### SEMESTER I

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

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

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

UNIT III X-RAY METHODS

UNIT IV SURFACE AND PARTICLE 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, dynamic light scattering.

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
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


UNIT II PHASE DIAGRAMS

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


UNIT IV ELECTRICAL AND ELECTRONIC PROPERTIES


UNIT V MAGNETIC , THERMAL AND OPTICAL PROPERTIES


REFERENCE


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

UNIT II STRENGTH
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
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
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
Fatigue of ceramics – types, mechanism, measurement, life time prediction. Wear of ceramics – types, mechanism, measurement, factors affecting.
REFERENCES

CR8104 TRADITIONAL CERAMICS

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

UNIT II THEORY OF PACKING

UNIT III FABRICATION PROCESS

UNIT IV GLAZING
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

REFERENCES

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.
5. Thermal Analysis – TGA, DTA.
6. Microscopy – Optical, SEM.
7. Atomic Force Microscope
8. Vicker’s Hardness.
10. Compressive Strength.

TOTAL : 45 PERIODS
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
Carbides – nitrides – oxides – SiAlON – borides – silicides – composites

UNIT II
ELECTRONIC CERAMICS

UNIT III
MAGNETIC CERAMICS
Spinel Ferrites – Hexogonal Ferrites – Garnet – Processing and Applications

UNIT IV
SPECIAL GLASSES AND GLASS CERAMICS

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

TOTAL : 45 PERIODS

REFERENCES
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

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

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
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
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.

UNIT II                    PHASE DIAGRAMS
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

UNIT III                   PHASE TRANSFORMATIONS
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
Techniques for determining phase diagrams – dynamic, static, microscopic methods –
optical, electron microscopy, X-ray methods, thermal analysis.
UNIT V APPLICATIONS
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

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
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
Silica – raw materials, manufacturing steps, properties, applications; Alumina – raw materials, manufacturing steps, properties, applications; Al₂O₃–SiO₂ phase diagram; Alumino-Silicate – raw materials, types of refractories, manufacturing steps, properties, applications.

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

UNIT IV SPECIAL REFRACTORIES
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
Castables – types, composition, properties, applications; Plastics – types, composition, properties, applications. Dry mixes – types, composition, properties, applications. TOTAL : 45 PERIODS

REFERENCES

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, Andreasen Pipette

2. Fabrication Techniques
   1. Uniaxial Pressing
   2. Cold Extrusion
   3. Slip Casting


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
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
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
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

UNIT II  COATED ABRASIVES 9

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

TOTAL : 45 PERIODS

REFERENCES
2. Coated Abrasives – Modern Tool of Industry, Coated Abrasive Manufacturer’s Institute, Cleaveland, Ohio, 1982.
The course is aimed to impart basic knowledge about non-conventional powder preparation techniques and advanced ceramic processing.

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

UNIT II AGGLOMERATION PROCESS

UNIT III BIOMORPHIC CERAMICS
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

UNIT V ADVANCED CONSOLIDATION TECHNIQUES
Hot Isostatic Pressing – Spark Plasma Sintering – Explosive Shock Consolidation

TOTAL : 45 PERIODS

REFERENCES
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
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

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

**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  

**UNIT II TESTING AND QUALITY CONTROL**  
8  

**UNIT III TYPES OF CEMENT**  
10  
Types of Portland cement, blast furnace slag cement, trefi 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  

**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**
CR8006  CERAMIC CALCULATIONS  L T P C  3 0 0 3

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

OUTCOME
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, silica and feldspar - mica convention – substitution of clays in body recipes – triangular plot.

UNIT II  DETERMINATION OF PHYSICAL PROPERTIES  9

UNIT III  SLIP CALCULATIONS  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

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
3. R.Charan, Handbook of Glass Technology

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

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

UNIT IV ADVANCED COATING TECHNIQUES
Slurry coating – dip coating, spray coating, plasma spray – EVD, CVD, PVD, thermal spray, magnetic sputtering, laser ablation, nanocoatings - lithography techniques.
UNIT V  ENAMELS

REFERENCES

TOTAL : 45 PERIODS

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

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

UNIT IV  COMPOSITES
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.
UNIT V  CHARACTERIZATION
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

CR8009  ELECTRONIC CERAMIC MATERIALS AND THEIR APPLICATIONS

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
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, \( \text{Fe}_3\text{O}_4 \), \( \text{ZnCr}_2\text{O}_4 \), \( \text{Fe}_3\text{O}_4 \), \( \text{MgCr}_2\text{O}_4 \), PTC materials - \( \text{BaTiO}_3 \), \( \text{SrTiO}_3 \) 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.

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  

UNIT II  EQUIPMENT SELECTION  
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  
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  
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.Richardon, J.F. and R.K. Sinott, Chemical Engineering., Vol.6,
5. V.S.Sastri and Edward Ghalai, Corrosion-Prevention & Protection, A John Willey

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.
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

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 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

UNIT III GLASS MELTING FURNACES
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

UNIT V SPECIAL TREATMENTS
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
12. Glass & Ceramic Technology, NIIR Board of Consultants & Engineers, Asia Pacific Business Press Inc.
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

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
CR8014 MANUFACTURING AND TESTING OF STRUCTURAL CERAMICS  

L T P C  
3 0 0 3  

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  
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  
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  
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  
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  
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.  
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

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  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
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

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

TOTAL : 45 PERIODS

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

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

UNIT IV RADIATION PROTECTION
Types of nuclear waste - disposal- ICRP recommendations- radiation hazards and prevention- radiation dose units.

UNIT V SPACE CERAMICS
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
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 pertubation theories.

UNIT I  INTERPOLATION AND APPROXIMATION  9
Piecewise spline approximation, uniform approximation, rational approximation

UNIT II  NUMERICAL SOLUTIONS OF ORDINARY DIFFERENTIAL EQUATION  9

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
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 Quening model, M/M/I and M/M/C Queues.

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

CR8020 PROCESS MODELLING, SIMULATION & OPTIMISATION LT P C 3003

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.
UNIT I  BASIC MODELLING  

UNIT II  MODELLING OF HEAT, MASS AND MOMENTUM TRANSFER OPERATIONS  
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  
Rate equations, Linear and Non-Linear Regression Analysis, Design of Experiments, Factorial, Central, Fractional Design, Evolutionary Operation Techniques, Case studies.

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

UNIT V  APPLICATION OF OPTIMIZATION  

TOTAL: 45 PERIODS

REFERENCES

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

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.
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.

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.

[Signature]
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.

REFERENCES

TOTAL: 45 PERIODS

CR8024  SPECIAL GLASSES  L T P C
SPECIAL GLASSES  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

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