RAJASTHAN TECHNICAL UNIVERSITY

Teaching and Examination Scheme for B.Tech. (4 Year Course)
In
Ceramic Engineering

Year : II **Semester : III**

Code	Subject	Hrs./week			Exam Hrs.	Maximum Marks		
		L	T	P		*I.A.	Exam	Total
A. Theory Papers								
3CRE1	Ceramic Raw Materials and Characterization	3	-	-	3	20	80	100
3CRE2	Ceramic Processing	3	-	-	3	20	80	100
3CRE3	Material Science	3	-	-	3	20	80	100
3CRE4	Mathematics-III	3	1	-	3	20	80	100
3CRE5	Electronic Measurement & Instrumentation	3	-	-	3	20	80	100
3CRE6	Theory of Solid Mechanics	3	1	-	3	20	80	100
B. Practical & Sessional :								
3CRE7	Ceramic Material Analysis Lab		-	3				100
3CRE8	Mineralogy and Microscopy Lab		-	3				100
3CRE9	Electronics & Instrumentation Lab		-	3				75
3CRE10	Solid Mechanics & Machines Lab		-	3				75
3CRECS	**Discipline & Extra Curricular Activities**							50
	GRAND TOTAL	18	2	12				1000

* I.A. – Internal Assessment

RAJASTHAN TECHNICAL UNIVERSITY

Teaching and Examination Scheme for B.Tech. (4 Year Course)
In
Ceramic Engineering

Year : II **Semester : IV**

Code	Subject	Hrs./week			Exam Hrs.	Maximum Marks		
		L	T	P		*I.A.	Exam	Total
A. Theory Papers								
4CRE1	Ceramic analysis and Instrumentation	3	-	-	3	20	80	100
4CRE2	Heat and Mass Transfer	3	1	-	3	20	80	100
4CRE3	Particle and Fluid Mechanics	3	1	-	3	20	80	100
4CRE4	Electric Properties of Material	3	-	-	3	20	80	100
4CRE5	Mathematics- IV	3	1	-	3	20	80	100
4CRE6 4CRE6.1 4CRE6.2 4CRE6.3	Elective (Any one of the following) Data Base Management System Introduction to Nano-Technology Newer Machining Methods	3	-	-	3	20	80	100
B. Practical & Sessional :								
4CRE7	Instrumental & Analysis Lab	-	-	3				100
4CRE8	Heat and Mass Transfer Lab	-	-	3				100
4CRE9	Particle and Fluid Mechanics Lab	-	-	3				75
4CRE10	Computer Programming Lab	-	-	3				75
4CREDC **Discipline & Extra Curricular Activities**								50
	GRAND TOTAL	18	3	12				1000

* I.A. – Internal Assessment

3CRE1 CERAMIC RAW MATERIALS AND CHARACTERIZATION

UNIT I : Geology and its utility in ceramic industry. Broad outlines of crystal forms and symmetry, Description and classification of rocks and their formation.
UNIT 2 : Description and classification of various minerals based on their chemical compositions, Physical properties and occurence.
UNIT 3 : Study in detail of raw materials used in glass, Refractories, White wares, Potteries and cement.
UNIT 4 : Optical activity, Polarizing microscope, Isotropic and anisotropic minerals, Bi-referingence, 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.
UNIT 5 : Chemical characteristic of raw materials of alkali and alkaline earth elements, Silica, Silicates, Alumina, Aluminates, Titania, Zirconia and and zircon, Chromatography : Introduction, Paper and thin layer chromatorgraphy, Liquid chromatography, Types of liquid chromatography, Column and detection systems. Differential thermal analysis (DTA) and thermo gravimetric analysis (TGA) with suitable examples.

3CRE2 CERAMIC PROCESSING

UNIT 1 : Ceramic fabrication processes & their classifications.
UNIT 2 : COLLOIDAL PROCESSING OF CERAMICS : Types of colloids**,** Attractive surface forces, Electrostatic, Steric and electrostatic stabilizations, Structure of consolidated colloids. Detailed study of rheology of ceramic systems. Particle sol-gel processing.
UNIT 3 : FORMING OF CERAMICS AND POWDER CONSOLIDATION METHOD : Characteristics of solid particles, Particle shapes , Size, Equivalent particle diameter, Surface area, Average particle size & size distribution.
UNIT 4 : Packing of particles, Additives in forming processes, Selection of additives, Dry pressing, Plastic forming, Slip casting and tape casting methods & extrusion.
UNIT 5 : Introduction to sintering of ceramics, Hot and iso-static processing, Binder removal, Calcinations & affecting factors.

3CRE3 MATERIALS SCIENCE

UNIT 1: CRYSTALLOGRAPHY : Crystal structure, space lattice, Bravais lattice, Miller indices, crystal symmetry. Different crystal structures: BCC, FCC and HCP. Study of AX, A_mX_p, and $A_mB_nX_{p.}$ Need for required crystal structure.

UNIT 2 : TYPE OF STANDARD CRYSTAL STRUCTURES: Structure of silicates (orthosilicates, pyrosilicates, single chain, double chain, sheet and network silicates), zeolites and polymers. Liquid crystals.

UNIT 3 : CRYSTAL IMPERFECTION : Classification of defects in natural crystals: Point, Line, Plane, Electronic imperfections, Transient imperfection. Points defects: thermodynamics of point defects, Lattice vacancies, Schottky defects, Frenkel defects, Extrinsic vacancies and colour centers. Dislocations: Introduction, edge and screw dislocations, Burger vector, slip systems, Energy of dislocations, theory of dislocation, interaction between dislocations, Mechanism of plastic deformation.

UNIT 4 : Strengthening mechanism recovery, Dislocations in crystal growth. Effects of crystal imperfection on electronics, optical and mechanical properties and technique for imperfect detemination and controlling the crystal imperfection in crystal growth.

UNIT 5 : OPTICAL PROPERTIES: Interaction of electromagnetic waves with matter. Absorption, reflection, transmittance and colour of materials. Photoconductivity: Introduction. Photo conducting materials. Electronic transition in photoconductors. Absorption and Excitation. Trapping and capture. Simple model of a photoconductor. Luminescence: Introduction. Model for luminescence in sulphide phosphors. Thallium activated alkali halides. Electroluminescence.

3CRE4 MATHEMATICS-III

UNIT 1 : LAPLACE TRANSFORM - Laplace transform with its simple properties, applications to the solution of ordinary and partial differential equations having constant co-efficients with special reference to the wave and diffusion equations.

UNIT 2 : FOURIER SERIES & Z TRANSFORM – Expansion of simple functions in fourier series. Half range series, Change of intervals, Harmonic analysis. **Z TRANSFORM -** Introduction, Properties, Inverse Z Transform .

UNIT3 : FOURIER TRANSFORM - Complex form of Fourier Transform and its inverse, Fourier sine and cosine transform and their inversion. Applications of Fourier Transform to solution of partial differential equations having constant co-efficient with special reference to heat equation and wave equation.

UNIT 4 : COMPLEX VARIABLES - Analytic functions, Cauchy-Riemann equations, Elementary conformal mapping with simple applications, Line integral in complex domain, Cauchy;s theorem. Cauchy's integral formula.

UNIT 5 : COMPLEX VARIABLES -Taylor's series Laurent's series poles, Residues, Evaluation of simple definite real integrals using the theorem of residues. Simple contour integration.

3CRE5 ELECTRONIC MEASUREMENT & INSTRUMENTATION

UNIT 1 : THEORY OF ERRORS: Accuracy & precision, Repeatability, Limits of errors, Systematic & random errors Modeling of errors, Probable error & standard deviation, Gaussian error analysis, Combination of errors.

UNIT 2 : ELECTRONIC INSTRUMENTS FOR MEASURING BASIC PARAMETERS : Electronic Voltmeter, Electronic Multimeters, Digital Voltmeter, Component Measuring Instruments, Q meter, Vector Impedance meter, RF Power & Voltage Measurements. Measurement of frequency. Introduction to shielding & grounding.

UNIT 3 : OSCILLOSCOPES : CRT Construction, Basic CRO circuits, CRO Probes, Oscilloscope Techniques of Measurement of frequency, Phase Angle and Time Delay, Multibeam, multi trace, storage & sampling Oscilloscopes. Curve tracers.

UNIT 4 : SIGNAL GENERATION: - Sine wave generators, Frequency synthesized signal generators, Sweep frequency generators.

Signal Analysis **-** Measurement Technique, Wave Analyzers, Frequency - selective wave analyser, Heterodyne wave analyser, Harmonic distortion analyser, Spectrum analyser.

UNIT 5 : TRANSDUCERS - Classification, Selection Criteria, Characteristics, Construction, Working Principles, Application of following Transducers- RTD, Thermocouples, Thermistors, LVDT, RVDT, Strain Gauges, Bourdon Tubes, Bellows. Diaphragms, Seismic Accelerometers, Tachogenerators, Load Cell, Piezoelectric Transducers, Ultrasonic Flow Meters.

3CRE6 THEORY OF SOLID MECHANICS

UNIT I: STRESS-STRAIN: Tensile, Compressive, Shear stress and strain. Stress-strain diagram, Hooke's law, Poisson's ratio, elastic constants and their relationships for a isotropic homogeneous material, thermal stresses.Composites bars, simple elastic, plastic and visco-elastic behavior of common materials in tension and compression test, concept of factor of safety and permissible stress.

UNIT 2 : Types of load, types of beams, Introduction to bending moment and shear force diagrams, bending stress and shear stress distributions in various sections viz. circular, hollow, T etc; Torsional shear stress in solid, hollow and stepped circular shafts; Concept of equivalent bending and equivalent twisting moment, Mohr's circle of stress and strain, a brief theory of elastic failures.

UNIT 3 : KINEMATICS: Elements, pairs, mechanism, four bar chain and its inversions. Velocity and acceleration, Klein construction, Instantaneous center method, synthesis of mechanism, pantograph, Scott-Russel mechanism, trifler suspension and Hooke's joint.

UNIT 4 : FRICTION: Laws of static, dynamic and rolling friction, dry & viscous friction, inclined plane and screw jack, friction axis, bearing and theory of film lubrication, clutches. Introduction to thin and thick walled cylinders.

UNIT 5 : VIBRATION :

Single Degree of Freedom Systems - Degree of freedom for dynamic analysis, Single degree of freedom system, Force-displacement relation : linearly elastic system and inelastic system, damping force, Equation of motion : external force, application of Newton's second law of motion, dynamic equilibrium stiffness, damping and mass components, mass-spring damper systems, equation of motion-earthquake excitation, combining static and dynamic responses, methods of solution of the differential equation.

Free Vibration : Un-damped, Viscously damped free vibration : types of motion, under-damped systems, decay of motion, free vibration tests.

3CRE7 CERAMIC MATERIAL ANALYSIS LAB

1. Determination of sulphate and chlorides in a given sample.
2. Determination of bicarbonates in a given sample.
3. Estimation of Na_2O, K_2O and B_2O_3 present in a sample.
4. Chemical analysis of limestone for insoluble content R_2O_3 (R = Fe, Al etc.), CaO, MgO.
5. Chemical analysis of gypsum and dolomite for insoluble content.
6. Calculate different physical parameters under load (RUL) of a given refractory.
7. Chemical analysis of a given sample of sand.
8. Thermo gravimetric analysis of a given sample.
9. Spectrophotometer analysis of given sample solution.
10. Diffferential thermal analysis of given sample.

3CRE8 MINERALOGY AND MICROSCOPY LAB

Section A: Mineralogy

1. Determination of specific gravity of mineral by Walker's steelyard balance.
2. Megascopic identification of important rock forming minerals.

Section B: Microsocopy Laboratory

3. Study of a polarizing microscope and its different parts, setting of a polarizing microscope and centering of the object.
4. Study of Becke's effect and refractive index of given materials.
5. To prepare and identify the following minerals in thin section used in ceramic industries : Quartz, orthoclase, albite, silimanite, kyanite, andalusite, gypsum, calcite, hornblende, tourmaline, muscovite, biotite, quartzite, limestone, labradorite and other ceramic materials.
6. To study X-Ray diffractometer and determine crystal structure of the given ceramic samples.
7. Characterization of the given complexes by electronic and IR spectral data.
8. Determine the size, diameter and morphology in a given sample and then categorized them on the basis of their physical dimensions using Atomic Force Microscope/Surface Tunnel Microscope.
9. Determination of grain & surface morphology of given sample & characterize them using AFM (Atomic Force Microscopy/ Surface Tunnel Microscope).

3CRE9 ELECTRONICS AND INSTRUMENTATION LAB

1 Study the following devices:
   (a) Analog & digital multimeters
   (b) Function/ Signal generators
   (c) Regulated d. c. power supplies (constant voltage and constant current operations)
   (d) Study of analog CRO, measurement of time period, amplitude, frequency & phase angle using Lissajous figures.
2 Plot V-I characteristic of P-N junction diode & calculate cut-in voltage, reverse Saturation current and static & dynamic resistances.
3 Plot V-I characteristic of zener diode and study of zener diode as voltage regulator. Observe the effect of load changes and determine load limits of the voltage regulator.
4 Plot frequency response curve for single stage amplifier and to determine gain bandwidth product.
5 Plot drain current - drain voltage and drain current – gate bias characteristics of field effect transistor and measure of I_{dss} & V_p
6 Application of Diode as clipper & clamper
7 Plot gain- frequency characteristic of two stage RC coupled amplifier & calculate its bandwidth and compare it with theoretical value.
8 Plot gain- frequency characteristic of emitter follower & find out its input and output resistances.
9 Plot input and output characteristics of BJT in CB, CC and CE configurations. Find their h-parameters.
10 Study half wave rectifier and effect of filters on wave. Also calculate theoretical & practical ripple factor.
11 Study bridge rectifier and measure the effect of filter network on D.C. voltage output & ripple factor.

3CRE10 SOLID MECHANICS LAB

1. To determine the co-efficient of friction for the given surface and samples.
2. To determine moment of inertia of the given object using of Trifler suspension.
3. Direct tensile test of the given samples.
4. Torsion test on torsion testing machine of a given sample.
5. Shear/bending test of a given sample using UTM.
6. Determination of spring constant K of the given sample using spring testing machine.
7. Fatigue testing of a given sample.
8. Impact test of given sample

4CRE1 CERAMIC ANALYSIS AND INSTRUMENTATION

UNIT 1: CRYSTALLOGRAPHY: 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.

UNIT 2 : SPECTROSCOPIC ANALYSIS: Introduction, Absorption and reflection techniques, Atomic techniques: emission, absorption and fluorescence, Photo acoustic spectroscopy, Microwave spectroscopy and mass spectrometers. Atomic Absorption spectrometer, paleography and its applications in analysis of ceramic systems.

UNIT 3 : GAS AND LIQUID ANALYSIS: Infrared and ultraviolet absorption analyzers, Paramagnetic oxygen analyzers, Thermal conductivity analyzers, Chemical luminescence analyzers and flame photometer and its uses in analysis. PH meters, conductivity meter analyzers for measurement of ammonia, silica, sodium and dissolved oxygen. Chromatography and its use in separation and identification of different elements.

UNIT 4 : 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, TEM and EPMA.

UNIT 5 : PARTICLE SIZE, SURFACE AREA AND POROSITY MEASUREMENTS: Light scattering counter and sedimentation method for particle size, measurements. BET surface area measurements. Mercury porosity meter.

4CRE2 HEAT AND MASS TRANSFER

UNIT 1 : CONDUCTION: Heat transfer by conduction. Fourier's law, thermal resistances in series, conduction through infinites slab, thick walled cylinder and thick sphere, variation of conductivity with temperature. Convection: heat transfer through liquid. Newton's law, film coefficient, natural and forced, overall heat transfer coefficient, heat transfer coefficient based on inside and outside areas, dirt and foul factors, elementary concepts of dimensionless numbers, their use in predicting film coefficient, heat transfer to liquid under laminar and turbulent flows, forced convection outside tubes.

UNIT 2 : Radiation and furnace: Stefan-Boltzmann law, emissivity and absorbability, black and grey bodies, view factors, gas radiation, radiant heat transfer in glass melting. Furnaces: solid, liquid and gaseous fuels, their feeding devices, primary and secondary air for combustion, complete and partial combustion, calculation of radiant heat transfer in furnaces. Fuel gas: analysis and its utility, purpose of furnace linings and higher chimneys, application to steam boilers.

UNIT 3 : Heat Exchanger: Shell and tube heat exchangers, baffles, design of heat exchanger and their relative advantages, multi pass heat exchangers, mean temperature difference in co-current and counter current flows, LMTD correction factor for multi pass heat exchanger, plate heat exchanger, Current, counter current and cross-flow heat exchangers.

UNIT 4 : DIFFUSION AND DIFFUSIVITY: Fick's law, mass and molar rates of flow, different velocities and fluxes under static and moving co-ordinate system, concentration gradients in dimensional co-current and counter current flows, two film theory, analogy between mass momentum and heat transfer, mass transfer co-efficients, their experimental determination, use of dimensionless numbers, Sherwood, Lewis, Schmidt numbers.

UNIT 5 : ABSORPTION AND DRYING: absorption and desorption in packed beds and in plate columns, relative advantages. 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.

4CRE3 PARTICLE AND FLUID MECHANICS

UNIT 1 : 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.

UNIT 2 : SEPARATORS AND FILTERS: Law of motion of single particle sedimentation, free and hindred settling. Thickener and settling chambers. Flotation, 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, plate and frame filters, centrifugal filters, filter media, filter aids, washing of filter cakes, selection of filtration equipments.

UNIT 3 : BASIC DEFINITIONS AND FLUID PROPERTIES: Definition of Fluid, Incompressible and compressible fluids, Fluid as a continuum, Mass, Density, specific weight, relative density, specific volume, Bulk modulus, velocity of sound ideal fluid viscosity, Newtonian and Non-Newtonian fluid, Kinematic viscosity, Effect of temperature and pressure on viscosity, surface tension capillarity, vapour pressure and cavitations.

Fluid States : General differential equation, Hydrostatics manometry, Fluid forces on submerged surfaces. Curved surfaces, Aerostatics, Isothermal atmosphere, polytropic atmosphere.

UNIT 4 : KINEMATICS AND CONSERVATION OF MASS: Flow classifications. Fluid velocity and acceleration, streamlines and the stream function. Path lines and Rotational flow. Flownet, Laplace equation. Conservation of mass and the continuity equation for three dimensions. Equation of motion, Euler's equation of motion. Bernoulli's equation. Applications of Bernoulli's Pitot tube.

UNIT 5 : The Boundary Layer: Description of the boundary layer. Boundary Layer thickness boundary layer separation and control. The Prandtl boundary layer equation.

Flow round a body, Drag skin friction drag, pressure drag, combined skin friction & pressure drag (Profile drag) wave drag, lift induced drag . Variation of drug co- efficient with Reynolds's number.

4CRE4 ELECTRIC PROPERTIES OF MATERIALS

UNIT 1 : BAND THEORY & SOLIDS - Conductivity of metals, Mattheisen's rule, Sommerfield' model, Band theory of solids, Kronig-Penny model, Origin of energy gap, Brillouin zones, distinction between metals, insulators and semiconductors, Direct experimental evidence for band structure.

UNIT 2 : MAGNETIC MATERIALS - Classification of magnetic materials, Ferromagnetism, Diamagnetism and Paramagnetism, Origin of ferromagnetism and hysteresis loop, Domain and Magnetic anisotropy, Magnetostriction. Ferrimagnetic compounds, Spinel, Garnet. Properties: High temperature susceptibilities, Specific heat and thermal conductivity. Soft and hard magnetic materials and their applications.

UNIT 3 : POLARIZATION & DIELECTRIC MATERIALS IN STATIC FIELDS - Introduction. Polar and non-polar dielectrics, Polarization of dielectric, Clausius-Mossoti equation. Measurement of dielectric constant.

UNIT 4 : DIELECTRIC MATERIAL IN DYNAMIC FIELDS - Frequency dependence of polarisability, Dielectric relaxation. Dielectric losses and Breakdown of dielectrics, Electrets. Losses at microwave, IR & Optical frequencies

UNIT 5 : PIEZOELECTRIC & FERROELECTRIC MATERIALS - Piezoelectric effect: Introduction, theory and application of piezoelectric crystals. Ferroelectric effect: Introduction. Ferroelectric crystals, Change in crystal structure during polarization. Theory of Ferro-electricity, Ferroelectric domain, difference between ferroelectric and ferromagnetic domain. Use of ferroelectric materials.

4CRE5 MATHEMATICS IV

UNIT 1 : N**UMERICAL ANALYSIS -** Finite differences – Forward, Backward and Central differences. Newton's forward and backward differences, interpolation formulae. Stirling's formula, Lagrange's interpolation formula.

UNIT 2 : NUMERICAL ANALYSIS- Integration-Trapezoidal rule, Simpson's one third and three-eighth rules. Numerical solution of ordinary differential equations of first order - Picard's mathod, Euler's and modified Euler's methods, Miline's method and Runga-Kutta fourth order method.,Differentiation

UNIT 3 : SPECIAL FUNCTIONS – Bessel's functions of first and second kind, simple recurrence relations, orthogonal property of Bessel's , Transformation, Generating functions, Legendre's function of first kind. Simple recurrence relations, Orthogonal property, Generating function.

UNIT 4 : STATISTICS AND PROBABILITY - Elementary theory of probability, Baye's theorem with simple applications, Expected value, theoretical probability distributions-Binomial, Poisson and Normal distributions. Lines of regression, co-relation and rank correlation.

UNIT 5 : CALCULUS OF VARIATIONS - Functional, strong and weak variations simple variation problems, the Euler's equation.

4CRE6.1 DATA BASE MANAGEMENT SYSTEM

UNIT 1 :Introduction Need, purpose and goals of DBMS. DBMS Architecture, Concept of keys, Generalisation and specialization, Introduction to Relational data model, ER Modeling, Relational algebra.

UNIT 2: DATABASE DESIGN : Conceptual Data Base design. Theory of normalization, Primitive and composite data types, concept of physical and logical databases, data abstraction and data independence,. Relational calculus.

UNIT 3 : SQL : DDL and DML. Constraints assertions, views, data base security. Application Development using SQL : Host language interface, embedded SQL programming. GL's, Forms management and report writers. Stored procedures and triggers.

UNIT 4 INTERNAL OF RDBMS - Physical data organization in sequential, indexed, random and
hashed files. Inverted and multilist structures.

UNIT 5 : Transaction processing, concurrency control, Transaction model properties and state serialisability. Lock base protocols, two phase locking, Log based recovery Management.

4CRE6.2 INTRODUCTION TO NANO-TECHNOLOGY

UNIT 1 : PROPERTIES OF INDIVIDUAL NANO-PARTICLES - Meaning of nano-particle, metal nano-clusters : magic numbers, theoretical modeling of nano particles, geometric structure, electronic structure, reactivity, fluctuations, magnetic clusters, bulk to nano-transition ; semi-conducting nano-particles : optical properties, photofragmentation, coulombic explosion; rare gas and molecular clusters : inert gas clusters, superfluid clusters, molecular clusters; methods of synthesis: R F plasma, chemical methods, thermolysis, pulsed laser methods.

UNIT 2 : A. CARBON NANO STRUCTURES

Carbon Molecules : Nature of the carbon bond, new carbon structures; carbon clusters, carbon nanotubes : fabrication, structure, electrical mechanical and vibrational properties, applications of nano tubes including those in chemical sensors, catalysis, mechanical reinforcement.

B. BULK NANO-STRUCTURED MATERIALS

Solid Disordered Nanostructures : Methods of synthesis, failure mechanisms of conventional grain-sized materials, mechanical properties, nanostructured multilayers, electrical properties, arrays of nano particles in zeolites, porous silicon; nano-structured crystals including nanoparticle lattices in colloidal suspensions.

UNIT 3 : NANO STRUCTURED FERROMAGNETISM- Basics of ferromagnetism, effect of bulk nanostructuring on magnetic properties, dynamics of nano magnets, nano pore containment of magnetic particles, nano carbon ferro-magnets, giant and colossal magneto-resistance, ferro-fluids.

Nano-machines and Nano-devices : Micro-electromechanical systems (MEMSs). nanoelectromechanical systems (NEMSs), nano-devices and nano-machines.

UNIT 4 : QUANTUM WELLS, WIRES AND DOTS - Preparation of quantum nanostructures, size and dimensionality effects, excitations, applications including superconductivity

Self Assembly and Catalysis : Process of self assembly, semiconductor islands, monolayers; catalysis : nature of catalysis, surface area of nano particles, porous materials, pillared clays, colloids.

UNIT 5 : POLYMERS - Hydrocarbons, forming and characterizing polymers : polymerisation, sizes of polymers ; nanocrystals : condensed ring types, polydiacetylene types ; polymers: conductive polymers, block co-polymers; supramolecular structures : transition metal-mediated types, dendritic molecules, supramolecular dendrimers, micelles.

Biological materials including biological building blocks.

4CRE6.3 NEWER MACHINING METHODS

UNIT 1 : Introduction and classification of Advanced Machining Process, consideration in process selection, Difference between traditional and non-traditional process, Hybrid process.

UNIT 2 : MECHANICAL ADVANCED MACHINING PROCESS - Introduciton, Mechanics of Metal Removal, Process, Principle, Advantages, Disadvantages and applications of AJM, USM, WJC.

UNIT 3 : THERMO ELECTRIC ADVANCED MACHINING PROCESS - Introduction, Principle, Process, Parameters, Advantages and Disadvantages about EDM,EDG,LBM,PAM, EBM.

UNIT 4 ELECTROCHEMICAL AND CHEMICAL ADVANCED MACHINING PROCESS - ECM, ECG, ESD, Chemical Machining, Anode Shape Predition and tool design for ECM process. Tools (cathode) design for ECM process.

UNIT 5 : NON-CONVENTIONAL ABRASIVE FINISHING PROCESS - Abrasive flow machining, Magnetic abrasive finishing (for plain and cylindrical surfaces).

4CRE7 INSTRUMENTATION AND ANALYSIS LAB

1. Demonstration of DTA/Differential Enthalpy Analysis and 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 parameter.
4. Sample preparation of ceramic Materials for microstructure observation by optical microscope.
5. Spectrophotometric analysis of ceramic and glasses.
6. Demonstration of SEM/EPMA/TEM.
7. Determination of the following elements using flame photometer:
   a. Sodium and Potassium when present together.
   b. Lithium/calcium/barium/strontium.
   c. Cadmium and magnesium in tap water.
8. Thin layer chromatographic separation and identification of nickel, manganese, cobalt and zinc.
9. Determination of particles size in the given sample by using sedimentation laser method.
10. Determination of porosity in the given ceramic samples by using mercury porosity meter.
11. Analysis and measurement of ammonia, silica, sodium and dissolved oxygen by using conductivity meter.

4CRE8 HEAT AND MASS TRANSFER LAB

1&2 To determine (a) Thermal conductivity (b) Critical thickness (c) Thermal resistance of given ceramic material / insulating powder.
3. To determine the Stefan-Boltzmann constant.
4. Determination of heat transfer coefficient in natural and forced convection.
5. Determination of overall heat transfer coefficient and effectiveness for parallel and counter flow heat exchangers.
6. Determination of emissivity of a given test plate made by ceramic material with respect to black plate (standard).
7. Obtain the extraction efficiency of an agitating extractor for liquid- liquid system.
8. Study of (I) Gas inducing type agitators & (II) Cyclone separators.
9. Demonstration of effect of direction of mass heat transfer on coalescence foaming.
10. Determination of heat transfer Coefficient in natural and forced convection.

4CRE9 PARTICLE AND FLUID MECHANICS LAB

1. To classify particles/grains based on size, shape, density and surface properties.
2. To determine the terminal velocity of Cyclone separator.
3. Size reduction using Jaw & roller crusher and calculation of equivalent diameter of solid particle.
4. To analyze the given product for its particle size distribution using Sieve shaker.
5. To determine coefficient of viscosity of a given sample.
6. Determination of pressure using pressure gauge and other devices.
7. To verify Bernoulli's equation experimentally.
8. To determine the flow rate and coefficient of discharge using Venturimeter.
9. To determine the flow rate and coefficient of discharge using Orificemeter.
10. Calibration of orifice/notch.
11. Study of nature of flow using Heleshow's apparatus.

4CRE10 COMPUTER PROGRAMMING LAB

Programs in C++

1. Write a program to perform the complex arithmetic.
2. Write a program to perform the rational number arithmetic.
3. Write a program to perform the matrix operations. (Transpose, addition, subtraction, multiplication, test if a matrix is symmetric/ lower triangular/ upper triangular)
4. Implement Morse code to text conversion and vice-versa.
5. To calculate Greatest Common Divisor of given numbers.
6. To implement tower of Hanoi problem.

Program in Java

7. To implement spell checker using dictionary.
8. To implement a color selector from a given set of colors.
9. To implement a shape selector from a given set of shapes.
10. By mapping keys to pens of different colors, implement turtle graphics.
11. To implement a calculator with its functionality.
12. To implement a graph and display BFS/DFS order of nodes.

RAJASTHAN TECHNICAL UNIVERSITY
Teaching and Examination Scheme for B.Tech. (4 Year Course)
In
Ceramic Engineering

Year: III **Semester: V**

SUBJECTS		Hrs./week			Exam Hrs	Maximum Marks		
		L	T	P		I.A	Exam	Total
5CR 1	Red Clay (Terracotta) Technology	3			3	20	80	100
5CR 2	Pottery & Heavy Clayware Ceramics	3			3	20	80	100
5CR 3	Refractory	3			3	20	80	100
5CR 4	Electro- Ceramics -1	3			3	20	80	100
5CR 5	Glass and Glass Ceramics	3			3	20	80	100
5CR 6	Fuels, Furnaces and Pyrometers	3			3	20	80	100
	Total Theory :	18						
Practicals								
5CR 7	Red Clay Laboratory			3	3			100
5CR 8	Pottery & Heavy Clay Laboratory			3	3			100
5CR 9	Refractory Laboratory			3	3			75
5CR10	Glass & Electro-Ceramic Lab.			3	3			75
5CRCS	Discipline & Extra Curricular Activities							50
	GRAND TOTAL	18		12				1000

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

5CR1: Red Clay (Terracotta) Technology

UNIT I: Red Clay Pottery- Pre-historic Back ground, Raw-materials & Their types, Physical & Chemical Properties.

UNIT II: Clay Processing & Body mixes, Fabrication techniques for different red clay products.

UNIT III: Drying & Firing, Kilns & Kiln construction

UNIT IV:. Classification of Red Clay (Terracotta) Products and their qualities,, Common building bricks, roofing tiles. Value up-gradation of Red clay products.

UNIT V: Glazes & Glazing. Firing & Decoration techniques

5CR2: Pottery and Heavy Clayware

UNIT I: Ceramic Raw Materials: Plastic Raw materials-Clays geology & Mineralogy, Ries Classification, Properties of clays- Adsorption, Cation exchange, Flow properties, Thixotropy, Plasticity, Permeability, Green shrinkage & strength, Fired shrinkage & strength, Non- clay Plastic raw materials- Talc & Steatite, Pyrophyllite,

Unit II: Non-Plastic raw materials: Silicon atom & its building Silica, Feldspar, Nepheline Syenite. Sillimanite, Bone ash, Wollastonite other fluxes-Lithium, Sodium, Potassium, Magnesium, Calcium, Barium& Boron Compounds. Auxiliary raw-materials-water, Deflocculates, Flocculants, Organic Binders, Lubricants and sticking agents, Drying aids, Plaster of Paris,

UNIT III: Winning & Purification of Clays: Mining & Winning of clays,- China clay, Sedimentary clays, Machinery used in clay mining, Treatment of clays.

Unit IV: Action of Heat on Ceramic Raw-Materials- Changes non-altering Chemical composition, Changes Altering chemical composition, Incomplete & complete reaction, Melting ,Crystallization & glass formation, Structure of Glasses & Glazes, Phase diagram in Ceramic Bodies,

UNIT V: Ceramic Bodies: Composition of Ceramic Bodies, Brick wares, Stoneware, Fine stoneware, White Stoneware, Electrical stoneware, Earthenware, Vitreous China, Soft Porcelain, Bone China, Hard Porcelain, Chemical Porcelain, Electrical Porcelain, Methods of Fabrication: Throwing, jiggering and jollying, soft plastic methods, extrusion methods, stiff-plastic methods.

5CR3 Refractories:

UNIT I: Introduction: Definition of refractory, classification of Refractory, Ingredient of Refractory, manufacturing process and unit operation.

UNIT II: Manufacture, properties, and application: silica, high alumina, dolomite, Magnesite, zircon, Zirconia refractory, fusion cast refractory, ceramic fiber and heat insulating refractory.

UNIT III: Monolithic: Monolithic refractory, classification of monolithic refractory, bonding of monolithic Refractory, formulation of monolithic refractory, process control in monolithic production

UNIT IV: Properties and Measurement: Porosity, Bulk density, fusion point, permeability, cold crushing strength, Refractory under load, hot modulus of rupture, CRp behavior, abrasion resistance, thermal conductivity, thermal expansion and spalling.

UNIT V: Reaction of Refractory: slag, glasses, carbon monoxide, acids, alkalis, flue gases, corrosion of regenerator's Refractory by flue gases.

5CR4: Electro Ceramics -1

UNIT I: Ceramic Capacitors: Historical Background, Ferro Electricity in Capacitors Technology, Dielectric Properties of Multi-Phase systems, Basic Dielectric Materials, Varieties of Ceramic capacitor, Capacitor performance Parameters, Packaging of Ceramic Capacitors, Typical Ceramic Dielectric Compositions,

UNIT II: Piezo-electric and Electro-optic Ceramics: Piezoelectric Ceramic, Ferroelectric ceramic, Electrooptic Ceramic, Composition, Processing & Properties, Applications of Piezoelectric & Electrooptic ceramic,

UNIT III: **Magnetic Ceramics:** Spinal ferrites, Hexagonal ferrites, Rare earth-Garnet, Processing & application in various fields.

UNIT IV: **Ceramic Sensors:** Theory & Transducer classification, Transition from theory to Practice, Future Prospects, Thermo-physical Properties,

UNIT V: ZnO Varistors: Varistors electrical characteristics, Varistors Microstructure & Fabrication, Varistors equivalent circuit, Mechanics of Varistors behavior, Varistors applications.

5CR5: Glass & Glass Ceramics.

UNIT I : Glass: Definition of glass, Types and composition of glass, Glass constituents and batch ingredients, decolourisers and refining agents, batch calculation, batch preparation.

UNIT II : Glass melting: Factors that influence glass formation, Zachariasen's rules, Kinetic & Thermodynamic criteria for Glass formation, Tank furnaces, feeding of glass batches, melting process, refining of glass, batch Redox number, electric heating, cold top furnace, pot melting

UNIT III : Quality control of glasses: control of compositions, measurement of density, thermal expansion, viscosity, Liquid immiscibility and phase separation in glasses, structural theories of liquid immiscibility, thermodynamics of liquid immiscibility, mechanism of phase separation

UNIT IV: Fabrication & Defects: pressed and blown wares, flat glass, tubing and bulbs, fiber glass Defect in glass, gas inclusion, entrapped gas in batch, decomposition of batch materials, bubbles from refractory, nucleation and growth of bubbles from a supersaturated, detection of gases contained in bubble, detection of vitreous inclusions, removal of vitreous inclusion, crystalline inclusion, batch stones, refractory inclusion.

UNIT V: Glass–Ceramics: Definition, Production of Glass-ceramics, Description & application of various Glass ceramics, Photosensitive lithium Aluminum Silicate, Magnesium Aluminum Silicate, Machinable Glass ceramics, Bio-active Glass ceramics, Sintered Glass ceramics,

5CR6 : Fuels, Furnaces and Pyrometry

UNIT I. History of kilns : Traditional & Energy Efficient Kilns.

UNIT II: Fuel: characteristics & Classification of Solid, Liquid & Gaseous fuels, Solid fuels-wood& charcoals, coal, Liquid -Petroleum fuels, Gaseous fuels –Coal Gas, water gas, Producer Gas, Natural Gas, LPG, Electrical Heating- Nichrome & Kanthal, Silicon Carbide, Molybdenum Silicide, Selection of fuels in ceramic Industries.

UNITIII: Combustion & Heat saving devices: Chemistry of combustion, types of combustion, combustion of solids, liquid and gaseous fuels, Fuels-flame Characteristics, Fluidized bed, Combustion devices. Regenerators, Recuperators.

UNIT IV: Firing: Firing of Ceramic Wares, Ideal firing curves, setting of wares in kilns, Operation & Trouble shooting in Ceramic kilns, Temperature measuring devices i.e. thermocouple, radiation and optical pyrometer.

UNIT V: Kilns: Classification, design and description of different types of furnaces used in ceramic Industries as downdraft kiln, Shuttle kiln, chamber furnace, tunnel kiln, Roller kilns, , glass tank furnace, rotary kiln, Energy auditing & Management in Oil & Gas fired kilns. Heat Balance in Shuttle & Tunnel kilns

5CR7 : Ceramic Analysis Laboratory

1. Chemical & Rational Analysis of any Red clay product,,
2. Chemical & Rational Analysis of Quartz clay,
3. Chemical & Rational Analysis of Feldspar clay,
4. Chemical & Mineral Analysis of Red Clay
5. Compounding & manufacturing of Stoneware Terracotta.
6. Compounding & manufacturing of Earthen ware Terracotta.
7. Compounding & manufacturing of Vitrified Terracotta.
8. Determination of Dry & Fired properties of Stoneware Terracotta
9. Determination of Dry & Fired properties of Earthenware Terracotta
10. Determination of Dry & Fired properties of Vitrified Terracotta.

5CR8: Pottery & Heavy clay Laboratory

1. Determination of Plasticity of Ceramic Body mixes..
2. Determination of Dry Linear Shrinkage of Ceramic Body mixes ,
3. Determination of Fired Shrinkage of Ceramic Body mixes ,
4. Determination of Tensile strength of Insulator,
5. Determination of Porosity of Heavy clay ware.
6. Shaping of articles by throwing,
7. Shaping of articles by jigger and jollying,
8. Shaping of articles by slip casting
9. Shaping of articles by Pressing.
10. Making of Ceramic Body Mixes .

5CR9 Refractory Laboratory :

1. Determination of size of refractory brick,
2. Determination of Apparent porosity,
3. Determination of bulk density,
4. Determination of Specific gravity,
5. Determination of spalling resistance,
6. Determination of Cold crushing strength.
7. To prepare the sample of refractory by dry press method.
8. To find the action of $HF+H_2SO_4$ mixture on free silica in refractory bricks by Bow-Maker's method.
9. Determination of Modulus of Rupture of refractory block.
10. To prepare the sample of refractory by Pressing

5CR10: Glass & Electronic Ceramic Laboratory

1. Preparation of barium titanate based ceramic compositions by solid state method.
2. Preparation of Spinel ferrite by ceramic method.
3. Measurement of permeability on ferrite toroid.
4. Measurement of ionic conductivity of a ceramic solid electrolyte.
5. Measurement of electric conductivity of ceramic samples by two probe and four probe method.
6. Measurement of dielectric constant.
7. Melting of simple glasses
8. Measurements of Density of given Glass sample..

RAJASTHAN TECHNICAL UNIVERSITY
Teaching and Examination Scheme for B.Tech. (4 Year Course)
In
Ceramic Engineering

Year : III **Semester : VI**

SUBJECTS		Hrs./week			Exam Hrs	Maximum Marks		
		L	T	P		I.A	Exam	Total
6CR 1	Thermodynamics and Phase Equilibria	3			3	20	80	100
6CR 2	Thermal & Optical Properties of Ceramic Materials	3			3	20	80	100
6CR 3	Electrical & Magnetic Properties of Ceramic Materials	3			3	20	80	100
6CR 4	Cement Technology							
6CR 5	Ceramic Coating—Enamel & Glazes	3			3	20	80	100
6CR 6	Elective Paper **	3			3	20	80	100
	Total Theory :	18						
Practicals								
6CR 7	Electronic Ceramic Laboratory			3	3			100
6CR 8	Ceramic Coatings Laboratory			3	3			100
6CR 9	Cement Laboratory			3	3			75
6CR 10	Industrial Visits / Viva-voce							75
6CRCS	Discipline & Extra Curricular Activities							50
	GRAND TOTAL	18		9				1000

DETAILED SYLLABI

4 YEAR B.TECH. (CERAMIC ENGINEERING) **SEMESTER VI**

6CR1: Thermodynamics and Phase Equilibria

UNIT I:Introduction: 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.

UNIT II: Phase Equilibria: Solubility limit, phases, microstructure, phase Equilibria, binary isomorphous systems, interpretation of phase diagrams, lever rule, development of microstructure on isomorphous alloys, mechanical properties of isomorphous alloys, binary eutectic systems.

UNITIII: Thermodynamic stability of Materials. Equilibrium Diagrams having Intermediate phases & Compound, Eutectoid and Peritectic Reactions Congruent Phase transformation, Ceramic & Ternary Phase Diagrams, Ellingham diagram and its importance, application of electrochemical series in ceramics

UNIT IV: Behavior of gases: Equation of state of gas, internal energy of real gas, Ideal gases, experimental determination of heat capacities, quasi adiabatic process, Ruchhardts method of measuring gama, velocity of longitudinal waves, kinetic theory of ideal gas.

UNIT V: Chemical equilibrium: Daltons law, semi permeable membrane, Gibbs theorem, entropy of a mixture of inert ideal gases, Gibbs function of a mixture of inert ideal gases, chemical equilibrium ,condition for mechanical stability, thermodynamics equations for a phase, chemical potentials, Degree of reactions, equation of reaction equilibrium,.

6CR2: Thermal & Optical properties of Ceramic Materials

UNIT I. Thermal Properties: Heat capacity, Density and thermal expansion of crystal, Thermal Expansion, Density and Thermal expansion of Glasses, Effect of Heat Treatment, Thermal Expansion of Composite Bodies, Effect of polymorphic transformation, Micro-stresses, Glaze Stresses,

Unit II. Thermal Conduction Processes in Phonon:, Phonon Conductivity of Single phase crystalline, Temperature dependence, influence of structure and composition of pure materials, Boundary effect, Impurities and solid solutions, Phonon conductivity of single-phase glasses, Temperature dependence of glass conductivity, Effect of compositions

Unit III. Thermal Conduction Processes in Photon: Photon Conductivity, The Photon Mean Free Path, Temperature dependence, Effect of boundaries, Conductivity of multiphase ceramics

Unit IV. Optical Properties: Electromagnetic waves in ceramics, Refractive Index & Dispersion, Reflection & Refraction. Scattering, Refractive Index & Dispersion in Dielectric materials, Boundary Reflectance & Surface gloss, Opacity & Translucency,.

Unit V. Absorption, Colors & Applications: Absorption & Color, Bands, Color, Ligand-Field Chemistry Colorants, Ceramic Stains, Color specifications, Lasers, Phosphors, Fiber optics.

6CR3 :Electrical & Magnetic Properties of Ceramics

UNIT I: Mechanical Properties: Fracture Process, Elastic Deformation & Elasticity, Elastic Moduli, Anelasticity Behavior, Brittle Fracture & Crack propagation, Theoretical strength, Griffith- Orwan criteria, Statistical nature of strength, Strength & Fracture surface, Static fatigue, CRp fracture, Effect of microstructure,

UNIT II: Thermal & Compositional Stresses: Thermal Expansion & Thermal stresses, Temperature Gradient & Thermal stresses, Resistance to thermal shock & thermal spalling, Thermally tempered Glass, Annealing, Chemical strengthening.,

UNIT III: Electrical Conductivity: Electrical Conduction Phenomena**,** Ionic Conduction in crystal, Nernst-Einstein equation for diffusion and conductivity in ionic solids. Applications of ionic conductors, Electronic conduction in Crystals, Ionic conductance in Glasses, Absorption Current, Electrode Polarization, Temperature dependence, effect of composition, Mix Alkali effects, Electronic conduction in Glasses, . Non-stoichiometric, Solute-controlled Electronic conduction, Band structure of Zinc & Copper oxide.. Valency controlled semi conductors, Mixed Conductors in poor Conductors. Poly-crystalline Ceramics. Metallic conduction.

UNIT IV: Dielectric Properties: Electrical Phenomena Dielectric constant of Crystal & Glasses, Dielectric loss factor for crystal & Glasses, Dielectric Conductivity, Poly crystalline & Poly face Ceramics, Dielectric Strength, Ferro-electric Ceramics,

UNIT V: Magnetics Properties Phenomena,: Origin of Interaction in Ferrimagnetic materials. Direct Exchange Interaction and super exchange interactions, Double exchange Interaction, Spinal ferrite, Rare earth garnet and hexagonal ferrites. Polycrystalline Ferrites, Effects of composition & Grain size & Porosity on the magnetic behavior.

6CR4: Cement Technology

UNIT I: Introduction: Origin and development of cement and cementatious 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 & beneficiations of raw materials.

UNIT II: Processing: 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.

UNIT III: Clinker: 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.

UNIT IV: Types &Testing: Different types of cement:- Quick setting cement, low heat cement, Blast furnace slag cement, Trief cement , Sorrel cement, White and colored 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.. Testing of cement.

UNIT V: Gypsum: Gypsum, Plaster of paris, its properties and uses, manufacture of plaster of paris, setting and hardening of plaster of paris,

6CR 5: Ceramic Coating –Enamel & Glazes:

UNIT I: Enameling:. 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, colored enamels, properties and defects of enamel coating.

UNIT II: General information on Glaze: Nature, Origin and Importance of Ceramic Glazes, Ceramic Glazes as a Glassy State, Properties of Glass, Composing and Optimization of Glazes,

UNIT III: Raw Materials: Raw materials for Acidic Oxides, Basic Oxides, for simultaneously introducing Basic oxides & Acidic oxides , for amphoteric oxides. Auxiliary materials for opacifiers, Binders, Fixing agents, Water as a glaze component, Toxicity of raw materials. Adhesive agents& Stabilizers. Selection of raw materials.

UNIT IV: Technology of Glaze: Seger Formula, Glaze Calculation based on pure raw materials and based on fritted glaze and mill additives. Application of Glazes. Firing of Glazes, Cooling & Tensions in glaze layer. Coloring of Glazes, Molecular, Colloidal and Glaze Staining. Decolorization of glazes, Matting of Glazes, pacification of Glazes,

UNIT V: Classification of Glazes: Based on Body to be glazed, Based on Glaze Composition.

Elective Paper **:

6CR 6.1: Industrial Economics & Factory Management

UNIT I: Accounts: Types of accounts, book keeping, single entry and double entry, trading account, profit and loss account and balance sheet,

UNIT II: Cost Accounting: cost accounting and cost control. Economic laws, inCRasing and diminishing return, utility, total and marginal,

UNIT III: Business Organization: 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,

UNIT IV: Principle of management, management process schools, human factors, management by objective. Type of Organization Charts.

UNIT V: 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.

6CR 6.2: History of Ceramic Science & Technology

UNIT I: History of Red Clay Pottery & its technology: Rural Pottery, Studio Pottery.

UNIT II: History of White clay Pottery & its technology: Stoneware, Earthenware, & Vitrified Porcelain, Bone china,

UNIT III: History of Glass & its technology: Tableware, float glass, scientific Glasswares.

UNIT IV: History of Refractory products & its technology: Acid & Basic Refractories etc.

UNIT V: History of Cement & its technology: Portland , Pozzolana & Pozzolanic Cements.

6CR 7: Ceramic Properties Lab

1. Dimensional Analysis of Ceramic Products.
2. Determination of Whiteness of Ceramic materials.
3. Testing the ceramic sample for Crazing Test as per BIS standard.
4. The reflectance test of various Tile.
5. Determine the tensile strength of a given ceramic product.
6. Determine the compressive strength of a given ceramic product.
7. Determine the activation energy for a given ceramic product using resistivity meter
8. Study the Dielectric properties for ceramic insulator using LCR meter.
9. Determination of Impact strength of Given Ceramic sample.

6CR 8: Ceramic Coatings Laboratory

1. Preparation of Enamel batches, melting, fritting.
2. Preparation of Iron Sheet for enameling.
3. Preparation & Application of Enamel on Iron Sheet.
4. Testing of the enamel led plate for Acid Resistance as per BIS Standards.
5. Preparation & Application of Stoneware Glaze.
6. Preparation & Application of Insulator Glaze.
7. Preparation & Application of Bone china Glaze.
8. Preparation & Application of Terracotta Glaze.
9. Study & Description of defects in Glazes.

6CR 9: Cement Laboratory

1. Determination of consistency of standard cement paste,
2. Determination of Initial setting time and final setting time of given mix.,
3. Determination of Fineness of cement by dry sieving,

4. Determination of specific gravity of cement,
5. Determination of Tensile strength of cement.
6. Mixing of Plaster & making of moulds for slip Casting.
7. Determination of setting time of given Plaster of Paris
8. Determination of Soundness of cement by autoclave test method.
9. Determination of Compressive strength of cement.

6CR 10 Industrial Visits / Viva-voce

RAJASTHAN TECHNICAL UNIVERSITY
Teaching and Examination Scheme for B.Tech. (4 Year Course)
In
Ceramic Engineering

Year : IV **Semester : VII**

SUBJECTS		Hrs./week			Exam Hrs	Maximum Marks		
		L	T	P		I.A	Exam	Total
7CR 1	Traditional Ceramics & Processing Techniques	3			3	20	80	100
7CR 2	Advanced Ceramics & Processing Techniques	3			3	20	80	100
7CR 3	Electro Ceramics-2	3			3	20	80	100
7CR 4	Bio-Ceramics	3			3	20	80	100
7CR 5	Material Science & Engineering	3			3	20	80	100
7CR 6	Elective Paper**	3			3	20	80	100
	Total Theory :	18						
Practicals								
7CR 7	Ceramic Processing Lab			3	3			100
7CR 8	Electronic Ceramic Laboratory			3	3			100
7CR 9	Project of any Traditional Ceramic Product / Viva-voce							75
7CR 10	Industrial Visits / Viva-voce							75
7CRCS	Discipline & Extra Curricular Activities							50
	GRAND TOTAL	18		6				1000

7CR 1:Traditional Ceramics & Processing Techniques

UNIT I: Ceramic Building Materials: Common Bricks, Facing & Stock Bricks, Engineering Bricks, Blue Bricks, Hollow Bricks, Perforated Bricks, Hollow tiles, Glazed Bricks, Roofing Tiles, Flower Pots, Salt Glazed Stoneware Pipes, Floor Tiles, Wall Tiles, Exterior Decorated Tiles. Sanitary Earthen wares, Vitreous China Sanitary wares, Fireclay & Stoneware sanitary wares.

UNIT II: Ceramics in Home: Stoneware Table wares, Earthenware tableware vases etc, Semi-vitreous China wares, Hotel China wares, Bone china Dinnerware, Hard Porcelain tableware, Heat Resistant wares, Stoneware Kitchen wares, Art wares, Dental Porcelain.

UNIT III: Chemical & Technical Ceramics: Stoneware, Chemical Stoneware, White Chemical Stoneware, Chemical Porcelain, Carbon & Graphite Shapes, Delanium Carbon,& Graphite, Kemite& Karcite laboratory equipments & Filters .

UNIT IV: Engineering Wares: Mullite Porcelain, Steatite Porcelain, Sintered Boron Carbide, Sintered Silicon Carbide, Thoria & Uranium Dioxide Ceramics. Fused Alumina Grinding Wheels, Ceramic Cutting Tools.

UNIT V: Ceramics in Electrical Industries: Low Tension Insulators, High Tension Insulator, High Temperature Insulators, Sparking Plug Insulators, High Frequency Ceramic Insulators, Low Loss Steatite, Alumina, Zircon & Cordierite Ceramics.

7CR 2: Advanced Ceramics Processing & Sintering Techniques

UNIT I: Science of Colloidal Processing: Vander Waals forces between macroscopic bodies, Effect of intervening media, Lyophobic collides, Electrostatic stabilization in double layer and surface charges, Repulsion between two double layers, Stability of electrostatically colloids, Electrokinetic Phenomena, Polymeric Stabilization.

UNIT II: Sol-Gel Processing: Polymeric Gel Route, Metal Alkoxides - Preparation & its Properties, Sol-Gel Process for metal Alkoxides, Sol-Gel preparation techniques for Colloidal gel & polymeric gel, Application in thin film & coating, fiber, & Monolithices.

UNIT III: Solid –State and Viscous sintering: Sintering of Polycrystalline & amorphous materials, Theoretical analysis of sintering, Numerical simulations of sintering, Phenomenological sintering equations, Sintering stresses and its measurement,

UNIT IV: Powders synthesizing: Powder Characteristics, Powder preparation methods- Mechanical Synthesis, Mechnochemical Synthesis, Chemical methods, Vapor phase reactions.

UNIT V: Liquid Phase Sintering: Introduction, Elementary features of liquid Phase sintering, Microstructure produced by liquid phase sintering, Stages in liquid Phase sintering, Controlling factors,

7CR 3: Bio-ceramics

UNIT I: Bio-Ceramics: Introduction. Classification of Bio Ceramics materials.

UNIT II:Hard Tissues: Structure of Proteins, Structure Property relationship, Hard tissue – Healing & Remodeling, Biocompatibility

UNIT III: Hydroxyapatite: Source , Composition & Structure, Properties of Hydroxyapatite, Applications.

UNIT IV: Alumina and Zirconia in surgical implants: Source, Composition & Structure, Mechanical Properties, Fatigue Properties and Service life, Applications.

UNIT V: Glass-Ceramics, Carbon Implants: Formation of Glass-Ceramics, Properties of Glass-Ceramics, Coating & Composites, Source & Structure of Carbons, Manufacturing of carbon implants

7CR4 Electro- Ceramics-2

UNIT I: Ionically conducting ceramics: Kroger Vink Notation used for atomic defects, Formulation of reaction equations, Defect Equilibria and Kroger-Vink Diagrams for different systems.. Diffusion in stoichiometric and Nonstoichiometric oxides..

UNIT II: Super ionic solid Classification of super ionic solids. AgI based, β-Alumina and oxide based super ionic conductors and their applications in fuel cells and batteries.

UNIT III: Highly Conductive Ceramics: Defects Controlled transport, Fast Ions Conduction, Fast Ions Conduction in Glasses, Highly defective Solids, Application of High Conductive Ceramics,

UNIT IV: Superconductivity Superconductors, Meissner effect, Types of superconductors, BCS theory for superconductivity, Synthesis, characteristics and applications of High T_c Superconductors.

UNIT V: Thin Film Technology: Initial Materials, Processing, Conductors, Dielectrics, Resisters, Hybrids

7CR5: Material Science & Engineering

UNIT I: Nano-Science: Meaning of nano-particle, metal nano-clusters: magic numbers, theoretical modeling of nano-particles, geometric structure, electronic structure, reactivity, fluctuations, magnetic clusters. Carbon, Diamond, Graphite, Fullerenes, Carbon Nano tubes- methods of synthesis: R F plasma, chemical methods, thermolysis, pulsed laser methods.

UNIT II: Polymer Structure: Hydrocarbon Molecules, Polymer Molecules, Chemistry of Polymer molecules, Molecular weight, shape, Structure & Configuration. Thermoplastic & Thermosetting Polymers, Co-Polymers, Polymer Crystallinity, Polymer Crystals, Defects in Polymers, Diffusion in Polymeric materials,

UNIT III: Polymer's Characteristics, Applications, & Processing: Stress –Strain behavior, Macroscopic Deformation, Viscoelastic Deformation, Viscoelastic Relaxation Modulus, Viscoelastic CRp, Fracture of Polymers, Characteristics VIZ Impact Strength, Fatigue, Tear Strength, Hardness. Mechanism of Deformation strengthening, Crystallization, Melting & Glass Transition Phenomena in Polymers .Polymer types, Polymer synthesis & Processing, Polymer's applications.

UNIT IV: Composites: Introduction, Particle reinforced composites: Large Particle composites, Dispersion strengthened Composites. Fiber Reinforced Composites: Influence of Fiber length, Fiber orientation, Applications.

UNIT V: Corrosion & Degradation Of Materials: Corrosion of Metals: Electro Chemical Consideration, Electrode Potential, Corrosion Rates, Passivity, Environmental effects, Forms of Quotation, Corrosion environments, Corrosion prevention, Oxidation, Corrosion of Ceramic materials & Degradation of Polymers,

Elective Paper**

7CR 6.1: Environment & Energy Management.

UNIT I: 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.

UNIT II: Electrical Energy trends in India and electric power generation, its forecasting and efficiency with cost reduction, related to its production.

UNIT III: Nuclear energy. Its application of input-output methods to energy problems. Role of Oxide ceramics in Energy Management, SOFC.

UNIT IV: Nonconventional 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.

UNIT V:.Energy Management in Ceramic Industries: Electrical Energy, Fuel energy in Ceramic Kilns..

7CR 6.2 Computer Programming & application in Ceramic Engineering

Unit I; What is modeling and simulation, Basic concepts of modeling?

Unit II: Models based on mass and heat transfer (conduction, convection transport, radiation). Logic based industrial flow sheet with recycling.

Unit III: Optimization aspect from Linear and non-linear point of view, evolutionary approach to global optimization: Genetic algorithm, etc.

Unit IV: Simulation strategies: Sequential, equation solving approach, modular approach. Simulation software, object oriented programming,

Unit V: web based technology. Computer application in controlling ceramic processes and furnaces and other relevant accessories.

7CR 7:Traditional Ceramics & Processing Techniques

1. Compounding & Fabrication of Earthen wares.
2. Determination of Dry & Fired Properties of Earthen wares..
3. Compounding & Fabrication of Stoneware Table wares.
4. Determination of Dry & Fired Properties of Stoneware Table wares.
5. Compounding & Fabrication of Chemical Stoneware,
6. Determination of Dry & Fired Properties of Chemical Stoneware,.
7. Compounding & Fabrication of Electrical Porcelain
8. Determination of Dry & Fired Properties of Electrical Porcelain.
9. Determination of Electrical Properties of an Insulator by Impulse Test Equipment.
10. Determination of Mechanical properties of Insulator by UTM Machine.

7CR 8: Electronic Ceramic Laboratory

1. Synthesis of advanced ceramic sample by citrate-nitrate method.
2. Electrical Characterization of samples prepared through citrate-nitrate method.
3. Synthesis of advanced ceramic sample by co-precipitation method.
4. Electrical Characterization of samples prepared through co-precipitation method.
5. Synthesis of advanced ceramic sample by combustion method.
6. Electrical Characterization of samples prepared through combustion method.
7. Synthesis the varistors sample through solid state ceramic route
8. Study the varistors characteristics.

7CR 9: Project of any Traditional Ceramic Product / Viva-voce

7CR 10: Industrial Visits / Viva-voce

7CRCS: Discipline & Extra Curricular Activities

RAJASTHAN TECHNICAL UNIVERSITY
Teaching and Examination Scheme for B.Tech. (4 Year Course)
In
Ceramic Engineering

Year: IV **Semester: VIII**

SUBJECTS		Hrs./week			Exam Hrs	Maximum Marks		
		L	T	P		I.A	Exam	Total
8CR 1	Science & Technology of Special Glasses	3			3	20	80	100
8CR 2	Engineering Ceramic and Processing techniques.	3			3	20	80	100
8CR 3	Engineering Ceramic Products and Abrasive	3			3	20	80	100
8CR 4	Elective Paper**	3			3	20	80	100
	Total Theory :	12						
Practicals								
8CR 7	Glass Lab			3	3			100
8CR 8	Ceramic Lab.			3	3			100
8CR 9	Seminar Presentation							150
8CR 10	Project of any Ceramic Product / Viva-voce							200
8CRCS	Discipline & Extra Curricular Activities							50
	GRAND TOTAL	18		6				1000

DETAILED SYLLABI
4 YEARS B.TECH. (CERAMIC ENGINEERING) **SEMESTER VI**

8CR1: Science and Technology of Special Glasses

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

8CR2: Engineering Ceramics and Processing Techniques:

UNIT I: Engineering property requirements and limitations of traditional ceramics.
UNIT II: Advanced Processing techniques: Ultra structure processing and its potential impact on ceramic industry, powder Processing and characterization. Microwave sintering.
UNIT III: Fracture behavior of ceramic materials, The Weibull distribution, Weibull parameters, Sub-critical, stable crack propagation and R-curve behavior.
UNIT IV: Toughening mechanism. Toughening by transformation.
UNIT V: Mechanical behavior of aluminum oxide, silicon carbide, silicon nitride, zirconia and zirconia toughened materials and their engineering applications

8CR3: Engineering Ceramic Products and Abrasive:

UNIT I: Advanced ceramics for engineering application-reliability consideration, Toughening of ceramics, High temperature-carbide and nitride .

UNIT II: SIALON and other Ceramics. Engineering applications: Ceramics in heat engines, power generation, aerospace application, nuclear reactor, ceramics for tribological application, ceramic cutting tools. Porous ceramics and Ceramic fibers.

UNIT III: Abrasives, abrasive operations, natural abrasives, abrasives like aluminum oxides, silicon carbide, diamond and boron nitride, miscellaneous synthetic abrasives,

UNIT IV: Raw materials for abrasives, their proportioning, processing, manufacture of abrasives, grinding wheels, their drying, firing and testing.

UNIT V: The use of abrasives and grinding wheels in grinding. Evaluation of abrasives products. Loose abrasives operations. chemistry of grinding.

Elective Paper**

8CR 4.1: Pollution Control in Ceramic Industries

UNIT I: Different kinds of industrial pollution and their origin and influence on human being. The emission from burning coal,, furnace oil and their analysis. The improvement of combustion processes to reduce the formation of NO_X, SO_X, CO etc.

UNIT II: 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.

UNIT III: 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.

UNIT IV: Different types of pollution CRated from the solid wastes in the ceramic industries and the possibility of recycling them.

UNIT V: Sound and noise pollutions and their minimization techniques.

8CR 4.2: Energy Management in Ceramic Kilns

Unit I: Energy management: Introduction, Energy Auditing in Thermal Systems & Measures, Use of Non-Conventional Ceramic Raw-materials,

Unit II: Approaches & steps of Energy management in Ceramic Industries: Area of Activities. Limitations in Energy Treatment, Start up activities, Finalization of steps of Energy management, Incentives to Approach, Geographical Locations.

Unity III: Start up activities of Energy Auditing: Collection of Projected data & factual operational Values, Analysis of thermal treatment of Products, Working out of Proposals,

Unit IV: Practical Implementation in Kilns: Adjustment of Burning conditions, pressure conditions, firing curves, entrance & exit locks, Excess air etc. Heat recovery from heat load from cooling zone,InCRased output through quality improvement, low rejection, shorter firing cycle.

Unit V: Retrofitting steps for energy management: Hot air extraction from cooling zone, Kiln wall's Insulation, Excess combustion space, sizing of blowers, Multi bottom flue outlets, Air-injectors, designing of kiln cars.

PRACTICALS:

8CR 5: Glass Lab.

1. To determine the softening point of given glass fiber.
2. To determine the coefficient of viscosity of the given glass sample.
3. To measure the chemical durability of glass by BIS method.
4. To determine the hardness by Rockwell method.
5. To determine the dielectric constant of given glass sample.
6. To prepare a cobalt doped colored glass.
7. To prepare a Iron doped colored glass.
8. To determine the thermal conductivity of glass fiber.

8CR 6: Ceramic Lab:,

1. To determine the Water permeability of porous ceramics.
2. Demonstration of ceramic tools in machining.
3. Demonstration of ceramic products in daily life.
4. Grading of abrasive materials of different mesh
5. Compounding a batch for feldspar bonded ceramic abrasive wheel.
6. Compounding a batch for clay bonded ceramic abrasive wheel.
7. To prepare an Epoxy based Grinding wheels for marble polishing.

8CR 9: Seminar Presentation

8CR 10: Project of any Advanced Ceramic Product / Viva-voce

8CRCS: Discipline & Extra Curricular Activities

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