### SEMESTER I

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### TOTAL NUMBER OF CREDITS TO BE EARNED FOR AWARD OF THE DEGREE 68

## LIST OF ELECTIVES

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

OBJECTIVES
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
Diffusion: Fick’s laws of diffusion – mechanism and applications.

UNIT II PHASE DIAGRAMS
Gibb’s Phase rule – thermodynamic criteria for phase stability – phase diagrams - single, binary and ternary phase diagrams – lever rule – applications of phase diagrams

UNIT III MECHANICAL PROPERTIES

UNIT IV ELECTRICAL AND ELECTRONIC PROPERTIES

UNIT V MAGNETIC, THERMAL AND OPTICAL PROPERTIES

TOTAL: 45 PERIODS

REFERENCES
CR9112

SCIENCE AND TECHNOLOGY OF

TRADITIONAL CERAMICS

L T P C

3 0 0 3

AIM
The course is aimed to impart basic knowledge about ceramic raw materials, body preparation,, glazing and firing behaviour.

OBJECTIVES
On completion of the course the students are expected to

• Have a basic understanding about ceramic raw materials and their properties.
• Have learnt about various body preparation techniques.
• Have basic knowledge about firing behaviour and manufacturing processes of specific products.

UNIT I RAW MATERIALS

UNIT II THEORY OF PACKING

UNIT III FABRICATION PROCESS

UNIT IV GLAZING

UNIT V DRYING & FIRING

TOTAL: 45 PERIODS
REFERENCES

CR9113 REFRACTORIES L T P C 3 0 0 3

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

OBJECTIVES
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

UNIT II ALUMINO SILICATE REFRACTORIES 9

UNIT III BASIC REFRACTORIES 9

UNIT IV SPECIAL REFRACTORIES AND MONOLITHICS 9

UNIT V APPLICATIONS OF REFRACTORIES IN FERROUS & NON FERROUS INDUSTRY & TESTING OF REFRACTORIES 9
REFERENCES

CR9114 MECHANICAL BEHAVIOR OF CERAMICS LTPC 3003

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

OBJECTIVES
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.
- Ave basic knowledge about thermal shock resistance parameters.

UNIT I FRACTURE MECHANICS
Elasticity and brittle fracture, elastic constants, elastic deformation of isotropic and crystalline materials, measurement techniques, variation of elastic constant with temperature and porosity - Theoretical strength and stress concentrations, Griffith theory - charpy, instrumented charpy, DBDT - linear elastic fracture mechanics, microstructural aspects, fractography, fracture testing technique, impact resistance, toughness, dynamic fracture toughness, linear, elastoplastic and mechanical.

UNIT II STRENGTH AND TOUGHENING
Tensile strength, statistical treatment – Weibull analysis, statistical treatment ,subcritical crack propagation, stable crack propagation and R-curve behaviour, microstructural aspects, time dependent strength behaviour, cyclic fatigue, experimental techniques, SPT diagram toughening mechanisms, phase transformation toughening.

UNIT III CREEP AND THERMAL SHOCK BEHAVIOUR OF CERAMICS
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 IV  FATIGUE AND WEAR
Fatigue of ceramics – mechanism, measurement, life time prediction, wear of ceramics – mechanism, measurement, microstructural dependence

UNIT V  MECHANICAL PROPERTIES OF CMC, GLASS & GLASS CERAMICS
CMC – elastic behaviour, fracture behaviour, toughening mechanism of reinforcement.
Glass – elastic behaviour, strength and fracture, strength improvement, strength of glass ceramics

REFERENCES

CR9115  PROCESSING AND TESTING OF CERAMICS

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

OBJECTIVES
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 Materials – Density, Porosity, Water absorption, Shrinkage, Flexural Strength – 3 point & 4 point, Compressive Strength, Tensile Strength, Rheology study
4. Firing Studies

TOTAL: 45 PERIODS
AIM
The course is aimed to impart basic knowledge about powder preparation techniques and modern ceramic processing.

OBJECTIVES
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

UNIT II  PROCESSING ADDITIVES  7
Types, Properties and Effect of addition of liquids and wetting agents, deflocculants, coagulants, binders, bonds, 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

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, joining of ceramics – metal ceramic joints.

TOTAL:45 PERIODS

REFERENCES
CR9122 MODERN CERAMIC MATERIALS L T P C 3 0 0 3

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

OBJECTIVES
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 CERAMICS & COMPOSITES FOR HOSTILE ENVIRONMENTS 9

UNIT II ELECTRONIC CERAMICS 9

UNIT III STRUCTURAL CERAMICS 8

UNIT IV SPECIAL GLASSES AND GLASS CERAMICS 10

UNIT V BIOMATERIALS 9
Introduction – biomaterials, bioceramics – composition, interaction with biological systems, properties, applications, shape memory alloys.

TOTAL: 45 PERIODS

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

OBJECTIVES
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
Chemical Methods – Volumetric, Gravimetric and Colorimetric analysis. Thermal Methods – TGA, DTA and DSC.

UNIT II UNSPECTROSCOPIC METHODS
U-V, Visible, IR, FTIR and NMR spectroscopy – fluorescence and phosphorescence methods – flame photometry – atomic absorption – ICP.

UNIT III X-RAY METHODS

UNIT IV METHODS FOR SURFACE ANALYSIS
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.

UNIT V NON-DESTRUCTIVE METHODS
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
AIM
The course is aimed to enable the students to have a thorough knowledge about the importance of phase equilibrium and analyzing different systems.

OBJECTIVES
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
Introduction, phase, component, variable, Gibb’s phase rule, single component system – H₂O, SiO₂, iron, Hume Rothery’s rule; binary phase diagrams – eutectic, incongruent, solid solutions, complex diagrams.

UNIT II THERMODYNAMICS OF PHASE EQUILIBRIA
Introduction, criteria of phase equilibrium, criterion of stability, phase equilibria in single component system and multi component system; binary solutions – constant pressure system, constant temperature system, partially miscible system, immiscible system, liquid-liquid equilibrium diagrams, ternary equilibrium diagrams.

UNIT III PHASE DIAGRAMS
Al₂O₃ – SiO₂, MgO – Al₂O₃, MgO – SiO₂, Al₂O₃ – ZrO₂, stabilized zirconia, K₂O – Al₂O₃ – SiO₂, MgO – Al₂O₃ – SiO₂, Na₂O – Al₂O₃ – SiO₂. Prediction of alkali corrosion of alumino silicate refractories using phase diagrams.

UNIT IV PHASE TRANSFORMATIONS
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 EXPERIMENTAL METHODS
Techniques for determining phase diagrams – dynamic, static, microscopic methods – optical, electron microscopy, X-ray methods, thermal analysis.

TOTAL: 45 PERIODS

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

OBJECTIVES
On completion of the course the students are expected to
1. To have a basic understanding about different methods of characterizing a ceramic sample.
3. Thermal Analysis – TGA, DTA, DSC.
4. Determination of Viscosity by Brookfield Viscometer.
5. Particle Size Analysis – Laser Diffraction.
6. Microscopy – Optical, SEM.
7. Vicker’s Hardness.
8. Modulus of Rupture – 3 point & 4 point
10. Surface Area Measurement – BET.
11. Atomic Force Microscope
12. Mercury Porosimetry

TOTAL: 30 PERIODS

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

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

UNIT II SYNTHESIS & CONSOLIDATION
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
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
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
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

CR9151  CERAMIC COATING TECHNOLOGY  L T P C
3 0 0 3

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

OBJECTIVES
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
Introduction to surface engineering & modification – wear, abrasion, oxidation resistance – need for coating on the body – advantages

UNIT II  GLAZE
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
Raw material selection, 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

UNIT V  ENAMELS  9
Cleaning methods for iron and steel, sheet metals – chemical claning – electrolytic
cleaning – pickling – sand blasting – de enamellin – repairing – cleaning treatment for

TOTAL: 45 PERIODS

REFERENCES
2. Klein, L., (Ed), Sol-Gel Technology for Thin Films, Fibres, Performs, Electronic and
   Speciality Shapes, 1988, Noyes Publications, New Jersey, USA.
   New Jersey, USA.
   Longman.
   London.

CR9152  NUMERICAL TECHNIQUES  L T P C
14

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

OBJECTIVES
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 pertubation 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 Miline 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
2. Desai C.S. Elementary Finite Methods, Prentice Hall 1922 Ch.2&3

CR9153  ENVIRONMENTAL ENGINEERING  L T P C
3 0 0 3

AIM
The course is aimed to impart basic knowledge about pollution and it's control techniques.

OBJECTIVES
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

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 EQUIPMNENTS  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.

TOTAL: 45 PERIODS
REFERENCES

CR9154  PROCESS MODELLING, SIMULATION AND OPTIMISATION  L T P C
3 0 0 3

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

OBJECTIVES
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.

UNIT I  BASIC MODELLING  9

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

TOTAL: 45 PERIODS
REFERENCES

CR9155 OPERATION RESEARCH L T P C
3 0 0 3

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

OBJECTIVES
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 QUENING THEORY 8
Basic elements of the Queening 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
AIM
The course is aimed to impart basic knowledge about hazards, its effects, safety and waste management together with risk analysis.

OBJECTIVES
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.

UNIT I GENERAL
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
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 ACCIDENT REPORTING INVESTIGATION AND DOCUMENTATION
Reporting an accident – selling up closed loop reporting system – Automated system – Forming an investigation board – Conducting an investigation – investigation report – Documenting the accident – Retention of records – Public release of information.

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

UNIT V RISK ANALYSIS
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
AIM
The course is aimed to impart basic knowledge about ceramic materials used for electronic applications.

OBJECTIVES
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
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
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 GBBL capacitors.

UNIT III THERMISTORS AND VARISTORS
NTC materials: solid solutions of oxides with the spinel structure, Fe$_3$O$_4$, ZnCr$_2$O$_4$, Fe$_3$O$_4$, MgCr$_2$O$_4$, PTC materials - BaTiO$_3$, SrTiO$_3$ and BLT materials, principles of operation, properties and applications, ZnO varistors, properties and applications.

UNIT IV PIEZO – ELECTRIC CERAMICS.
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
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
2. Levinson, M.L., Electronic Ceramics, 1988, Marcel Dekker, NY.
AIM
The course is aimed to enable the students to have a sound knowledge about the types, properties and applications of monolithics and castables.

OBJECTIVES
On completion of the course the students are expected to
- Have learnt the types of castables, its composition and characteristics.
- Have a better understanding on the use of plastic refractories, ramming and gunning mixes as monolithic materials.
- Have studied about the composition and characteristics of mortars, coatings and dry vibratables.
- Have a clear idea on the methods of installing different monolithic materials, the application design and the lining materials used while laying monolithics.
- Have studied the wear mechanisms that cause failure in a monolithic lining and the methods to test a monolithic.

UNIT I  CASTABLES  10

UNIT II  PLASTIC REFRACTORIES, RAMMING AND GUNNING MIXES  10

UNIT III  MORTARS, COATINGS AND DRY VIBRATABLES  7

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  WEAR MECHANISMS AND TESTING  8
Wear mechanisms – introduction, abrasion, penetration, corrosion, spalling. Tests done on monolithics – chemical analysis, density, porosity, strength, high temperature properties, corrosion, erosion.

TOTAL: 45 PERIODS

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

OBJECTIVES
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  INTRODUCTION

UNIT II  COATED ABRASIVES
Raw material selection and preliminary treatments, maker coating, abrasive coating – methods – continuous, individual disc coating and types of coating, sizer coating, drying and humidification, flexing, forms of coated abrasives - belt making, sheet cutting, disc punching, flap wheels - quality control and testing.

UNIT III  METHODS OF USING COATED ABRASIVES
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 - drums, rolls, pads, and platens, types, characteristics, choice and uses.

UNIT IV  BONDED ABRASIVES
Abrasive grain type and characteristics required for bonded abrasives. Types of bonds – vitrified, silicate, resinoid, shellac, rubber, metal and oxychloride. 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  FUNDAMENTALS OF GRINDING AND POLISHING
Grinding wheel – definition, abrasives chosen, grinding chips, chemical reactions, grade selection, wheel wear, chemical grinding aids. Grinding fluids – properties, types and purpose. Types of grinding – cylindrical grinding, centre less grinding, surface grinding, internal grinding. Polishing – definition, types.

TOTAL: 45 PERIODS

REFERENCES
2. Coated Abrasives – Modern Tool of Industry, Coated Abrasive Manufacturer’s Institute, Cleaveland, Ohio, 1982.
AIM
The course is aimed to impart basic knowledge about composites, whiskers and fibres with their properties, manufacturing routes and applications.

OBJECTIVES
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

UNIT II REFRACTORY FIBRES
Alumina silicate, mullite, alumina, silica, zirconia and boron, structure, fibre manufacturing process, properties and applications silicon carbide fibre – manufacturing process – CVD, polymer pyrolysis, applications.

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

UNIT IV COMPOSITES – TEAM WORK & SYNERGY IN MATERIALS

UNIT V CHARACTERIZATION
Physical – density, porosity, pore size distribution, fibre length, fibre orientation, fibre concentration, Thermal – thermal expansion coefficient, thermal conductivity, Mechanical – tensile, flexural, interlaminar shear stress, oxidation resistance, electrical conductivity, interface characteristics, fracture toughness, charpy test, XRD, microstructure evaluation.

TOTAL: 45 PERIODS

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

OBJECTIVES
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  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-Al₂O₃-SiO₂, Na₂O-CaO-SiO₂ etc.

UNIT II  RAW MATERIALS AND BATCH PREPARATION  9

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. Heat recovery systems. Major reactions and physiochemical changes during glass melting.

UNIT IV  FORMING PROCESS  9

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

OBJECTIVES
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 MONOLITHIC REFRACTORIES
Different kinds of monolithic refractories, advantages of monolithic refractories over shaped refractories, detailed study of raw materials, manufacturing steps, properties and applications.

UNIT II CARBON BASED REFRACTORIES
Magnesia – carbon, alumina – carbon – manufacturing process, properties and applications

UNIT III OXIDE AND NON OXIDE REFRACTORIES

UNIT IV APPLICATIONS
Application of sintering, microstructure and phase diagram of refractories

UNIT V RECENT TRENDS
Recent trends of application of refractories to secondary steel making, continuous casting, fertilizer, petrochemical and steel plant industries

TOTAL: 45 PERIODS

REFERENCES
OBJECTIVES
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

UNIT II
BURNERS AND COMBUSTION

UNIT III
FURNACES
Introduction, definition, 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.

UNIT IV
KILNS
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
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
AIM
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.

OBJECTIVES
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.

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

OBJECTIVES
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

UNIT II CALCIUM PHOSPHATE CERAMICS

UNIT III BIOACTIVE GLASSES AND GLASS CERAMICS
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
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
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
AIM
The course is aimed to enable the students to have a thorough knowledge about the special applications of glasses in various fields.

OBJECTIVES
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

UNIT II    OPTICAL GLASSES  9

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

OBJECTIVES
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
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

UNIT III ULTRASONIC TESTING
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
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

TOTAL:45 PERIODS
AIM
The course is aimed to enable the students to the basic concepts about processing the ceramic materials in microwave atmosphere.

OBJECTIVES
On completion of the course the students are expected to
- Have learnt the introduction about microwave processing.
- Have learnt the concepts of microwave heating circuit.
- Have learnt the applicator types of microwave.
- Have studied the industrial applications of microwave processing.
- Have studied the hazard and safety of microwave processing.

UNIT I  INTRODUCTION
Dielectric Behavior of materials- power dissipation- propagation factor and skin depth- heat and mass transfer phenomena- temperature distribution- wall loss.

UNIT II  MICROWAVE HEATING CIRCUIT
Power sources- klystron and magnetron- operating characteristics- protection system- high frequency breakdown phenomena- automatic control of the process- automation, tuning and machining.

UNIT III  APPLICATION TYPES
Travelling wave applicators- multimode applications- power transfer- uniformity of heating.

UNIT IV  INDUSTRIAL APPLICATIONS
Microwave drying- microwave sintering- application to laboratory models and pilot system- comparison with pilot heating.

UNIT V  HAZARDS AND SAFETY
Exposure standards- industrial- frequency band- leakage from industrial equipment- batch system- continuous flow system- safety precautions.

TOTAL: 45 PERIODS

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

OBJECTIVES
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  FUNDAMENTALS OF NUCLEAR CERAMICS  9
Atomic structure - atomic number- mass number- isotopes- nuclear energy and nuclear forces, binding energy- nuclear stability- radio activity- nuclear reactions- nuclear fission- nuclear fusion.

UNIT II  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 III  FUELS  9
Methods of production and properties, uranium oxide, thorium oxide, beryllium oxides- encapsulation, nuclear fuel cycle, spent fuel characteristics, reprocessing techniques.

UNIT IV  RADIATION PROTECTION  9
Types of 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.

REFERENCES
AIM
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.

OBJECTIVES
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
Temperature and thermal conditions in furnace, calculation of thermal operation of furnaces – heat balance, furnace productivity.

UNIT II HEAT EXCHANGERS

UNIT III REGENERATORS
Principle of operation, types of regenerators, design and construction, materials of construction and applications.

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

UNIT V ENERGY CONSERVATION DESIGNS
Prevention of energy loss in furnace – insulation, coatings, low thermal mass materials – importance, design and applications.

TOTAL: 45 PERIODS

TEXT BOOKS

REFERENCES
AIM
The course is aimed to enable the students to have a basic knowledge about the methods of calculating the various ceramic properties.

OBJECTIVES
On completion of the course the students are expected to
- Have learnt the basic methods of calculating the properties of ceramic raw materials.
- Have learnt to calculate the properties of ceramic bodies.
- Have learnt to calculate the properties of suspensions.
- Have learnt to formulate glaze batches by varying the parameters.
- Have learnt to formulate glass batches.

UNIT I ULTIMATE & RATIONAL ANALYSIS
9
Ultimate analysis, proximate analysis, rational analysis of clay, stone and feldspar -mica convention – substitution of clays in body recipes – triangular plot.

UNIT II DETERMINATION OF PHYSICAL PROPERTIES
9

UNIT III CALCULATIONS OF BODY & SUSPENSIONS
9

UNIT IV GLAZE CALCULATIONS
9
Molecular weights – formula and use of chemical equations – oxides – percentage composition and formula – calculation of a recipe from a simple glaze formula – given the recipe of a glaze calculate the formula – synthesis of a fritted glaze – given the recipe calculate the formula for a fritted glaze – calculation of the percentage composition of the mill batch

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.

TOTAL: 45 PERIODS

REFERENCES
3. R.Charan, Handbook of Glass Technology
AIM
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.

OBJECTIVES
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 of a concrete mixture.
- Have understood the different properties of concrete and the testing methods of the same.

UNIT I CEMENT

UNIT II TESTING AND QUALITY CONTROL

UNIT III TYPES OF CEMENT
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

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

OBJECTIVES
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
2. Richardson, D.W., Modern Ceramic Engineering Properties, Processing and use in design, 1992, Marcel Dekker, Inc., NY.
AIM
The course is aimed to impart basic knowledge about structural ceramics, its properties, and applications.

OBJECTIVES
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.

UNIT II MECHANICAL PROPERTIES AT ROOM TEMPERATURE
Elastic modulus, tensile and flexural strength, hardness, fatigue, fracture, wear, mechanical shock.

UNIT III MECHANICAL PROPERTIES AT ELEVATED TEMPERATURES
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
Wear resistance, rolling element bearings, cutting tool, IC engine, gas turbine, design considerations and failure analysis, material selection.

UNIT V SPECIAL APPLICATIONS
Infra red window materials, lamp envelops, chemical degradation, nuclear waste storage materials, nuclear fuels and fuel cell, ceramic membranes, ceramic armours, ceramic radomes.

TOTAL: 45 PERIODS

REFERENCES
2. Howlettt, S.P. and D.Taylor (Ed), Special Ceramics, Vol.8 1986, The Institute of Ceramics Shelton, Stock On- Trent, Staff, U.K.