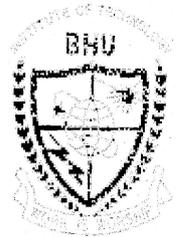


BANARAS HINDU UNIVERSITY
INSTITUTE OF TECHNOLOGY
Department of Ceramic Engineering
Faculty of Engineering & Technology



PROSPECTUS OF STUDIES



BACHELOR OF TECHNOLOGY
IN
CERAMIC ENGINEERING
2006-2007

4 YEARS B.TECH. CERAMIC ENGINEERING (PART II)

SEMESTER III

<u>SUBJECTS</u>		<u>CONTACT HOURS</u>	<u>CREDIT</u>
CR-2101	Ceramic Raw Materials and Analysis	4	4
CR-2102	Fundamentals of Ceramic Processing	3	3
CR-2103	Materials Science	3	3
AM-2101A	Mathematical Methods	3	3
EC-2101A	Electronics & Instrumentation	3	3
ME-2101A	Theory of Machines & Design	4	4
Total Theory	:	20	20
<u>Practicals</u>			
CR-2301	Ceramic Materials Analysis Laboratory	3	2
CR-2302	Mineralogy and Microscopy Laboratory	3	2
EC-2301A	Electronics & Instrumentation Laboratory	3	2
Total Practicals	:	9	6
TOTAL FOR SEMESTER III		29	26

SEMESTER IV

<u>SUBJECTS</u>		<u>CONTACT HOURS</u>	<u>CREDIT</u>
CR-2201	Ceramic Instrumental Analysis	3	3
CR-2202	Heat and Mass Transfer	4	4
CR-2203	Particle Mechanics and Fluid Flow Process	4	4
CR-2204	Process Calculations	3	3
AM-2201A	Numerical Methods	3	3
EE-2201A	Electrical Engineering	3	3
Total Theory	:	20	20
<u>Practicals</u>			
CR-2401	Industrial Operation Laboratory	3	2
CR-2402	Instrumental Analysis Laboratory	3	2
EE-2401A	Electrical Engg. Laboratory	3	2
Total Practicals	:	9	6
TOTAL FOR SEMESTER IV		29	26
TOTAL FOR PART II		--	52

4 YEARS B.TECH. CERAMIC ENGINEERING (PART III)

SEMESTER V

<u>SUBJECTS</u>	<u>CONTACT HOURS</u>	<u>CREDIT</u>
CR-3101 Electro Ceramics	3	3
CR-3102 Engineering Ceramic and Abrasives	3	3
CR-3103 Fuels, Furnaces and Pyrometry	3	3
CR-3104 Pottery & Heavy Clayware	3	3
CR-3105 Refractories	3	3
CR-3106 Thermodynamics and Phase Equilibria	3	3
Total Theory :	18	18
<u>Practicals</u>		
CR-3301 Ceramic Technical Analysis Laboratory	3	2
CR-3302 Electronic Ceramic Laboratory	3	2
CR-3303 Fuel, Furnaces & Pyrometry Laboratory	3	2
CR-3304 Pottery & Refractory Laboratory	3	2
Total Practical :	12	8
TOTAL FOR SEMESTER V	30	26

SEMESTER VI

<u>SUBJECTS</u>	<u>CONTACT HOURS</u>	<u>CREDIT</u>
CR-3201 Cement Technology	3	3
CR-3202 Ceramic Processing and Coatings	3	3
CR-3203 Ceramic Instrumentation & Process Control	3	3
CR-3204 Glass and Glass Ceramics	3	3
CR-3205 Properties of Ceramic Materials	3	3
Open Elective (Humanities)*	3	3
Total Theory :	18	18
<u>Practicals</u>		
CR-3401 Cement Laboratory	2	1
CR-3402 Glass & Ceramic Coatings Laboratory	3	2
CR-3403 Instrumentation & Process Control Lab.	3	2
CR-3404 Industrial Visits / Viva-voce	--	1
ME-3401A Ceramic Engg. Drawing & Design	3	2
Total Practical :	11	8
TOTAL FOR SEMESTER VI	29	26
TOTAL FOR PART III		52

* Any one of the Open Elective(Humanities) paper to be chosen from the following;

1. HU-321:History of Science and Technology
2. HU-322: Industrial and Organizational Psychology
3. HU-323: Intellectual Property Rights.
4. HU-324: Energy Management
5. HU-325: Industrial Sociology
6. HU-326: Ethics, Philosophy and Values.
7. HU-327: Entrepreneurship Development

4 YEARS B.TECH. CERAMIC ENGINEERING (PART IV)

SEMESTER VII

SUBJECTS	CONTACT HOURS	CREDIT
CR-4101 Cement, Concrete and Composites	3	3
CR-4102 Glass Technology	3	3
CR-4103 Plant Equipment & Furnace Design	3	3
CR-4104 Industrial Economics & Factory Management	3	3
Elective* I	3	3
Total Theory :	15	15
Practicals		
CR-4301 Cement and Concrete Laboratory	3	2
CR-4302 Glass Laboratory	3	2
CR-4303 Project I (Evaluation and Viva-voce)	3	2
CR-4304 Seminar and Group Discussion	3	2
CR-4305 Training Report & Viva-Voce	-	2
Total Practicals :	12	10
TOTAL FOR SEMESTER VII	27	25
* Any one of the elective paper to be chosen from the following;		
CR-4105 Advanced Building materials and Composites		
CR-4106 Bio-Ceramics		
CR-4107 Environment, Energy and Ecology		
CR-4108 Engineering Ceramics and Processing Techniques		
CR-4109 Science & Technology of Special glasses		

SEMESTER VIII

SUBJECTS	CONTACT HOURS	CREDIT
CR-4201 Pollution Control in Ceramic Industries	3	3
CR-4202 Pottery & Porcelain	3	3
CR-4203 Refractories	3	3
Elective* II	3	3
Total Theory :	12	12
Practicals		
CR-4401 Pottery Laboratory	3	2
CR-4402 Refractories Laboratory	3	2
CR-4403 Project II (Evaluation and viva-voce)	9	6
CR-4404 Comprehensive Viva-voce	-	2
Total Practicals :	15	12
TOTAL FOR SEMESTER VIII	27	24
TOTAL FOR PART IV		49
TOTAL FOR B.TECH. COURSE		203
* Any one of the elective paper to be chosen from the following;		
CR-4204 Ceramic Matrix Composites		
CR-4205 Ceramic Whitewares		
CR-4206 Computer Programming & Application in Ceramic Engineering.		
CR-4207 Electrical & Electronic Ceramics		
CR-4208 Super and Monolithic Refractories		

DETAILED SYLLABE

4 YEARS B. TECH. (CERAMIC ENGINEERING) PART II

SEMESTER- III

CR-2101 : Ceramic Raw Materials and Analysis (Credit- 4)

Chemistry of Ceramic Materials: Raw materials used in Glass, Refractories, Whitwares, Potteries and Cement. Chemical characteristics of raw materials of alkali and alkaline earth elements, silica, silicates, alumina, aluminates, titania, zirconia and zircon. Spectrophotometric analysis, Differential Thermal Analysis (DTA) and Thermo Gravimetric Analysis(TGA) with suitable examples.

Geology of Ceramic Materials: Geology and its utility in ceramic industry, Broad outlines of crystal forms and symmetry, Elementary ideas about rocks and their formation. Description and Classification of various minerals based on their chemical compositions, physical properties and occurrence.

Optical characterization of minerals using Polarizing Microscope: Polarizing microscope. Isotropic and anisotropic minerals, Bi-refringence, Pleo-chroism. Propagation of light through uni-axial and bi-axial minerals, extinction, cleavage and interference figures. Beck's effect. Systematic description of minerals under polarizing microscope.

CR- 2102: Fundamentals of Ceramic Processing (Credit- 3)

An overview of Ceramic fabrication processes.

Colloidal processing of ceramics: Types of Colloids, Attractive surface forces. Electrostatic, steric and electrosteric stabilization, Structure of consolidated colloids. Detailed study of rheology of ceramic systems. Particle sol-gel processing.

Forming of Ceramics and Powder Consolidation Method: Characteristics of solid particles; particle shapes, size, equivalent particle diameter, surface area, average particle size, size distribution. Packing of particles, Additives in forming processes, Selection of Additives, Dry pressing, plastic forming, Slip Casting and Tape Casting Methods. Binder removal. Calcination. Introduction to sintering of ceramics, Hot and iso-static processing.

CR-2103 : Materials Science (Credit- 3)

Crystal Structure: Unit cell, crystallographic directions and planes, crystal symmetry, point groups, space groups. Close packed crystal structures and coordination polyhedra. Common metallic structures. Density calculations. Types of Crystal structures; AX, A_mX_p and $A_m B_n X_p$ type crystal structures. Structure of Rock salt, rutile, zinc blend, wurtzite, cesium chloride, cadmium iodide, perovskites, spinel, garnet, high T_c super conductors. Structure of silicates (Orthosilicates, pyrosilicates, single chain, double chain, sheet and network silicates), Zeolites and Polymers. **Crystal Imperfections:** Types of defects, Points Defects; Kro'ger Vink notations, Thermodynamics of point defects, Elementary defect chemistry. Effect of impurities on concentration of defects. Intrinsic and extrinsic donors and acceptors. Line defects: Edge and screw dislocations, Burger vector, Slip systems, Energy of dislocations, Interaction between dislocations motion, plastic deformation, Frank Read source. Strengthening mechanisms. **Electrical Properties:** Conductivity of Metals. Mattheisen's Rule, Sommerfield, Band Theory of Solids. Metals, Semiconductors and Insulators. Intrinsic and Extrinsic Semiconductors. Concentration and mobility of charge carriers and their variation with temperature. Semi-conducting materials. **Magnetic Properties:** Origin of Ferromagnetism and hysteresis loop, Domains and Magnetic Anisotropy, Magnetostriction. Soft and Hard Magnetic Materials and their Applications. **Optical Properties:** Interaction of Electromagnetic waves with matter. Absorption, reflection, transmittance and colour of materials. Lasers.

AM-2101A: Mathematical Methods (Credit-3)

Ordinary and partial differential equations and their applications: Power series solutions of second order equations, Legendre's equation, Bessel equation; recurrence relations, orthogonality of Legendre polynomials, Hermite polynomials and Bessels functions of first and second kinds; Sturm-Liouville problem. Partial Differential equations separations of variable one dimensional wave and heat equations, Laplace's equations in R^2 and R^3 .

Statistical Methods in Science and Engineering: Concept of randomness. Random variables, discrete and continuous probability distributions. Binomial, Poisson, negative binomial, exponential, normal (Gaussian) laws. Joint distribution of two variables, conditional distribution, bivariate normal distribution, regression and correlation. Multivariate normal distribution. Random sample, Statistical estimation of parameters. Test of hypotheses. Goodness of fit. Non-parametric tests. Introduction to stochastic processes and queuing theory.

Integral Transforms and their applications: Laplace transform, inverse transform, linearity and other properties, periodic and other functions, partial fractions. Convolution. Application to solution of differential equations. Initial-value and boundary value problems; Laplace equation, heat equation and wave equation

EC-2101A: Electronics & Instrumentation (Credit :3)

Semiconductor diode characteristics, LOAD LINE half wave and full wave rectifiers, filters, power supply, regulators (723, 78XX, 79XX), amplifying devices (vacuum tube, BJT, FET), their characteristics with LF equivalent CKt. Single stage and multi-stage RC coupled amplifiers, (including types of coupling), calculation of V. Gain, impedances, frequency response, FEEDBACK. High input impedance CKts. Oscillators (RC, LC, distributed) criterion and one practical CKt. Op-Amp. and its applications, filters, V.C.C. & PLL, logic gates and basic logic circuits (SSI, MSI and basic system ACs). TIMER and applications to systems, transducers, load cell, strain gauge, LVDT, optical shaft encoder, display devices, A/D and D/A converters. CRO and Multimeters (A&D) (Intersil's A/D for instrumentation). A typical instrumentation system. Introduction to Microprocessors and its basic peripherals.

ME-2101A: Theory of machines and Design (Credit: 4)

Stress-strain diagrams; Hooks law, elastic constants, temperature stresses, bending and shearing, stress distribution of beams. torsion of circular cross section, Mohr's circle, strain Rosettes, deflection of beams by different methods, effect of loading. Thin walled cylinder spherical shells. Theory of gears, gear trains; turning moment diagram; flywheels; balancing of reciprocating and rotating machinery.

Principles of mechanical designs, estimation of design loads, design for safety; consideration of creep and thermal stresses in design principle of standardization; selection of materials and treatment, human and aesthetic aspects; design of springs and shafts; clutches, breakes and dynamometers, design of transmission elements like belts, ropes, chains and gears.

PRACTICALE

CR-2301: Ceramic Materials Analysis Laboratory (Credit- 2)

Determination of moisture, chloride, sulphate and bicarbonate in the given sample. Estimation of Na_2O and B_2O_3 present in the sample. Analysis of limestone dolomite etc. for insoluble content, R_2O_3 (R=Fe, Al, etc.), CaO and MgO.

CR-2302: Mineralogy and Microscopy Laboratory (Credit- 2)

Section A: Mineralogy

Determination of specific gravity of mineral by Walker's steelyard balance, megascopic identification of important rock forming minerals and minerals of economics importance, with special reference to ceramic industry and important rocks.

Section B: Microscopy Laboratory

Study of a polarizing microscope and its different parts, setting of a polarizing microscope and centering of the object. To find the magnifying power of a microscope. Study of Becke's effect, refractive index. To study and identify a few of the following minerals in thin section used in ceramic industries: Quartz, orthoclase, albite, kyanite, silimanite, andalusite, gypsum, calcite, hornblende, tourmaline, muscovite, biotite, quartzite, limestone, labradorite and other ceramic materials.

EC-2301A: Electronics & Instrumentation Laboratory (Credit- 2)

Experiment based on EC-2101A.

4 YEARS B. TECH. (CERAMIC ENGINEERING) PART II

SEMESTER- IV

CR-2201 : Ceramic Instrumental Analysis (Credit- 3)

Continuous and characteristic emission of X-rays. Absorption. Filters. Diffraction. Brag's Law. Powder and Single Crystal X-ray diffractometer. Atomic scattering factor, Geometrical structure factor. Indexing of Diffraction patterns, Selection rules. Determination of structure and lattice parameters. Applications of X-ray diffraction in ceramic systems.

Spectrophotometry, Atomic Absorption Spectrometer, Polarography and its applications in analysis of ceramic systems.

Electron Microscopy- Principle, construction and operation of Scanning Electron Microscope. Principle, construction and working of Transmission Electron Microscope (TEM). Electron diffraction, Bright field and dark field images, SAD. Sample preparation of ceramic materials for SEM and TEM.

Particle size, surface area and porosity measurements- Light scattering, Coulter counter and Sedimentation method for particle size measurements. BET surface area measurements. Mercury porosimeter.

CR-2202: Heat and Mass Transfer (Credit- 4)

Heat Transfer: Steady state conduction with and without heat source in one dimension for single, composite plane, cylindrical and spherical walls. Thermal insulation and selection of insulating materials. Unsteady heat conduction; use of charts.

Concept of film resistance and thermal boundary layer, heat transfer coefficient solution of laminar forced convection of flat plate, working formulae and dimensionless correlation for forced convection inside tubes, annular spaces and normal to single tube banks. Elementary idea of Reynolds, Prandtl and colburn analogies. Current, counter-current and cross-flow heat exchangers. Code in heat exchangers design.

Basic laws of radiative heat transfer. View factors and derivation for simple systems and also their determination using charts. Radiative heat transfer in glass melting and calculations of radiative heat transfer in furnaces.

Mass Transfer: Mass transfer by molecular diffusion. Mass Transfer in system of fluids, granular solids and fluidized beds. Mass transfer coefficient and their correlation. Height of Transfer Unit (H.T.U.) and Number of Transfer Units (N.T.U.) calculations. Mass Transfer applied to absorption. Continuous contact equipment for gas-absorption. Psychometry; Humidity, wet and dry bulb temperatures. Adiabatic humidification and dehumidification. Pumping of fluids calculation/design.

Drying: Internal flow of moisture within the solids, surface evaporation, drying shrinkage, estimation of drying rates and achievement of maximum drying rate. Detail study of the various driers used in ceramic industries: Tray driers, tunnel driers, drum driers, vacuum driers and spray driers.

CR-2203: Particle Mechanics and Fluid Flow Processes (Credit- 4)

Particle Mechanics: Theory of Crushing and grinding. Crushers, Grinders and Ultra fine grinders. Close and open circuit grinding, selection of equipment and power requirement. Sieve analysis, cumulative and differential plots. Industrial screening equipments, Separation based on size shape, density and surface properties.

Law of motion of single particle, sedimentation, free and hindered settling. Thickener and settling chambers. Flotations, Rotary fluids, Centrifuge, cyclone, electrostatic and magnetic separators.

Pneumatic and hydraulic transportation of solids; Jansen's equation. Conveyors, bins, silos and hoppers. Different equipment for mixing of fluids and solids, mixing index.

Filtration: Flow through filter cake and medium, Kozeny-Carman equation for flow through packed column, plate and frame filters, centrifugal filters, Filter Media, Filter Aids, Washing of filter cakes, selection of filtration equipments.

Fluid Flow Operation : Physical properties of fluids, SI Units and dimensions. Type of fluids; Compressible, Incompressible, Newtonian and non-Newtonian fluids. Pressure-density-height relationship. Pressure measurements; Manometers, Forces on submerged objects. Buoyancy and stability. Reynold's experiment; Description of velocity fields, streamline, angular velocity, circulation, irrotational flow. Integral equation of continuity of flow, conservation of linear momentum and angular momentum, Bernoulli's equation, energy relationship. Buckingham's Theorem, important dimensionless numbers and their physical significance, similitude criteria. Viscous flow, laminar and turbulent flow through closed conduits. Velocity profiles, friction factor for smooth and rough pipes. Head losses due to friction in pipes, annular spaces and fittings. Hydraulic radius. Orifice meter, Venturimeter, Pitot tube, Rotameter. Flow through notches and weirs, physical methods of flow measurement, wet gas meter, dry gas meter, hot wire anemometer and other types of advanced techniques for flow measurement. Detailed study of pumps, compressors, blowers and fans; their selection and characteristics.

CR-2204: Process Calculation (Credit- 3)

Fundamental of material and energy balance for ceramic industry. Non-reactive, reactive and transient processes. Concepts of limiting and excess reactivates, recycles, by pass energy balances. Material and energy balances for ceramic materials and processing. Ceramic body calculation. Batch calculation of glass and enamel, calculation of different physical properties such as density, refractive index, thermal expansion coefficient, thermal conductivity etc. of different ceramic products.

AM-2201A: Numerical Methods (Credits:3)

Solutions of algebraic and transcendental equations: Graphical method, regula-falsi, Newton-Raphson method, multiple or near multiple and complex roots. Solution of systems of linear equations, method of elimination, method of relaxation, iterative methods, ill-conditioned systems.

Interpolation: Absolute, relative, round-off truncation errors, significant digits, estimation of errors, tabulation of a function, ordinary differences, operators E and subtabulation, divided differences, Aitkons methods, Newton-Cotes formula, Lagrange's formula, central differences, formula of gauss, Bessel, Everett. Method of least Squares, cubic splines.

Numerical Integration: Finite-difference methods, Gaussian quadrature, Euler-Maclaurin series, asymptotic expansions. Solution of Ordinary Differential Equations: Series solution, methods of Milne, Adams-Bashforth, Milne-Simpson multistep and Runge-kutta.

Difference Equations: Numerical solution, relaxation method, solution of ordinary and partial differential equations by difference method. Numerical solutions of elliptic, parabolic and hyperbolic partial differential equations.

EE-2201A: Electrical Engineering (Credit :3)

Electrical Circuits: Network element-Voltage and current sources, Kirchhoff's voltage and current law, loop and nodal analysis, Superposition theorem, Thevenin's theorem, Norton's theorem, Maximum Power Transfer theorem, Sinusoidal Steady State analysis- R L and C elements, power and power factor, phasor diagram, resonance, Mutual inductance and coefficient of coupling. Three-phase circuits- Line and Phase relationship, Power measurement.

Electrical Machines: Transformer- Principal of working, EMF equation, Equivalent circuit, voltage regulation and efficiency, Open-circuit and short-circuit tests, autotransformer. DC Machines- Constructional features, DC Generators- No load Magnetization and external characteristic. DC motor-starting, speed-torque characteristic, speed control, applications. Induction Machines- Principle of operation, constructional details, torque-slip characteristic, starting and speed control. Synchronous Machines- Constructional features. Alternators-Voltage regulation and its determination by synchronous impedance method. Synchronous Motor- Starting, V and Inverted-V curves, applications.

Distribution of Electrical Power- Tariff calculation. House and factory wiring.

Introduction of Electrical Measurements: Indicating instruments, voltmeter, ammeter, wattmeter and energy meter.

PRACTICALE

CR-2401: Industrial Operation Laboratory (Credit- 2)

Experiments based on CR-2202 and CR-2203

CR-2402: Instrumental Analysis Laboratory (Credit- 2)

1. Demonstration of DTA/TGA and its analysis- Determination of the enthalpy of a reaction and percentage weight change.
2. Demonstration of X-ray Diffractometer.
3. Indexing of XRD patterns and calculation of lattice parameters.
4. Sample preparation of ceramic materials for microstructure observation by optical microscope.
5. Spectrophotometric analysis of ceramic and glasses.
6. Demonstration of SEM and TEM.

EE-2401A: Electrical Engineering Laboratory (Credit- 2)

Experiment based on EE-2201A

DETAILED SYLLABI
4 YEARS B.TECH. (CERAMIC ENGINEERING) PART III
SEMESTER V

CR- 3101: Electro Ceramics (Credit- 3)

Ceramic Capacitor Technology: Ferroelectric ceramic materials, Basic Ceramic Dielectric formulation for capacitors. Performance Categories of Ceramic Capacitors, Grain Boundary Barrier Layer Capacitors, Multi Layer Capacitors, Relaxor ferroelectrics.

Magnetic Ceramics: Super exchange interactions, Spinel ferrites, Garnets and Hexagonal Ferrites. Effect of composition, processing and microstructure on the magnetic properties.

Ionically conducting ceramics: Defect equilibria and Kroger-Vink Diagrams for different systems.. Diffusion in ionic solids. Ionic and Superionic conductivity. Classification of superionic solids. AgI based, β -Alumina and oxide based superionic conductors and their applications in fuel cells and batteries.

Piezoelectric ceramics: Piezoelectric constants. Hysteresis, poling and equivalent circuit for piezoelectric ceramics. Piezoelectric material systems, their processing, properties and applications.

CR- 3102: Engineering Ceramic and Abrasive (Credit- 3)

Fracture behavior of ceramic materials, The Weibull distribution, Weibull parameters, Sub-critical, stable crack propagation and R-curve behavior. Toughening mechanism. Toughening by transformation. Mechanical behavior of aluminum oxide, silicon carbide, silicon nitride, zirconia and zirconia toughened materials and their engineering applications

Abrasive: Abrasives, abrasive operations, natural abrasives, abrasives like aluminium oxides, silicon carbide, diamond and boron nitride, miscellaneous synthetic abrasives, raw materials for abrasives, their proportioning, processing, manufacture of abrasives, grinding wheels, their drying, firing and testing. The use of abrasives and grinding wheels in grinding. Evaluation of abrasives products. Loose abrasives operations. The chemistry of grinding.

CR-3103: Fuels, Furnaces and Pyrometry (Credit- 3)

Composition, classification and characterization of industrial fuels; wood, charcoals, coal and its qualities, petroleum, oil and natural gas, LPG, producer gas, water gas and carbureted-water gas, characteristics of coal, coal washing and blending, carbonization of coal, manufacture of coke and recovery by products, pulverized coal, chemistry of combustion, types of combustion, combustion of solids, liquid and gaseous fuels, fuels flame characteristics, fluidized bed combustion.

Classification, design and description of different types of furnaces used in ceramic and metallurgical industries as down-draft kiln, tunnel kiln, chamber furnace, glass tank furnace, rotary kiln, blast furnace, open-hearth furnace, bessemer-converter, coke-oven batteries, Heat saving devices i.e. regenerators, recuperators. General idea of temperature measuring devices i.e. thermocouple, radiation and optical pyrometer.

CR- 3104 : Pottery and Heavy Clayware (Credit- 3)

Raw materials and their physical chemical and thermal properties. Clays, quartz, feldspar, nepheline syenite, whiting, talc, pyrophyllite, kyanite, sillimanite, bone-ash and clay for building materials, winning and beneficiation of clays. Chemical and mineral composition, colour, texture, hardness and resistance to abrasion, mechanical strength, soluble salts and physico-chemical relationships of clay and water. Forms of water in clays. Plasticity, nature of plasticity, factors

affecting plasticity, methods of measurement of workability, extra ability and binding power. Body preparation: Body composition and batch calculations.

Methods of Fabrication: Throwing, zigging and jollying, soft plastic methods, extrusion methods, stiff-plastic methods. Drying and dry-shrinkage, finishing, firing and cooling schedule. Stacking the wares, support and kiln furniture.

Manufacture, properties and uses: Terracotta bodies, common building bricks, roofing tiles, building tiles, majolica, earthenware, china bodies and salt glazed stone ware pipes and sanitary fittings, agricultural land drains, hollow blocks and acid resisting products.

Glazing and Decoration: body-glaze relationship, types of glaze, glaze materials, colouring ingredients, decorating methods, compounding of glazes. Processing and application of glaze, firing properties and defects of glazes.

CR- 3105: Refractories (Credit- 3)

Materials with special references to their refractory characteristics . Selection of raw materials for specific products. Machinery and equipments for different production sections. Particle size and its proportioning, batch preparation and mixing, fabrication, drying and firing. Phase diagram with special reference to refractory characteristics. Manufacture and properties of silica, alumina-silicate, refractories, perielase, magnesite, magnesite-chrome, chrome-magnesite, dolomite, forsterite high and low temperature insulating refractories, acid proof bricks and carbon based refractories. Properties and their Measurement: Porosity, Bulk density, fusion point, permeability, cold crushing strength, refractories under load, hot modulus of rupture, creep behavior, abrasion resistance, thermal conductivity, thermal expansion and spalling. Reaction of refractories; slag, glasses, carbon monoxide, acids, alkalis, flue gases, corrosion of regenerator refractories by flue gases.

CR-3106: Thermodynamics and Phase Equilibria (Credit- 3)

Brief introduction to laws of thermodynamics, concept of states of matter, intensive and extensive properties of systems, thermal and statistical entropy. Auxiliary Functions: Thermodynamic functions, Maxwell's equations and their applications in solution of problems.

Phase Equilibria in ceramic systems : Phase rule, isobaric phase rule and application to unary, binary and ternary systems, eutectic and eutectoid, peritectic and peritectoid diagrams, lever rule and its application.

Behavior of gases: Ideal gases and non-ideal gases, concepts of fugacity, reactions involving gases and condensed phase.

Thermodynamic stability of materials. Ellingham diagram and its importance, application of electrochemical series in ceramics.

Behavior of solutions: Ideal solution, Gibb's-Duhem equation, regular solutions, free energy-composition diagrams for ideal and regular solutions.

PRACTICAL

CR-3301: Ceramic Technical Analysis Laboratory (Credit- 2)

Analysis of raw materials for ceramic industries, analysis of ceramic products eg. glass, enamels, pottery, refractories and cement by chemical methods.

CR-3302: Electronic Ceramic Laboratory**(Credit- 2)**

1. Preparation of barium titanate based ceramic compositions by solid state method.
2. Preparation of spinel ferrite by ceramic method.
3. Measurement of ionic conductivity of a ceramic solid electrolyte.
4. Measurement of electric conductivity of ceramic samples by two probe and four probe method.
5. Measurement of dielectric constant.
6. Measurement of magnetic susceptibility by Gouy method.

CR-3303: Fuel, Furnace and Pyrometry Laboratory**(Credit- 2)**

To find the sulphur in coal. To analyse the flue gas by Orsat's apparatus. To determine the tar content in a coal sample, to estimate the moisture content in coal by Dean-Stark's method, to estimate the amount of nitrogen in solid fuels by Kjeldahl's method, to determine smoke point and Reid vapor pressure of oil. To determine the swelling index of coal, to determine the ash content of liquid fuel. Proximate analysis of coal, to determine the carbon residue number of oil. To find out the calorific value of the flue gas by Junker's method, to find out the calorific value of solid fuel by Bomb calorimeter.

CR-3304: Pottery and Refractory Laboratory**Credit- 2)**

Pottery Laboratory: To study the physical properties of clay-like texture, plasticity, shrinkage, tensile strength, porosity, fired colour, etc. Shaping of articles by different methods, throwing, jigger and jollying, slip casting and pressing. Making of majolica body and its glazing.

Refractory Laboratory: Determination of size of refractory brick, apparent porosity, bulk density, true specific gravity, true density, spalling resistance, cold crushing strength. To prepare the sample of refractories by dry press method. To find the action of HF+H₂SO₄ mixture on free silica in refractory bricks by Bow-Maker's method. Determination of packing density of supplied grogs. To prepare the sample of refractories by slip casting methods.

4 YEARS B. TECH. (CERAMIC ENGINEERING) PART III

SEMESTER- VI

CR-3201 : Cement Technology (Credit- 3)

Origin and development of cement and cementitious materials, raw materials and their classification, selection of raw materials, crushing of lime stone and other calcareous materials, proportioning of raw materials, grinding of raw materials and preparation of raw meal, blending & benefications of raw materials. Burning of raw mix, reactions occurring in cement making at different temperature. Pre heater and pre calcinators in cement industry, heat recovery devices and waste heat utilization. Firing system and kiln residence time, working of rotary kiln and clinkering reactions, clinker coolers. Gypsum, clinker and their storage, cement grinding mills, cement storage and silos, conveying, packing and dispatch of cement, cement packing machines. Dust and dust collection in cement industries. Different classes of building lime and their properties. Plaster of paris, its properties and uses, manufacture of plaster of paris, setting and hardening of plaster of paris, Keens cement and parian cement. Testing of cement.

CR-3202 Ceramic Processing and Coatings (Credit- 3)

Ceramic Processing: Solid state method for synthesis of Ceramics. Freeze drying, Spray drying. Co-precipitation method. Sol-Gel process. Chemical vapor deposition, Mechano chemical , synthesis, Hydrothermal synthesis, plasma spraying. Combustion method for synthesis of ceramics. Synthesis of nano-ceramics by physical and chemical methods.

Sintering: Driving force, diffusion in solids, defects and defects chemistry, vapor pressure over curved surface. Theory of solid state and Viscous sintering, scaling laws. Hot Pressing. Liquid Phase Sintering. Stages in liquid phase sintering, Basic Mechanisms of liquid phase sintering.

Coating: Brief description of raw materials used in enamel. Batch calculations of frit making, Milling and Slip Preparation . Preparation of metal parts, Applications of Slip. Firing process, colourd anamels, properties and defects of enamel coating. Theory of adhesion on metal surface. New Coating Processes: Thermal Spraying, Flame spraying, HVOF process, Plasma spraying, Physical deposition, Sol-gel method of coating, Sputtering.

CR-3203: Ceramic Instrumentation & Process Control (Credit-3)

Types of process control. Automatic/semi automatic control process. Two position, proportional and integral control. Combined proportional and integral control. Integral and derivative modes. Open loop and closed loop systems as applied in ceramic industry. Flow measuring instruments, Pitot's tube, Venturimeter, Foxboro and flow raters (rotameters). Pressure relief valve. Compressed air pressure regulators. Adjustable part valve. Sensitrol valve, Ratiotrol, injectors. Feeder temperature control, furnace pressure control, level control temperature measuring instruments. Dynamic characteristics of physical systems, elements of process dynamics- resistance, capacitance, twice constants in industrial processes and its analytical treatment with suitable examples.

CR-3204: Glass and Glass-Ceramics (Credit- 3)

Glassy State; Kinetic and thermodynamic criteria for glass formation, use of $\text{Na}_2\text{O-SiO}_2$ and $\text{Na}_2\text{O-CaO-SiO}_2$ phase diagrams in glass manufacture, types of glasses and their chemical compositions, Physical properties of glasses, density, refractive index and dispersion, design of lenses, thermal expansion and thermal stresses, thermal endurance of glass, toughening of glasses, strength and

fracture behavior of glass and its articles, surface tension, viscosity and its measurement, effect of temperature and composition on the physical properties of glasses.

Absorption and colours in glasses; role of transition metal ions in glass, sulphur and selenium in glass, oxidation-reduction equilibria in glass, effect of temperature, composition and partial pressure of oxygen on redox equilibria in glass, application of redox reactions in glass industry for coloration, decolorization and refining of glasses. Oxygen ion activity in glasses. Chemical durability of glasses; mechanism of reactions of solutions with glass surfaces, factors affecting the chemical durability, measurements of chemical durability of glass.

Glass ceramics; Nucleation and crystal growth in glasses, nucleation through micro miscibility, nucleating agents, properties and applications of glass-ceramics

CR-3205: Properties of Ceramic Materials

(Credit- 3)

Thermal Properties: Heat capacity, Thermal Expansion, Thermal Conductivity: Thermal shock resistance, Radiative heat transfer.

Mechanical Properties: Elastic, Plastic, anelastic and viscoelastic behaviour. Griffith- Orwan criteria for brittle fracture. Statistical treatment of failure of ceramic materials, Strengthening of ceramics, hardness, abrasion tribology.

Electrical behaviour: Electronic and ionic conduction in ceramics. Band structure of ceramic materials. Broad band and narrow band semiconductors. Hopping conduction. Non-stoichiometric and valency controlled semi conduction, metallic conduction. Nernst Einstein equation for diffusion and conductivity in ionic solids. Effect of temperature, pressure and impurities.

Super Conductivity: BCS theory, High T_c superconductors, colossal and giant magneto resistance.

Dielectric behaviour: Clausius-Mosotti equation, behaviour of dielectrics in DC and AC electric fields. Linear and non-linear dielectrics, Ferroelectricity, dielectric behaviour of polycrystalline and polyphase ceramics.

Magnetics Ceramics: Exchange and super exchange interactions, crystal field splitting. Spin-order, Spinel, garnet and hexagonal ferrites. Effect of microstructure and composition on the magnetic behaviour.

Optical Properties: Reflection, transmission, absorption and scattering of radiation. Coloration, luminescence, fluorescence and phosphorescence, laser and maser.

PRACTICAL

CR-3401: Cement Laboratory (Credit- 1)

Determination of consistency of standard cement paste, initial setting time, final setting time, soundness of cement by LeChatelier's mould, fineness of cement by dry sieving, specific gravity of cement, workability of cement mortar, lime and plaster of paris, tensile strength of cement.

CR-3402: Glass and Ceramic Coatings Laboratory (Credit-2)

Grading of sands, melting of simple glasses and measurements of their density. Process of grinding, polishing, etching and sand blasting. Preparation of ceramic coating batches, melting, fritting, slip preparation and blending and colour. Milling techniques and consistency testing methods. Preparation of metal surface, application of ceramic coatings and firing. Defects causes and controls. Scratch hardness and reflectance, thickness-testing of finished products.

CR-3403: Instrumentation and Process Control Laboratory (Credit- 2)

1. Level control system
2. Temperature control system
3. Dynamics of a pressure tank.
4. Flow characteristics of a pneumatic control valve
5. Calibration of pneumatic proportional counter.
6. Calibration of orifice flow meter.
7. Dead weight pressure gauge tester.
8. Liquid level measurement by air purge method.
9. Dynamics of pressure spring thermometer.
10. Dynamics of mercury manometer.

CR-3404: Industrial Visits/ Viva-voce (Credit-1)

ME-3401A: Ceramic Engineering Drawing and Design (Credit-2)

DETAILED SYLLABI
4 YEARS B.TECH. (CERAMIC ENGINEERING) PART IV
SEMESTER VII

CR-4101 : Cement, Concrete and Composites. (Credit- 3)

Constitution of ordinary Portland cement, Crystal structure of anhydrous cement compounds and their hydration product. Action of acid, alkali and sulphate water on cement phases.

Different types of cement:- Quick setting cement, low heat cement, Blast furnace slag cement, Trief cement, Sorrel cement, White and coloured cement, Iron ore cement, Oil well cement, Hydrophobic cement, Water proof cement, Masonry cement, expanding and self stressing cement, Sulphate resisting cement, Super sulphate cement, High alumina and other refractory cements, refractory castables. Pozzolana and Pozzolanic cements.

Hydration of anhydrous cement and cement compounds cementing qualities of cement compounds, formation of C-S-H and generation of skeleton of artificial cement stone. Phase equilibria in cement hydration, effect of alkalis, fluorides and other minor constituents on the hydration of cement, role of free magnesia and free lime in cement, various theories of cement hydration and modern views, structure of hydrated cement phases and gels, steam curing of cement.

Additives and their classification- accelerators retarders, workability aids, water proofers, pigments and colorants, air-entraining agent, surface active agents and cement base protective coating, plain and fiber reinforced concrete, different types of fibers, glass fiber, steel fiber, polymer fiber, carbon fiber, polymer concrete.

CR-4102: Glass Technology (Credit- 3)

Glass making raw materials, criteria for selection of raw materials, concept of batch house operations, glass melting and homogenization, addition of cullet to the batch, reactions amongst the constituents of glass, thermal currents and flow pattern in the glass tank furnace, electrical boosting and bubbling of glasses, Defects in glass, bubbles and seeds, cords, stresses and colour inhomogeneity and their remedies, annealing of glasses.

Manufacture of glasses: Glass forming machines, Manufacture of glass bottles, rods, tubes, bulbs and bangles, glass blocks and laboratory glass wares, sheet, plate and rolled glass, toughened safety glass, laminated safety glass, glass fiber and wool, foam glass, optical and ophthalmic glasses by blowing and / or pressing process with semi-automatic and fully automatic machines, preparation of photosensitive and photochromic glasses.

CR-4103: Plant, Equipment and Furnace Design (Credit-3)

Section A: Plant & Equipment Design:

Plant Design: Plant location, plant layout, assembling of economic and engineering data, calculations pertaining to the processes, process vessels, etc. piping and instrument flow diagrams, process flow diagrams, design of a ceramic plant, feasibility report and cost estimation of the plant. Economics of the plant, commercial aspects etc.

Equipment Design: Principles of design of the following process equipments: Crushers, materials handling systems, filter press, sieves and pug-mills, moulding equipments. Principles of design of glass moulds such as blank mould, blow mould and neckring moulds. Drying and different types of driers used in Ceramic industries. Principles of design of simple supports, i.e. footings and foundations for process equipments such as overhead tanks, motors, compressors and crushers. Different types of size-radiation equipment used in ceramic industry i.e. crushers and grinders including their design calculations.

Section B: Furnace Design:

Detailed study of common types of furnaces i.e. glass melting furnaces, tunnel kiln, chamber kiln and down-draft kiln, shuttle-kiln, roller-hearth kiln, rotary cement kiln and annealing lehrs. Blast furnace, open hearth furnace and converters for steel melting, Natural and forced draft stack, stack calculations. Chimney foundations. Essential operations of a furnace i.e. firing, charging, melting, reversal. Preheating of air, gas and fuel oil, flame systems, temperature and its control. Thermal current in a glass melting furnace. Furnace atmosphere. Furnace life and selection of refractories. Heating up and cooling down of a furnace, furnace construction, furnace capacity, fuel efficiency and firing efficiency, design, construction and thermal calculation pertaining to at least one of the above mentioned furnace.

CR-4104: Industrial Economics & Factory Management (Credit- 3)

Types of accounts, book keeping, single entry and double entry, trading account, profit and loss account and balance-sheet, cost accounting and cost control. Economic laws, increasing and diminishing return, utility, total and marginal, forms of business organization, private, partnership, joint stock companies and cooperative societies, limited and unlimited liabilities, shares, debentures, bonds, valuation and depreciation. Fixed cost and variable cost, business, principle of management, management process schools, human factors, management by objective. Type of organization charts.

Materials management: purchase, inventory, control, ABC analysis, break even analysis, stores, sales and material handling, S.Q.C. and standardization, PERT and planning. Site selection and factory layout.

ELECTIVE PAPER

(One elective paper to be chosen out of the following)

CR-4105: Advanced Building Materials and composites (Credit- 3)

Composites and multiphase materials, components of cement based matrices, preparation, properties of polymer cement mixes, polymer impregnated concrete (PIC), Polymer Cement Concrete (PCC), Cement based smoothing and screeding compounds. The use of water dispersed polymers in cement mixes for floor topping and concrete repair, Macro defect free cements, Reinforcement of cement based composites. Different types of fibers- steel fibre, carbon fibre, natural fibre, proportioning of fibres and cement, design and structure of cement composites. Bonding between fibres and cement, interaction between cement, polymer and fibres, permeability, corrosion resistance, abrasion resistance, creep and other mechanical properties of fibres reinforced concrete, special kind of cement based composites, Cracking of cement matrix and crack propagation. Behavior of cement matrix composites in service conditions. Fire resistance of polymer and fibre reinforced concrete, Application and development of cement based composites.

CR-4106: Bio-ceramics (Credits 3)

Definition and scope of bio-materials. Structure-property relationship of biological materials, structure-property relationship of hard tissues cell, bone, teeth and connective tissues. Structure, properties and functional behaviour of bio-materials. Tissues response to implants (bio-compatibility, wound healing process), body response to implants, blood compatibility.

Classification of bio-ceramic materials for medical applications. Alumina and zirconia in surgical implants, bioactive glasses and their clinical applications, A.W. machinable and phosphate glass

ceramics. Dense and porous hydroxyl apatite calcium phosphate ceramics, coatings and resorbable ceramics. Characterization of bio-ceramics. Regulation of medical devices.

CR-4107: Environment, Energy and Ecology (Credit-3)

Energy and related units its resources and demands with economic prosperity and patterns of energy consumption, fossil fuel and energy resources.

Sectorial energy demand and conservation. Energy problem in India in different sectors like domestic, transportation, industrial. Electric energy trends in India and electric power generation, its forecasting and efficiency with cost reduction, related to its production, Nuclear energy. Its application of input-output methods to energy problems. Non-conventional resources of energies like waste and scrap, solar energy, geothermal power, wind mill energy, utilization of oceanic energy, bio-mass energy, total energy systems. Energy policies. Energy audit in ceramic industries. Pollution control on the basis of SO_x , NO_x , CO_x , SPM amount emitted from different industrial entities related to ceramic industries. Role of ceramics in Energy Management, SOFC, Nuclear Energy.

Ecology: Thermal and thermo chemical environments. Thermal shock environments. Thermo mechanical environments. Stress corrosion and hydrostatic stress environments. Electromagnetic and nuclear radiation environments.

CR-4108: Engineering Ceramics and Processing Techniques (Credit-3)

Engineering property requirements and limitations of traditional ceramics. Advanced ceramics for engineering application-reliability consideration, toughening of ceramics, high temperature-ceramide, nitride. SIALON and other Ceramics. Engineering applications: Ceramics in heat engines, power generation, aerospace application, nuclear reactor, ceramics for tribological application, ceramic cutting tools.

Advanced Processing techniques: Ultrastructure processing and its potential impact on ceramic industry, powder processing and characterization. Fabrication techniques: Powder compaction, isostatic pressing, hot pressing, hot isostatic pressing. Slip processing, organic slips, slip casting, tape casting and injection moulding-process considerations. Porous ceramics and ceramic fibres. Microwave sintering.

CR-4109: Science and Technology of Special Glasses (Credit- 3)

Non conventional processing of glasses; Sol-Gel method, Chemical vapor deposition method. Acid-base concept in glass. Technology of making radiation shielding glasses, Heat absorbing glasses, Solder glasses, Chalcogenide and Halide glasses and their applications. Low durability glasses for agricultural purpose. Glass for optical fibre communication, TV picture tube, Glass filters. Fixation of nuclear wastes in glass, LASER glasses and their use, Solarized glasses.

PRACTICAL

CR-4301: Cement and Concrete Laboratory (Credit- 2)

Determination of : Surface area of cement by Blaine's air permeability apparatus. Tensile strength of cement. Particle size by Turbidimeter. Soundness of cement by autoclave test method. Workability of cement mortar. Workability of concrete. Compressive strength of cement. Transverse strength of cement. Water retention value of cement. Heat of hydration of cement. Air entrainment in cement.

CR-4302: Glass Laboratory (Credit- 2)

Preparation of batches and melting of different types of glasses. Determination of various properties of glass, e.g. density, chemical durability, thermal endurance, bursting pressure of bottles, refractive index, low temperature viscosity, softening point. Absorption of light and use of spectrophotometer for qualitative and quantitative analysis of glass. Use of strain viewer and quantitative determination of strain in glass. Examination of common defects of glass wares. Examination of stones in glass.

CR-4303: Project I (Evaluation and Viva-voce) (Credit- 2)

CR-4304: Seminar and Group Discussion (Credit- 2)

CR-4305: Training Report & Viva-voce (Credit- 2)

4 YEARS B. TECH. (CERAMIC ENGINEERING) PART IV
SEMESTER- VIII

CR-4201: Pollution Control in Ceramic Industries (Credit-3)

Different kinds of industrial pollution and their origin and influence on human being. The emission from burning coal, pet coke, furnace oil and their analysis. The improvement of combustion processes to reduce the formation of NO_x , SO_x , Co etc. The fine particles released from the crushing grinding of the ceramic raw materials. The equipment and methods to arrest the release of fine particulate materials and unwanted gases to atmosphere. Chemicals used in different ceramic industries e.g. Tiles, Potteries, Refractory, and Glass industries. Possibility of leaching of the chemicals to ground water and to rivers and lakes. Possible ways to stop the leaching of suitable chemicals. Different types of pollution created from the solid wastes in the ceramic industries and the possibility of recycling them. Sound and noise pollutions and their minimization techniques.

CR-4202: Pottery and Porcelain (Credit-3)

Manufacture, properties and uses of floor and wall tiles, table wares, sanitary wares, art wares, dental porcelains, bone-china, parian, electrical porcelains, chemical stone wares, chemical porcelains, refractory porcelains. Types of insulator bodies, low tension products, high voltage and high frequency insulators, low loss insulators, cordierite ceramics, steatite ceramics, honeycomb ceramics and other new ceramic materials.

Details of glazes, their properties and uses: Lead, leadless, opaque, transparent, crystalline, matt and colored glazes. Decoration in glaze, under glaze and on glaze, computerized decoration. Fast firing of glaze decoration. Instrumentation in ceramic processing. Microstructure and its effects on the properties.

CR- 4203: Refractories (Credit-3)

Different kinds of Monolithics Refractories and their design aspects. Advantages of Monolithic Refractories over shaped Refractories. Magnesita Carbon, Alumina Carbon Refractories, Manufacturing and properties. Slide gate plate, SEN and shrouds. Spinel, Zircon, Borides, Carbides, Nitride Refractories. Manufacturing and properties of synthetic raw materials. Insulating refractories of different kinds, their manufacturing and properties. Carbon Refractories manufacturing and properties. Application of refractories in Blast furnace, Coke oven, Hot metal mixer, Basic oxygen furnace, Electric Arc furnace, ladles and continuous casting. Refractory application in copper, Aluminium, Cement and lime, rotary kiln, glass industry, Microstructure study and its importance to characterize Refractory product. Application of sintering, phase diagram in refractory technology.

ELECTIVE PAPER

(One elective paper to be chosen out of the following)

CR-4204: Ceramic Matrix Composites (Credit- 3)

Definition. Introduction to ceramic matrix materials and ceramic reinforcements. Processing of monolithic ceramics and particulate composites, whisker and short fiber reinforced composites ; long fiber composites. Cold pressing and sintering, hot-pressing. Reaction bonding, infiltration, directed oxidation, sol-gel and in-situ chemical reaction techniques. Characteristics of matrix and

reinforcement interfaces. Micromechanics, thermal and physical properties of composites. Mechanical and creep behaviour of ceramic matrix composites. Applications of composite,

CR- 4205: Ceramic Whitewares (Credit: 3)

Effect of size, shape, texture, physical properties and chemical composition of raw materials on whitewares. Factors which influence the porosity, water absorption, strength, colour of whiteware bodies. Compositions of triaxial and other whitewares. Firing and temperature control. Grain growth, sintering, vetrification and microstructure of whitewares. Modern trends in firing of whitewares. Strength of porcelain insulators, factors affecting breakdown of high and low voltage insulators. Body preparation; role of synthetic steatite, cordierite in ceramic bodies. Manufacture properties and uses of bone china, chemical porcelain, sanitary wares, electrical porcelain. Defects in whiteware bodies caused by thermal expansion. Ceramic glazes, their properties and uses. Ceramic colours and decoration. Recent developments and control, techniques as applied to whiteware processes.

CR-4206: Computer Programming & Application in Ceramic Engineering (Credit- 3)

What is modeling and simulation, Basic concepts of modeling: Models based on mass and heat transfer (conduction, convection transport, radiation). Logic based industrial flow sheet with recycling. Optimization aspect from Linear and nonlinear point of view, evolutionary approach to global optimization: Genetic algorithm, etc. Simulation strategies: Sequential, equation solving approach, modular approach. Simulation software, object oriented programming, web-based technology. Computer application in controlling ceramic processes and furnaces and other relevant accessories.

CR-4207: Electrical and Electronic Ceramics (Credit- 3)

Ceramic Insulators -Thermal, insulation and dielectric properties. Composition and their manufacture, Cordierite and steatite. Electronic behavior of Ceramics - Band structures of ceramic oxides, narrow band oxides, Jahn Teller effect, controlled valency semiconductors, Non-stoichiometry in oxides and its effect on electrical conductivity; Grain boundary effects on electrical properties. Highly Conducting Ceramics. Synthesis, characteristics and applications of High Tc Superconductors. Function, fabrication, microstructure, characteristics and applications of varistor. Classification, structure and applications of solid electrolytes. Fuel cells and batteries. Negative and positive temperature coefficient thermistor devices. Gas and humidity sensors technology. Thick film hybrid circuit ceramic technology. Collosol and Giant magneto-resistance.

CR-4208: Super and Monolithic Refractories (Credit- 3)

Scope of beneficiation of indigenously available low grade refractory raw materials and their agglomeration. New production technology: Introduction of high intensity mixer, Vacuum pressing, high pressure press, isostatic press, precast refractories. Development of carbon bearing refractories: Magcarbon, alumina carbon, alumina-magnesia-carbon, alumina-SiC-C, Zirconia refractories and carbon refractory. Different binders used for manufacture of carbon bearing refractories. Refractory application in secondary steel making, continuous casting, fertilizer and petrochemical industries. Factors affecting the performance of refractories. Status of refractory industries in India in context to production of steel, cement glass and its future. Technological aspects of design and application of monolithics: Castables of different kinds, gunning and spraying, ramming masses, mortars. Microstructure and properties of refractory products. Better understanding of phase equilibrium and sintering in controlling microstructure for various refractory properties.

PRACTICAL

CR-4401: Pottery Laboratory (Credit-2)

Lab experiments are based on theory subject.

CR-4402: Refractories Laboratory (Credit-2)

Lab experiments are based on theory subject.

CR-4403: Project II (Evaluation and Viva-voce) (Credit-6)

CR-4404: Comprehensive Viva-voce (Credit- 2)

