electronics**, Marcel Dekker Inc., NY, 1991.
4. San Ping jiang, "**Materials for High Temperature Fuel Cells**" Wiley – VCH, 2013
5. Duncan W. Bruce., "**Energy Materials**", Wiley, John Wiley & Sons, UK. 2011.

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

Course Articulation Matrix:

Course Outcomes	Statement	Program Outcome													
		PO1	PO2	PO3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	Develop a basic understanding of the electrochemical, thermodynamic and transport processes governing fuel cell operation.	1	2	2	3	3	3	-	-	-	-	-	3	3	3	3
CO2	Acquire technical competency in fuel cell technology including design, performance assessment, and quantitative analysis related to ceramic fuel cells	1	2	2	3	3	3	-	-	-	-	-	3	3	3	3
CO3	Develop an appreciation for practical aspects of ceramic fuel cells	1	2	2	3	3	3	-	-	-	-	-	3	3	3	3
CERAMIC FUEL CELLS		1	2	2	3	3	3	-	-	-	-	-	3	3	3	3

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

CR5006 **CERAMIC MACHINING AND JOINING** **L T P C**
3 0 0 3

OBJECTIVES

The course is aimed to

- Acquire knowledge on the concepts of ceramic machining and joining technology
- Apply them for the advanced manufacturing processing suitable for various structural engineering applications.

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 METHOD **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

OUTCOMES

On completion of the course, the students are expected to

CO1. Solve the materials problems associated with machining and joining technology

CO2. Select a suitable process for machining of ceramic materials

CO3. Produce the engineering structure with the dissimilar materials

CO4. Provide the low cost manufacturing possibilities by appropriate selection of the joining process.

TEXT BOOKS

1. Ioan D.Marinesar, "**Handbook of Advanced Ceramics Machining**", 2006, CRC press.
2. Ioan D.Marinesar, Hans Kurt Tonshoff, Ichiro Inasaki, "**Handbook of Ceramic Grinding and Polishing**", 2000, Noyes Publication.

REFERENCE

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. S.J. Schneider, R.W.Rice, "**The Science of Ceramic Machining and Surface Finishing**", 1970, National Bureau of Standards Special Publication.
4. Jain V. K., **Advance Machining Processes**, Allied Publisher.
5. Pandey P. C., **Modern Machining Processes**, TMH Publication.
6. El-Hofy, H., **Advanced Machining Processes-Non-traditional and Hybrid Machining Processes,** McGraw-Hill, NewYork.
7. McGough J. A., **Advanced Methods of Machining**, Chapman and Hall Ltd., London.

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

Course Articulation Matrix:

Course Outcomes	Statement	Program Outcome													
		PO1	PO2	PO3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	Solve the materials problems associated with machining and joining technology	1	2	2	3	3	3	-	-	-	-	-	3	3	3	3
CO2	Select a suitable process for machining of ceramic materials	1	2	2	3	3	3	-	-	-	-	-	3	3	3	3
CO3	Produce the engineering structure with the dissimilar materials	1	2	2	3	3	3	-	-	-	-	-	3	3	3	3
CO4	Provide the low cost manufacturing possibilities by appropriate selection of the joining process.	1	2	2	3	3	3	-	-	-	-	-	3	3	3	3
CERAMIC MACHINING AND JOINING		1	2	2	3	3	3	-	-	-	-	-	3	3	3	3

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

CR5007 **CERAMIC MATRIX COMPOSITES** **L T P C**
3 0 0 3

OBJECTIVES

The course is aimed to

- Enlarge the students' knowledge in functional composite materials (the functions include structural/traditional, thermal, electrical, electromagnetic, thermoelectric, electromechanical, dielectric, magnetic, optical, electrochemical and biomedical),
- Empower the students with the skills needed for the design, manufacture and analysis of composite materials.

UNIT I MATRIX AND REINFORCEMENT 9

Introduction – composite materials – engineering requirements – implementation of new materials – design and lifetime predictions – applications and requirements – manufacturing requirements – Matrix – metal, ceramic, polymer; implications of fibre properties - continuous reinforcements – time and temperature dependent properties of oxide and non oxide fibers - performance characteristics – processing – microstructure, discontinuous reinforcements – whiskers, particles, laminates – processing and properties

UNIT II PROCESSING 9

Introduction – particle based processes – cold compaction, slurry impregnation, sol gel processing, electrophoretic deposition, slurry based process, plastic forming; reaction bonding process – self propagating high temperature synthesis – in situ processing - melt processing – polymer infiltration and pyrolysis – chemical vapor infiltration – chemical vapor deposition – Sullivan process.

UNIT III INTERFACE 9

Introduction – wettability – effect of surface roughness; crystallographic nature of interface – interactions at the interface – types of bonding at the interface – mechanical bonding, physical bonding, chemical bonding; optimum interfacial bond strength – very weak interface, very strong interface, optimum interfacial bond strength; Tests for measuring interfacial strength – flexural tests, single fibre pull out tests, curved neck specimen test, instrumented indentation tests, fragmentation test, Laser spallation technique.

UNIT IV EVALUATION OF COMPOSITES 9

Introduction – Mechanical Properties – elastic, strength, creep, creep rupture, fatigue, notch sensitivity, interfacial shear properties, environmental properties – thermal expansion, conductivity, environment, environmental effects, oxidation – thermal shock resistance, reactions at the interface, electrical properties, dielectric properties, impact resistance, static and dynamic fatigue, interlaminar shear properties

UNIT V TAILORING COMPOSITE MATERIALS 9

Tailoring by component selection – Polymer Matrix Composites, Metal Matrix Composites, Ceramic matrix Composites; Tailoring by interface modification – interface bond modification, interface composition modification, interface microstructure modification; Tailoring by surface modification – Tailoring by microstructure control – crystallinity control, porosity control.

TOTAL :45 PERIODS

OUTCOMES

On completion of the course, the students are expected to

CO1. Understand the purpose and the ways to develop new materials upon proper combination of known materials

CO2. Predict a wide range of mechanical and transport properties of materials as a function of parameters such as volume fraction, orientation & regularity arrangement and particle aspect ratio

CO3. Compare/evaluate the relative merits of using alternatives for important engineering and other applications.

TEXT BOOKS

1. Chawla,K.K., "**Ceramic Matrix Composites**", 1993, Chapman & Hall, NY.
2. Richard Warren, "**Ceramic-Matrix Composites**", 1992, Blackie, Glasglow.
3. M Balasubramaniam, **"Composite Materials and Processing**", CRC Press, 1st Edition, 2013.

REFERENCES

1. Mazdiyasmi, K.S., "**Fibre Reinforced Ceramic Composites**", 1990, Noyes Publications, New Jersey.
2. Murray, J.G., "**High Performance Fibre Composites**", 1987, Academic Press, NY.
3. Ashes, K.H.G., "**Fundamentals Principles of Fibre Reinforced Composites**", 1989, Technomic Publishing Co. Inc.
4. Bhagwan D Agarwal, Lawerence J Broutman, K Chandrasekara., "**Analysis and Performance of Fiber Composites**", 2006, Wiley Publications.
5. I M Low, **"Advances in Ceramic Matrix Composites",** Woodhead Publishing, Second Edition, 2018.

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

Course Articulation Matrix:

Course Outcomes	Statement	Program Outcome													
		PO1	PO2	PO3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	Understand the purpose and the ways to develop new materials upon proper combination of known materials	1	2	2	3	3	3	-	-	-	-	-	3	3	3	3
CO2	Predict a wide range of mechanical and transport properties of materials as a function of parameters such as volume fraction, orientation & regularity arrangement and particle aspect ratio	1	2	2	3	3	3	-	-	-	-	-	3	3	3	3
CO3	Compare/evaluate the relative merits of using alternatives for important engineering and other applications.	1	2	2	3	3	3	-	-	-	-	-	3	3	3	3
CERAMIC MATRIX AND COMPOSITES		1	2	2	3	3	3	-	-	-	-	-	3	3	3	3

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

CR5008 **DESIGN AND SELECTION OF ABRASIVES** **L T P C**
3 0 0 3

OBJECTIVES

The course is aimed at

- Imparting basic knowledge about classification of abrasives
- Importance of grinding /polishing and selection of abrasives for a given application.

UNIT I RAW MATERIALS FOR ABRASIVES 9

Abrasives – definition, classification, applications. Abrasive grains – classification, characteristics like hardness, toughness etc., preliminary treatments. Backings – cloth, paper, fibre, combination backing, characteristics like strength, flexibility etc., preliminary treatments. Adhesives – classification, characteristics.

UNIT II DESIGN OF COATED ABRASIVES 9

Flow sheet for Coated abrasive preparation. Preparation steps – maker coating, abrasive coating, sizer coating, drying and humidification, flexing, forms of coated abrasives - belt making, sheet cutting, disc punching. Special products - flap wheels, individual disc coating; Quality control and testing.

UNIT III DESIGN OF COATED ABRASIVE BACKUPS 9

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; Other backups – drums, rolls, pads, and platens – types, characteristics, choice and uses.

UNIT IV DESIGN OF BONDED ABRASIVES 9

Bonded wheel manufacture with different bonds and their characteristics. Shapes and sizes of wheels. Factors determining grinding action – characteristics of abrasive grain, bond type, structure. Other types of wheels – Diamond wheels, reinforced wheels, mounted wheels.

UNIT V SELECTION OF GRINDING MACHINE AND ABRASIVES 9

Types of grinding – cylindrical grinding, centre less grinding, surface grinding, internal grinding. Grinding fluids – properties, types and purpose. Material, surface finish and process considerations for selection of grinding method, selection of abrasive type, and selection of coolant.

TOTAL :45 PERIODS

OUTCOMES:

On completion of the course the students are expected to

CO1. Have a basic understanding about contact wheels, belt tension etc.

CO2. Have learnt in detail about coated abrasives.

CO3. Have basic knowledge about grinding and polishing

CO4. Have learnt in detail about bonded abrasives.

TEXT BOOKS

1. Coes L Jr., **Abrasive,** Springer Verlag, New York, 1971.
2. Metzger J.L, **Super Abrasive Grinding**, Butterworths, UK, 1986.
3. Francis T.Farago, **Abrasive Methods Engineering**, Vol.2, Industrial Press Inc., NY, 1980.

REFERENCES

1. **Coated Abrasives – Modern Tool of Industry**, Coated Abrasive Manufacturer's Institute, Cleaveland, Ohio, 1982.
2. Kenneth B.Lewis, William F.Schleicher, **The Grinding Wheel**, The Grinding Wheel Institute, Cleaveland, Ohio, 1976.
3. Stephen Malkin & Changsheng Guo, **Grinding Technology**, 2nd Edn., American Society of Civil Engineers, 2008.
4. Edwards R, **Cutting Tools**, The Institute of Materials, Cambridge, 1993.
5. Brian Rowe W, **Principles of Modern Grinding Technology**, William Andrew Publications, 2009.
6. Ioan D. Marinescu, **Handbook of Advanced Ceramics Machining**, Taylor and Francis, 2007.
7. **Selection and use of grinding wheels**

   https://www.ee.co.za/article/selection-use-grinding-wheels.html

   Rules for selection of abrasive tool

   http://www.andreabrasive.com/technical-description/rules-for-selection-of-abrasive-tool-characteristics-to-grinding-operations

   Selecting grinding wheels

   http://www.iabrasive.com/articles/selecting-grinding-wheels

   Choosing the right grinding wheel

   https://www.cratex.com/Grinding-Wheels/choosing-the-right-grinding-wheel

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

Course Articulation Matrix:

Course Outcomes	Statement	Program Outcome													
		PO1	PO2	PO3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	Have a basic understanding about contact wheels, belt tension etc	1	2	2	3	3	3	-	-	-	-	-	3	3	3	3
CO2	Have learnt in detail about coated abrasive	1	2	2	3	3	3	-	-	-	-	-	3	3	3	3
CO3	Have basic knowledge about grinding and polishing	1	2	2	3	3	3	-	-	-	-	-	3	3	3	3
CO4	Have learnt in detail about bonded abrasives	1	2	2	3	3	3	-	-	-	-	-	3	3	3	3
DESIGN AND SELECTION OF ABRASIVES		1	2	2	3	3	3	-	-	-	-	-	3	3	3	3

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

CR5009	FUNCTIONAL GLASSES	L T P C 3 0 0 3

OBJECTIVE

The course is aimed to

- Impart knowledge about the various functional applications of glass.

UNIT I HEAT RESISTANT AND SAFETY GLASSESS 9

Borosilicate glasses – pyrex glass and jona type, composition – fabrication of laboratory ware – vycor glass. Safety glasses – toughened glass, laminated glass.

UNIT II OPTICAL GLASSES 9

Manufacture of crown and flint glass – ophthalmic glass filters – photo chromic glass – laser glass – electro chromic glass – GRIN lenses and components – chalcogenide, chalcohallide and halide glasses – applications in optical components.

UNIT III GLASS FIBRES 9

Composition for fibre glass, glass wool, manufacturing process and applications. Optical fibres – optical properties of fibres, silica based glass fibres – Applications in optical communication.

UNIT IV GLASS CERAMICS 9

Glass composition, heat treatment schedule, crystal nucleation in glass, nucleating agent, microstructure and properties, applications, machinable glass ceramics.

UNIT V COATED GLASS 9

Coating methods – physical vapour deposition, chemical vapour deposition. Types of coatings, characteristics of coated glass, applications of coated glasses, quality control of coated glass.

TOTAL:45 PERIODS

OUTCOMES:

On completion of the course the students are expected to

CO1. Have a clear understanding on the types and properties of heat resistant and safety glasses.

CO2. Have studied the manufacture, types and applications of optical glasses.

CO3. Have studied the composition of glass fibres and optical fibres, and their applications.

CO4. Have learnt the composition, preparation and properties of glass ceramics.

CO5. Have a knowledge on the methods and types of coatings on glass, their applications and quality control.

TEXT BOOKS

1. Lewis M.H, **Glasses and Glass Ceramics**, Chapman and Hall, London, 1989.
2. Cable M and Parker M.J, **High Performance Glasses**, Chapman and Hall, NY, 1992.

REFERENCES

1. Heinz G.Plaender, **Schott Guide to Glass**, Chapman and Hall, 1996.
2. Hans Bach, **Low Thermal Expansion Glass Ceramics**, Springer, 1995.
3. Philips C.J, **Glass, Its Industrial Applications**, Reinhold Publishing Co., NY, 1960.
4. K J Rao, "**Structural Chemistry of Glasses**", Elsevier Science, 1st Edition, 2002.
5. Arun K Varshneya, "**Fundamentals of Inorganic Glasses**" Academic Press, 1994.

Course Articulation Matrix:

Course Outcomes	Statement	Program Outcome														
		PO1	PO2	PO3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	Have a clear understanding on the types and properties of heat resistant and safety glasses.	1	2	2	3	3	3	-	-	-	-	-	3	3	3	3
CO2	Have studied the manufacture, types and applications of optical glasses.	1	2	2	3	3	3	-	-	-	-	-	3	3	3	3
CO3	Have studied the composition of glass fibres and optical fibres, and their applications.	1	2	2	3	3	3	-	-	-	-	-	3	3	3	3
CO4	Have learnt the composition, preparation and properties of glass ceramics.	1	2	2	3	3	3	-	-	-	-	-	3	3	3	3
CO5	Have a knowledge on the methods and types of coatings on glass, their applications and quality control.	1	2	2	3	3	3	-	-	-	-	-	3	3	3	3
FUNCTIONAL GLASSES		1	2	2	3	3	3	-	-	-	-	-	3	3	3	3

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

CR5010 GLASS SCIENCE AND TECHNOLOGY L T P C
3 0 0 3

OBJECTIVE

The course is aimed to

- Impart basic knowledge on manufacture, properties and applications of glass.

UNIT I GLASS FORMATION 10

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 – CaO-Al_2O_3-SiO_2, Na_2O-CaO-SiO_2 etc.

UNIT II RAW MATERIALS AND BATCH PREPARATION 9

Raw materials – Network former, network modifier, intermediate glass former, minor additives, cullet. Handling and storage – problems and remedies – Briquetting and Pelletizing. Glass compositions – Glass Batch Calculation.

UNIT III GLASS MELTING FURNACES 10

Construction and operation of pot furnace and day tank furnace. Tank furnace – types, design & construction, refractories used. Electric tank furnace – design & operation, electrodes used, electric boosting in tank furnace. Major reactions and physiochemical changes during glass melting.

UNIT IV FORMING PROCESS 9

Forehearth & Feeder, hand operations; Flatware – sheet glass, float glass, plate glass, patterned glass. Hollow ware – press & blow, blow & blow, IS machine, bulbs & tubes. Annealing – Importance – Strain release – Annealing cycle – Annealing lehr.

UNIT V SPECIAL TREATMENTS 7

Mirror, chemical vapour deposition, physical vapour deposition process, laminated glass, tempered glass, decorated glasses, vycor & micro porous glass, sealing glass, neutral glass, photosensitive glass, glass ceramic, glass fibers.

TOTAL :45 PERIODS

OUTCOMES

On completion of the course the students are expected to

CO1. Have a basic understanding about raw materials and batch charging.
CO2. Have learnt about various fuels and glass melting furnaces.
CO3. Have basic knowledge about forming and annealing processes
CO4. Have learnt about the properties and applications of special glasses.

TEXT BOOKS

1. Tooley F.V, **Handbook of Glass Manufacture, Vol I&II,** Ogden Publishing Co., NY, 1960.
2. James E.Shelby, **Introduction to Glass Science & Technology**, The Royal Society of Chemistry, 1997.
3. **Glass Furnaces-Design, Construction & Operation**, Wolfgang Trier, Society of Glass Technology, 2000.

REFERENCES

1. Paul, **Chemistry of Glasses**, 2nd Edn, Chapman & Hall, 1990.
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. A. Charles A Harper, **Handbook of Ceramic Glasses & Diamonds**, McGraw Hill, 2001.

4. Volf V.B, **Technical Approach to Glass**, Elsevier, 1990.

5. Adalbert Feltz, **Amorphous Inorganic Materials and Glasses**, VCH Verlagsgesellschaft mbH, 1993.

6. B O Mysen and P.Richet, **Silicate Glasses & Melts, Properties and Structure**, Elsevier, 1986.

7. Narottan P.Bansal & R.H. Doremus, **Handbook of Glass Properties**, Elsevier, 1986.

8. **Glass & Ceramic Technology**, NIIR Board of Consultants & Engineers, Asia Pacific Business Press Inc.

9. James F.Shackelford, **Ceramic & Glass Materials**, Springer, 2008.

10. M.Cable and J.M. Parker, **High Performance Glasses**, Blackie, Glasglow & London published by Chapman and Hall, New York 1992.

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

Course Articulation Matrix:

Course Outcomes	Statement	Program Outcome														
		PO1	PO2	PO3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	Have a basic understanding about raw materials and batch charging.	1	2	2	3	3	3	-	-	-	-	-	3	3	3	3
CO2	Have learnt about various fuels and glass melting furnaces.	1	2	2	3	3	3	-	-	-	-	-	3	3	3	3
CO3	Have basic knowledge about forming and annealing processes	1	2	2	3	3	3	-	-	-	-	-	3	3	3	3
CO4	Have learnt about the properties and applications of special glasses.	1	2	2	3	3	3	-	-	-	-	-	3	3	3	3
GLASS ENGINEERING		1	2	2	3	3	3	-	-	-	-	-	3	3	3	3

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

CR5011 INDUSTRIAL HAZARDS AND SAFETY L T P C
3 0 0 3

OBJECTIVES

The course is aimed to

- Recognize and evaluate occupational safety and health hazards in the workplace
- Determine appropriate hazard controls following the hierarchy of controls.
- Analyze the effects of workplace exposures, injuries and illnesses, fatalities and the methods to prevent incidents using the hierarchy of controls
- Effective safety and health management systems and task oriented training.

UNIT I INTRODUCTION 9

Introduction – industrialization - current scenario – population growth, lifestyle, globalization, technological developments and renovations, buyer market, Industrial Health, Safety & Environment – Industry & Environment, Industry & Society - Impact of industrialization on society.

UNIT II INDUSTRIAL HAZARDS 9

Industrial hazards – List of hazards, disaster, Health risk – fires – fire triangle concept, classification, mechanism of fire, fire protection, fire & emergency, firefighting equipment – explosions – classifications.

UNIT III OTHER HAZARDS 9

Flammable liquids – Toxic gases – Hazards while using machinery – Classification of Hazardous materials – Hazard analysis methods – inherent safer design strategies.

UNIT IV SAFETY 9

Introduction – safety elements – strategies – lifecycle approach – layers of protection – Accidents – conceptual planning, detailed design and evaluation – Training & education – personal protective equipment – Risk analysis.

UNIT V HEALTH, SAFETY AND ENVIRONMENT MANAGEMENT (HSE) 9

Introduction – HSE leadership and commitment – HSE policy – organization, responsibilities, resources, standards & documents – Hazards & effects management – planning and procedures – implementation and monitoring – HSE audit – management commitment – environment management – sustainable development.

TOTAL :45 PERIODS

OUTCOMES

On completion of the course, the students are expected to

CO1. Evaluate workplace to determine the existence of occupational safety and health hazards
CO2. Identify relevant regulatory and national consensus standards along with best practices that are applicable.
CO3. Select appropriate control methodologies based on the hierarchy of controls
CO4. Analyze injury and illness data for trends.

TEXTBOOKS

1. Ratan Raj Taiya, **"Elements of Industrial Safety"**, CRC Press, 2011.
2. **"Health and Safety in Ceramics"**, 2nd Edition, Institute of Ceramics, Pergamon press, 1986
3. Norman Thomson, **"Fire Hazards in Industry"**, Division of Reed Educational & Professional publishing Ltd.,

REFERENCES

1. Ralph W King, John Magid, **"Industrial Hazard & Safety Handbook" 3rd Edition**, Butterworth & co Publishers Ltd., 1982.
2. Amit Gupta, **"Industrial Safety and Environment",** Laxmi Publications, 2006

Course Articulation Matrix:

Course Outcomes	Statement	Program Outcome													
		PO1	PO2	PO3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	Evaluate workplace to determine the existence of occupational safety and health hazards	-	-	-	2	2	3	3	3	-	-	-	3	-	-	3
CO2	Identify relevant regulatory and national consensus standards along with best practices that are applicable.	-	-	-	2	2	3	3	3	-	-	-	3	-	-	3
CO3	Select appropriate control methodologies based on the hierarchy of controls	-	-	-	2	2	3	3	3	-	-	-	3	-	-	3
CO4	Analyze injury and illness data for trends.	-	-	-	2	2	3	3	3	-	-	-	3	-	-	3
INDUSTRIAL HAZARDS AND SAFETY		-	-	-	2	2	3	3	3	-	-	-	3	-	-	3

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

CR5012 **LEADERSHIP SKILLS** **L T P C**
3 0 0 3

OBJECTIVE

The course is aimed to

- Impart increasing knowledge, skills, ability and confidence needed to become an effective leader in the community

UNIT I INTRODUCTION 9

Fundamentals – characteristics – ineffective leadership traits – strategies used by effective leaders – practice makes perfect – listening – mentoring – leadership styles – fixed versus growth mindset – shared leadership – values – emotional intelligence – stress.

UNIT II ETHICS, PROFESSIONALISM AND TIME MANAGEMENT 9

Introduction – ethics – professionalism – organizational culture – character ethics and personality ethics – time management – time allocation, planning and organization.

UNIT III QUALITIES 9

Establish trust and creditability – risk taking – creativity – confidence – create mission and vision.

UNIT IV TEAM BUILDING 9

Importance of team building – appointing right members – leader approaches to effective team operation – cross cultural teams – collegiativity – motivation – running effective meetings – making decisions – managing changes – relationship between team building and change.

UNIT V COMMUNICATION 9

Verbal communication – writing communication – communication with non- technical peoples – positive approaches to offering negative messages.

TOTAL :45 PERIODS

OUTCOMES

On completion of the course, the students are expected to

CO1. Understand the history of leadership and current leadership theories. In addition, students will understand how leadership models are put into practice personally, locally, and globally.
CO2. Gain knowledge of diverse cultures, cross-cultural communication, the dynamics of privilege and oppression, and the uses of power between groups.
CO3. Understand how ethics, morals, and values relate to their leadership dilemmas.
CO4. Integrate their lived experiences into their leadership development process.

TEXT BOOKS

1. John Adair, **"Develop your Leadership Skills"**, Kogan Page Limited, 2007.
2. Dennis W Hess, **"Leadership by Engineers and Scientist"**, Wiley Publications, 2018.
3. Career Skills Library, Ferguson Publishing, 3rd Edition, 2009.

REFERENCES

1. Jeffrey K Pinto, Jeffrey W Trailer, "**Leadership Skills for Project Managers"**,1998.
2. Paul Newton, **"Leadership Models"**, 1st Edition, 2016.

Course Articulation Matrix:

Course Outcomes	Statement	Program Outcome														
		PO1	PO2	PO3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	Understand the history of leadership and current leadership theories. In addition, students will understand how leadership models are put into practice personally, locally, and globally.	-	-	-	-	-	-	-	2	3	3	2	2	-	-	-
CO2	Gain knowledge of diverse cultures, cross-cultural communication, the dynamics of privilege and oppression, and the uses of power between groups.	-	-	-	-	-	-	-	2	3	3	2	2	-	-	-
CO3	Understand how ethics, morals, and values relate to their leadership dilemmas.	-	-	-	-	-	-	-	2	3	3	2	2	-	-	-
CO4	Integrate their lived experiences into their leadership development process.	-	-	-	-	-	-	-	2	3	3	2	2	-	-	-
LEADERSHIP SKILLS		-	-	-	-	-	-	-	2	3	3	2	2	-	-	-

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

CR5013 MANAGEMENT CONCEPTS IN ENGINEERING L T P C
3 0 0 3

OBJECTIVES

The course is aimed to

- Impart the basic concepts of management.
- Identify the key competencies needed to be an effective manager.
- Provide the students with the capability to apply theoretical knowledge in simulated and real-life settings.

UNIT I INTRODUCTION 9

Introduction - Characteristics of Management - Nature of Management - Management Functions - Functional areas of Management - Management & Administration - Role of Management - Levels of Management - Evolution of Management.

UNIT II PLANNING AND DECISION MAKING 9

Planning with organizations - Levels of planning, planning horizons, single use plans and standing plans, contingency planning - strategic planning - setting mission, vision, values and goals, external and internal analysis, Strength, Weaknesses, Opportunities and Threat analysis(SWOT) - Action plans - implementation - benefits and pitfalls of planning - Decision making.

UNIT III ORGANIZATION AND CONTROL 9

Organizing architecture - designing structure - vertical differentiation, horizontal differentiation, integrating mechanism, control systems - establishing goals and standards, measuring performance, comparing with goals and standards, taking corrective action.

UNIT IV EFFECTIVE LEADERSHIP 9

Managing and leadership - power influence perspective, competency perspective, behaviour perspective, contingency perspective, transformational perspective - gender differences in leadership.

UNIT V COMMUNICATION 9

Communication process - communication channels - organizational communication - communication barriers and breakdowns - improving communication – case studies – current industrial problems

TOTAL :45 PERIODS

OUTCOMES

On completion of the course, the students are expected to

CO1. Discuss and communicate the management evolution and how it will affect future managers.
CO2. Identify and evaluate social responsibility and ethical issues involved in business situations and logically articulate own position on such issues.
CO3. Practice the process of management's four functions: planning, organizing, leading, and controlling.
CO4. Evaluate leadership styles to anticipate the consequences of each leadership style.
CO5. Gather and analyze both qualitative and quantitative information to isolate issues and formulate best control methods.
CO6. Work effectively with diverse colleagues in team situations.

TEXTBOOKS

1. Charles WL Hill, Steven L Mcshane, **"Principles of Management"**, McGraw Hill, 2008.
2. Samuel C Certo, S Treuis Certo, **"Modern Management"**, XII Edition, Prentice Hall, 2012.

REFERENCES

1. Veerabhadrappa Havinal, **"Management and Entrepreneurship",** New Age International, 2009.
2. Fausto Pedro Garcia Marquez, Benjamin Leu, **" Engineering Management"**, Intech Publishing, 2013.

Course Articulation Matrix:

Course Outcomes	Statement	Program Outcome														
		PO1	PO2	PO3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	Discuss& communicate management evolution and how it will affect future managers.	-	3	3	3	3	3	-	-	-	-	3	3	-	-	-
CO2	Identify and evaluate social responsibility and ethical issues involved in business situations and logically articulate own position on such issues.	-	3	3	3	3	3	-	-	-	-	3	3	-	-	-
CO3	Practice the process of management's four functions: planning, organizing, leading, controlling.	-	3	3	3	3	3	-	-	-	-	3	3	-	-	-
CO4	Evaluate leadership styles to anticipate the consequences of each leadership style.	-	3	3	3	3	3	-	-	-	-	3	3	-	-	-
CO5	Gather & analyze both qualitative& quantitative information to isolate issues and formulate best control methods.	-	3	3	3	3	3	-	-	-	-	3	3	-	-	-
CO6	Work effectively with diverse colleagues in team situations.	-	3	3	3	3	3	-	-	-	-	3	3	-	-	-
MANAGEMENT CONCEPTS IN ENGINEERING		-	3	3	3	3	3	-	-	-	-	3	3	-	-	-

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

CR5014 **NON DESTRUCTIVE EVALUATION** **L T P C**
3 0 0 3

OBJECTIVES

The course is aimed to

- Understand the basic principles of various NDT methods, fundamentals, discontinuities in different product forms, importance of NDT, applications, limitations of NDT methods and techniques and codes, standards and specifications related to non-destructive testing technology.
- Introduce to relevant quality assurance and quality control requirements in accordance with standards.

UNIT I INTRODUCTION **9**

Conditions for effective non destructive testing – Discontinuities origin and classification – primary production of metals, castings, cracks, welding discontinuities, discontinuities from plastic deformation, corrosion induced discontinuities, operationally induced discontinuities, geometric discontinuities.

UNIT II PENETRANT AND MAGNETIC PARTICLE TESTING **9**

Penetrant Testing – theory and principles, penetrant equipment and materials, penetrant procedures, techniques and variables, evaluation and disposition, penetrant testing applications, quality control considerations, advantages and limitations; Magnetic particle testing – theory and principles, equipment and accessories, techniques, variables, evaluation of tests, applications, advantages and limitations

UNIT III RADIOGRAPHIC TESTING **9**

Theory and principles – radiographic equipment and accessories – variables – techniques and procedures – radiographic evaluation – applications – advantages and limitations

UNIT IV ULTRASONIC AND ACOUSTIC EMISSION TESTING **9**

Ultrasonic - Theory and Principles – equipment for ultrasonic testing – techniques – variables – evaluation of results – applications – advantages and limitations; Acoustic emission – principle – advantages and limitations – case studies

UNIT V EDDY CURRENT TESTING **9**

Theory and Principles – Alternating current principles – eddy currents – test equipment – eddy current applications and signal display – advantages and limitations – other electromagnetic test techniques – case studies.

TOTAL :45 PERIODS

OUTCOMES

On completion of the course, the student are expected to

CO1. Ability to apply scientific and technical knowledge to the field of non-destructive testing.
CO2. Ability to use the relevant non-destructive testing methods for various engineering practice.
CO3. Ability to recognize and achieve high levels of professionalism in their work.
CO4. Recognition of the need and ability to engage in lifelong learning, thought process and development

TEXT BOOKS

1. J Prasad ,G K Nair**. Non Destructive Testing and Evaluation of Materials** Tata MC Crew**.**
2. B.Hull and V.John, **Non Destructive Testing**, McMillan Education Ltd, 1968.

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

REFERENCES

1. **Metals Handbook**, Volume 2, 8th Edn, ASTM, Metals Park, Ohio.
2. Mc Gonnagle, W.J, **Non-Destructing Testing Methods**, Mc Graw Hill Co., NY, 1961.
3. Peter J Shull, "**Non Destructive Evaluation**", Marcel Dekker, 2001
4. Charles Hellier, "**Handbook of Non Destructive Evaluation",** McGraw Hill, 2003.
5. Mohammed Ommar, **"Non Destructive Testing Methods and New Applications"**, InTech, 2012.

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

Course Articulation Matrix:

Course Outcomes	Statement	Program Outcome														
		PO1	PO2	PO3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	Ability to apply scientific and technical knowledge to the field of non-destructive testing.	1	3	3	3	3	-	-	-	-	-	-	3	-	-	3
CO2	Ability to use the relevant non-destructive testing methods for various engineering practice.	1	3	3	3	3	-	-	-	-	-	-	3	-	-	3
CO3	Ability to recognize and achieve high levels of professionalism in their work.	1	3	3	3	3	-	-	-	-	-	-	3	-	-	3
CO4	Recognition of the need and ability to engage in lifelong learning, thought process and development	1	3	3	3	3	-	-	-	-	-	-	3	-	-	3
NON DESTRUCTIVE EVALUATION		1	3	3	3	3	-	-	-	-	-	-	3	-	-	3

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

CR5015 **PHASE EQUILIBRIA IN CERAMICS** **L T P C**
3 0 0 3

OBJECTIVES

The course is aimed to

- Use phase equilibrium diagrams to develop an understanding of the phase transformations.
- Interpretation of the microstructural evolution of the alloys. Materials of interest range from single to multi-component systems.
- Binary equilibrium diagrams can adequately represent many of the industrial important systems, ternary or higher order diagrams are often necessary to the understanding of more complex systems.

UNIT I INTRODUCTION **9**

Introduction, Thermodynamics of Phase Equilibria - Criteria for Phase Equilibrium, criteria for stability, Phase Equilibria in Single component and Multi component system, Gibb's phase rule, single component system – H_2O, SiO_2, iron, binary phase diagrams – complete solid solutions, limited solid solution, peritectic and incongruent melting, sub solidus phase Equilibria, solidus and liquidus temperatures, Lever rule, Microstructure development.

UNIT II TERNARY PHASE DIAGRAMS **9**

Features of ternary diagrams, primary phase field, congruent and incongruent melting components, boundary curve and temperature contour, ternary invariant points, compatibility triangles, solidus temperatures, liquid-liquid immiscibility, construction of binary diagrams from ternary diagrams, construction of isothermal section, ternary lever rule, reactions upon heating and cooling - ternary eutectic reaction, ternary peritectic reaction, reactions upon heating through ternary eutectic and ternary peritectic, equilibrium crystallization path, Non-Equilibrium crystallization path.

UNIT III PHASE DIAGRAMS AND ITS APPLICATIONS **9**

Phase Diagrams, microstructural constituent, significance of binary systems - $Al_2O_3 – SiO_2$, $MgO – Al_2O_3$, $MgO – SiO_2$, $Al_2O_3 – ZrO_2$ - Phase Diagrams, microstructural constituent, significance of ternary systems $K_2O – Al_2O_3 – SiO_2$, $MgO – Al_2O_3 – SiO_2$, $Na_2O – Al_2O_3 – SiO_2$. Applications - Prediction of alkali corrosion of alumino silicate refractories using phase diagrams, Silicon Nitride Ceramics, Composites.

UNIT IV PHASE TRANSFORMATIONS **9**

Introduction, Time Scale for phase transformations, types of transformations – spinoidal, nucleation & growth, theory of transformation kinetics, kinetics of solid state reactions occurring at elevated temperatures, solid, liquid and dissociation reactions; nucleation and growth – nucleation kinetics, homogeneous nucleation, heterogeneous nucleation, growth and overall transformation kinetics, sintering & crystallization in ceramics and glass forming systems.

UNIT V CONSTRUCTION AND DETERMINATION OF PHASE DIAGRAMS **9**

Construction of phase diagrams - cooling curves, thermal analysis, techniques introduction, ex-situ methods - sample preparation and non equilibration, phase and compositional analysis, identification of new phases, in-situ methods - thermal analysis, coulometric titration, high temperature XRD, thermo-microscopy, optical methods, oscillation method of phase analysis - in-situ electric, dielectric and magnetic measurements

TOTAL:45 PERIODS

OUTCOMES:

On completion of the course, the students are expected to

CO1. Understand the scientific bases of phase equilibrium diagrams
CO2. Know the relations between the composition, temperature and phase amounts, being able to apply it to phase equilibrium diagrams of different systems
CO3. Possess the understanding of how the microstructure is formed, and how this structure influences materials properties
CO4. Use phase equilibrium diagrams as a point of departure to establish the microstructural evolution of materials with temperature.

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

TEXT BOOKS

1. Kingery W.D, Yet Ming Chiang and Dunbar P.Birnie III, **Physical Ceramics – Principles for Ceramic Science and Engineering**, John Wiley & Sons, 1995.
2. Flake C Campbell, **Phase Diagrams - Understanding the Basics,** ASM International, 2012

REFERENCES

1. Kingery W.D, Bowen H.K and Uhlmann D.R, **Introduction to Ceramics,** 2nd Edn., John Wiley & Sons, 2004.
2. Allen M.Alper, **Phase diagrams in Advanced Ceramics**, Academic Press Inc., 1995.
3. Barsoum M.W, **Fundamentals of Ceramics**, McGraw Hill, 1997.
4. J C Zhao, **Methods for Phase Diagram Determination**, Elsevier, 2007
5. D R F West, N Saunders, **Ternary Phase Diagrams in Material Science**, Woodhead Publishing, 2006

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

Course Articulation Matrix:

Course Outcomes	Statement	Program Outcome														
		PO1	PO2	PO3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	Understand the scientific bases of phase equilibrium diagrams	3	3	3	3	3	-	-	-	-	-	-	3	3	-	3
CO2	Know the relations between the composition, temperature and phase amounts, being able to apply it to phase equilibrium diagrams of different systems	3	3	3	3	3	-	-	-	-	-	-	3	3	-	3
CO3	Possess the understanding of how the microstructure is formed, and how this structure influences materials properties	3	3	3	3	3	-	-	-	-	-	-	3	3	-	3
CO4	Use phase equilibrium diagrams as a point of departure to establish the microstructural evolution of materials with temperature.	3	3	3	3	3	-	-	-	-	-	-	3	3	-	3
PHASE EQUILIBRIA IN CERAMICS		3	3	3	3	3	-	-	-	-	-	-	3	3	-	3

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

CR5016 PRODUCT DESIGN, DEVELOPMENT AND SUSTAINABILITY L T P C
3 0 0 3

OBJECTIVES

The course is aimed to

- Introduction to multidisciplinary aspects of product development and innovation.
- Familiarize with the basic methodology and tools that can be used in product development projects.
- Identify practical problem in cooperation with companies in order to simulate real product development situations.

UNIT I INTRODUCTION 9

Definition – Design by Evolution – Design by innovation – essential factors of product design – Production consumption cycle – seven phases of morphology of design – Role of allowance, process capability and Tolerance in detailed design and assembly.

UNIT II PRODUCT DEVELOPMENT 9

Approach to design with ceramics – properties of Ceramics and glass – Production design factors for Ceramic parts – problems of manufacturers of Ceramic Parts – Special consideration for design of glass parts – dimensional factors and tolerances.

UNIT III COSTING DESIGNS 9

Introduction – component costing – Development of the model, Basic processing cost, relative cost coefficient, material cost, model validation, component costing, despoke costing development – manual assembly costing – assembly costing model, assembly structure diagram.

UNIT IV SUSTAINABLE DEVELOPMENT 9

Introduction – Major challenges – emerging drives – scale of changes needed – Design for sustainability – Product life cycle – Material selection – Impact of use – Length of life – end of life – Needs.

UNIT V METHODS AND TOOLS FOR DESIGN FOR SUSTAINABILITY 9

Environmental Assessment tools – Strategic Design Tools – Idea generation – User centered design – Information provision – case study of product Improvement and redesign.

TOTAL :45 PERIODS

OUTCOMES

On completion of the course, the students are expected to

CO1. Understand the technical and business aspects of the product development process
CO2. Acquire skill development in implementation of gathering data from customers and establish technical specification
CO3. Understand product functional decomposition
CO4. Participate in engineering problem solving
CO5. Understand the principles behind sustainability of the developed product.

TEXTBOOKS

1. Ameresh Chakrabarti, "**Sustainable Product Development**", Springer, 2013.
2. Traey Bhamra, **"Design for Sustainability – A Practical Approach",** Gower Publishing Ltd., 2007.

REFERENCES

1. K.G.Swift JD Booker, "**Process Selection from Design to Manufacture**" 2nd Edition, Butterworth-Heimann Publicaitons, 2003.
2. A.K.Chitale, R.C.Gupta, "**Product and Manufacturing"** 5th Edition, PHI Learning Pvt., Ltd., 2011.
3. Mike Ashby, Kara Johnson, "**Materials and Design – The Art and Science of Material Selection in Product Design**", Butterworth – Heinmann Publications, 2002.
4. Ulrich, K.T., Eppinger, S.D.: **Product Design And Development**; McGraw-Hill; 2004.

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

5. Otto, K.N., Wood, K.L.: **Product Design – Techniques In Reverse Engineering And New Product Development;** Prentice Hall; 2001.
6. Pahl G., Beitz W., Feldhusen J., Grote K.H.: **Engineering Design - A Systematic Approach,** Springer 2007.

Course Articulation Matrix:

Course Outcomes	Statement	Program Outcome														
		PO1	PO2	PO3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	Understand the technical and business aspects of the product development process	-	3	3	3	3	-	-	-	-	-	-	3	-	-	3
CO2	Acquire skill development in implementation of gathering data from customers and establish technical specification	-	3	3	3	3	-	-	-	-	-	-	3	-	-	3
CO3	Understand product functional decomposition	-	3	3	3	3	-	-	-	-	-	-	3	-	-	3
CO4	Participate in engineering problem solving	-	3	3	3	3	-	-	-	-	-	-	3	-	-	3
CO5	Understand the principles behind sustainability of the developed product.	-	3	3	3	3	-	-	-	-	-	-	3	-	-	3
PRODUCT DESIGN, DEVELOPMENT AND SUSTAINABILITY		-	3	3	3	3	-	-	-	-	-	-	3	-	-	3

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

CR5017 **REFRACTORY ENGINEERING** **L T P C**
3 0 0 3

OBJECTIVESS

The course is aimed to

- Enable the students to have a basic knowledge about Refractory lining
- Discuss in detail about the structural and mechanical behavior of refractory linings

UNIT I INTRODUCTION 9

Introduction-types of loading-Stress controlled and strain controlled loads –Design philosophy of structures based on load types –Material properties required for structural analysis.

UNIT II CRITERIA FOR SELECTION OF REFRACTORY MATERIALS 9

ASTM strength tests– Choosing best refractory for thermo-mechanical application – Verification from field test study- static compressive stress strain data-Creep data -Influence of stress state on the strength of refractories –Thermal expansion data.

UNIT III REFRACTORY LINING JOINTS 9

Joints –Refractory mortar joint fundamentals- finite element analysis of a mortar joint – behavior of structural masonry mortar joint-Influence of mortar joint thickness on mortar joint behavior - mechanical behavior of dry joint – Fundamental of refractory Hinges- Aspects of Hinge behavior – analytical study of hinge joint.

UNIT IV FUNDAMENTALS OF DIFFERENT LINING DESIGNS 9

Basics of refractory brick arch behavior – Fundamentals of brick lined cylindrical shells – Brick dome behavior –fundamentals of flat brick linings – Cylindrical refractory-lined vessel analysis – Refractory sprung arch – spherical refractory silica brick dome. Dos and Don'ts in Refractory lining design

UNIT V REFRACTORY DESIGN 9

Design of shaped dense materials, Design with shaped heat insulating materials, Design with unshaped monolithic refractory materials, Design with ceramic fiber, High temperature glass fibers

TOTAL:45 PERIODS

OUTCOMES

On completion of the course the students are expected to

CO1. Have learnt the basics of structural and mechanical behavior of refractory linings
CO2. Have a sound knowledge on selecting suitable refractory for a application
CO3. Be familiar with the refractory lining designs and joints
CO4. Do the lining designs

TEXT BOOKS

1. C. A. Schacht, **Refractory Linings: Thermo-mechanical Design and Applications**, CRC Press, 1995.
2. S. C. Caniglia and G. L. Barna, **Handbook of Industrial Refractories Technology**, William Andrews Publishing, NY, 1992.

REFERENCES

1. C. A. Schacht, **Refractories Handbook,** CRC Press. , NY, 2004
2. S. Banerjee, **The Changing Refractories Industry: New Technologies, Materials and Markets**, Business Communication Co, 1999.
3. Norton F.H, **Refractories**, 4th Edn., McGraw Hill Book Co.,1968.
4. Nandi D.N, **Handbook of Refractories**, Tata McGraw-Hill Publishing Co., New Delhi,1991.
5. Akira Nishikawa, **Technology of Monolithic Refractories**, Plibrico, Japan Co. Ltd., Tokyo,1984.

Course Articulation Matrix:

Course Outcomes	Statement	Program Outcome													
		PO1	PO2	PO3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	Have learnt the basics of structural and mechanical behavior of refractory linings	1	2	2	3	3	3	-	-	-	-	-	3	3	3	3
CO2	Have a sound knowledge on selecting suitable refractory for a application	1	2	2	3	3	3	-	-	-	-	-	3	3	3	3
CO3	Be familiar with the refractory lining designs and joints	1	2	2	3	3	3	-	-	-	-	-	3	3	3	3
CO4	Do the lining designs	1	2	2	3	3	3	-	-	-	-	-	3	3	3	3
REFRACTORY ENGINEERING		1	2	2	3	3	3	-	-	-	-	-	3	3	3	3

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

CR5018 **SCIENCE OF MATERIALS** **L T P C**
3 0 0 3

OBJECTIVES

The course is aimed to

- Review the physics and chemistry in the context of materials science & engineering.
- Describe the different types of bonding in solids, and the physical ramifications of these differences.
- Introduction to the relation between processing, structure, and physical properties.
- Understand the structure, properties, performance, and processing of materials to solve complex engineering problems
- Adapt to the rapidly changing scientific and technological landscape, recognize the implications of their work, and drive the development of future technologies.

UNIT I INTRODUCTION TO MATERIAL SCIENCE 9

Materials and Engineering- Classification - Atomic Structure - Bonding - Primary, secondary, Crystal Structure - Crystalline and Non- Crystalline, Imperfections - Point, Line, Surface, Volume, Experimental Techniques for identification of Microstructure and defects, Diffusion in solids - Atomic diffusion in solids - Mechanism, Steady state diffusion, Non-Steady state diffusion, factors influencing diffusion, diffusion in ionic materials and polymeric materials.

UNIT II PHASE DIAGRAMS 9

Introduction - Gibb's Phase rule, Single Component system - Binary system - Isomorphous alloy, Eutectic alloy, Peritectic alloy, Invariant Reactions, Phase Diagrams with intermediate phase and compounds - ternary phase diagrams - development of microstructure - basic concepts of phase transformation.

UNIT III MECHANICAL PROPERTIES 9

Stress and Strain in metals, Tensile stress and Stress - Strain diagram, plastic deformation of Metal Single Crystals - Slip planes, slip systems, slip mechanisms, Critical resolved shear stress, twinning - Plastic deformation of polycrystalline materials, Fracture - Ductile, Brittle, Fracture Toughness, Fatigue, Creep, Hardness, Wear, Corrosion.

UNIT IV ELECTRICAL AND ELECTRONIC PROPERTIES 9

Electrical conduction in metals - Classic model for Electrical conduction in metals, Energy band model, Relationship between mobility and diffusivity,-Conduction-Ionic, Electronic, Mixed conductivity- Semiconductors - Intrinsic, Extrinsic, Compound, Electrical Properties of ionic Ceramics and polymers, Dielectric behaviour - polarization, types, frequency depended of dielectric constant, dielectric strength, dielectric material, super conductivity - BCS theory, Magnetic properties of superconductors, High temperature super conducting oxides.

UNIT V MAGNETIC , THERMAL AND OPTICAL PROPERTIES 9

Introduction – types of magnetism - dia- para -ferro- antiferro and ferri magnetic materials – magnetic semiconductors -ferromagnetic domains, types energy that determine the structure of ferromagnetic domains, soft magnetic materials, hard magnetic materials, ferrites – specific heat capacity – thermal conductivity – thermal diffusivity - thermal expansion – Optical -light and electromagnetic spectrum, absorption, transmission and reflection of light, color, opacity and translucency, applications of optical phenomena luminescence - optical fibers

TOTAL:45 PERIODS

OUTCOMES

At the end of the course, the students are expected to

CO1. Conceptually explain the classification schemes that are used to categorize engineering materials.

CO2. Describe how and why defects (point, line and interfacial) in materials greatly affect engineering properties and limit their use in service

CO3. Apply ethical principles, engineering codes of ethics, and professional responsibilities in the selection of materials in engineering design.
CO4. Understand how thermal treatments affect the microstructure and, thus, properties of materials

TEXT BOOKS

1. William F.Smith, **"Foundations of Materials Science and Engineering"** McGraw Hill Book Company, Sixth Edition, 2019.
2. William D Callister Jr, David D Rethwisch, **"Materials Science & Engineering – An Introduction"**, Eighth Edition, John Wiley & Sons, 2010.

REFERENCES

1. Raghavan,V., "**Materials Science and Engineering**", Prentice Hall India, New Delhi. 1982.
2. Saxena, B.S., R.C. Gupta and P.N. Saxena, "**Fundamentals of Solid State Physics**", Pragathi Pragasan, Meerut., 1988.
3. Yet - Ming Chiang, "**Physical Ceramics - Principles for Ceramic Science and Engineering**", John & Willey Sons Inc., 1997.
4. Schewmon, P.G. "**Diffusion of Solids**", McGraw- Hill Book Company, New York, 1963.
5. Bergeron, C.G., and S.H.Risbud, "**Introduction to Phase Equilibria in Ceramics",** Am. Ceram.Soc, Inc., Westerwile Ohio, USA. 1984.
6. Arzamasov, B., "**Materials Science**", Mir Publishers, Moscow 1989.
7. Weidmann, G., P.Lewis and N.Reid, "**Structural Materials**", Butterworths, London 1990.

Course Articulation Matrix:

Course Outcomes	Statement	Program Outcome														
		PO1	PO2	PO3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	Conceptually explain the classification schemes that are used to categorize engineering materials.	3	3	3	3	3	–	–	–	–	–	–	3	3	-	3
CO2	Describe how and why defects (point, line and interfacial) in materials greatly affect engineering properties and limit their use in service	3	3	3	3	3	–	–	–	–	–	–	3	3	-	3
CO3	Apply ethical principles, engineering codes of ethics, and professional responsibilities in the selection of materials in engineering design.	3	3	3	3	3	–	–	–	–	–	–	3	3	-	3
CO4	Understand how thermal treatments affect the microstructure and, thus, properties of materials	3	3	3	3	3	-	-	-	-	-	-	3	3	-	3
SCIENCE OF MATERIALS		3	3	3	3	3	-	-	-	-	-	-	3	3	-	3

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

CR5019 SYNTHESIS AND CONSOLIDATION OF NANO MATERIALS L T P C
3 0 0 3

OBJECTIVE

The course aims at providing general and broad introduction to the multi-disciplinary field of nanotechnology. It describes the basic knowledge of the physical phenomena, theoretical concepts and experimental techniques behind the recent vastly improved ability to observe, fabricate and manipulate individual structures on the nanometer scale.

UNIT I INTRODUCTION 9

Introduction – Concept of nano technology – Classification of nano materials – zero dimension, one dimensional and two dimensional structures – Synthesis of nano structures – Properties of nano materials – optical, magnetic, electronic, mechanical, catalystic, non-linear optical properties – Characterization of nano materials – optical, morphological, electrical, magnetic, anti bacterial, in vivo characterizations – Applications of nano materials

UNIT II SYNTHESIS OF NANO MATERIALS-CHEMICAL PROCESSESS 9

Chemical precipitation and co-precipitation, polyol, and borohydrate reduction methods, Sol-Gel synthesis; Micro emulsions synthesis; Hydrothermal, Solvothermal synthesis methods, Microwave assisted synthesis; Sonochemical assisted synthesis, Core-Shell nanostructure, Organic-Inorganic hybrid nanocomposites, Quantum dot(QDs) synthesis.

UNIT III SYNTHESIS OF NANO MATERIALS-PHYSICAL PROCESSESS 9

Fabrication of Nanomaterials by Physical Methods: Inert gas condensation, Arc discharge, RF-plasma arc technique, Ion sputtering, Laser ablation Laser pyrolysis, Ball Milling, Molecular beam epitaxy (MBE), Chemical vapor deposition (CVD) method. Template assisted synthesis, Catalyst assisted chemical vapor deposition (CCVD).

UNIT IV CHARACTERIZATION OF NANO STRUCTURED MATERIALS 9

X-ray diffraction (XRD), SEM, EDAX, TEM, Elemental mapping, FTIR, UV-Visible spectrophotometer, Laser Raman Spectroscopy, Nanomechanical Characterization using Nanoindentation, Differential Scanning Calorimeter (DSC), Differential Thermal Analyzer (DTA), Thermo gravimetric Analysis (TGA), TEM, X-ray Photoelectron Spectroscopy (XPS), Electrochemical Characterization measurements.

UNIT V APPLICATION OF NANO MATERIALS 9

Nano electronics-nano optics-nano scale chemical and bio sensing-bio medical applications-photo voltaic, fuel cells, batteries and energy related applications-high strength nano composites-nano energetic materials

TOTAL :45 PERIODS

OUTCOMES

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

CO1. Describe and explain Nanotechnology.
CO2. Describe Nanomaterials based on their dimensionality. Explain the importance of reduction in materials dimensionality, and its relationship with materials properties.
CO3. Explain top-down and bottom up approaches for Nanomaterial fabrication, and give some examples.
CO4. Give examples on the use of Nanotechnology in biomedical applications, optical applications, microelectronics.

TEXT BOOKS

1. Frank J. Owens and Charles P. Poole Jr, **"The Physics and Chemistry of NanoSolids"** Wiley-Interscience, 2008.
2. A.S. Edelstein and R.C. Cammarata, **"Nanomaterials- Synthesis, Properties and Applications"** , Edited by Institute of Physics Publishing, London, 19.

REFERENCES

1. G. Ozin and A. Arsenault, **"Nanochemistry: A Chemical Approach to Nanomaterials"** ,RSC Publishing, 2005
2. Edward L. Wolf, **"Nanophysics and Nanotechnology: An Introduction to Modern Concepts in Nanoscience",** Wiley-VCH, 2nd Reprint (2005)
3. Jin Zhang, Zhong-lin Wang, Jun Liu, Shaowei Chen and Gang-yu Liu, "**Self Assembled Nanostructures",** Kluwer Academic/Plenum Publishers.2003, ISBN: 978-0-306-47299-2.
4. Bharat Bhushan, **"Hand book of Nanotechnology**", Springer Hand Book. 2007 ISBN: 978-3-540-29855-7.
5. Mark Ratner and Daniel Ratner , "**Nanotechnology: A Gentle Introduction to the Next Big Idea**", 5th Edition, Pearson Education India 2009 . ISBN: 978-8-177-58743-2.

Course Articulation Matrix:

Course Outcomes	Statement	Program Outcome													
		PO1	PO2	PO3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	Describe and explain Nanotechnology	1	2	2	3	3	3	-	-	-	-	-	3	3	3	3
CO2	Describe Nanomaterials based on their dimensionality. Explain the importance of reduction in materials dimensionality, and its relationship with materials properties.	1	2	2	3	3	3	-	-	-	-	-	3	3	3	3
CO3	Explain top-down and bottom up approaches for Nanomaterial fabrication, and give some examples.	1	2	2	3	3	3	-	-	-	-	-	3	3	3	3
CO4	Give examples on the use of Nanotechnology in biomedical applications, optical applications, microelectronics.	1	2	2	3	3	3	-	-	-	-	-	3	3	3	3
SYNTHESIS AND CONSOLIDATION OF NANO MATERIALS		1	2	2	3	3	3	-	-	-	-	-	3	3	3	3

Attested

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

OPEN ELECTIVE COURSES (OEC)

OE5091 BUSINESS DATA ANALYTICS L T P C
3 0 0 3

OBJECTIVES:

- To understand the basics of business analytics and its life cycle.
- To gain knowledge about fundamental business analytics.
- To learn modeling for uncertainty and statistical inference.
- To understand analytics using Hadoop and Map Reduce frameworks.
- To acquire insight on other analytical frameworks.

UNIT I OVERVIEW OF BUSINESS ANALYTICS 9

Introduction – Drivers for Business Analytics – Applications of Business Analytics: Marketing and Sales, Human Resource, Healthcare, Product Design, Service Design, Customer Service and Support – Skills Required for a Business Analyst – Framework for Business Analytics Life Cycle for Business Analytics Process.

Suggested Activities:

- Case studies on applications involving business analytics.
- Converting real time decision making problems into hypothesis.
- Group discussion on entrepreneurial opportunities in Business Analytics.

Suggested Evaluation Methods:

- Assignment on business scenario and business analytical life cycle process.
- Group presentation on big data applications with societal need.
- Quiz on case studies.

UNIT II ESSENTIALS OF BUSINESS ANALYTICS 9

Descriptive Statistics – Using Data – Types of Data – Data Distribution Metrics: Frequency, Mean, Median, Mode, Range, Variance, Standard Deviation, Percentile, Quartile, z-Score, Covariance, Correlation – Data Visualization: Tables, Charts, Line Charts, Bar and Column Chart, Bubble Chart, Heat Map – Data Dashboards.

Suggested Activities:

- Solve numerical problems on basic statistics.
- Explore chart wizard in MS Excel Case using sample real time data for data visualization.
- Use R tool for data visualization.

Suggested Evaluation Methods:

- Assignment on descriptive analytics using benchmark data.
- Quiz on data visualization for univariate, bivariate data.

UNIT III MODELING UNCERTAINTY AND STATISTICAL INFERENCE 9

Modeling Uncertainty: Events and Probabilities – Conditional Probability – Random Variables – Discrete Probability Distributions – Continuous Probability Distribution – Statistical Inference: Data Sampling – Selecting a Sample – Point Estimation – Sampling Distributions – Interval Estimation – Hypothesis Testing.

Suggested Activities:

- Solving numerical problems in sampling, probability, probability distributions and hypothesis testing.
- Converting real time decision making problems into hypothesis.

Suggested Evaluation Methods:

- Assignments on hypothesis testing.
- Group presentation on real time applications involving data sampling and hypothesis testing.
- Quizzes on topics like sampling and probability.

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

UNIT IV ANALYTICS USING HADOOP AND MAPREDUCE FRAMEWORK 9

Introducing Hadoop– RDBMS versus Hadoop–Hadoop Overview – HDFS (Hadoop Distributed File System) – Processing Data with Hadoop– Introduction to MapReduce – Features of MapReduce – Algorithms Using Map-Reduce: Matrix-Vector Multiplication, Relational Algebra Operations, Grouping and Aggregation – Extensions to MapReduce.

Suggested Activities:

- Practical – Install and configure Hadoop.
- Practical – Use web based tools to monitor Hadoop setup.
- Practical – Design and develop MapReduce tasks for word count, searching involving text corpus etc.

Suggested Evaluation Methods:

- Evaluation of the practical implementations.
- Quizzes on topics like HDFS and extensions to MapReduce.

UNIT V OTHER DATA ANALYTICAL FRAMEWORKS 9

Overview of Application development Languages for Hadoop – PigLatin – Hive – Hive Query Language (HQL) – Introduction to Pentaho, JAQL – Introduction to Apache: Sqoop, Drill and Spark, Cloudera Impala – Introduction to NoSQL Databases – Hbase and MongoDB.

Suggested Activities:

- Practical – Installation of NoSQL database like MongoDB.
- Practical – Demonstration on Sharding in MongoDB.
- Practical – Install and run Pig
- Practical – Write PigLatin scripts to sort, group, join, project, and filter data.
- Design and develop algorithms to be executed in MapReduce involving numerical methods for analytics.

Suggested Evaluation Methods:

- Mini Project (Group) – Real time data collection, saving in NoSQL, implement analytical techniques using Map-Reduce Tasks and Result Projection.

TOTAL:45 PERIODS

OUTCOMES:

On completion of the course, the student will be able to:

- Identify the real world business problems and model with analytical solutions.
- Solve analytical problem with relevant mathematics background knowledge.
- Convert any real world decision making problem to hypothesis and apply suitable statistical testing.
- Write and Demonstrate simple applications involving analytics using Hadoop and MapReduce
- Use open source frameworks for modeling and storing data.
- Apply suitable visualization technique using R for visualizing voluminous data.

REFERENCES:

1. VigneshPrajapati, “Big Data Analytics with R and Hadoop”, Packt Publishing, 2013.
2. Umesh R Hodeghatta, UmeshaNayak, “Business Analytics Using R – A Practical Approach”, Apress, 2017.
3. AnandRajaraman, Jeffrey David Ullman, “Mining of Massive Datasets”, Cambridge University Press, 2012.
4. Jeffrey D. Camm, James J. Cochran, Michael J. Fry, Jeffrey W. Ohlmann, David R. Anderson, “Essentials of Business Analytics”, Cengage Learning, second Edition, 2016.
5. U. Dinesh Kumar, “Business Analytics: The Science of Data-Driven Decision Making”, Wiley, 2017.
6. A. Ohri, “R for Business Analytics”, Springer, 2012
7. Rui Miguel Forte, “Mastering Predictive Analytics with R”, Packt Publication, 2015.

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	1	1	2	3	1
CO2	2	1	1	2	1	1
CO3	1	1	2	3	3	1
CO4	2	2	1	2	1	1
CO5	1	1	2	2	1	1
CO6	1	1	1	3	2	1

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

OE5092 **INDUSTRIAL SAFETY** **LT P C**
3 0 0 3

OBJECTIVES:

- Summarize basics of industrial safety
- Describe fundamentals of maintenance engineering
- Explain wear and corrosion
- Illustrate fault tracing
- Identify preventive and periodic maintenance

UNIT I INTRODUCTION 9

Accident, causes, types, results and control, mechanical and electrical hazards, types, causes and preventive steps/procedure, describe salient points of factories act 1948 for health and safety, wash rooms, drinking water layouts, light, cleanliness, fire, guarding, pressure vessels, etc, Safety color codes. Fire prevention and firefighting, equipment and methods.

UNIT II FUNDAMENTALS OF MAINTENANCE ENGINEERING 9

Definition and aim of maintenance engineering, Primary and secondary functions and responsibility of maintenance department, Types of maintenance, Types and applications of tools used for maintenance, Maintenance cost & its relation with replacement economy, Service life of equipment.

UNIT III WEAR AND CORROSION AND THEIR PREVENTION 9

Wear- types, causes, effects, wear reduction methods, lubricants-types and applications, Lubrication methods, general sketch, working and applications, i. Screw down grease cup, ii. Pressure grease gun, iii. Splash lubrication, iv. Gravity lubrication, v. Wick feed lubrication vi. Side feed lubrication, vii. Ring lubrication, Definition, principle and factors affecting the corrosion. Types of corrosion, corrosion prevention methods.

UNIT IV FAULT TRACING 9

Fault tracing-concept and importance, decision tree concept, need and applications, sequence of fault finding activities, show as decision tree, draw decision tree for problems in machine tools, hydraulic, pneumatic, automotive, thermal and electrical equipment's like, I. Any one machine tool, ii. Pump iii. Air compressor, iv. Internal combustion engine, v. Boiler, vi. Electrical motors, Types of faults in machine tools and their general causes.

UNIT V PERIODIC AND PREVENTIVE MAINTENANCE 9

Periodic inspection-concept and need, degreasing, cleaning and repairing schemes, overhauling of mechanical components, overhauling of electrical motor, common troubles and remedies of electric motor, repair complexities and its use, definition, need, steps and advantages of preventive maintenance. Steps/procedure for periodic and preventive maintenance of: I. Machine tools, ii. Pumps, iii. Air compressors, iv. Diesel generating (DG) sets, Program and schedule of preventive maintenance of mechanical and electrical equipment, advantages of preventive maintenance. Repair cycle concept and importance

TOTAL:45 PERIODS

OUTCOMES:

CO1: Ability to summarize basics of industrial safety
CO2: Ability to describe fundamentals of maintenance engineering
CO3: Ability to explain wear and corrosion
CO4: Ability to illustrate fault tracing
CO5: Ability to identify preventive and periodic maintenance

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

REFERENCES:

1. Audels, Pump-hydraulic Compressors, Mcgrew Hill Publication, 1978.
2. Garg H P,Maintenance Engineering, S. Chand and Company,1987.
3. Hans F. Winterkorn ,Foundation Engineering Handbook, Chapman & Hall London,2013.
4. Higgins & Morrow , Maintenance Engineering Handbook,Eighth Edition,2008

OE5093 OPERATIONS RESEARCH LT P C
3 0 0 3

OBJECTIVES:

- Solve linear programming problem and solve using graphical method.
- Solve LPP using simplex method
- Solve transportation , assignment problems
- Solve project management problems
- Solve scheduling problems

UNIT I LINEAR PROGRAMMING 9

Introduction to Operations Research – assumptions of linear programming problems - Formulations of linear programming problem – Graphical method

UNIT II ADVANCES IN LINEAR PROGRAMMING 9

Solutions to LPP using simplex algorithm- Revised simplex method - primal dual relationships – Dual simplex algorithm - Sensitivity analysis

UNIT III NETWORK ANALYSIS – I 9

Transportation problems -Northwest corner rule, least cost method,Voges's approximation method - Assignment problem -Hungarian algorithm

UNIT IV NETWORK ANALYSIS – II 9

Shortest path problem: Dijkstra's algorithms, Floyds algorithm, systematic method -CPM/PERT

UNIT V NETWORK ANALYSIS – III 9

Scheduling and sequencing - single server and multiple server models - deterministic inventory models - Probabilistic inventory control models

TOTAL:45 PERIODS

OUTCOMES:

CO1: To formulate linear programming problem and solve using graphical method.
CO2: To solve LPP using simplex method
CO3: To formulate and solve transportation, assignment problems
CO4: To solve project management problems
CO5: To solve scheduling problems

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

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

REFERENCES:

1. Harvey M Wagner, Principles of Operations Research: Prentice Hall of India 2010
2. Hitler Libermann, Operations Research: McGraw Hill Pub. 2009
3. Pant J C, Introduction to Optimisation: Operations Research, Jain Brothers, Delhi, 2008
4. Pannerselvam, Operations Research: Prentice Hall of India 2010
5. Taha H A, Operations Research, An Introduction, PHI, 2008

OE5094 COST MANAGEMENTOF ENGINEERING PROJECTS L T P C
3 0 0 3

OBJECTIVES:

- Summarize the costing concepts and their role in decision making
- Infer the project management concepts and their various aspects in selection
- Interpret costing concepts with project execution
- Develop knowledge of costing techniques in service sector and various budgetary control techniques
- Illustrate with quantitative techniques in cost management

UNIT I INTRODUCTION TO COSTING CONCEPTS 9

Objectives of a Costing System; Cost concepts in decision-making; Relevant cost, Differential cost, Incremental cost and Opportunity cost; Creation of a Database for operational control.

UNIT II INTRODUCTION TO PROJECT MANAGEMENT 9

Project: meaning, Different types, why to manage, cost overruns centres, various stages of project execution: conception to commissioning. Project execution as conglomeration of technical and nontechnical activities, Detailed Engineering activities, Pre project execution main clearances and documents, Project team: Role of each member,Importance Project site: Data required with significance, Project contracts.

UNIT III PROJECT EXECUTION AND COSTING CONCEPTS 9

Project execution Project cost control, Bar charts and Network diagram, Project commissioning: mechanical and process, Cost Behavior and Profit Planning Marginal Costing; Distinction between Marginal Costing and Absorption Costing; Break-even Analysis, Cost-Volume-Profit Analysis, Various decision-making problems, Pricing strategies: Pareto Analysis, Target costing, Life Cycle Costing.

UNIT IV COSTING OF SERVICE SECTOR AND BUDGETERY CONTROL 9

Just-in-time approach, Material Requirement Planning, Enterprise Resource Planning, Activity-Based Cost Management, Bench Marking; Balanced Score Card and Value-Chain Analysis, Budgetary Control: Flexible Budgets; Performance budgets; Zero-based budgets.

UNIT V QUANTITATIVE TECHNIQUES FOR COST MANAGEMENT 9

Linear Programming, PERT/CPM, Transportation problems, Assignment problems, Learning Curve Theory.

TOTAL:45 PERIODS

Annexure

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

OUTCOMES

CO1 – Understand the costing concepts and their role in decision making
CO2–Understand the project management concepts and their various aspects in selection
CO3–Interpret costing concepts with project execution
CO4–Gain knowledge of costing techniques in service sector and various budgetary control techniques
CO5 - Become familiar with quantitative techniques in cost management

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

REFERENCES:

1. Ashish K. Bhattacharya, Principles & Practices of Cost Accounting A. H. Wheeler publisher, 1991
2. Charles T. Horngren and George Foster, Advanced Management Accounting, 1988
3. Charles T. Horngren et al Cost Accounting A Managerial Emphasis, Prentice Hall of India, New Delhi, 2011
4. Robert S Kaplan Anthony A. Alkinson, Management & Cost Accounting, 2003
5. Vohra N.D., Quantitative Techniques in Management, Tata McGraw Hill Book Co. Ltd, 2007

OE5095 COMPOSITE MATERIALS L T P C
3 0 0 3

OBJECTIVES:

- Summarize the characteristics of composite materials and effect of reinforcement in composite materials.
- Identifythe various reinforcements used in composite materials.
- Compare the manufacturing process of metal matrix composites.
- Understand the manufacturing processes of polymer matrix composites.
- Analyze the strength of composite materials.

UNIT I INTRODUCTION 9

Definition – Classification and characteristics of Composite materials - Advantages and application of composites - Functional requirements of reinforcement and matrix - Effect of reinforcement (size, shape, distribution, volume fraction) on overall composite performance.

UNIT II REINFORCEMENTS 9

Preparation-layup, curing, properties and applications of glass fibers, carbon fibers, Kevlar fibers and Boron fibers - Properties and applications of whiskers, particle reinforcements - Mechanical Behavior of composites: Rule of mixtures, Inverse rule of mixtures - Isostrain and Isostress conditions.

UNIT III MANUFACTURING OF METAL MATRIX COMPOSITES 9

Casting – Solid State diffusion technique - Cladding – Hot isostatic pressing - Properties and applications. Manufacturing of Ceramic Matrix Composites: Liquid Metal Infiltration – Liquid phase sintering. Manufacturing of Carbon – Carbon composites: Knitting, Braiding, Weaving - Properties and applications.

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

UNIT IV MANUFACTURING OF POLYMER MATRIX COMPOSITES 9

Preparation of Moulding compounds and prepregs – hand layup method – Autoclave method –Filament winding method – Compression moulding – Reaction injection moulding - Properties and applications.

UNIT V STRENGTH 9

Laminar Failure Criteria-strength ratio, maximum stress criteria, maximum strain criteria, interacting failure criteria, hygrothermal failure. Laminate first play failure-insight strength; Laminate strength-ply discount truncated maximum strain criterion; strength design using caplet plots; stress concentrations.

TOTAL:45 PERIODS

OUTCOMES:

- CO1 - Know the characteristics of composite materials and effect of reinforcement in composite materials.
- CO2 – Know the various reinforcements used in composite materials.
- CO3 – Understand the manufacturing processes of metal matrix composites.
- CO4 – Understand the manufacturing processes of polymer matrix composites.
- CO5 – Analyze the strength of composite materials.

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

REFERENCES:

1. Cahn R.W. - Material Science and Technology – Vol 13 – Composites, VCH, WestGermany.
2. Callister, W.D Jr., Adapted by Balasubramaniam R, Materials Science and Engineering, An introduction, John Wiley & Sons, NY, Indian edition, 2007.
3. Chawla K.K., Composite Materials, 2013.
4. Lubin.G, Hand Book of Composite Materials, 2013.

OE5096 **WASTE TO ENERGY** **L T P C**
3 0 0 3

OBJECTIVES:

- Interpret the various types of wastes from which energy can be generated
- Develop knowledge on biomass pyrolysis process and its applications
- Develop knowledge on various types of biomass gasifiers and their operations
- Invent knowledge on biomass combustors and its applications on generating energy
- Summarize the principles of bio-energy systems and their features

UNITI INTRODUCTION TO EXTRACTION OF ENERGY FROM WASTE 9

Classification of waste as fuel – Agro based, Forest residue, Industrial waste - MSW – Conversion devices – Incinerators, gasifiers, digestors

UNITIIBIOMASS PYROLYSIS 9

Pyrolysis – Types, slow fast – Manufacture of charcoal – Methods - Yields and application – Manufacture of pyrolytic oils and gases, yields and applications.

UNITIII BIOMASS GASIFICATION 9

Gasifiers – Fixed bed system – Downdraft and updraft gasifiers – Fluidized bed gasifiers – Design, construction and operation – Gasifier burner arrangement for thermal heating – Gasifier engine arrangement and electrical power – Equilibrium and kinetic consideration in gasifier operation.

UNITIV BIOMASS COMBUSTION 9

Biomass stoves – Improved chullahs, types, some exotic designs, Fixed bed combustors, Types, inclined grate combustors, Fluidized bed combustors, Design, construction and operation - Operation of all the above biomass combustors.

UNITV BIO ENERGY 9

Properties of biogas (Calorific value and composition), Biogas plant technology and status - Bio energy system - Design and constructional features - Biomass resources and their classification - Biomass conversion processes - Thermo chemical conversion - Direct combustion - biomass gasification - pyrolysis and liquefaction - biochemical conversion - anaerobic digestion - Types of biogas Plants – Applications - Alcohol production from biomass - Bio diesel production -Urban waste to energy conversion - Biomass energy programme in India.

TOTAL:45 PERIODS

OUTCOMES:

CO1 – Understand the various types of wastes from which energy can be generated
CO2 – Gain knowledge on biomass pyrolysis process and its applications
CO3 – Develop knowledge on various types of biomass gasifiers and their operations
CO4 – Gain knowledge on biomass combustors and its applications on generating energy
CO5 – Understand the principles of bio-energy systems and their features

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

REFERENCES:

1. Biogas Technology - A Practical Hand Book - Khandelwal, K. C. and Mahdi, S. S., Vol. I & II, Tata McGraw Hill Publishing Co. Ltd., 1983.
2. Biomass Conversion and Technology, C. Y. WereKo-Brobby and E. B. Hagan, John Wiley & Sons, 1996.
3. Food, Feed and Fuel from Biomass, Challal, D. S., IBH Publishing Co. Pvt. Ltd., 1991.
4. Non Conventional Energy, Desai, Ashok V., Wiley Eastern Ltd., 1990.

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

AUDIT COURSES (AC)

AX5091 ENGLISHFOR RESEARCHPAPERWRITING L T P C
2 0 0 0

OBJECTIVES

- Teach how to improve writing skills and level of readability
- Tell about what to write in each section
- Summarize the skills needed when writing a Title
- Infer the skills needed when writing the Conclusion
- Ensure the quality of paper at very first-time submission

UNITI INTRODUCTION TO RESEARCH PAPER WRITING 6

Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness

UNIT II PRESENTATION SKILLS 6

Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticizing, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts, Introduction

UNIT III TITLE WRITING SKILLS 6

Key skills are needed when writing a Title, key skills are needed when writing an Abstract, key skills are needed when writing an Introduction, skills needed when writing a Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check

UNIT IV RESULT WRITING SKILLS 6

Skills are needed when writing the Methods, skills needed when writing the Results, skills are needed when writing the Discussion, skills are needed when writing the Conclusions

UNIT V VERIFICATION SKILLS 6

Useful phrases, checking Plagiarism, how to ensure paper is as good as it could possibly be the first-time submission

TOTAL: 30 PERIODS

OUTCOMES

CO1 –Understand that how to improve your writing skills and level of readability
CO2 –Learn about what to write in each section
CO3 –Understand the skills needed when writing a Title
CO4 – Understand the skills needed when writing the Conclusion
CO5 – Ensure the good quality of paper at very first-time submission

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

REFERENCES

1. Adrian Wallwork , English for Writing Research Papers, Springer New York Dordrecht Heidelberg London, 2011
2. Day R How to Write and Publish a Scientific Paper, Cambridge University Press 2006
3. Goldbort R Writing for Science, Yale University Press (available on Google Books) 2006
4. Highman N, Handbook of Writing for the Mathematical Sciences, SIAM. Highman's book 1998.

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

AX5092 **DISASTER MANAGEMENT** **L T P C**
2 0 0 0

OBJECTIVES

- Summarize basics of disaster
- Explain a critical understanding of key concepts in disaster risk reduction and humanitarian response.
- Illustrate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.
- Describe an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.
- Develop the strengths and weaknesses of disaster management approaches

UNIT I INTRODUCTION 6

Disaster: Definition, Factors and Significance; Difference between Hazard And Disaster; Natural and Manmade Disasters: Difference, Nature, Types and Magnitude.

UNIT II REPERCUSSIONS OF DISASTERS AND HAZARDS 6

Economic Damage, Loss of Human and Animal Life, Destruction Of Ecosystem. Natural Disasters: Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods, Droughts And Famines, Landslides And Avalanches, Man-made disaster: Nuclear Reactor Meltdown, Industrial Accidents, Oil Slicks And Spills, Outbreaks Of Disease And Epidemics, War And Conflicts.

UNIT III DISASTER PRONE AREAS IN INDIA 6

Study of Seismic Zones; Areas Prone To Floods and Droughts, Landslides And Avalanches; Areas Prone To Cyclonic and Coastal Hazards with Special Reference To Tsunami; Post-Disaster Diseases and Epidemics

UNIT IV DISASTER PREPAREDNESS AND MANAGEMENT 6

Preparedness: Monitoring Of Phenomena Triggering a Disaster or Hazard; Evaluation of Risk: Application of Remote Sensing, Data from Meteorological And Other Agencies, Media Reports: Governmental and Community Preparedness.

UNIT V RISK ASSESSMENT 6

Disaster Risk: Concept and Elements, Disaster Risk Reduction, Global and National Disaster Risk Situation. Techniques of Risk Assessment, Global Co-Operation in Risk Assessment and Warning, People's Participation in Risk Assessment. Strategies for Survival

TOTAL : 30 PERIODS

OUTCOMES

CO1: Ability to summarize basics of disaster
CO2: Ability to explain critical understanding of key concepts in disaster risk reduction and humanitarian response.
CO3: Ability to illustrate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.
CO4: Ability to describe an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.
CO5: Ability to develop the strengths and weaknesses of disaster management approaches

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

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

REFERENCES

1. Goel S. L., Disaster Administration And Management Text And Case Studies", Deep & Deep Publication Pvt. Ltd., New Delhi,2009.
2. Nishitha Rai, Singh AK, "Disaster Management in India: Perspectives, issues and strategies "'New Royal book Company,2007.
3. Sahni, Pardeep Et.Al. ," Disaster Mitigation Experiences And Reflections", Prentice Hall Of India, New Delhi,2001.

AX5093 SANSKRIT FOR TECHNICAL KNOWLEDGE L T P C
2 0 0 0

OBJECTIVES

- Illustrate the basic sanskrit language.
- Recognize sanskrit, the scientific language in the world.
- Appraise learning of sanskrit to improve brain functioning.
- Relate sanskrit to develop the logic in mathematics, science & other subjects enhancing the memory power.
- Extract huge knowledge from ancient literature.

UNIT I ALPHABETS 6

Alphabets in Sanskrit

UNIT II TENSES AND SENTENCES 6

Past/Present/Future Tense - Simple Sentences

UNIT III ORDER AND ROOTS 6

Order - Introduction of roots

UNIT IV SANSKRIT LITERATURE 6

Technical information about Sanskrit Literature

UNIT V TECHNICAL CONCEPTS OF ENGINEERING 6

Technical concepts of Engineering-Electrical, Mechanical, Architecture, Mathematics

TOTAL: 30 PERIODS

OUTCOMES

- CO1 - Understanding basic Sanskrit language.
- CO2 - Write sentences.
- CO3 - Know the order and roots of Sanskrit.
- CO4 - Know about technical information about Sanskrit literature.
- CO5 - Understand the technical concepts of Engineering.

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

REFERENCES

1. "Abhyaspustakam" – Dr.Vishwas, Samskrita-Bharti Publication, New Delhi
2. "Teach Yourself Sanskrit" Prathama Deeksha-Vempati Kutumbshastri, Rashtriya Sanskrit Sansthanam, New Delhi Publication
3. "India's Glorious Scientific Tradition" Suresh Soni, Ocean books (P) Ltd., New Delhi, 2017.

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

AX5094	VALUE EDUCATION	L T P C
		2 0 0 0

OBJECTIVES

Students will be able to

- Understand value of education and self-development
- Imbibe good values in students
- Let the should know about the importance of character

UNIT I

Values and self-development–Social values and individual attitudes. Workethics,Indianvisionofhumanism.Moralandnon-moralvaluation.Standards and principles. Value judgements

UNIT II

Importance of cultivation of values. Sense of duty. Devotion, Self-reliance. Confidence, Concentration. Truthfulness, Cleanliness. Honesty, Humanity. Power of faith, National Unity. Patriotism. Love fornature, Discipline

UNIT III

Personality and Behavior Development-Soul and Scientific attitude. Positive Thinking. Integrity and discipline. Punctuality, Love and Kindness. Avoid fault Thinking. Free from anger, Dignity of labour. Universal brother hood and religious tolerance. True friendship. Happiness Vs suffering, love for truth. Aware of self-destructive habits. Association and Cooperation. Doing best for saving nature

UNIT IV

Character and Competence–Holy books vs Blind faith. Self-management and Good health. Science of reincarnation. Equality, Nonviolence, Humility, Role of Women. All religions and same message. Mind your Mind, Self-control. Honesty, Studying effectively.

TOTAL: 30 PERIODS

OUTCOMES

Students will be able to

- Knowledge of self-development.
- Learn the importance of Human values.
- Developing the over all personality.

Suggested reading

1. Chakroborty, S.K."Values and Ethics for organizations Theory and practice", Oxford University Press, New Delhi

AX5095 **CONSTITUTION OF INDIA** **L T P C**
2 0 0 0

OBJECTIVES

Students will be able to:

- Understand the premises informing the twin themes of liberty and freedom from a civil rights perspective.
- To address the growth of Indian opinion regarding modern Indian intellectuals' constitutional
- Role and entitlement to civil and economic rights as well as the emergence nation hood in the early years of Indian nationalism.
- To address the role of socialism in India after the commencement of the Bolshevik Revolutionin1917and its impact on the initial drafting of the Indian Constitution.

UNIT I HISTORY OF MAKING OF THE INDIAN CONSTITUTION:

History, Drafting Committee, (Composition &Working)

UNIT II PHILOSOPHYOFTHE INDIANCONSTITUTION:

Preamble, Salient Features

UNIT III CONTOURS OF CONSTITUTIONAL RIGHTS AND DUTIES:

Fundamental Rights, Right to Equality, Right to Freedom, Right against Exploitation, Right to Freedom of Religion, Cultural and Educational Rights, Right to Constitutional Remedies, Directive Principles of State Policy, Fundamental Duties.

UNIT IV ORGANS OF GOVERNANCE:

Parliament, Composition, Qualifications and Disqualifications, Powers and Functions, Executive, President, Governor, Council of Ministers, Judiciary, Appointment and Transfer of Judges, Qualifications, Powers and Functions.

UNIT V LOCAL ADMINISTRATION:

District's Administration head: Role and Importance, • Municipalities: Introduction, Mayor and role of Elected Representative, CEO, Municipal Corporation. Pachayati raj: Introduction, PRI: Zila Pachayat. Elected officials and their roles, CEO Zila Pachayat: Position and role. Block level: Organizational Hierarchy(Different departments), Village level:Role of Elected and Appointed officials, Importance of grass root democracy.

UNIT VI ELECTION COMMISSION:

Election Commission: Role and Functioning. Chief Election Commissioner and Election Commissioners - Institute and Bodies for the welfare of SC/ST/OBC and women.

TOTAL: 30 PERIODS

OUTCOMES

Students will be able to:

- DiscussthegrowthofthedemandforcivilrightsinIndiaforthebulkofIndiansbeforethe arrival of Gandhi in Indian politics.
- Discusstheintellectualoriginsoftheframeworkofargumentthatinformedtheconceptualization
- of social reform sliding to revolution in India.
- DiscussthecircumstancessurroundingthefoundationoftheCongressSocialistParty[CSP] under the leadership of Jawaharlal Nehru and the eventual failure of the proposal of direct elections through adult suffrage in the Indian Constitution.
- DiscussthepassageoftheHinduCodeBillof1956.

Suggested reading

1. TheConstitutionofIndia,1950(BareAct), Government Publication.
2. Dr. S. N. Busi, Dr. B. R.AmbedkarframingofIndianConstitution,1st Edition,2015.
3. M.P. Jain,IndianConstitutionLaw,7th Edn.,Lexis Nexis,2014.
4. D.D. Basu, Introduction to the Constitution of India, Lexis Nexis,2015.

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

AX5096	PEDAGOGY STUDIES	L T P C 2 0 0 0

OBJECTIVES

Students will be able to:

- Review existing evidence on there view topic to inform programme design and policy
- Making under taken by the DfID, other agencies and researchers.
- Identify critical evidence gaps to guide the development.

UNIT I INTRODUCTION AND METHODOLOGY:

Aims and rationale, Policy background, Conceptual framework and terminology - Theories of learning, Curriculum, Teacher education - Conceptual framework, Research questions **-** Overview of methodology and Searching.

UNIT II THEMATIC OVERVIEW

Pedagogical practices are being used by teachers in formal and informal classrooms in developing countries - Curriculum, Teacher education.

UNIT III EVIDENCE ON THE EFFECTIVENESS OFPEDAGOGICALPRACTICES

Methodology for the in depth stage: quality assessment of included studies - How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy? - Theory of change - Strength and nature of the body of evidence for effective pedagogical practices - Pedagogic theory and pedagogical approaches - Teachers' attitudes and beliefs and Pedagogic strategies.

UNIT IV PROFESSIONAL DEVELOPMENT

Professional development: alignment with classroom practices and follow up support - Peer support - Support from the head teacher and the community - Curriculum and assessment - Barriers to learning: limited resources and large class sizes

UNIT V RESEARCH GAPS AND FUTURE DIRECTIONS

Research design – Contexts – Pedagogy - Teacher education - Curriculum and assessment - Dissemination and research impact.

TOTAL: 30 PERIODS

OUTCOMES

Students will be able to understand:

- Whatpedagogicalpracticesarebeingusedbyteachersinformalandinformalclassrooms in developing countries?
- What is the evidence on the effectiveness soft he sepedagogical practices, in what conditions, and with what population of learners?
- How can teacher education(curriculum and practicum)and the school curriculum and guidance materials best support effective pedagogy?

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

Suggested reading

1. Ackers, HardmanF(2001)ClassroominteractioninKenyanprimaryschools,Compare,31(2): 245-261.
2. AgrawalM (2004)Curricular reform in schools: The importance of evaluation, JournalofCurriculumStudies,36(3):361-379.
3. AkyeampongK(2003)TeachertraininginGhana-doesitcount?Multi-siteteachereducationresearchproject(MUSTER) country report 1.London:DFID.
4. Akyeampong K,LussierK, PryorJ, WestbrookJ (2013) Improving teaching and learning of basic maths and reading in Africa: Does teacher preparation count? International Journal Educational Development, 33(3): 272–282.
5. Alexander RJ(2001) Culture and pedagogy: International comparisons in primary education. Oxford and Boston: Blackwell.
6. ChavanM (2003) Read India: Amass scale, rapid, 'learningtoread 'campaign.
7. www.pratham.org/images/resource%20working%20paper%202.pdf

AX5097 **STRESS MANAGEMENT BY YOGA** **L T P C**
2 0 0 0

OBJECTIVES

- To achieve overall health of body and mind
- To overcome stress

UNIT I

Definitions of Eight parts of yoga.(Ashtanga)

UNIT II

Yam and Niyam - Do's and Don't'sin life - i) Ahinsa, satya, astheya, bramhacharya and aparigraha, ii) Ahinsa, satya, astheya, bramhacharya and aparigraha.

UNIT III

Asan and Pranayam - Various yog poses and their benefits for mind & body - Regularization of breathing techniques and its effects-Types of pranayam

TOTAL: 30 PERIODS

OUTCOMES

Students will be able to:

- Develop healthy mind in a healthy body thus improving social health also
- Improve efficiency

SUGGESTEDREADING

1. 'YogicAsanasforGroupTarining-Part-I":JanardanSwamiYogabhyasiMandal, Nagpur
2. "Rajayogaorconquering the Internal Nature" by Swami Vivekananda, Advaita Ashrama (Publication Department),Kolkata

AX5098	PERSONALITY DEVELOPMENT THROUGH LIFE ENLIGHTENMENT SKILLS	L T P C 2 0 0 0

OBJECTIVES

- To learn to achieve the highest goal happily
- To become a person with stable mind, pleasing personality and determination
- To a waken wisdom in students

UNIT I

Neetishatakam-holistic development of personality - Verses- 19,20,21,22 (wisdom) - Verses- 29,31,32 (pride & heroism) – Verses- 26,28,63,65 (virtue) - Verses- 52,53,59 (dont's) - Verses- 71,73,75,78 (do's)

UNIT II

Approach to day to day work and duties - Shrimad BhagwadGeeta: Chapter 2-Verses 41, 47,48 - Chapter 3-Verses 13, 21, 27, 35 Chapter 6-Verses 5,13,17,23, 35 - Chapter 18-Verses 45, 46, 48.

UNIT III

Statements of basic knowledge - Shrimad BhagwadGeeta: Chapter2-Verses 56, 62, 68 Chapter 12 - Verses 13, 14, 15, 16,17, 18 -Personality of role model - shrimadbhagwadgeeta - Chapter2-Verses 17, Chapter 3-Verses 36,37,42 - Chapter 4-Verses 18, 38,39 Chapter18 – Verses 37,38,63

TOTAL: 30 PERIODS

OUTCOMES

Students will be able to

- Study of Shrimad- Bhagwad- Geeta will help the student in developing his personality and achieve the highest goal in life
- The person who has studied Geeta will lead the nation and man kind to peace and prosperity
- Study of Neetishatakam will help in developing versatile personality of students.

Suggested reading

1. Gopinath, Rashtriya Sanskrit Sansthanam P, Bhartrihari's Three Satakam, Niti-sringar-vairagya, New Delhi,2010
2. Swami Swarupananda , Srimad Bhagavad Gita, Advaita Ashram, Publication Department, Kolkata, 2016.