

UNIVERSITY DEPARTMENTS
ANNA UNIVERSITY : : CHENNAI 600 025
REGULATIONS - 2013

I TO IV SEMESTERS CURRICULUM AND SYLLABUS (FULL TIME)

M.TECH. CERAMIC TECHNOLOGY

SEMESTER I

COURSE CODE	COURSE TITLE	L	T	P	C
THEORY					
CR8101	Material Characterization Techniques	3	0	0	3
CR8102	Materials Science	3	0	0	3
CR8103	Mechanical Behaviour of Ceramics	3	0	0	3
CR8104	Traditional Ceramics	3	0	0	3
	Elective I	3	0	0	3
	Elective II	3	0	0	3
PRACTICAL					
CR8111	Material Characterization Lab	0	0	3	2
TOTAL CREDITS		18	0	3	20

SEMESTER II

COURSE CODE	COURSE TITLE	L	T	P	C
THEORY					
CR8201	Advanced Ceramic Materials	3	0	0	3
CR8202	Ceramic Processing	3	0	0	3
CR8203	Phase Equilibria in Ceramic Systems	3	0	0	3
CR8204	Refractories	3	0	0	3
	Elective III	3	0	0	3
	Elective IV	3	0	0	3
PRACTICAL					
CR8211	Processing and Testing of Ceramics Lab	0	0	3	2
TOTAL CREDITS		18	0	3	20

SEMESTER III

COURSE CODE	COURSE TITLE	L	T	P	C
THEORY					
CR8301	Nanoscience and Technology of Ceramics	3	0	0	3
	Elective – V	3	0	0	3
	Elective – VI	3	0	0	3
PRACTICAL					
CR8311	Industrial Training (Two weeks duration during II Semester summer vacation)	0	0	0	1
CR8312	Project Work – Phase I	0	0	12	6
CR8313	Seminar	0	0	2	1
TOTAL CREDITS		9	0	14	17

SEMESTER IV

COURSE CODE	COURSE TITLE	L	T	P	C
PRACTICAL					
CR8411	Project Work – Phase II	0	0	24	12
TOTAL CREDITS		0	0	24	12

TOTAL NUMBER OF CREDITS TO BE EARNED FOR AWARD OF THE DEGREE 69

LIST OF ELECTIVES

COURSE CODE	COURSE TITLE	L	T	P	C
CR8001	Abrasives	3	0	0	3
CR8002	Advanced Processing Techniques for Ceramics	3	0	0	3
CR8003	Advanced Refractory Engineering	3	0	0	3
CR8004	Bio-ceramics	3	0	0	3
CR8005	Cement and Concrete	3	0	0	3
CR8006	Ceramic Calculations	3	0	0	3
CR8007	Ceramic Coating Technology	3	0	0	3
CR8008	Ceramic Fibres and Composites	3	0	0	3
CR8009	Electronic Ceramic Materials and Their Applications	3	0	0	3
CR8010	Environmental Engineering	3	0	0	3
CR8011	Fuels, Furnaces and Pyrometry	3	0	0	3
CR8012	Glass Engineering	3	0	0	3
CR8013	Heat Recovery Systems	3	0	0	3
CR8014	Manufacturing and Testing of Structural Ceramics	3	0	0	3
CR8015	Monolithics and Castables	3	0	0	3
CR8016	Non Destructive Testing	3	0	0	3
CR8017	Nuclear and Space Ceramics	3	0	0	3
CR8018	Numerical Techniques	3	0	0	3
CR8019	Operation Research	3	0	0	3
CR8020	Process Modelling, Simulation and Optimization	3	0	0	3
CR8021	Properties and Applications of Structural Ceramics	3	0	0	3
CR8022	Quality Control and Management in Ceramic Industries	3	0	0	3
CR8023	Safety Engineering	3	0	0	3
CR8024	Special Glasses	3	0	0	3

OBJECTIVE

The course is aimed to impart basic knowledge about various characterization techniques employed to characterize a ceramic material.

OUTCOME

On completion of the course the students are expected to

- Have a basic understanding about chemical methods, spectroscopic techniques, surface analysis.
- Have learnt about various non-destructive methods.
- Have basic knowledge about X-Ray diffraction spectroscopy.

UNIT I CHEMICAL AND THERMAL METHODS 9

Elemental analysis by wet chemical methods – Volumetric, Gravimetric and Colorimetric analysis. Thermal Methods – TGA, DTA and DSC.

UNIT II SPECTROSCOPIC METHODS 8

U-V, Visible, FTIR, Raman and NMR spectroscopy – fluorescence and phosphorescence methods – flame photometry – atomic absorption – ICP.

UNIT III X-RAY METHODS 10

Single crystal techniques – powder diffraction – materials identification, composition and phase diagram analysis – X-ray Fluorescence.

UNIT IV SURFACE AND PARTICLE ANALYSIS 10

Optical Microscope, SEM, TEM – particle size and surface study – electron microprobe analysis – ion scattering spectrometry (ISS), secondary ion mass spectrometry (SIMS), auger emission spectrometry (AES), electron spectroscopy for chemical analysis (ESCA), AFM, Surface area, pore volume measurements by B.E.T. method, Mercury porosimetry - Particle size measurement – laser diffraction, x-ray diffraction, dynamic light scattering.

UNIT V NON-DESTRUCTIVE METHODS 8

Analysis of finished goods – ultrasonic techniques – reflection techniques – back reflection and pulse-echo – thickness measurement by resonance; Acoustic emission techniques- Radiographic testing - thermographic testing.

TOTAL : 45 PERIODS**REFERENCES**

1. Willard, H.H., L.L.Meritt, J.A.Denn and F.A.Settle, Instrumental Methods of Analysis, 1986, CBS Publishers, New Delhi.
2. Sibilia, J.P., A Guide to Materials Characterization and Chemical Analysis, 1988, VCH Publishers and Co.
3. Cullity, B.D. Elements of X-ray Diffraction, 1978, Addison –Wesley Publishing Company Inc, Massachusetts.
4. Ewing, G.W., Instrumental Methods of Chemical Analysis, 1985, McGraw-Hill Book Company, New York.
5. Gabriel, B.L., SEM: A User's Manual for Material Science, 1985, American Society for Metals Park.
6. R.S.Khandpur, Handbook of Analytical Instruments, 1989, Tata Mcgraw Hill Publications.

*Attested**Sobhan*
DIRECTORCentre For Academic Courses
Anna University, Chennai-600 025.

OBJECTIVE

The course is aimed to impart basic knowledge about crystal structures, phase diagrams and properties of materials.

OUTCOME

- On completion of the course the students are expected to
- Have a basic understanding about crystal structures and various laws related to structures.
 - Have learnt about various properties.
 - Have basic knowledge about phase diagrams.

UNIT I CRYSTAL STRUCTURE 9

Introduction – material classification of materials – structure- property relationship - atomic Structure - space lattice and crystal structure - Miller indices, crystal planes – symmetry – crystal imperfections – point, line, surface, volume – solid solutions - ceramic crystal structures. Diffusion: Fick's laws of diffusion – mechanism and applications – Kirkendal effect – atomistic model of diffusion.

UNIT II PHASE DIAGRAMS 9

Gibb's Phase rule – Phase, component, variable, phase diagrams - single, binary and ternary phase diagrams – lever rule – applications of phase diagrams

UNIT III MECHANICAL PROPERTIES 9

Elastic behavior – plastic deformation by slip – dislocation movement – effect of stress and temperature – work hardening – creep – fracture, modes of fracture - fracture toughness – hardness – wear - corrosion.

UNIT IV ELECTRICAL AND ELECTRONIC PROPERTIES 9

Classification of materials using free electron theory and band theory -conductivity of metals – Matheisen's Rule – concentration and mobility of charge carriers and their variation with temperature .– energy gap in solids – dielectric materials - types of polarizations – polarization calculations – dielectric constant – dielectric loss – dielectric breakdown – polymer dielectrics – Fast ionic conductors – ionic conduction in zirconia and other systems - dipole moment – static permittivity – superconductivity – semiconducting materials

UNIT V MAGNETIC ,THERMAL AND OPTICAL PROPERTIES 9

Introduction – types of magnetic materials - Classification of dia- para -ferro- antiferro and ferri magnetic materials – magnetic semiconductors – specific heat capacity – thermal conductivity – measurement by Laser Flash and other methods - thermal expansion – Light Interaction with solids – optical properties of metals & non metals – refraction, reflection, absorption, transmission , color, opacity, translucency – applications

TOTAL : 45 PERIODS**REFERENCES**

1. Saxena, B.S., R.C. Gupta and P.N. Saxena, Fundamentals of Solid State Physics, 1988, Pragathi Pragasan, Meerut.
2. V.Raghavan and Asoke K. Ghosh, Material Science and Engineering, 2004, Prentice hall of India Pvt. Ltd.
3. Schewmon, P.G. Diffusion of Solids, 1963, McGraw- Hill Book Company, New York.
4. Bergeron, C.G., and S.H.Risbud, Introduction to Phase Equillibria in Ceramics, 1984, Am.Ceram.Soc, Inc., Westerwile Ohio, USA.
5. Arzamasov, B., Materials Science, 1989, Mir Publishers, Moscow.
6. Weidmann, G., P.Lewis and N.Reid, Structural Materials, 1990, Butterworths, London.

Attested



DIRECTOR

 Centre For Academic Courses
 Anna University, Chennai-600 025.

7. William D Callister.Jr, Materials Science & Engineering, 2000, John Wiley & Sons
8. O.P.Khanna and ISH Kapur, Material Science & Metallurgy, 2002, Dhanpat Rai publications.
9. E.S.Machlin, Materials Science Microelectronics, 2005, 2nd Edition, Elsevier Ltd,.
10. John Martin, Materials for Engineering, 2002, 2nd edition, Woodhead publishing & Maney Publishing,.
11. G. S. Upadhyaya and Anish Upadhyaya, Materials Science & Engineering, 2006, Viva Books Pvt.Ltd,.
12. R.W.Cahn, P.Haasen and E.J.Kramer, Material Science & Technology Vol.5, 1991, VCH Verlagsgesellschaft MBH.

CR8103

MECHANICAL BEHAVIOR OF CERAMICS

**L T P C
3 0 0 3**

OBJECTIVE

The course is aimed to impart basic knowledge about elasticity, fracture methods, strength, creep behaviour and thermal shock behaviour of ceramic materials.

OUTCOME

On completion of the course the students are expected to

- Have a basic understanding about elasticity, deformation point of isotropic and crystalline materials.
- Have learnt about various fractures, fracture testing techniques, strength behaviour and creep on application of loads.
- Have basic knowledge about thermal shock resistance parameters.

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, 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 behaviour, cyclic fatigue, SPT diagram.

UNIT III

TOUGHENING

8

Toughening mechanisms – crack deflection, crack bowing, crack branching, crack tip shielding by process zone & bridging effect; Stable crack propagation and R-curve behaviour,

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 – types, mechanism, measurement, life time prediction. Wear of ceramics – types, mechanism, measurement, factors affecting.

Attested

Sobhan
DIRECTOR

Centre For Academic Courses
Anna University, Chennai-600 025.

REFERENCES

1. John B.Watchman, Mechanical Properties of Ceramics, 1996, John Wiley & Sons Inc., NY.
2. Davidge, R.W., Mechanical Behaviour of Ceramics, Ceramic Book Literature Service, 1979, London, UK.
3. Hasselman, D.P.H and R.A.Heller(Ed), Thermal Stresses in Service Environments, 1989, Plenum Press.
4. A.C.F Cocks and A.R.C Ponter, 1989, Mechanics of creep brittle material -1 & 2, Elsevier Applied Science.
5. Jahanmir Said, Friction and Wear of Ceramics, 1993, Marcel Dekker Inc.
6. Roy.W.Rice, Mechanical Properties of Ceramics and Composites, 1993, Marcel Dekker Inc.
7. V.Z.Parton and V.G.Borishkovsky, Dynamic Fracture Mechanics (VOI-2) , 1990, Hemisphere Publishing.
8. K.Kusmaul, Fracture Mechanics Verification by Large-Scale Testing, 1991, Mechanical Engg. Publication.
9. R.C.Brat, D.P.H.Hasselman,D.Munz, M.Sakai and V.Ya.Shevchenko, Fracture Mechanics of Ceramics, 1991, Plenom Press Publication.
10. V.S.Sastri and Edward Ghalai, Corrosion-prevention& protection, 2007, John Willey & Sons.

CR8104

TRADITIONAL CERAMICS

**L T P C
3 0 0 3**

OBJECTIVE

The courses is aimed to impart basic knowledge about traditional ceramics its raw materials, body preparation, glazing and firing behavior.

OUTCOME

On completion of the course the students are expected to have a basic understanding about traditional ceramics.

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.

UNIT IV GLAZING 9

Glaze – definition – composition – raw materials; Engobe – definition – raw materials – process; Fritting – definition – fritting rules – manufacturing process; Glaze batch

Attested
Sobhan
DIRECTOR
Centre For Academic Courses
Anna University, Chennai-600 025.

calculation; Glaze application techniques – types; Glaze defects; Glaze properties – fusibility, viscosity, surface tension, thermal and mechanical properties, glaze-body interface layer, opacity and translucency.

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.

TOTAL : 45 PERIODS

REFERENCES

1. Worrall, W.E, Ceramic Raw Materials, 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. Sudhir Sen, Ceramic Whiteware, Oxford & IBH Publishing Co., New Delhi, 1992
6. Singer, F and Singer, S.S, Industrial Ceramics, Oxford & IBH Publishing Co., 1991
7. Ryan, W and Radford, C, Whitewares: Production, Testing and Quality Control, Pergamon Press, NY, 1987.
8. H.Nosbusch and I.V Mitchell, Clay based material for the ceramics industry, 1996, Elsevier Publications.
9. Terry A.Ring, Fundamentals of ceramic powder processing and synthesis, 1996, Academic press.
10. Rex W.Grimshaw, Chemistry and Physics of Clays and Allied Ceramic Materials, 1971, Benn, London for chemical analysis (ESCA), AFM, Surface area, pore volume measurements by B.E.T. method, Mercury porosimetry - Particle size measurement – laser diffraction, x-ray diffraction, dynamic light scattering.

CR8111

MATERIAL CHARACTERIZATION LAB

**L T P C
0 0 3 2**

OBJECTIVE

The course is aimed to impart practical knowledge about characterization of a ceramic sample.

OUTCOME

- On completion of the course the students are expected to
- To have a basic understanding about different methods of characterizing a ceramic sample.
1. Particle Size Analysis – Laser Diffraction.
 2. Surface Area Measurement – BET.
 3. Determination of Viscosity by Brookfield Viscometer.
 4. Analysis of Trace Elements using Spectrophotometer, Flame Photometer and Atomic Absorption Spectroscopy.
 5. Thermal Analysis – TGA, DTA.
 6. Microscopy – Optical, SEM.
 7. Atomic Force Microscope
 8. Vicker's Hardness.
 9. Modulus of Rupture – 3 point & 4 point.
 10. Compressive Strength.
 11. Wear and Abrasion Resistance.
 12. Mercury Porosimetry.

TOTAL : 45 PERIODS

Attested

Sobhan
DIRECTOR

Centre For Academic Courses
Anna University, Chennai-600 025.

OBJECTIVE

The course is aimed to impart basic knowledge about various advanced ceramic materials and its structure, properties and applications.

OUTCOME

On completion of the course the students are expected to

- Have a basic understanding about ceramics in turbine blades, piezoelectrics.
- Have learnt about various advanced and structural ceramics.
- Have basic knowledge about special glasses and glass ceramics.

UNIT I	STRUCTURAL CERAMICS	9
Carbides – nitrides – oxides – SiAlON – borides – silicides – composites		
UNIT II	ELECTRONIC CERAMICS	9
Ferro-electrics – electrical insulators – smart ceramics - piezo electrics – PLZT sensors metallised ceramics – gas sensors – superconducting ceramics.		
UNIT III	MAGNETIC CERAMICS	8
Spinel Ferrites – Hexagonal Ferrites – Garnet – Processing and Applications		
UNIT IV	SPECIAL GLASSES AND GLASS CERAMICS	10
High purity silica glasses – laser glasses – optical glasses – fibre glasses – oxide and non-oxide glasses – oxy-nitride glasses - photosensitive glasses – conducting glasses - glass ceramics, applications of glass ceramics – glass for satellite applications.		
UNIT V	BIOMATERIALS	9
Introduction – biomaterials, bioceramics – composition, interaction with biological systems, properties, applications, shape memory alloys.		
TOTAL : 45 PERIODS		

REFERENCES

1. Larsen ,D.C., C.W., Adams., L.R.Johnson, A.P.S. Teotia and L.G.Hill, Ceramic Materials for Advanced Heat Engines, 1985,Noyes Pub., New Jersey, USA.
2. Dorre, E., and H.Hibner, Alumina Processing, Properties and Applications,1984, Springer-Verlag, NY.
3. Stevens, R.,Zirconia and Zirconia Ceramics, 1986,Magnesium Elektron Ltd.
4. Lewis,M.H., Glasses and Glass Ceramics,1987,Chapman and Hall, London.
5. Somiya, S., Advanced Ceramics 3,1990,Elseivr Applied Science, NY.
6. Gernot Kostorz, High-Tech. Ceramics,1989, Academic Press, NY.
7. Brook, R.J.(Ed), Concise Encyclopedia of Advanced Ceramic Materials, 1991,Pergamon Press, NY.
8. Noboru Ichinose, Introduction to Fine Ceramics, 1987, John Wiley & Sons.
9. Robert B. Heimann, Classic and Advanced Ceramics, 2010, Wiley VCH Verlag GMBH & co.
10. P.Ramakrishnan and Mohan Primplani, Advanced Ceramics, 1992, Oxford ISH Publications Pvt. Ltd.

OBJECTIVE

The course is aimed to impart basic knowledge about powder preparation techniques and modern ceramic processing.

OUTCOME

On completion of the course the students are expected to

- Have a basic understanding about powder preparation, characterization and compaction.
- Have learnt about various techniques for modern processing.
- Have basic knowledge about sintering and fired product characterization.

UNIT I POWDER PREPARATION 9

Powder preparation by mechanical methods – comminution, mechano-chemical synthesis. Powder synthesis by chemical methods – solid state reaction, liquid solutions, vapour phase reactions, combustion synthesis; Synthesis of nano scale ceramic powder.

UNIT II PROCESSING ADDITIVES 7

Types, Properties and Effect of addition of liquids and wetting agents, deflocculants, coagulants, binders, plasticizers, foaming and antifoaming agents, lubricants, preservatives.

UNIT III FORMING 10

Forming of ceramics – dry and semidry pressing - die compaction and isostatic compaction; casting methods - slip casting, pressure casting, gel casting, electrophoretic deposition; plastic forming methods - extrusion, co-extrusion, injection molding, solid freeform fabrication - particle filled polymer methods, powder methods, suspension methods- Porous ceramic forming- foaming, intrusion, organic additives – advanced composite manufacture – CVI, polymer impregnation followed by pyrolysis(PIP).

UNIT IV SINTERING 11

Solid state sintering – driving force, effect of surface curvature and boundary defects, mechanism, stages of sintering. Liquid phase sintering – stages, kinetic and thermodynamic factors, phase diagram in liquid phase sintering. Grain growth – different grain growth process, control of grain growth, grain growth and pore evolution in a porous compact, interaction between pore and grain boundary. Pressure assisted sintering – hot pressing and hot iso-static pressing. Reaction bonded sintering, microwave sintering.

UNIT V POST FORMING PROCESSES 8

Mechanism of material removal and its effect on strength; Surface grinding and mechanical polishing - non abrasive finishing - ceramic surface coating; Cutting techniques – water jet cutting, laser ablation; Etching; Joining of ceramics – metal ceramic joints.

TOTAL : 45 PERIODS

REFERENCES

1. Mohamed N.Rahaman, Ceramic Processing, Taylor & Francis, 2007.
2. David W. Richerson, Modern Ceramic Engineering, 3rd Edn., Taylor & Francis, 2005.
3. Paul De Garmo E, Black J.J and Ronald A.Kohser, Materials and Processes in Manufacturing, 8th Edn., Prentice – Hall India Pvt. Ltd., New Delhi, 1997.

Attested

Sobhan
DIRECTOR

Centre For Academic Courses
Anna University, Chennai-600 025.

4. Reed J.S, Introduction to the Principles of Ceramic Processing, Wiley, New York, 1988.
5. John G.P.Binner (Ed), Advanced Ceramics Processing and Technology, Noyes Publications, New Jersey, 1990.
6. Burtrand Lee and Sridhar Komarnei (Eds.), Chemical Processing of Ceramics, 2nd Edn., Taylor & Francis, 2005.
7. K.K.Chawla, Ceramic Matrix Composites
8. R.A.Terpstra, P.P.A.C Pex and A.H de Vries, Ceramics Processing, Chapman & Hall, 1995.
9. Joahnan.R.Groger, James.F.Shackelford and Michael.T.Power, Material Processing, Taylor&Francic grop 2007

CR8203

PHASE EQUILIBRIA IN CERAMIC SYSTEMS

**L T P C
3 0 0 3**

OBJECTIVE

The course is aimed to enable the students to have a thorough knowledge about the importance of phase equilibrium and analyzing different systems.

OUTCOME

On completion of the course the students are expected to

- Have learnt the basics of phase equilibrium and phase diagrams.
- Have studied the thermodynamics behind phase equilibria.
- Have a better understanding on the different two component and three component phase diagrams.
- Have studied the types and theory behind phase transformations and also about nucleation and growth.
- Have gained knowledge on the different experimental methods to determine phase diagrams.

UNIT I INTRODUCTION

9

Introduction, criteria of phase equilibrium, criterion of stability, phase equilibria in single component system and multi component system; Gibb's phase rule – phase, component, variable; Single component system – H₂O, SiO₂, iron; Binary phase diagrams – Hume Rothery's rule, congruent and incongruent, solid solutions; Ternary phase diagrams.

UNITII PHASE DIAGRAMS

9

Binary Systems – Phase diagram, microstructural constituents, significance of Al₂O₃ – SiO₂, MgO – Al₂O₃, MgO – SiO₂, Al₂O₃ – ZrO₂; Ternary Systems – Phase diagram, microstructural constituents, determination of crystallization path during heating and cooling of K₂O – Al₂O₃ – SiO₂, MgO – Al₂O₃ – SiO₂, Na₂O – Al₂O₃ – SiO₂, CaO – Al₂O₃ – SiO₂.

UNIT III PHASE TRANSFORMATIONS

9

Introduction, Time Scale for phase transformations; Types of transformations – spinoidal, nucleation & growth, theory of transformation kinetics; Nucleation and growth – nucleation kinetics, homogeneous nucleation, heterogeneous nucleation, growth and overall transformation kinetics; Sintering & crystallization in ceramics and glass forming systems.

UNIT IV EXPERIMENTAL METHODS

9

Techniques for determining phase diagrams – dynamic, static, microscopic methods – optical, electron microscopy, X-ray methods, thermal analysis.

UNIT V APPLICATIONS 9

Prediction of alkali corrosion of alumino silicate refractories using phase diagrams – Use of phase diagrams in the study of Silicon nitride ceramics – Application of phase diagrams to the production of advanced composites.

TOTAL : 45 PERIODS

REFERENCES

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. Floyd A.Hammel, Phase Equilibria in Ceramic Systems, Marcel Dekker, 1984.
3. Kingery W.D, Bowen H.K and Uhlmann D.Rm Introduction to Ceramics, 2nd Edn., John Wiley & Sons, 2004.
4. Allen M.Alper, Phase diagrams in Advanced Ceramics, Academic Press Inc., 1995.
5. Barsoum M.W, Fundamentals of Ceramics, McGraw Hill, 1997.

CR8204

REFRACTORIES

**L T P C
3 0 0 3**

OBJECTIVE

The course is aimed to impart basic knowledge about refractories, fabrication methods, testing and monolithics.

OUTCOME

On completion of the course the students are expected to

- Have a basic understanding about refractory raw materials, classification and properties.
- Have learnt about various fabrication techniques and testing.
- Have basic knowledge about monolithics and its applications.

UNIT I INTRODUCTION 9

Definition; Classification of Refractories based on raw materials, temperature, shapes; Fundamental Properties of Refractories – Physical, Thermal, Mechanical, Chemical and Electrical; Process industry standards – Indian and International test methods (ISI) – QC procedures – Statistical QC, ISO 9000 Etc.

UNIT II SILICA & ALUMINO SILICATE REFRACTORIES 9

Silica – raw materials, manufacturing steps, properties, applications; Alumina – raw materials, manufacturing steps, properties, applications; Al_2O_3 – SiO_2 phase diagram; Alumino-Silicate – raw materials, types of refractories, manufacturing steps, properties, applications.

UNIT III BASIC REFRACTORIES 9

Types - Forsterite, Dolomite, Magnesite, Magnesia Carbon, and Chrome based refractories; Raw materials, Manufacturing Steps, Properties and Applications.

UNIT IV SPECIAL REFRACTORIES 9

Raw materials, manufacturing steps, properties and applications of Oxide based – Cordierite, Zirconia, Thoria, Beryllia; Carbide based – Silicon carbide, boron carbide; Nitride based – silicon nitride; Fused cast refractories – raw materials, manufacturing step, properties, applications; Ceramic Fibers – types, properties, applications; Insulating refractories – preparation, properties, applications.

UNIT V MONOLITHICS**9**

Castables – types, composition, properties, applications; Plastics – types, composition, properties, applications. Dry mixes – types, composition, properties, applications.

TOTAL : 45 PERIODS**REFERENCES**

1. D.N.Nandi, Handbook of Refractories, Tata McGraw Hill Publishing Co, New Delhi, 1991.
2. Chester, J.H., Steel Plant Refractories, Second Edition., 1973, The United Steel Companies Ltd., Sheffield, UK.
3. Chester, J.H. Refractories, Production and Properties, 1973, Iron and Steel Institute, London.
4. Robert E.Fisher, Advances in Refractory Technology, Ceramic Transaction, Vol.4, 1990, American Ceramic Society, Westerville, Ohio, USA.
5. Handbook of Monolithics, 1980, Plibrico, Japan.
6. Modern Refractories Practice, 1961, Harbison Walker Comp., Pittsburgh.
7. Charless.A.Schacht, Refractories Handbook, 2007, Marcel Dekkar Publications.
8. G.V.Samsonov & J.M.Vinitskii, Handbook of Refractory, 1980, IFI Publications.

CR8211**PROCESSING AND TESTING OF CERAMICS LAB****L T P C
0 0 3 2****OBJECTIVE**

The course is aimed to impart basic practical knowledge about processing and testing of ceramic materials.

OUTCOME

On completion of the course the students are expected to

- Have a basic understanding about different tests done on ceramic materials in the laboratory.
 1. Analysis of Ceramic Raw Materials
 1. Moisture
 2. Loss on ignition
 3. Silica Content
 4. Particle Size Distribution – Hydrometer, Andreason Pipette
 2. Fabrication Techniques
 1. Uniaxial Pressing
 2. Cold Extrusion
 3. Slip Casting
 3. Analysis of Ceramic Body – Plasticity Index of Plastic Body, Flow Behavior of Slurry, Solid Content Estimation in Slurry, Slurry Thixotropy Estimation.
 4. Analysis of Properties of Shaped Ceramic – Density, Porosity, Water absorption, Shrinkage, Flexural Strength – 3 point & 4 point, Compressive Strength, Tensile Strength, Rheology study
 5. Firing Studies

TOTAL : 45 PERIODS*Attested**Sobhan*
DIRECTOR

Centre For Academic Courses
Anna University, Chennai-600 025.

OBJECTIVE

The course is aimed to enable the students to have a basic knowledge about the developing field on nanotechnology , nanoceramics and composites.

OUTCOME

On completion of the course the students are expected to have a complete knowledge about the preparation, characterization and applications of nano ceramics and composites.

UNIT I INTRODUCTION**9**

General definition and size effects–important nano structured materials and nano particles- importance of nano materials- applications.

UNIT II SYNTHESIS & CONSOLIDATION**9**

Bottom up and Top down approach for obtaining nano materials - Precipitation methods – sol gel technique – high energy ball milling, CVD and PVD methods, gas phase condensation, magnetron sputtering and laser deposition methods – laser ablation, sputtering.

UNIT III NANOCERAMICS**9**

Introduction to nano ceramics- properties of nano ceramics- advanced nano ceramics- carbon nano tubes, fibres, nanosilica-nano alumina- nano titania and zinc oxide-applications.

UNIT IV NANO COMPOSITES**9**

Definition- importance of nanocomposites- nano composite materials-classification of composites- metal/ceramics, metal-polymer- thermoplastic based, thermoset based and elastomer based- influence of size, shape and role of interface in composites-applications.

UNIT V CHARACTERIZATION METHODS**9**

X-ray diffraction, Raman spectroscopy- UV- visible spectroscopy, scanning probe microscopy, atomic force microscopy, scanning electron microscopy and transmission electron microscopy techniques.

TOTAL : 45 PERIODS**REFERENCES**

1. R.H.J.Hannink & A.J.Hill, Nanostructure Control, Wood Head Publishing Ltd.,Cambridge, 2006.
2. C.N.R.Rao, A.Muller, A.K.Cheetham, The Chemistry of Nanomaterials: Synthesis, Properties and Applications Vol. I & II, 2nd edition, 2005, Wiley VCH Verlag Gbtl & Co
3. J.Stows Hall, Nanofuture, Manas Publications, 2006.
4. Mick Wilson, Kamali Kannangara,Geoff Smith, Michelle Simmom, Burkhard Raguse, “ Nano Technology: Basic Science & Engineering Technology”, 2005, Overseas Press.
5. Karl.M.Kadish, Rodney S.Rnoff, “Fullereness : Chemistry, Physics and Technology”, John Wiley & Son Inc. Publications, 2000.

*Attested**Sobhan*
DIRECTORCentre For Academic Courses
Anna University, Chennai-600 025.

OBJECTIVE

The course is aimed to impart basic knowledge about classification of abrasives and importance of grinding and polishing.

OUTCOME

On completion of the course the students are expected to

- Have a basic understanding about contact wheels, belt tension etc.
- Have learnt in detail about coated abrasives.
- Have basic knowledge about grinding and polishing
- Have learnt in detail about bonded abrasives.

UNIT I RAW MATERIALS 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 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 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 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 GRINDING AND POLISHING 9

Grinding – definition, grinding chips, chemical reactions, wheel wear, chemical grinding aids. Types of grinding – cylindrical grinding, centre less grinding, surface grinding, internal grinding. Grinding fluids – properties, types and purpose. Polishing – definition, types.

TOTAL : 45 PERIODS**REFERENCES**

1. Coes L Jr., Abrasive, Springer Verlag, New York, 1971.
2. Coated Abrasives – Modern Tool of Industry, Coated Abrasive Manufacturer's Institute, Cleaveland, Ohio, 1982.
3. Metzger J.L, Super Abrasive Grinding, Butterworths, UK, 1986.
4. Francis T.Farago, Abrasive Methods Engineering, Vol.2, Industrial Press Inc., NY, 1980.
5. Kenneth B.Lewis, William F.Schleicher, The Grinding Wheel, The Grinding Wheel Institute, Cleaveland, Ohio, 1976.
6. Stephen Malkin & Changsheng Guo, Grinding Technology, 2nd Edn., American Society of Civil Engineers, 2008.
7. Edwards R, Cutting Tools, The Institute of Materials, Cambridge, 1993.
8. Brian Rowe W, Principles of Modern Grinding Technology, William Andrew Publications, 2009.
9. Ioan D. Marinescu, Handbook of Advanced Ceramics Machining, Taylor and Francis, 2007

Attested
Sobhan
DIRECTOR
Centre For Academic Courses
Anna University, Chennai-600 025.

OBJECTIVE

The course is aimed to impart basic knowledge about non-conventional powder preparation techniques and advanced ceramic processing.

OUTCOME

On completion of the course the students are expected to

- Have a better understanding on powder preparation by sol-gel process and agglomeration process.
- Have learnt about biomorphic ceramics and microwave processing of ceramics.
- Have basic knowledge about advanced consolidation techniques.

UNIT I SOL-GEL PROCESS 9

Introduction - Hydrolysis & condensation of silicates and non-silicates – particulate sol & gel – gelation – aging of gel – drying – structural evolution during consolidation – comparison of gel derived and conventional ceramics

UNIT II AGGLOMERATION PROCESS 9

Introduction – Agglomeration Theories – Agglomeration Technologies: Tumble/Growth Agglomeration, Pressure Agglomeration, Agglomeration by Heat / Sintering – Engineering Criteria and Development.

UNIT III BIOMORPHIC CERAMICS 9

Preparation and Characteristics of Biomorphous carbide ceramics: SiC, TiC, SiSiC – Biomorphous oxide ceramics: Al₂O₃, ZrO₂, TiO₂, ZnO – Biomorphous ceramic composites

UNIT IV MICROWAVE PROCESSING OF CERAMICS 9

Introduction - Fundamentals of Microwave Heating - Dielectric Properties - Development of the Basic Theoretical Concepts - Applicators - Heat Transfer - Applications

UNIT V ADVANCED CONSOLIDATION TECHNIQUES 9

Hot Isostatic Pressing – Spark Plasma Sintering – Explosive Shock Consolidation

TOTAL : 45 PERIODS**REFERENCES**

1. C. Jeffrey Brinker, George W. Scherer, Sol-Gel Science: The Physics and Chemistry of Sol-Gel Processing, Academic Press, 1990.
2. Wolfgang Pietsch, Agglomeration Processes, Wiley-VCH, 2008.
3. Jon G. P. Biner and I.S.Ivanov, Advanced Ceramic Processing and Technology, Noyes Publications, 1990.
4. Mohamed N.Rahaman, Ceramic Processing, Taylor & Francis, 2007.
5. David W. Richerson, Modern Ceramic Engineering, 3rd Edn., Taylor & Francis, 2005.
6. Paul De Garmo E, Black J.J and Ronald A.Kohser, Materials and Processes in Manufacturing, 8th Edn., Prentice – Hall India Pvt. Ltd., New Delhi, 1997.
7. Reed J.S, Introduction to the Principles of Ceramic Processing, Wiley, New York, 1988.

Attested

Sobhan
DIRECTORCentre For Academic Courses
Anna University, Chennai-600 025.

OBJECTIVE

The course is aimed to impart basic knowledge about refractory for various industries and conservation.

OUTCOME

On completion of the course the students are expected to

- Have a basic understanding about applications of refractories in steel, cement, glass industries.
- Have learnt about various choice of refractory for kiln furniture.
- Have basic knowledge about energy conservation using ceramic fibres.

UNIT I SELECTION CRITERIA & INSTALLATION 9

Criteria for refractory selection – thermal criteria and calculations, structural criteria, chemical criteria. Installation – refractory bricks & shapes, castables, plastics, ceramic fibers.

UNIT II REFRACTORIES FOR FERROUS INDUSTRIES 9

Design, construction and refractories used in coke ovens, blast furnace, steel making furnaces, secondary steel making furnaces, continuous casting, heat treating & forging industries.

UNIT III REFRACTORIES FOR NON-FERROUS METALLIC INDUSTRIES 9

Design, construction and refractories used in copper, aluminum, lead, zinc extraction and processing industries.

UNIT IV REFRACTORIES FOR NON-METALLIC INDUSTRIES 9

Refractories used in refining & petrochemical, fertilizer, cement, glass, ceramic industries. Refractories used in combustors, boilers, incinerators, boilers etc.

UNIT V MAINTENANCE & SAFETY 9

Refractory maintenance & repair; Refractory Economics; Safety, health hazards, pollution control & ecology.

TOTAL : 45 PERIODS**REFERENCES**

1. Chester, J.H., Steel Plant Refractories, Second Ed., 1973, The United Steel Companies LTD., Sheffield, UK.
2. Chester, J.H., Refractories, Production and Properties, 1973, Iron and Steel Institute, London.
3. Robert E.Fisher, Advances in Refractory Technology, Ceramic Transaction Vol.4.,1990, American Ceramic Society, Westerville, Ohio, USA.
4. Handbook of Monolithics, 1980, Plibrico, Japan.
5. Modern Refractories Practice, 1961, Habbison Walker Comp., Pittsburgh.
6. Amavis, R., Refractories for the Steel Industry, 1990, Elsevier Publications
7. G.V.Samsonov & J.M.Vinitskii, Handbook of Refractory, 1980, IFI Publications.
8. D.N.Nandi, Handbook of Refractories, 1987, Tata Mc Graw-Hill Publications.
9. Charless.A.Schacht, Refractories Handbook, 2007, Marcel Dekkar Publications.

*Attested**Sobhan*
DIRECTORCentre For Academic Courses
Anna University, Chennai-600 025.

OBJECTIVE

The course is aimed to enable the students to have a sound knowledge about the applications of ceramic materials in biological field.

OUTCOME

On completion of the course the students are expected to

- Have learnt the various applications of ceramic materials in the medical field.
- Have a complete knowledge about the various calcium phosphate based ceramic materials along with the preparation, properties and applications.
- Have studied about the different bioactive glasses and glass ceramic materials.
- Have studied about the different bioactive composites.
- Have studied about the different bioactive coatings.

UNIT I MATERIALS IN MEDICINE 9

Implant areas – dental, orthopedic. Implant materials – bio polymers, bio metals, ceramic implants – porous ceramics, surface active ceramics, resorbable ceramics. Biological performance of the materials, body reaction to implant materials – corrosion, biodegradation and biocompatibility. Invitro and invivo test methods of implant materials.

UNIT II CALCIUM PHOSPHATE CERAMICS 9

Chemistry of calcium phosphate bio ceramics – preparation, mechanical properties and biological performance of tri calcium phosphate, tetra calcium phosphate, biphasic calcium phosphate, hydroxyapatite and other phosphates. Calcium phosphate bone cements – preparation, properties, setting behavior and bio compatibility.

UNIT III BIOACTIVE GLASSES AND GLASS CERAMICS 9

Surface active glasses, bioactive glass – preparation, mechanical properties, bonding mechanism to living tissue – interfacial bonding. Doped bioactive glasses. High strength bioactive glass ceramics – mechanical and biological properties, bone bonding mechanism, mechanism of surface apatite formation, compositional dependence.

UNIT IV BIOACTIVE COMPOSITES 9

Hydroxyapatite composites with zirconia, alumina and titania – preparation and properties. SiC whisker reinforced hydroxyapatite and bioactive glass ceramics, zirconia toughened and bioactive glass ceramics, bioglass-hydroxyapatite composites, carbon composites.

UNIT V BIOACTIVE COATINGS 9

Importance of bioactive coatings. Hydroxyapatite coated metal implants – coating methods, characterization and properties. Bioglass and bioactive glass ceramics coating over metals and alloys.

TOTAL : 45 PERIODS

REFERENCES

1. Yamamura T, Hench L.L and Wilson J, CRC Handbook of Bioactive Ceramics, Vol I & II, CRC Press, Boca Raton, 1990.
2. Park J.B, Biomaterials: An Introduction, Plenum Press, New York, 1979.
3. Bonfield V, Hastings C.H and Tanner K.E (eds.), Bioactive Ceramics, Vol4, Butterworth – Heinemann Ltd., Oxford, 1991.
4. Hans Bach, Low Thermal Expansion Glass Ceramics, Springer, 1995.
5. Hench L.L and Ethridge E.C, Biomaterials: An Interfacial Approach, Academic Press, New York, 1982.

Attested
Sobhan
DIRECTOR
Centre For Academic Courses
Anna University, Chennai-600 025.

6. Joon Park, Bioceramics-Properties, Charactersization and Applications, Springer Publications,2008
7. Tadashi Kokubo, Bio-Ceramic & Their Applications, Woodhead Publications,2008
8. Bikramjit Basu, Dharendra, S.Katti, Ashok and A Joham, Advanced Biomaterial, Fundamentals, Processing and Applications, Wiley & Sons Inc,2009
9. Heimo O.Ylaner, Bioactive Glasses - Materials, Properties and Applications, Woodhead Publishing Materials, 2011.

CR8005

CEMENT AND CONCRETE

L T P C
3 0 0 3

OBJECTIVE

The course is aimed to enable the students to have a complete knowledge on the manufacture, quality control and types of cement, and preparation, properties and different types of concrete.

OUTCOME

On completion of the course the students are expected to

- Have studied the raw materials, manufacturing process and mechanism of hydration of cement.
- Have learnt the tests done on cement and the quality control procedures.
- Have studied the different types of cements and their characteristics.
- Have learnt the types of aggregates and admixtures used for concrete making and the preparation, properties and testing methods of concrete.

UNIT I CEMENT 7

Raw materials, manufacturing process-wet & dry process. Composition of cement phases – effect of composition on burnability of clinker, influence of minor components. Hydration of cement.

UNIT II TESTING AND QUALITY CONTROL 8

Tests on properties of cement – consistency of standard paste, setting time, soundness, strength of cement. Quality control – litre-weight test, microscopic and X-ray investigation of clinker materials.

UNIT III TYPES OF CEMENT 10

Types of Portland cement, blast furnace slag cement, trief cement, high alumina cement, white and coloured cement, oil well cement, hydrophobic cement, water proof cement, super sulphate cement, sulphate resisting cement.

UNIT IV CONCRETES 10

Aggregates – types, characteristics. Admixtures – types, characteristics. Proportioning of concrete mixtures – consideration, procedure. Recent advances in concretes – types, significance, characteristics.

UNIT V PROPERTIES OF CONCRETE 10

Strength, permeability, creep, thermal expansion, shrinkage, moisture movement, penetration of X-ray, abrasion resistance, fire resistance, freeze-thaw resistance, electrical properties.

TOTAL : 45 PERIODS

REFERENCES

1. P. Kumar Mehta and Paulo J.M.Monteiro, Concrete – Microstructure, Properties and Materials, 3rd Edn., Tata McGraw Hill, 2006.

Attested
Sobhan
DIRECTOR
Centre For Academic Courses
Anna University, Chennai-600 025.

UNIT V GLASS CALCULATIONS**9**

Determination of molecular formula of glass from chemical composition of the glass and from glass batch – determination of batch from molecular formula of glass – determination of batch from the given chemical composition – glass yield calculation.

TOTAL : 45 PERIODS**REFERENCES**

1. R.Griffiths & C.Radford, Calculations in Ceramics, Johns Hill, 1965.
2. A.I.Andrews, Ceramic Tests and Calculations, John Wiley & Sons, 1928.
3. R.Charan, Handbook of Glass Technology
4. Hiraoki Yanagida, The Chemistry of Ceramics, John Wiley and Sons, 1996.
5. Terpstra, Ceramic Processing, Chapman and Hall, 1995.
6. Tooley F.V, Handbook of Glass Manufacture, Vol I&II, Ogden Publishing Co., NY, 1960.
7. Alexis G.Pincus, Melting Furnace Operation in the Glass Industry, Magazines for Industry Inc., NY, 1980.

CR8007**CERAMIC COATING TECHNOLOGY****L T P C
3 0 0 3****OBJECTIVE**

The course is aimed to impart basic knowledge about glaze and advanced coating techniques.

OUTCOME

On completion of the course the students are expected to

- Have a basic understanding about glazes, manufacturing processes.
- Have learnt about various selection and control methods.
- Have basic knowledge about advanced coating techniques.

UNIT I INTRODUCTION**9**

Introduction to surface engineering & modification – wear, abrasion, oxidation resistance – types of coating-need for coating on the body – advantages & disadvantages.

UNIT II GLAZE**9**

Definitions, classification, raw materials, frit preparation, compounding, frit characteristics and quality testing - glaze body reactions, glaze formulation, additives, thermal characterization, chemical resistance, evaluation methods.

For glasses and coating, unit operations and processes, glaze application methods, selection of glaze to suit end product characteristics, glaze stains, ceramic colors, lusters.

UNIT III CONTROL METHODS**9**

Raw material selection, composition, process selection and controls, defects / fracture classification – defect cure methods – instrumentation – typical quality control system.

UNIT IV ADVANCED COATING TECHNIQUES**9**

Slurry coating – dip coating, spray coating, plasma spray – EVD, CVD, PVD, thermal spray, magnetic sputtering, laser ablation, nanocoatings - lithography techniques.

UNIT V ENAMELS 9

Cleaning methods for iron and steel, sheet metals – chemical cleaning-etching – electrolytic cleaning – pickling – sand blasting – de-enameling – repairing – cleaning treatment for aluminum alloys and base metals – frit making – additives – applications - firing

TOTAL : 45 PERIODS

REFERENCES

1. Taylor, J.R., and A.C.Bull, Ceramic Glaze Technology, 1986, Pergamon Press, NY.
2. Klein, L., (Ed), Sol-Gel Technology for Thin Films, Fibres, Performs, Electronic and Speciality Shapes, 1988, Noyes Publications, New Jersey, USA.
3. Bunshah.R.F. (Ed), Films and Coatings for Technology, 1982, Noyes Date Corp., New Jersey, USA.
4. Hocking, M.G., V.Vasantasree and P.S.Sidky, Metallic and Ceramic Coatings, 1989, Longman.
5. Kenneth Shaw, Ceramic Glazes, 1971, Elsevier Publishing Co., NY.
6. Emmanuel Cooper, The Potter Book of Glaze Recipes, 1986, B.T. Batsford Ltd, London.

**CR8008 CERAMIC FIBRES AND COMPOSITES L T P C
3 0 0 3**

OBJECTIVE

The course is aimed to impart basic knowledge about composites, whiskers and fibres with their properties, manufacturing routes and applications.

OUTCOME

On completion of the course the students are expected to

- Have a basic understanding about whiskers and their forming mechanism.
- Have learnt about various fibres, their properties and applications.
- Have basic knowledge about manufacturing of composites.

UNIT I CERAMIC FIBRES 9

Introduction – difference between material in bulk form and fibre form – types of fibres – fibre flexibility -fibre manufacturing technology, – glass fibres – manufacture & applications – carbon and graphite fibres – PAN based, pitch based , vapor grown – manufacture (PAN based), grades of carbon fibres.

UNIT II REFRACTORY FIBRES 9

Alumina silicate, mullite, alumina, silica, zirconia aramid and boron fibres - structure, fibre manufacturing process, properties and applications; silicon carbide fibre – manufacturing process – CVD, polymer pyrolysis , properties and applications.

UNIT III WHISKERS 9

Whisker forming mechanism, VLS, CVD, silicon carbide, boron carbide and strontium hexa-aluminate whiskers and platelets microstructure, properties and application.

UNIT IV COMPOSITES 9

Introduction to composite materials – definition, characteristics, classification; Matrix Materials – polymers, metals and ceramics; Fabrication of thermosetting resin matrix composites, thermoplastic resin matrix composites, metal matrix composites, ceramic matrix composites, carbon – carbon composites.

Attested
Sobhan
DIRECTOR

UNIT V CHARACTERIZATION**9**

Physical – density, constituent weight and volume fractions, void volume fraction, thermal expansion co-efficient, moisture absorption and diffusivity, moisture expansion co-efficients; Mechanical properties – properties in tension, compression, in place shear properties, flexural properties, impact properties; damage identification using non destructive evaluation techniques – ultrasonics, acoustic emission, x-ray, thermography, laser shearography.

TOTAL : 45 PERIODS**REFERENCES**

1. Chawla, K.K., Ceramic Matrix Composites, 1993, Chapman & Hall, NY.
2. Richard Warren, Ceramic-Matrix Composites, 1992, Blackie, Glasgow.
3. Mazdiyasmī, K.S., Fibre Reinforced Ceramic Composites, 1990, Noyes Publications, New Jersey.
4. Murray, J.G., High Performance Fibre Composites, 1987, Academic Press, NY.
5. Ashes, K.H.G., Fundamentals Principles of Fibre Reinforced Composites, 1989, Technomic Publishing Co. Inc.
6. Bhagwan D Agarwal, Lawrence J Broutman, K Chandrasekara., Analysis and Performance of Fiber Composites, 2006, Wiley Publications.

CR8009 ELECTRONIC CERAMIC MATERIALS AND THEIR APPLICATIONS**L T P C
3 0 0 3****OBJECTIVE**

The course is aimed to impart basic knowledge about ceramic materials used for electronic applications.

OUTCOME

On completion of the course the students are expected to

- Have a basic understanding about gas sensors and fuel cells, Piezo-electric Ceramics..
- Have learnt about various thermistors and varistors..
- Have basic knowledge about insulators and capacitors.

UNIT I CERAMIC INSULATORS**9**

Porcelain insulators, low tension and high tension, steatite, forsterite, cordierite and high alumina insulators, glass insulators. thermal and mechanical properties, dielectric properties, insulation resistance, electrical conduction, defects, diffusion, oxide conduction.

UNIT II CERAMIC CAPACITORS**9**

Properties of barium titanate, effect of various additives and composition on dielectric properties, manufacturing techniques – film capacitors, single layer discrete capacitors, multilayer capacitors, barrier layer, multilayer GBL capacitors.

UNIT III THERMISTORS AND VARISTORS**9**

NTC materials: solid solutions of oxides with the spinel structure, Fe_3O_4 , ZnCr_2O_4 , Fe_3O_4 , MgCr_2O_4 , PTC materials - BaTiO_3 , SrTiO_3 and BLT materials, principles of operation, properties and applications, ZnO varistors, properties and applications.

Attested
Sobhan
DIRECTOR

UNIT IV PIEZO – ELECTRIC CERAMICS 9

Preparation of various types of PZT ceramics, effect of additives, various types of PZT and PLZT devices, PMN, PMMN their properties and applications, actuators.

UNIT V GAS SENSORS AND FUEL CELLS 9

Sensors – principle, types - Zirconia and titania based gas sensors, properties and applications, humidity sensors, fuel cells – principle of operation , fuel cell reaction, types, hydrogen oxygen fuel cell, carbon-oxygen, hydrazine and ammonia fuel cells, high temperature fuel cell, applications.

TOTAL : 45 PERIODS

REFERENCES

1. Moulson, A.J., and J.M. Herbert, Electroceramics, 1990, Chapman and Hall, London.
2. Levinson, M.L., Electronic Ceramics, 1988, Marcel Dekker, NY.
3. Buchanan, R.C., Ceramic Materials for Electronics, 1986, Marcel Dekker, NY.
4. Steele, B.C.H., Electronic Ceramics, 1991, Elsevier Applied Science, London.
5. Setter, N. and E.L.Colla, Ferroelectric Ceramics, 1993, Birkhauser Verlag, Base.

CR8010

ENVIRONMENTAL ENGINEERING

**L T P C
3 0 0 3**

OBJECTIVE

The course is aimed to impart basic knowledge about pollution and its control techniques.

OUTCOME

On completion of the course the students are expected to

- Have a basic understanding about atmospheric dispersion of pollutants.
- Have learnt about various choice of equipments selection.
- Have basic knowledge about control procedures and various filtration techniques.

UNIT I POLLUTION DYNAMICS 9

Air pollutants – transportation - introductory treatment of atmospheric dispersion of pollutants - Diffusion of stack effluents.

UNIT II EQUIPMENT SELECTION 9

Choice of techniques - selection of equipment for the treatment of gaseous particulate and liquid effluents of chemical, petrochemical and ceramic industries.

UNIT III TREATMENT AND DESIGN 9

Waste disposal and treatment for the recovery of valuable chemicals, design of pollution control devices, design of chimneys, stacks for pollution control

UNIT IV CONTROL TECHNIQUES AND EQUIPMENTS 9

Counter current wet scrubber, venturi scrubber, absorption system design, adsorption and combustion devices, bag filters, electrostatic precipitation, reverse osmosis, recycle systems and sustainable development.

UNIT V CONTROL PROCEDURES

9

Sampling procedures, analytical methods, odours and their control, noise pollution and abatement, high voltage transmission and safety, legislative aspects of management. Pollution Act.

TOTAL : 45 PERIODS

REFERENCES

1. Theodore L. and Buomlore A.J, Air Pollution Control Equipments, Prentice Hall Inc., N.Y,1982
2. Coulson, J.M.Richardson, J.F. and R.K. Sinott, Chemical Engineering., Vol.6, Pergamon Press, 1989.
3. Rao, C.S, Environmental Pollution Control Engineering, Wiley – Eastern Ltd., 1991.
4. Rao, M.N. and H.V.N.Rao, Air – Pollution, Tata McGraw Hill Pub.Co.,Ltd.1989
5. V.S.Sastri and Edward Ghalai, Corrosion-Prevention & Protection, A John Willey Sons, 2007.

CR8011

FUELS, FURNACES AND PYROMETRY

L T P C

3 0 0 3

OBJECTIVE

The course is aimed to enable the students to have a thorough knowledge on the fuels used and equipments involved in firing of a ceramic article, and the temperature measurement methods.

OUTCOME

On completion of the course the students are expected to

- Have a thorough knowledge on the different types of fuels and burners used based on the fuel type and the types of flame produced from burners.
- Have studied the different types of furnaces and their operation.
- Have a better knowledge on different types of kilns, their construction and working.
- Have a clear understanding on the temperature and heat measurement techniques in kilns and furnaces.

UNIT I FUELS

9

Definition. Solid fuels – wood, coal, agro based fuels and its qualities. Liquid fuels – liquid petroleum products, synthetic liquid fuels, bio fuels. Gaseous fuels – LPG, producer gas, water gas, other gaseous fuels – characterization of coal, coal washing, blending, carbonization of coal, manufacture of coke and recovery by products, pulverized coal.

UNIT II BURNERS AND COMBUSTION

9

Burner – classification, atomization, low pressure burner for gaseous fuel, high pressure burner for liquid fuels, advantage & disadvantage of different burners. Air requirement, combustion processes of solid, liquid, gaseous fuels, control of combustion process, combustion stoichiometry. Flames – nature of flames, laminar & turbulent, premixed & diffusion, burning velocity.

Attested

Sobhan
DIRECTOR

Centre For Academic Courses
Anna University, Chennai-600 025.

UNIT III FURNACES 9

Introduction, definition, various parts of furnaces classification and description of different types of furnaces– metal heating furnaces, reheating furnace, continuous furnace, sintering furnace, crucible furnaces, electric furnace, unit melters and smelters, muffle furnace, glass tank furnace, chamber furnace, blast furnace, coke oven batteries. Prevention of energy losses in furnace.

UNIT IV KILNS 9

Introduction, definition, classification – draught kiln, chamber kiln, tunnel kiln, roller kiln, rotary kiln, continuous kiln, shuttle kiln, top hat kiln, muffle kiln, Hoffman's kiln – principle, materials used in foundation and construction, working.

UNIT V PYROMETRY 9

Introduction and thermometry, thermocouples, radiation pyrometers, low temperature measurement, temperature control, heat work recorders – Segar cone, Holdcroft's bar, Buller rings, Watkin recorders.

TOTAL : 45 PERIODS

REFERENCES

1. Samir Sarkar, Fuels and Combustion, 2nd Edn., Orient Longman, Bombay, 1990.
2. Om Prakash Gupta, Elements of Fuels, Furnaces and Refractories, Khanna Publishers, 1995.
3. Suryanarayana A.V.K, Fuels, Furnaces, Refractories and Pyrometry, BS Publications, 2005.
4. Robert D.Reed, Furnace Operation, Gulf Publishing Co., Paris, 1991.
5. Shaha A.K, Combustion Engineering and Fuel Technology, Oxford & IBH Publishing Co., New Delhi, 1974.
6. Daniel Rhodes, Kilns: Design, Construction and Operation, Chilton Book Co., Pennsylvania, 1974
7. Wilfrid Fransis & Martin C.Peters, Fuels and Furnace Technology, Pergmon Press, 1990.

**CR8012 GLASS ENGINEERING L T P C
3 0 0 3**

OBJECTIVE

The course is aimed to impart basic knowledge on manufacture, properties and applications of glass.

OUTCOME

On completion of the course the students are expected to

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

UNIT I GLASS FORMATION

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-Al₂O₃-SiO₂, Na₂O-CaO-SiO₂ etc.

10
Attested
Sobhan
DIRECTOR
Centre For Academic Courses
Anna University, Chennai-600 025.

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

REFERENCES

1. James E. Shelby, Introduction to Glass Science & Technology, The Royal Society of Chemistry, 1997.
2. Paul, Chemistry of Glasses, 2nd Edn, Chapman & Hall, 1990.
3. 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.
4. Tooley F.V, Handbook of Glass Manufacture, Vol I&II, Ogden Publishing Co., NY, 1960.
5. A. Charles A Harper, Handbook of Ceramic Glasses & Diamonds, McGraw Hill, 2001.
6. Glass Furnaces-Design, Construction & Operation, Wolfgang Trier, Society of Glass Technology, 2000.
7. Volf V.B, Technical Approach to Glass, Elsevier, 1990.
8. Adalbert Feltz, Amorphous Inorganic Materials and glasses, VCH Verlagsgesellschaft mbH, 1993.
9. BO Mysen and P.Richet, Silicate Glasses & Melts, Properties and Structure, Elsevier, 1986.
10. Narottan P.Bansal & R.H. Doremus, Handbook of Glass Properties, Elsevier, 1986.
11. Charles.A.Harper, Handbook of Ceramics, Glasses and Diamonds, McGraw Hill, 2001.
12. Glass & Ceramic Technology, NIIR Board of Consultants & Engineers, Asia Pacific Business Press Inc.
13. James F.Shackelford, Ceramic & Glass Materials, Springer, 2008.
14. M.Cable and J.M. Parker, High Performance Glasses, Blackie, Glasgow & London published by Chapman and Hall, Newyork 1992.

OBJECTIVE

The course is aimed to enable the students to have a sound knowledge about the methods to recover the waste heat from furnaces and also methods to minimize wastage of heat.

OUTCOME

On completion of the course the students are expected to

- Have a thorough knowledge on thermal operation of furnaces.
- Have studied the various heat exchange equipments like heat exchangers, boilers, calandrias and extended surface equipments.
- Have learnt the types, design and construction of regenerators.
- Have learnt the types, design and construction of recuperators.
- Have understood the methods of minimizing heat loss and heat consumption in furnace by proper design.

UNIT I ENERGY BALANCE IN FURNACE 9

Temperature and thermal conditions in furnace, calculation of thermal operation of furnaces – heat balance & heat capacity of furnace, furnace efficiency, furnace productivity and durability.

UNIT II HEAT EXCHANGERS 9

Definition, types of exchangers – parallel & counter flow exchangers, single pass 1-1, multi pass 1-2 & 2-4. Heat transfer coefficients in heat exchangers. Boilers and calandrias, extended surface equipments – types, efficiency and calculation, fouling of heat exchangers.

UNIT III REGENERATORS 11

Principle of operation, types of regenerators, design and construction, materials of construction and applications, performance estimation.

UNIT IV RECUPERATORS 8

Principle of operation, types of recuperators, design, applications, comparison over regenerator.

UNIT V ENERGY CONSERVATION DESIGNS 8

Prevention of energy loss in furnace – insulation, coatings, low thermal mass materials – importance, design and applications.

TOTAL : 45 PERIODS**REFERENCES**

1. Glinkov M.A and Glinkov G.M, A General Theory of Furnaces, Mir Publishers, Moscow, 1980.
2. Perry R.H and Green D (eds), Perry's Chemical Engineers' Handbook, 6th Edn., McGraw-Hill, New York, 1984.
3. Shaw K, Refractories and their Uses, App. Science Publishers, UK, 1972.
4. Robert E.Fisher (ed), Advances in Refractory Technology, Ceramic Transaction Vol 4, American Ceramic Society, 1990.
5. Warren L.McCabe, Julian C.Smith and Peter Harriott, Unit Operations of Chemical Engineering, 7th Edn., McGraw Hill International Edition, 2005.
6. Industrial Furnaces, Vol I, 4th Edn.

Attested

Sobhan
DIRECTORCentre For Academic Courses
Anna University, Chennai-600 025.

OBJECTIVE

The course is aimed to impart basic knowledge about powder processing, densification in kilns, machining, polishing and testing.

OUTCOME

On completion of the course the students are expected to

- Have a basic understanding about powder making and densification.
- Have learnt about various inspection and testing methods to maintain the standards.
- Have basic knowledge about ceramic machining and surface finishing techniques.

UNIT I POWDER PROCESSING AND SHAPE FORMING PROCESSES 9

Spray drying, precipitation, freeze drying, Sol-Gel, CVD, grinding and milling, agglomeration and de agglomeration, slip casting, injection molding, hot iso-static pressing, doctor blade processing.

UNIT II DENSIFICATION 9

Solid state and liquid state sintering, effect of sintering variables, pressure assisted sintering, super plastic forming, self propagating high temperature synthesis, forming from vapour phase, consolidation of ceramic fibres and whiskers.

UNIT III CERAMIC MACHINING AND SURFACE FINISHING 9

Surface grinding and mechanical polishing, non-abrasive finishing, effect of surface finishing properties, ceramic coating - joining of ceramics, mechanical joints, vacuum joints, diffusion bonding, joining by laser.

UNIT IV INSPECTION AND TESTING 9

Visual inspection, intrinsic and extrinsic defects, non-destructive evaluation using X-Ray technique, microwave technique, ultrasonic technique, SEM, TEM laser and acoustic imaging, failure analysis, special acceptance tests.

UNIT V STANDARDS 9

Product standards and standardization, manufacturing system standards and standardizations, ISO, BS, ASTM, IEC, DIN, EN and NEMA.

TOTAL : 45 PERIODS**REFERENCES**

1. McColm, I.J and N.J., Clark, Forming Shaping and Working of High Performance Ceramics, Blackie, London.
2. Richardson, D.W., Modern Ceramic Engineering Properties, Processing and use in design, 1992, Marcel Dekker, Inc., NY.
3. Wang, F.F.Y., Treatise on Materials Science and Technology, Vol.A., Ceramic Fabrication Processes, 1976, Academic Press, NY.
4. Rahaman. M.N., Ceramic Processing and Sintering, 1995, Marcel Dekker, Inc., NY.
5. Loehman, R.E., Characterization of Ceramics, 1993, Butterwoth-Heinemann, Boston.
6. P.ramakrishnan and Mohan Primlani, Advanced Ceramics, Oxford ISHPublications Pvt.Ltd, 1992.
7. Robert B. Heimann, Classic and Advanced Ceramics, Wiley VCH verleg gmbh & Co, 2010

Attested
Sobhan
DIRECTOR

Centre For Academic Courses
Anna University, Chennai-600 025.

OBJECTIVE

The course is aimed to enable the students to have a sound knowledge about the types, properties and applications of monolithics and castables.

OUTCOME

On completion of the course the students are expected to

- Have learnt the types of castables, its composition and characteristics.
- Have studied about the composition and characteristics of plastic refractories, ramming and gunning mixes, mortars, coatings and dry vibratables.
- Have a clear idea on the methods of installing different monolithic materials, the application design and have studied the wear mechanisms and methods to test a monolithic.

UNIT I CASTABLES 10

Introduction, types – conventional castables, low cement castables, ultra low cement castables, cement free castables – manufacture, composition, characteristics, applications. Other castables – insulating castables, pumpable castables – manufacture, composition, characteristics and applications.

UNIT II PLASTIC REFRACTORIES, RAMMING AND GUNNING MIXES 10

Plastic refractories – introduction, manufacture, composition, properties and applications. Ramming mix – manufacture, characteristics and applications. Gunning mix – manufacture, characteristics and applications.

UNIT III MORTARS, COATINGS AND DRY VIBRATABLES 7

Mortars – introduction, classification, characteristics. Coatings – introduction, characteristics. Dry vibratables – introduction, principle and applications.

UNIT IV MONOLITHIC INSTALLATION 10

Methods of installations of castables, plastic refractories, ramming mix and gunning mix. Drying and heating up of installed monolithic lining. Application designs – blast furnace trough design, trough lining, and form design, tundish, steel ladle, electric arc furnace. Linings in installation – anchors, steel fibre reinforcements.

UNIT V PROPERTIES AND TESTING METHODS 8

Tests done on monolithics – chemical analysis, density, porosity, strength, high temperature properties, wear - corrosion, erosion, penetration, spalling.

TOTAL : 45 PERIODS

REFERENCES

1. Subrata Banerjee, Monolithic Refractories, World Scientific Publishing Co. Pte. Ltd., 1998.
2. Taikabutsu Overseas Vol.9 No.1, Recent Progress in Castable Refractories, Techno Japan, Fuji Marketing Research Co. Ltd., Japan, 1995.
3. Charles A. Schacht, Refractories Handbook, Marcel Dekker Inc, New York, 2004.
4. Norton F.H, Refractories, 4th Edn., McGraw Hill Book Co., 1968.
5. Nandi D.N, Handbook of Refractories, Tata McGraw-Hill Publishing Co., New Delhi, 1991.
6. Akira Nishikawa, Technology of Monolithic Refractories, Plibrico, Japan Co. Ltd., Tokyo, 1984.
7. David R. Lankard, Monolithic Refractories, ACI Committee 547, Refractory Concrete, 1982.
8. Robert E. Fisher, New Developments in Monolithic Refractories, ACI Committee 547, Refractory Concrete, 1985.

OBJECTIVE

The course is aimed to enable the students to have a basic knowledge about the various non-destructive methods of testing.

OUTCOME

On completion of the course the students are expected to

- Have studied the basic concepts of non-destructive testing and surface NDT methods
- Have learnt about small business and preparation of feasibility chart.
- Have a basic knowledge about establishment of a business.
- Have learnt about how to manage a business unit.
- Have some basic concepts about promotion of entrepreneurship and practical knowledge about some case studies.

UNIT I SURFACE NDT METHODS 7

Introduction- Definition of terms, discontinuities and defects/flaws- fracture mechanics concept of design and the role of NDT- life extension and life prediction- penetrant testing and magnetic particle testing - basic principle, limitations & advantages – development and detection of large flux – longitudinal and circular magnetization – demagnetization.

UNIT II RADIOGRAPHIC TESTING 12

Electromagnetic spectrum – sources - x-ray, gamma ray – x-ray generation, spectrum, equipment controls, properties, attenuation and differential attenuation- interaction of radiation with matter – radiographic testing – principle and mechanism, recording medium- films and fluorescent screens- non-imaging detectors- film radiography detectors- film radiography- calculation of exposure for X-ray and gamma rays- quality factors- image quality indicators and their use in radiography.

UNIT III ULTRASONIC TESTING 10

Ultrasonic waves- velocity, period, frequency and wavelength- reflection and transmission- near and far field effects and attenuation- generation- piezoelectric and magnetostriction methods- normal and angle probes- methods of Ultrasonic testing- Principle of pulse echo method- Equipment – examples- rail road inspection, wall thickness measurement- range and choice of frequency.

UNIT IV EDDY CURRENT TESTING 8

Introduction- principles of eddy current inspection- conductivity of a material- magnetic properties- coil impedance- lift off factor and edge effects- skin effect- inspection frequency- coil arrangements - inspection probes- types of circuit- Reference pieces- phase analysis-display methods-typical application of eddy current techniques.

UNIT V OTHER METHODS 7

Imaging- principle and applications- testing of composites- acoustic emission testing- application of AET- on-line monitoring or continuous surveillance and application in materials science- optical methods of NDT- photo elasticity- evaluation procedure- Holographic NDT procedure- Speckle phenomenon- speckle interferometry-speckle shear interferometry.

TOTAL : 45 PERIODS**REFERENCES**

1. B.Hull and V.John, Non Destructive Testing, McMillan Education Ltd, 1968.
2. Metals Handbook, Volume 2, 8th Edn, ASTM, Metals Park, Ohio.
3. Dainty, Laser Speckle & Related Phenomena, Springer – Verlag, New York, 1984.
4. Mc Gonnagle, W.J, Non-destructing testing methods, Mc Graw Hill Co., NY, 1961.
5. Jayakumar T, Baldev Raj and Thavasimuthu M, Practical Non-destructive Testing, Narosa Publishing House, 2012.

OBJECTIVE

The course is aimed to enable the students to the basic concepts of ceramic materials used for nuclear and space applications.

OUTCOME

On completion of the course the students are expected to

- Have studied the basic concepts of nuclear physics.
- Have learnt about the nuclear reactors.
- Have studied in detail about the production and properties of various fuels.
- Have studied about the radiation protection.
- Have studied the basics about space ceramics.

UNIT I NUCLEAR REACTORS 9

Types of reactors- ordinary water moderated reactors- heavy water cooled and moderated reactors- design, construction and control of nuclear reactors- moderators- coolants- reflectors and structural materials.

UNIT II CERAMICS IN NUCLEAR REACTORS 9

Structure, preparation and properties of oxides, carbides, nitrides and composites used in nuclear reactors.

UNIT III NUCLEAR FUEL 9

Different physical forms of nuclear fuels, nuclear fuel cycle, spent fuel characteristics, post irradiation examination, reprocessing techniques.

UNIT IV RADIATION PROTECTION 9

Types of nuclear waste - disposal- ICRP recommendations- radiation hazards and prevention- radiation dose units.

UNIT V SPACE CERAMICS 9

Materials aspects of missile and satellite re entry- aerospace nuclear propulsion technology, auxiliary space powder devices- rocket nozzle technology- the space environment and its effects.

TOTAL : 45 PERIODS

REFERENCES

1. Merrite L.C, Basic Principles of Nuclear Science and Reactors, Wiley Eastern, 1977.
2. Benedict M and Pigter T.A, Nuclear Chemical Engineering, McGraw Hill, 1981.
3. Norton, F.H, Fine Ceramics, Technology and Applications, McGraw Hill, London, NY, 1970.
4. Terpstra, Ceramic Processing, Chapman and Hall, 1995.
5. Gan-Moog, chow and Kenneth E Gonslaves, Nanotechnology, American Chemical Society, 1996.

Attested

Sobhan
DIRECTOR

Centre For Academic Courses
Anna University, Chennai-600 025.

OBJECTIVE

The course is aimed to impart basic knowledge about numerical solutions of partial differential equations.

OUTCOME

On completion of the course the students are expected to

- Have a basic understanding about interpolation and approximation..
- Have learnt about various numerical solutions for ordinary and partial differential equations.
- Have basic knowledge about perturbation theories.

UNIT I INTERPOLATION AND APPROXIMATION 9

Piecewise spline approximation, uniform approximation, rational approximation

UNIT II NUMERICAL SOLUTIONS OF ORDINARY DIFFERENTIAL EQUATION 9

Euler Method, Improved Euler Method, Modified Euler method, Runge Kutta Method of Second and Fourth orders, Predictors – Corrector Methods of Milne and Adams – Bashforths.

UNIT III NUMERICAL SOLUTIONS OF PARTIAL DIFFERENTIAL EQUATIONS 9

Second order equations, elliptic, parabolic, hyperbolic types using finite difference methods.

UNIT IV FINITE ELEMENT METHODS 9

One dimensional stress deformation, global and local co-ordinates, one dimensional problems, interpolation functions, relations between global local coordinates, requirements for approximation functions, stress and strain relations, principle of minimum potential energy, potential energy approach for assembly, boundary conditions.

UNIT V PERTURBATION METHOD 9

Perturbation theory, Regular and singular Perturbation Theory. Perturbation methods for linear Eigen Value problems, asymptotic matching

TOTAL : 45 PERIODS

REFERENCES

1. Jain M.K, S.R.K.Iyengar and R.K.Jain, Numerical Methods for Simple and Engineering Computation, Eastern Ltd 1995.
2. Desai C.S. Elementary Finite Methods, Prentice Hall 1922 Ch.2&3
3. Bender C.M and S.A Orzag, Advanced Mathematical Methods for Scientists and Engineers, McGraw Hill, International Edition 1998.

Attested

Sobhan
DIRECTOR

Centre For Academic Courses
Anna University, Chennai-600 025.

OBJECTIVE

The course is aimed to impart basic knowledge about linear programming and the various control methods.

OUTCOME

On completion of the course the students are expected to

- Have a basic understanding about linear programming and its branches.
- Have learnt about various control methods and path calculations of a process in inline.
- Be capable of understanding failure distributions.

UNIT I MATHEMATICAL PROGRAMMING 12

Introduction, linear programming, solution by simplex methods, duality, sensitivity analysis, dual simplex method, integer programming, branch and bound method.

UNIT II DYNAMIC PROGRAMMING 9

Elements of DP models, Bellman's optimality criteria, Recursion formulae, solution of multistage decision problem by DP method.

UNIT III PERT, CPM 9

Network representation of projects, critical path calculation, construction of the time chart and resource leveling, probability and cost consideration in project scheduling, project control.

UNIT IV ELEMENTS OF QUEUING THEORY 8

Basic elements of the Queuing model, M/M/I and M/M/C Quenes.

UNIT V ELEMENTS OF RELIABILITY THEORY 7

General failure distribution of components, Exponential failure distributions, General model, maintained and non-maintained systems.

TOTAL : 45 PERIODS

REFERENCES

1. Hamdeh A. Taha, Operations Research, An introduction, Macmillan Publishing Co., Third Edition, 1982(Ch 3,4,8,9,12 and 15 except 15.4, 15.5 and 15.6).
2. Narayan Bhat.U., Elements of Applied Stochastic Processes, John Wiley and Sons, 1972, Chennai 12

**CR8020 PROCESS MODELLING, SIMULATION & OPTIMISATION LT P C
3 0 0 3****OBJECTIVE**

The course is aimed to impart basic knowledge about Modelling, Optimization and modelling of heat, mass and momentum transfer operations.

OUTCOME

On completion of the course the students are expected to

- Have basic understanding about formulation, analytical and numerical techniques.
- Have learnt about various optimization techniques.
- Have basic knowledge about model discrimination, parameter estimation and transfer operations.

Attested

Sobhan
DIRECTOR

Centre For Academic Courses
Anna University, Chennai-600 025.

UNIT I BASIC MODELLING 9
Introduction of modeling, Application and Scope Of Coverage, Formulation, Review of Algebraic Equators, Ordinary and Partial Differential Equation. Analytical and Numerical Techniques, Smoothing Techniques, Spline function approximations.

UNIT II MODELLING OF HEAT, MASS AND MOMENTUM TRANSFER OPERATIONS 9
Review of heat, mass and momentum transfer operations, Modelling of heat Exchangers, Evaporators, Absorption Columns, Extractors, Distillation columns, Membrane processes.

UNIT III MODEL DISCRIMINATION AND PARAMETER ESTIMATION 9
Rate equations, Linear and Non-Linear Regression Analysis, Design of Experiments, Factorial, Central, Fractional Design, Evolutionary Operation Techniques, Case studies.

UNIT IV OPTIMIZATION TECHNIQUES 9
Functions, Analytical and numerical methods for single variable and multivariable system, Constrained optimization techniques.

UNIT V APPLICATION OF OPTIMIZATION 9
Heat transfer and energy conservation, separation techniques, Fluid Flow Systems, Chemical Reactor Design.

TOTAL : 45 PERIODS

REFERENCES

1. Edgar, T.F. and D.M.Himmelblau, Optimization of Chemical Processes, McGraw Hill Book Co. NewYork, 1989.
2. Lubeyn W.L., Process Modelling, Simulation and Control Engineering, McGraw Hill Book Co. NewYork, 1990.
3. Chemical Engineering Tutorial Numerical Methods, Chemical Engineering, August 17, October 26, 1987 Feb.15, April 25, July 18, Nov.21 1988, July 14, 1989.
4. Chemical Engineering Tutorial Statistics for Chemical Engineers, Chemical Engineering, July.23, Sep.17, Nov.26, 1984. Jan.21, Mar.18, Jun.10, Sep.30, 1985, Feb.3, Apr.14, Jun.23, Sep.1, 1986.

CR8021 PROPERTIES AND APPLICATIONS OF STRUCTURAL CERAMICS

L T P C
3 0 0 3

OBJECTIVE

The course is aimed to impart basic knowledge about structural ceramics, its properties, and applications.

OUTCOME

On completion of the course the students are expected to

- Have a basic understanding about microstructure, nature of grain boundaries.
- Have learnt about elastic modulus, thermal shock resistance, etc.
- Have basic knowledge about mechanical, optical and chemical applications of structural ceramics.

UNIT I MICROSTRUCTURE

Quantitative analysis of texture, nature of grain boundaries, development of microstructure, grain growth, microstructure in glass ceramics, effect of particle size, pressure and sintering, dependence of mechanical and thermal properties on microstructure.

9
Attested
Sobhan
DIRECTOR
Centre For Academic Courses
Anna University, Chennai-600 025.

UNIT II MECHANICAL PROPERTIES AT ROOM TEMPERATURE 9

Elastic modulus, tensile and flexural strength, hardness, fatigue, fracture, wear, mechanical shock.

UNIT III MECHANICAL PROPERTIES AT ELEVATED TEMPERATURES 9

Thermal expansion, thermal conductivity, thermal shock resistance, creep, oxidation, long term stability under severe environmental conditions, toughening of ceramics, tensile & flexural strength (ASTM Standard).

UNIT IV MECHANICAL APPLICATIONS 9

Wear resistance, rolling element bearings, cutting tool, IC engine, gas turbine, design considerations and failure analysis, material selection.

UNIT V SPECIAL APPLICATIONS 9

Infra red window materials, lamp envelopes, chemical degradation, nuclear waste storage materials, nuclear fuels and fuel cell, ceramic membranes, ceramic armours, ceramic radomes.

TOTAL : 45 PERIODS

REFERENCES

1. Richardson D.W., Modern Ceramic Engineering Properties, Processing and Use in Design, 1992, Marcel Dekker, New York.
2. Howlett, S.P. and D.Taylor (Ed), Special Ceramics, Vol.8 1986, The Institute of Ceramics Shelton, Stock On- Trent, Staff, U.K.
3. Wachtmen, J.B., Structural Ceramics, Treatise on Materials Science and Technology, Vol.29, 1989, Academic Press Inc., NY.
4. Mellinger, G.B. Nuclear Waste Management 3, Ceramic Transactions, Vol.9., 1990, The American Ceramic Society Inc., Westerville, Ohio, USA.
5. Ales Koller, Structure and Properties of Ceramics, 1994, Elsevier, Amsterdam.
6. Loehman, R.E., Characterization of Ceramics, 1993, Butterworth-Heinemann, Boston.
7. P. Ramakrishnan and Mohan Primplani, Advanced Ceramics, Oxford ISH Publications Pvt.Ltd, 1992.
8. Robert B. Heimann, Classic and Advanced Ceramics, Wiley VCH verleggbmh& co, 2010.

CR8022 QUALITY CONTROL AND MANAGEMENT IN CERAMIC INDUSTRIES

L T P C

3 0 0 3

OBJECTIVE

The course is aimed to impart basic knowledge about standardization, quality and preparation of quality manual to keep up with the best end use property.

OUTCOME

On completion of the course the students are expected to

- Have a basic understanding about concepts of quality and standardization.
- Have learnt about various tools for quality control.
- Have basic knowledge about quality cost and preparation of quality manual.

Attested

Sobhan
DIRECTOR

Centre For Academic Courses
Anna University, Chennai-600 025.

UNIT I	CONCEPTS OF STANDARDISATION	9
Historical development of standards, aims, techniques, management, formulation, implementation of company standards, economic benefits of standardization.		
UNIT II	CONCEPTS OF QUALITY	9
Definition of quality, quality related terminology, key terms of quality systems, quality management, assurance and audit as per ISO 9000 guidelines.		
UNIT III	TOOLS OF QUALITY CONTROL	9
Tools of quality management, concepts and management of quality assurance, quality system, quality loop, quality management and its relationship to overall management.		
UNIT IV	PREPARATION OF QUALITY MANUAL	9
Internal quality audit, audit management, external quality audit, quality certification, quality system maintenance.		
UNIT V	QUALITY COST	9
Quality improvement, concepts of TQC, TQM, KANBAN, JIT, continuous improvement, HRD in quality management, quality circles, Dr.Deming's 14 point Management Concept.		

TOTAL : 45 PERIODS

REFERENCES

1. Juran, J.M. and F.M. Gryna, Jr., Quality Control Handbook, 4th Edition, 1988, McGraw Hill Book Co., NY.
2. Murthy, M.N., (Ed) Excellence Through Quality and Reliability, 1989, Applied Statistic Centre, Madras.
3. Madhav N.Sinha and Walten W.O.Willborn, The Management of Quality Assurance, 1985, John Wiley & Sons, NY.
4. Guide on Company Standardization by Institute of Standards Engineers, 1989.
5. Total Quality Control at Enterprise Level BY International Trade Centre (UNCTAD/GATT/GENEVA), 1986 (Division of United Nations) – Published in India by CMTI – Perfect Machine Tool Trust, Bangalore in Association With National Centre for Quality Management.
6. International Organization for Standardization, 1992, Case Postale 56, CH-1211-Geneve 20, Switzerland, ISO 9000 Compendium, Vision 2000, ISBN 92- 67, 101722
7. H.Lal, Total Quality Management, New Age International Publications, 1990

CR8023

SAFETY ENGINEERING

L T P C
3 0 0 3

OBJECTIVE

The course is aimed to impart basic knowledge about hazards, its effects, safety and waste management together with risk analysis.

OUTCOME

On completion of the course the students are expected to

- Have a basic understanding about hazard identification and checks for safety.
- Have learnt about various waste management techniques.
- Have basic knowledge about risk analysis, format and methods.

Attested
Sobhan
DIRECTOR

Centre For Academic Courses
Anna University, Chennai-600 025.

UNIT I GENERAL 10
Safety - total definition - hazard identification, general hazards of plant operation, toxic hazards, fire & explosions – hazards transport of chemicals with safety unforeseen deviations emergency management, planning for safety, selecting basis of safety preventive and protective measures, safety based on emergency, relief systems, safety based on containment, operational safety procedural instructions Sla-routine checks, process and product charges, safety checks, checklist for safety, leaks and detection.

UNIT II HAZARDS AND EFFECTS 10
Hazards of plant operation, toxic hazards, fire and explosion hazards, reaction hazards, literature calculations & explosions screening, normal reaction, gas evolution, characterizing runaways, control and mitigation of gas emanations, absorption with chemical reaction, health and environ effects.
special problem of developing countries, safety gadgets, dispersions, degree of hazard, disposals, hierarchy of options, I.C.A. application, nil hazards & alternate methods, threshold limits, laws of safety, accident reporting.

UNIT III WASTE MANAGEMENT AND ECONOMICS 10
Storage, central handling safety, unintentional spills, run offs emits, containment economics, waste disposal and environmental projection, incineration, alternatives.

UNIT IV RISK ANALYSIS 15
Risk analysis, evaluation, mitigation, hazop, hazan, definition, probability, quantification-risk, engineering, clean technology, initiatives, standards, emergency handling, accident investigation, legislation, nil risk quantification methods, case histories of accidents, examples of hazards assessment, examples of use of hazan, explosion hazards in batch units, technical process, documentation for hazardous chemicals, format and methods.

TOTAL: 45 PERIODS

REFERENCES

1. Rohatga.A.K. Safety Handling of Hazardous Chemicals Enterprises, Bombay (1986).
2. Shukla.S.K.-Enviro Hazards and Techno Legal Aspects, Shashi Publications, Jaipur-India(1993).
3. Wells G.L. and R.M.C.Seagrave –Flow Sheeting for Safety, I.Ch.E.London, U.K.(1977).
4. Learning from Accidents- Trevur Kletz Butterworths London U.K.(1988).
5. Chemical Reaction Hazards – A Guide to Safety, Institution of Chemical Engineering London U.K. Ed by John Barton and Richards Rogers (1997).

CR8024

SPECIAL GLASSES

**L T P C
3 0 0 3**

OBJECTIVE

The course is aimed to enable the students to have a thorough knowledge about the special applications of glasses in various fields.

OUTCOME

On completion of the course the students are expected to

- Have a clear understanding on the types and properties of heat resistant and safety glasses.
- Have studied the manufacture, types and applications of optical glasses.
- Have studied the composition of glass fibres and optical fibres, and their applications.

- Have learnt the composition, preparation and properties of glass ceramics.
- Have a knowledge on the methods and types of coatings on glass, their applications and quality control.

UNIT I HEAT RESISTANT AND SAFETY GLASSES 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

REFERENCES

1. Lewis M.H, Glasses and Glass Ceramics, Chapman and Hall, London, 1989.
2. Philips C.J, Glass, Its Industrial Applications, Reinhold Publishing Co., NY, 1960.
3. Cable M and Parker M.J, High Performance Glasses, Chapman and Hall, NY, 1992.
4. Heinz G.Plaender, Schott Guide to Glass, Chapman and Hall, 1996.
5. Hans Bach, Low Thermal Expansion Glass Ceramics, Springer, 1995.
6. Zdencek Strand, Glass-Ceramic Materials, Elsevier, 1986.
7. Christroper.W.Sinton, Glass Ceramics, Sources, Processes and Quality Control, A John Wiley & Sons, 2006.

PROGRESS THROUGH KNOWLEDGE

Attested

 DIRECTOR

Centre For Academic Courses
 Anna University, Chennai-600 025.