SCHEME & SYLLABUS OF UNDERGRADUATE DEGREE COURSE

Ceramic Engineering and Technology

Effective for the students admitted in year 2021-22 and onwards.

B.Tech.: Ceramic Engineering and Technology
3rd Year - V Semester

SN	Category	Course Code	Course Title	Hours			Marks				Cr
				L	T	P	Exm Hrs	IA	ETE	Total	
THEORY											
1	DC	5CR4 – 01	Physical Ceramics-II (Properties of Ceramic materials)	3	0	0	3	30	**70**	**100**	**3**
2		5CR4 – 02	Refractory	3	0	0	3	30	**70**	**100**	**3**
3		5CR4 – 03	Glass and Glass Ceramics	3	0	0	3	30	**70**	**100**	**3**
4		5CR4 – 04	Electroceramics	3	0	0	3	30	**70**	**100**	**3**
5		5CR4 – 05	Fuels, Furnaces and Pyrometers	3	0	0	3	30	**70**	**100**	**3**
6		5CR5 – 11	Introduction to Metallurgical Processes	2	0	0	2	30	**70**	**100**	**2**
		5CR5 – 12	Refractory for Steel Making								
		5CR5 – 13	Plant, Equipment And Furnace Design								
7	DE	5CR5 – 14	Theory Of Solid Mechanics	2	0	0	2	30	70	**100**	**2**
		5CR5 – 15	Electronic Measurement & Instrumentation								
		5CR5 – 16	Nanoceramics								
			Sub Total	19	0	0	-	210	490	**700**	**19**
PRACTICAL & SESSIONAL											
8	DC	5CR4 – 20	Refractory Lab	0	0	2	-	60	40	**100**	**1**
9		5CR4 – 21	Glass and Glass Ceramics Lab	0	0	2	-	60	40	**100**	**1**
10		5CR4 – 22	Electro-Ceramic Lab	0	0	2	-	60	40	**100**	**1**
11	UI	5CR7 – 30	Industrial Training	0	0	1	-	60	40	**100**	**3**
12	UGE/CA	5CR8 – 00									**1**
			Sub- Total	0	0	7	-	240	160	**400**	**7**
		TOTAL OF V SEMESTER		19	0	7	-	450	650	**1100**	**26**

L: Lecture, T: Tutorial, P: Practical, Cr: Credits, ETE: End Term Exam, IA: Internal Assessment

5CR4-01: Physical Ceramics-II (Properties of Ceramic materials)

Credit: 3Max. **Marks: 100(IA: 30, ETE: 70)**
3L+0T+0P **End Term Exam: 3 Hour**

Course Objectives

1. To impart knowledge on thermal and mechanical properties of ceramic materials.

Course Outcomes

1. To learn thermal & compositional stresses and thermal conduction processes in phonon
2. To acquire knowledge of viscous flow, plastic deformation, creep, elasticity, anelasticity and strength

SN	Contents	Hours
1	**Thermal Properties:** Introduction, 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.	8
2	**Thermal & Compositional Stresses:** Thermal expansion & thermal stresses, temperature gradient & thermal stresses, micro- stresses, glaze stresses. Thermal shock, resistance to thermal shock & thermal spalling, thermally tempered glass, annealing and chemical strengthening.	8
3	**Thermal Conduction Processes in Phonon :** Phonon conductivity of single-phase crystalline, temperature dependence, The influence of structure and composition of pure materials, boundary effect, impurities and solid solutions, effect of boundaries, conductivity of multiphase ceramics. Phonon conductivity of single-phase glasses, temperature dependence of glass conductivity, effect of compositions, photon conductivity, photon mean free path ,temperature dependence.	9
4	**Viscous Flow, Plastic Deformation, and Creep:** Introduction, plastic deformation, creep deformation, viscous deformation. Plastic deformation: of rock salt, fluorite crystal and Al2O3, creep of single crystal and polycrystalline ceramics.	7
5	**Elasticity, Anelasticity and Strength:** 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, creep fracture, effect of microstructure.	8
	Total	**40**

TEXT BOOK

1. W. D. Kingery, H. K. Bowen and D. R. Uhlmann/ Introduction to Ceramics, 2nd Ed./ John Wiley & Sons, Singapore. 1991
2. Fundamentals of Ceramics By: Michel W Barsoum, Published by Institute of Physics Publishing, The Institute of Physics, London

REFERENCE BOOKS

1. V. Raghavan/ Materials Science and Engineering 4th Ed/ PrenticeHall of India Pvt. Ltd, New Delhi. 2004
2. W. D. Calister/ Material Science and Engineering By/Willy India 2006

5CR4-01 Refractory

Credit: 3
3L+0T+0P

Max. Marks: 100(IA: 30, ETE: 70)
End Term Exam: 3 Hours

Course Objectives

1. To enable the students to have a basic knowledge about the various types of refractories used in the industries and reaction of refractory.

Course Outcomes

1. To Analysis and learnt the basics about refractories and its demand.
2. To have knowledge on various testing of refractories.
3. Have learnt the properties and applications of different types refractories.
4. Ability to learnt about the various basic refractories.
5. To have a knowledge about special refractories and effect of refractory in metallurgical and non metallurgical industries.

SN	Contents	Hours
1	**Introduction:** Definition of refractory, Raw material used for refractory processing, Properties of various refractories, Classification of Refractories, Fabrication process and unit operation.	4
2	**Fabrication, Properties, and application:** Silica, high alumina, dolomite, Magnesite, zircon, zirconia refractory, fusion cast refractory, ceramic fiber, heat insulating refractory.	6
3	**Composite Refractories:** Alumina-carbon, magnesia-carbon, spinel, alumina-silicon carbide- carbon, zirconia-carbon.	6
4	**Properties and Testing:** Chemical analysis, mineralogical analysis by X-ray diffraction, microscopic examination, bulk density and apparent Porosity, true density and true porosity, fusion point, permeability, cold crushing strength (CCS), refractory under load (RUL), hot modulus of rupture (H-MOR), pyrometric cone equivalent (P.C.E.), creep behavior, abrasion resistance, thermal shock resistance, thermal conductivity, thermal expansion and spalling, slag resistance..	6
5	**Refractory For Glass And Ceramic Industry** Refractories for glass industry – refractory practices in sidewall, basin, throat, forehearth and roof of glass tank, regenerator systems. Refractories for ceramic industry – kiln design – LTM concept, fast firing technology, kiln furnitures – types, properties, requirements – applications in different ceramic industries.	6
6	**Refractory For Non-Ferrous Metallic Industries** Design, construction and refractories used in copper, aluminum, lead, zinc extraction and processing industries.	6
7	**Reaction of Refractory**: slag, glasses, carbon monoxide, acids, alkalis, flue gases, corrosion of regenerator's refractory by flue gases.	6
	Total	**40**

TEXT BOOK

1. Ritwik Sarkar, Refractory Technology: Fundamentals & Application
2. J. H. Chesters/ Refractories- Production and Properties/ The Iron and Steel Institute, London 1973
3. Nandi D.N, Handbook of Refractories, Tata McGraw-Hill Publishing Co., New Delhi, 1991.
4. C. A. Schacht/ Refractories Handbook/ CRC Press
5. Charles A.Schacht, Refractories Handbook, Marcel Dekker Inc, New York, 2004.

REFERENCE BOOKS

1. P. P. Budnikov/ The Technology of Ceramics and Refractories/ Translated by Scripta Technica, Edward Arnold, The MIT Press, 4th Ed, 2003
2. Refractories by F. H. Norton 1931, Tata McGraw-Hill Publishing inc., New York
3. S. Kumar/ Hand Book of Ceramics/Kumar and Associates 1995
4. Philippe Boch and Jean-Claude Niepce/ Ceramic Materials Processes, Properties and Applications/ ISTE USA 2007

5CR4-03: Glass and Glass- Ceramics

Credit: 3
3L+0T+0P

Max. Marks: 100(IA: 30, ETE: 70)
End Term Exam: 3 Hours

Course Objectives

1. To understand and knowledge on the principle of glass formation, raw materials and melting of glass batch, glass properties and quality control and defects in glass.

Course Outcomes

1. An idea on preparation of glass and different glass articles
2. To have a knowledge on defects found in a flat ware and a hollow ware, and the quality control procedure for various types of glass
3. To have knowledge on the composition, preparation and properties of glass ceramics.

SN	Contents	Hours
1	**Glass:**Definition of glass, model of glass structure, types and composition of glass, Glass constituents and batch ingredients, decolourisers and refining agents, batch calculation, batch preparation.	8
2	**Glass melting:** Fundamental of glass formation, factors that influence glass formation, Zachariasen's rules, kinetic & thermodynamic criteria for glass formation, nucleation and crystal growth, TTT diagram, structural models of silicate and non- silicate glasses, bridging and non-bridging oxygen, tank furnaces, feeding of glass batches, melting process, refining of glass, batch redox number, electric heating, cold top furnace, pot melting.	6
3	**Fabrication and Properties of Glass:** 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, chemical durability of glass. Fabrication: pressed and blown wares, flat glass, tubing and bulbs, fiber glass.	8
4	**Defects:** Defect in glass - stones, seeds, cords and blisters, 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.	7
5	**Glass–Ceramics:** Definition, fabrication process of glass-ceramics, description & application of various glass ceramics, types of glass ceramic; photosensitive lithium aluminum silicate, magnesium aluminum silicate, machinable glass ceramics, bio-active glass ceramics, sintered glass ceramics.	5
6	**Special Glasses:** Technology of making radiation shielding glasses, heat absorbing glasses, solder glasses. Optical properties of glass, optical glass, photosensitive glasses, coating of glass, colored glass including photochromic and electrochromic glass.	6
	Total	40

TEXT BOOKS

1. Paul/Chemistry of Glasses 2nd Ed./ Springer 1990
2. S. Kumar/ Hand Book of Ceramics/Kumar and Associates 1995
3. J. E. Shelby/ Introduction to Glass Science and Technology/The Royal Society of Chemistry 2005
4. Sinton/Raw Materials for Glass and Ceramics /Wiley 2006

REFERENCE BOOKS

1. P. W. McMillan/ Glass Ceramics/ 2nd Ed., Academic Press, NY 1979
2. M. H. Lewis/ Glass & Glass Ceramics/Chapman & Hall, London 1989
3. A.R. West/ Solid State Chemistry/John Wiley&Sons 2003
4. H. Bachs and D. Krause/ Low Thermal Expansion Glass Ceramics/ Springer 2005
5. K. Varshneya/ Fundamentals of Inorganic Glass/Academic press 1994
6. Tooley F.V, Handbook of Glass Manufacture, Vol I&II, Ogden Publishing Co., NY, 1960.

5CR4-04: Electro-Ceramics

Credit: 3 **Max. Marks: 150(IA: 30, ETE: 70)**

3L+0T+0P **End Term Exam: 3 Hours**

Course Objectives

1. To know the basic concepts of ceramic materials used for electronic applications and their applications in various fields.

Course Outcomes

1. To studied the use of ceramic materials as insulators and capacitors and their properties.
2. Knowledge about the processing, properties and various applications of ceramic materials in ferroelectric applications.
3. The ability to know the manufacture, characteristics and properties of magnetic ceramics
4. Students have basic knowledge about superconductivity and knowledge about the manufacture, characteristics and properties of varistor

SN	Contents	Hours
1	**Introduction:** Objective, scope and outcome of the course. 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.	6
2	**Piezo-electric and Electro-optic Ceramics:** Piezoelectric Ceramic, Ferroelectric ceramic, Electro optic Ceramic, Composition, Processing & Properties, Applications of Piezoelectric & Electro optic ceramics.	5
3	**Magnetic Ceramics:** Spinal ferrites, Hexagonal ferrites, Rare earth Garnet, Processing & application in various fields.	5
4	Ceramic Sensors: Theory and practice: Theory & Transducer classification, Transition from theory to Practice, Future Prospects, Thermo-physical Properties of ceramic sensors.	5
5	**ZnOVaristors:** Varistors electrical characteristics, Varistor's Microstructure & Fabrication,Varistors equivalent circuit, Mechanics of Varistors behavior, Varistors applications.	5
6	**Ionically conducting ceramics:** Kroger Vink Notation used for atomic defects, formulation of reaction equations, defect equilibria and Kroger-Vink diagrams for different systems,Diffusion: Diffusion in stoichiometric and nonstoichiometric oxides.	5
7	**Superconductivity:** Superconductors, Meissner effect, types of superconductors, BCS theory for superconductivity, Synthesis, characteristics and applications of High Tc superconductors.	5
8	**Materials Aspects of Thick Film Technology:** Initial materials, processing, conductors, dielectrics, resisters, completing the hybrids.	4
	Total	40

TEXT BOOKS:

1. J. Moulson and J. M. Herbert/ Electroceramics: Materials, Properties and Applications/ Springer, 1990
2. R. C. Buchanan/Ceramic Materials for Electronics:processing, properties & applications, Marcel Dekker, NY 1986
3. L. M. Levinson/ Electronic Ceramics: properties, device and applications/ CRC 1987
4. Hench L.L and J.K.West, Principles of Electronic Ceramics, John Wiley, New York, 1990.

REFERENCE BOOKS

1. E. Dorre and H. Hubner/Alumina: Processing, Properties and Application/, Springer- Verlag, Berlin Heidelberg, 1984
2. Jaffe, W. R. Cook, H. Jaffe and H. L. C. Jaffe/Piezoelectric Ceramics/ R.A.N Publishers, 1990
3. A.R. West/ Solid State Chemistry/Wiley India 1985
4. Setter N and Colla SL, Ferroelectric Ceramics, Birkhauser Ver Lag, 1993.

5CR4 – 05: Fuels, Furnaces and Pyrometers

Credit: 3
3L+0T+0P

Max. Marks: 100(IA: 30, ETE: 70)
End Term Exam: 3 Hours

Course Objectives

1. Knowledge about different types of fuels used in industries and the mechanism involved in converting the fuel into a useful source of energy.
2. Knowledge on the equipments involved in firing of a ceramic article and the temperature measurement methods.

Course Outcomes

1. Idea about the occurrence and characteristics of the different types of fuels and its properties
2. basic knowledge about the combustion process involved in the fuels
3. Knowledge on the different burners used based on the fuel type and the types of flame produced from burners.
4. Have a better knowledge on different types of kilns, their construction and working.
5. Have a clear understanding on the temperature and heat measurement techniques in kilns and furnaces.

SN	Contents	Hours
1	**History of kilns:** Traditional & Energy Efficient Kilns	3
2	**Fuel:** characteristics & Classification of Solid, Liquid & Gaseous fuels, Solid fuels-wood & charcoals, coal, Liquid -Petroleum fuels, Gaseous fuels –Coal Gas, water gas, Producer Gas, NaturalGas, LPG, Electrical Heating- Nichrome & Kanthal, Silicon Carbide, Molybdenum Silicide, Selection of fuels in ceramic Industries	9
3	**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.	9
4	**Temperature measuring devices**: Introduction and thermometry, thermocouples, radiation pyrometers and optical pyrometer; low temperature measurement, temperature control, heat work recorders – Segar cone, Holdcroft's bar, Buller rings, Watkin recorders.	9
5	**Kilns:** Firing of Ceramic Wares, Ideal firing curves, setting of wares in kilns Classification, design and description of different types of furnaces/kilns 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	10
	Total	40

TEXT BOOK

1. Suryanarayana A.V.K, Fuels, Furnaces, Refractories and Pyrometry, BS Publications, 2005.
2. Robert D.Reed, Furnace Operation, Gulf Publishing Co., Paris, 1991
3. Samir Sarkar, Fuels and Combustion, 2nd Edn., Orient Longman, Bombay, 1990.
4. Om Prakash Gupta, Elements of Fuels, Furnaces and Refractories, Khanna Publishers, 1995.

REFERENCES

1. Harold E. Soisson, Instrumentation in Industry, John Wiley and Sons, NY, 1995.
2. Sarkar B.K, Thermal Engineering, Tata McGraw-Hill Publishing Co. Ltd., 1998.
3. Wilfrid Francis and Martin C.Peter, Fuels and Fuel Technology, Pergamon Press, 1980.
4. J.P.Holman, Heat Transfer, McGraw – Hill, 1997.
5. J.D.Gilchrist, Fuels, Furnaces and Refractories, Pergamon Press, NY, 1977.
6. A.K.Shaha, Combusiton Engineering and Fuel Technology, Oxford & IBH Publishing Co., New Delhi, 1974

5CR5 – 11: Introduction to Metallurgical Processes

Credit: 2
2L+0T+0P

Max. Marks: 100(IA: 30, ETE: 70)
End Term Exam: 3 Hours

Course Objectives

1. To have a basic knowledge about the basics of metallurgy, the various operations in the metallurgical process and in specific about steel making.

Course Outcomes

1. To know about the basics about metals, ores and its extraction.
2. To know about the various metallurgical processes that takes place during the high temperature operation.
3. To know about to measure and estimate the physical properties of metals.
4. Immense knowledge about the Iron and Iron-Carbon (Fe-Fe3C) Phase Diagrams
5. To know about the basic knowledge about powder metallurgy

SN	Contents	Hours
1	**Introduction** – classification – metals, metallic ores, sampling, identification, extraction – copper, aluminum, lead, iron & steel – iron carbon diagram – heat treatment process – annealing, normalizing, hardening, tempering, surface hardening process – carburizing, nitriding, cyaniding, carbonitriding, flame hardening, metallography – sampling, grinding, polishing, microscope – metallurgical, electron, testing – hardness, impact, creep, non destructive testing.	8
2	**Iron and Iron-Carbon (Fe-Fe3C) Phase Diagrams:** Iron-Carbon phase diagram, eutectoid/hypoeutectoid/hypereutectoid transformations in carbon-steels, nucleation & growth of pearlite, understanding ferrite, cementite, austenite formation in carbon-steel, TTT diagram, determination of TTT diagram for eutectoid steel, transformation of austenite to pearlite or bainite or martensite, role of solute, effect of cooling rate, diffusionless transformation, factors affecting TTT diagrams, end-quench method, Jominy test, the effect of cooling rate, critical cooling rate (CCR), factors affecting CCR.	9
3	**Heat Treatment of Steel:** Theory and purpose of heat treatment, stages of heat treatment, Annealing, full annealing, process annealing, causes of residual stress, stress relief, partial annealing, spheroidization annealing, advantages, recovery, recrystallization, grain growth, recrystallization annealing, difference between annealing and normalizing, objectives of hardening, Jominy end-quench test, tempering, martempering and austempering, quenching, surface hardening, case hardening, nitriding.	8
4	**Powder Metallurgy:** Introduction – production process of powders – mechanical routes, atomization routes, physical routes, chemical routes, plasma forming process- powder consolidation, compaction and sintering – advantages – disadvantages – limitations- applications.	8
5	**Physical Properties:** Single crystals, polycrystalline materials and factors affecting their mechanical properties. Yield strength, tensile strength and rupture strength. Ductility and malleability, toughness and hardness of materials.	7
	Total	**40**

Text and Reference Books:

1. Principles of Extractive Metallurgy: J. Newton 1959 (J. Wiley)
2. Seshadri Seetharaman, Fundamentals of Metallurgy, 1st Edn, Wood head Publishing Limited, 2005.
3. Materials Science and Engineering :V. Raghavan 2008(PHI)
4. Elements of Materials Science :Van Vlack 1998(Addison Wesley)
5. Engineering Materials Science :Richards 1961(Wadsworth Pub. Co.)
6. Structure and Properties of Materials :Wulff Series 1966(John Wiley (New York))
7. Material Science :Callister 2008(John Wiley)
8. Principles of Material Science and Engineering: Smith 1990(Mc Graw Hill)

5CR5-12 Refractory for Steel Making

Credit: 2 **Max. Marks: 100(IA: 30, ETE: 70)**
2L+0T+0P **End Term Exam: 3 Hours**

Course Objectives

1. To have information on different steel making route and different unit associated for making steel
2. To know the importance of refractories for making clean steel and its specific consumption and cost
3. To know the scope of different refractories for different units of steel plant and its failure

Course Outcomes

1. Differentiate different steel making route and different unit associated for making steel.
2. Identify the importance of refractories for making clean steel and its specific consumption and cost
3. Find out the suitability of refractories for basic iron and steel making practice.
4. Select suitable refractories for coke oven, sinter plant, blast furnace, Corex process and ladle used in iron making processes and Identify refractories suitable for BOF/LD, EAF etc. and mill zone CO
5. Select the refractories used in continuous casting process

SN	Contents	Hours
1	**Introduction:** Overview of different routes of steel making in integrated and special steel plants, Importance of refractory materials in iron & steel making process from the point of view of clean steel making, Undesirable and impact of refractory inclusions in finished steel product	5
2	**Refractory in Iron making - I** **Coke Oven**: Role of coke in iron making process, Importance of silica, fireclay refractory in wall and doors of coke oven battery, Desirable properties of coke oven refractory for high campaign life, concept of average battery life in Indian and global scenario. **Sinter Plant**: Role of sinter in iron making process, Application of refractory in ignition hood of sinter plant.	10
3	**Refractory in Iron making - II** **Calcination Plant**: Role of calcined limestone and dolomite in steel making process, Types of refractory in lime and dolomite 15 kilns. **Blast Furnace**: Application of refractory in different zones of blast furnace stove and cast house area. Role of carbon block in the hearth of blast furnace, Concept of grouting for periodic repair of tap hole. **Torpedo Ladle/Transfer Ladle**: Usage of torpedo ladle in steel plant, lining pattern of torpedo ladle, Concept of average life of torpedo ladle in Indian and global scenario.	12
4	**Refractory in steel making - II** **Basic Oxygen Furnace/LD Converter:** BOF steel making process and slag formation. Necessity of using basic refractory in converter; Concept of requirement of different types of refractory in impact zone, metal zone, slag zone and taphole area; Concept of heat size; Role of gunning in increasing the service life of converter. Slag coating/ slag splashing practice to improve converter life. **Electric Arc Furnace:** Lining pattern and type of refractory used in EAF steel making.	8
5	**Refractory in steel making - II** **Steel Ladle:** Lining pattern of steel ladle refractory, Concept of Ladle Metallurgy, Role of operational parameters in service life, Purging refractory and slide gate mechanism, Role of gunning and patching mass for hot repair. **Argon Rinsing Station and RH Degasser:** Types of refractory used in these processes. **Continuous Casting:** Importance of tundish refractory (spray mass, back up castable, impact pad, turbo stop, cover flux , insulating materials, dams and weirs) in continuous casting, Concept of open and closed casting, Concept of sequence casting, Analysis of black refractory (ladle shroud, mono block stopper, sub entry nozzle, sub immersion ladle) in billet, slab and bloom caster; An overview of manufacturing process of black refractory. Burner Cover: Application of ceramic fibre blankets and modules in the burner cover of ladle preheater and tundish preheater.	5
	Total	**40**

Text Book

1. Chester, J.H., Steel Plant Refractories, Second Ed., 1973, The United Steel Companies LTD., Sheffield, UK.
2. Chester, J.H., Refractories, Production and Properties, 1973, Iron and Steel Institute, London.
3. O.P Gupta: Elements of Fuels Furnaces & Refractories, Khanna Publishers
4. Ahindra Ghosh and Amit Chatterjee: Iron making & Steel making: Theory & Practice, PHI Learning
5. P.P.Budnikov: The Technology of Ceramics and Refractories. The MIT press, 4th Ed,2003
6. C. A. Schacht: Refractory Linings: Thermo-mechanical Design and Applications, CRC Press, 1995.
7. Refractories Hand Book, The Technical Association of refractories, Japan, a Funding Member of UNITCER

Reference Books

1. Amavis, R., Refractories for the Steel Industry, 1990, Elsevier Publications
2. Robert E.Fisher, Advances in Refractory Technology, Ceramic Transaction Vol.4.,1990, American Ceramic Society, Westerville, Ohio, USA.
3. Refractory material selection for steelmaking-Wiley-American Ceramic Society (2016) Tom Vert, Jeffrey D. Smith-
4. Handbook of industrial refractories technology : principles, types, properties, and applications by Stephen C. Carniglia and Gordon L. Bama, Noyes Publications Westwood, New Jersey, U.S.A(1992).

5CR5-13: Plant, Equipment and Furnace Design

Credit: 2
2L+0T+0P
Max. Marks: 100(IA: 30, ETE: 70)
End Term Exam: 3 Hours

Course Objective

1. To have a sound knowledge on designing the layout of the plant and designing of the furnaces.

Course Outcomes

2. To know the factors for selection of a plant layout.
3. To studied the ways of assembling the various sections in the plant for proper functioning.
4. To studied and understand the principles of designing equipments and the principle and designing of furnaces.
5. To studied and know the construction of furnaces.

SN	Contents	Hours
1	**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.	8
2	**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.	7
3	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	8
4	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 glassmelting furnace. Furnace atmosphere	8
5	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 glass melting furnaces.	9
	Total	**40**

TEXT BOOK

1. S. M. Walas, Chemical Process Equipment: Selection and Design, Butterworths -Heinemann, Butterworths, 1988.
2. H.J. Sandler, and E.T. Luckiewicz, Practical Process Engineering: A Working Approach to Plant Design, McGraw Hill Book Company, 1987.

REFERENCE BOOK

1. V. C. Davis, Calculation in Furnace Technology, Pergamon Press ltd, 1970.
2. W. L. McCabe, J. C. Smith and P. Harriot, Unit Operations of Chemical Engineering, McGraw Hill professional, 2005.
3. W. Trinks and M. H. Macwhinney, A. Shannon, R. J. Reed and J. R. Garvey, Industrial Furnaces, 6th Ed., Wiley-Interscience, 2003.

5CR5-14: Theory of Solid Mechanics

Credit: 2
2L+0T+0P

Max. Marks: 100(IA: 30, ETE: 70)
End Term Exam: 3 Hours

Course Objective

1. To have a sound knowledge on stress and strain, Bending moment and theory of elastic failures.
2. To understand the types of load and beams and kinematics mechanism and also study the law of friction

Course Outcomes

1. To know the factors for selection of stress-strain
2. To studied the ways of plastic and viscous-elastic behavior of common materials in tension and compression test.
3. To studied and understand the principles and mechanism of kinematics and friction.
4. To studied the Introduction to thin and thick walled cylinders..

SN	Contents	Hours
1	**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.	8
2	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. Mohr's circle of stress and strain, a brief theory of elastic failures.	7
3	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,	8
4	**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.	8
5	**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.	9
	Total	**40**

Text and Reference Books:

1. Theory of Solid Mechanics, Timmosoko.
2. Theory of Solid Mechanics, B.C. Punnia.
3. An Introduction to the Mechanics of Solids, Crandall, Dahl and Lardner, Tata McGraw Hill.
4. Mechanics of Materials, Beer, Johnston, Dewolf and Mazurek, Tata McGraw Hill.
5. Strength of Materials, Ryder G.H., Macmillan India.
6. Strength of Materials, Sadhu Singh, Khanna Publishers.
7. Mechanics of Material, Punmia, Jain and Jain, Laxmi Publications.

5CR5-15: Electronic Measurement & Instrumentation

Credit: 2
2L+0T+0P

Max. Marks: 100(IA: 30, ETE: 70)
End Term Exam: 3 Hours

SN	Contents	Hours
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.	8
2	**Electronic Instruments for measuring basic parameters:** Electronic Voltmeter, Electronic Multimeters, Digital Voltmeter, Component Measuring Instruments, Qmeter, Vector Impedance meter, RF Power & Voltage Measurements. Measurement of frequency. Introduction to shielding & grounding	7
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.	8
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	8
5	**Transducers:** Introduction, 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.	9
	Total	**40**

Text and Reference Books:

1. A.K. Sawhney, Electronic Measurement & Instrumentation Dhanpat Rai & Sons.
2. H.S. Kalsi, **E**lectronic Measurement & Instrumentation Tata Mc Graw Hill.
3. Electronic Measurements & Instrumentation, Bernard Oliver, TMH
4. Instrumentation Measurement & Analysis, B.C.Nakra, K.K. Chaudhry, TMH
5. Electronic Measurements & Instrumentation, Bernard Oliver, John Cage, TMH
6. Electronic Measurements And Instrumentation, Lal Kishore, Pearson
7. Elements Of Electronic Instrumentation And Measurement, Carr, Pearson
8. Electronic Instrument And Measurment, Bell, Oxford
9. Electronic Measurements And Instrumentation, Dally, Wiley
10. Theory And Design For Mechanical Measurements, Figliola, Wiley
11. Electronic Instrumentation And Measurements, David A. Bell, PHI
12. Introduction To Measurements And Instrumetation, Arun K. Ghosh, PHI

5CR5-16: Nanoceramics

Credit: 2
2L+0T+0P

Max. Marks: 100(IA: 30, ETE: 70)
End Term Exam: 3 Hours

Course Objectives

1. To provide the students with basic knowledge of processing and design of Nanoceramic.

Course Outcomes

2. Basic Terminology and concepts and knowledge of properties of Individual Nano-Particles.
3. Concept on Nano Structured Ferromagnetism and properties.
4. Analyze the Behavior of preparation of quantum nanostructures, size and dimensionality effects, excitations, applications including superconductivity.
5. Know the basic Process of self assembly and nature of catalysis & surface area of nano particles.

SN	Contents	Hours
1	**Properties of Individual Nano-Particles:** Meaning of nano-particle, metal nanoclusters, magic numbers, theoretical modeling of nano particles, geometric structure, electronic structure, reactivity, fluctuations, magnetic clusters, bulk to nano-transition; semi-conducting nanoparticles optical properties, photofragmentation, coulombic explosion; rare gas and molecular clustersinert gas clusters, superfluid clusters, molecular clusters; methods of synthesis: R F plasma, chemicalmethods, thermolysis, pulsedlaser methods.	8
2	**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.	8
3	**Bulk Nano-Structured Materials:** Solid Disordered Nanostructures: Methods of synthesis, failure mechanisms of conventional grainsized materials, mechanical properties, nanostructured multilayers, electrical properties, arrays of nano particles in zeolites, porous silicon; nano-structured crystals including nanoparticle lattices in colloidal suspensions.	8
4	**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 Nanodevices: Micro-electromechanical systems (MEMSs). nanoelectromechanical systems (NEMSs), nanodevices and nano-machines	8
5	**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.	8
	Total	**40**

Text and Reference Books:

1. M. Wilson, K. Kannangara, G. Smith and M. Simmons, Nanotechnology: Basic Science and Emerging Technologies, CRC Press, 2002.
2. R. Freer, Nanoceramics: A British Ceramic Proceedings. British Ceramic Society, 1993.
3. S. Edelstein, R. C. Cammarata, Nanomaterials: synthesis, properties and applications, CRC Press, 1998.
4. M. A. Ratner and D. Ratner, Nanotechnology: A Gentle Introduction to the Next Bigdea, Prentice Hall PTR, 2003.
5. G. Cao, Nanostructures and Nanomaterials: Synthesis, Properties and Applications, Imperial College Press, 2004.
6. H. G Rubahn, Basics of Nanotechnology, 3rd Edition, Wiley, 2008
7. N. R. Rao, A. Müller and A. K. Cheetham, The Chemistry of Nanomaterials: Volume 1, Synthesis, Properties and Applications; Wiley-VCH, 2006.
8. Nanotechnology by Schutte

5CR5-20 Refractory Lab

Credit: 1
0L+0T+2P

Max. Marks: 100 (IA: 60, ETE: 40)

Contents of the Subject

1. Determination of size of refractory brick,
2. Determination of apparent porosity and true porosity of given refractory.
3. Determination of bulk density.
4. Determination of true density of given refractory.
5. Determination of Hot Modulus of Rupture (H-MOR) of refractories.
6. Determination of spalling resistance,
7. Determination of cold crushing strength.
8. Determine RUL of given refractory.
9. Determination of Modulus of Rupture (MOR)of refractories.
10. Determination of thermal expansion behavior of refractory sample.

5CR4-21: Glass and Glass Ceramics Lab

Credit: 1 0L+0T+2P **Max. Marks: 100 (IA: 60, ETE: 40)**

Contents of the Subject

1. Batch calculation and preparation of soda-lime-silicate glass.
2. To prepare iron and cobalt doped colored glass.
3. Preparation of glass fiber and determine the softening point of given glass fiber.
4. To determine the coefficient of viscosity of the given glass sample.
5. To measure the chemical durability of glass by BIS method.
6. To determine the hardness by Rockwell method.
7. To determine the dielectric constant of given glass sample.
8. Chemical analysis of ordinary soda-lime-silicate glass.
9. Measurements of density of given glass sample by Archimedes Principle.
10. .To determine thermal expansions of given glass sample.
11. Preparation of any one glass ceramic sample.

5CR4-22: Electro-Ceramic Lab

Credit: 1
0L+0T+2P

Max. Marks: 100 (IA: 60, ETE: 40)

Contents of the Subject

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. Study and operation of hydraulic press and determination of green density.
5. Measurement of ionic conductivity of a ceramic solid electrolyte.
6. Determination of Curie temperature for a ferroelectric material.
7. Measurement of electric conductivity of ceramic samples by two probe and four probe method.
8. Study of PTC and NTC behaviour.

5CR7-30: Industrial Training

Credit: 3
0L+0T+1P

Max. Marks: 100 (IA: 60, ETE: 40)

B.Tech. Ceramic Engineering and Technology
3rd Year - VI Semester

SN	Category	Course Code	Course Title	Hours			Marks				Cr
				L	T	P	Exm Hrs	IA	ETE	Total	
THEORY											
1	DC	6CR4 – 01	Monolithic Refractory	3	0	0	3	30	70	**100**	**3**
2		6CR4 – 02	Pottery and Heavy Clayware Ceramics	3	0	0	3	30	70	**100**	**3**
3		6CR4 – 03	Ceramic Coating-Enamel and Glazes	3	0	0	3	30	70	**100**	**3**
4		6CR4 – 04	Bioceramics	3	0	0	3	30	70	**100**	**3**
5		6CR4 – 05	Oxide and Non-Oxide Ceramics	3	0	0	3	30	70	**100**	**3**
6	DE	6CR5 – 11	Electric Properties of Materials	2	0	0	2	30	70	**100**	**2**
7		6CR5 – 12	Polymer Science and Engineering								
8		6CR5 – 13	Waste Management of Ceramic Industries								
			Sub Total	17	0	0	-	180	420	**600**	**17**
PRACTICAL & SESSIONAL											
9	DC	6CR4 – 20	Monolithic Refractory Lab	0	0	2	-	**60**	**40**	**100**	**1**
10		6CR4 – 21	Pottery and Heavy Clayware Lab	0	0	2	-	**60**	**40**	**100**	**1**
11		6CR4 – 22	Ceramic Coating Lab	0	0	2	-	**60**	**40**	**100**	**1**
12	UI	6CR7 – 50	Mini Project	0	0	3	-	**60**	**40**	**100**	**2**
13	UGE	6CR8 – 00									**2**
			Sub- Total	0	0	9	-	240	160	**400**	**7**
		TOTAL OF VI SEMESTER		19	0	9	-	420	580	**1000**	**24**

L: Lecture, T: Tutorial, P: Practical, Cr: Credits, ETE: End Term Exam, IA: Internal Assessme

6CR4 – 01 Monolithic Refractory

Credit: 3 **Max. Marks: 100(IA: 30, ETE: 70)**
3L+0T+0P **End Term Exam: 3 Hours**

Course Objectives

1. To enable the students to have a sound knowledge about the types, properties and applications of monolithics and castables as well as knowledge of Raw material and equipments which are used for process monolithics.

Course Outcomes

1. To study and learnt the types of castables, its composition and characteristics.
2. To better understanding on the use of plastic refractories, ramming and gunning mixes as monolithic materials.
3. To studied about the composition and characteristics of mortars, coatings and dry vibratables.
4. To Know the clear idea on the methods of installing different monolithic materials, the application design and the lining materials used while laying monolithics.
5. To studied the wear mechanisms that cause failure in a monolithic lining and the methods to test a monolithic.

SN	Contents	Hours
1	**INTRODUCTION:** Introduction to monolithic refractories, advantages and disadvantages; classifications based on application techniques. Machinery and equipment for making unshaped refractories, chemical constituents and purity; Raw materials and their selection.	6
2	**CASTABLES:** Introduction, types – conventional castables, low cement castables, ultra low cement castables, cement free castables – composition, characteristics, applications. Other castables – insulating castables, pumpable castables – composition, characteristics, applications.	8
3	**PLASTIC REFRACTORIES, RAMMING AND GUNNING MIXES** Plastic refractories– Introduction, composition, properties and applications. Ramming mix – introduction, binder systems, characteristics and applications. Gunning mix – introduction, binder systems, characteristics and applications.	6
4	**MORTARS, COATINGS AND DRY VIBRATABLES** Mortars – introduction, classification, characteristics. Coatings – introduction, characteristics. Dry vibratables – introduction, principle and applications.	6
5	**MONOLITHIC INSTALLATION:** Methods of installations of castables, plastic refractories, ramming mis and gunning mix. Drying and heating up of installed monolithic lining. Application designs – blast furnace trough design, trough lining, and form design, tundish, steel ladle, electric arc furnace. Linings in installation – anchors, steel fibre reinforcements.	8
6	**WEAR MECHANISMS AND TESTING:** Wear mechanisms – introduction, abrasion, penetration, corrosion, spalling Tests done on monolithics – chemical analysis, density, porosity, strength, high temperature properties, corrosion, erosion	6
	Total	**40**

TEXT BOOKS

1. Subrata Banerjee, Monolithic Refractories, World Scientific Publishing Co. Pte. Ltd., 1998.
2. Taikabutsu Overseas Vol.9 No.1, Recent Progress in Castable Refractories, Techno Japan, Fuji Marketing Research Co. Ltd., Japan, 1995.
3. Ritwik Sarkar Refractory Technology: Fundamentals & Application

REFERENCES

1. Charles A.Schacht, Refractories Handbook, Marcel Dekker Inc, New York, 2004.
2. Norton F.H, Refractories, 4th Edn., McGraw Hill Book Co., 1968.
3. Nandi D.N, Handbook of Refractories, Tata McGraw-Hill Publishing Co., New Delhi, 1991.
4. Akira Nishikawa, Technology of Monolithic Refractories, Plibrico, Japan Co. Ltd., Tokyo, 1984.

6CR4 – 02 Pottery and Heavy Clayware Ceramics

Credit: 3
3L+0T+0P

Max. Marks: 100(IA: 30, ETE: 70)
End Term Exam: 3 Hours

Course Objectives

1. To understanding of the science of Ceramic Processing and Fabrication.
2. To design appropriate processing method for ceramic fabrication for a specific use.
3. To utilize the knowledge of different raw material and ceramic bodies and its strategic applications.

Course Outcomes

1. To know the ceramic processing routes and to use them to fabricate ceramic products for different applications.
2. To understand the importance of ceramic and characteristics to developed the ceramic product.
3. To know and analysis the ceramic raw materials for better understanding of the property of ceramic products made out of those raw materials.
4. To understand the importance of processing science with raw materials characteristics to the developed whiteware product.

SN	Contents	Hours
1	**Red Clay (Terracotta) Technology:** Pre-historic back ground, raw-materials & their types, physical & chemical properties. Clay processing & body mixes, Classification of red clay (Terracotta) products and their qualities, common building bricks, roofing tiles, Firing & Decoration techniques for red clay products.	8
2	**Plastic & Non 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;talc& steatite, pyrophyllite, silicon atom & its building silica, feldspar, nephelinesyenite, sillimanite, bone ash, wollastonite other fluxes-Li, Na, K, Mg, Ca, Ba &B compounds.Water, deflocculates, flocculants, organic binders, lubricants and sticking agents, drying aids, plaster of paris (POP).	9
3	**Winning & Purification of Clays:** Mining & winning of clays; china clay, sedimentary clays, machinery used in clay mining, treatment of clays.	5
4	**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.	6
5	**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.	7
6	**Methods of Fabrication:** Throwing, jiggering and jollying, soft plastic methods, extrusion methods, stiff-plastic methods.	5
7.	**Matrix Ceramics:** Definition of matrix Ceramic, Classification of Matrix Ceramics, Poly-crystalline Feldsphatic ceramics - Vitreous and Vitrified Ceramics Tiles, Sintered Ceramics.	
	Total	**40**

TEXTBOOKS

1. Er. A. K. Gupta/Hand Book on Red Clay Technology /KVIC
2. Felix Singer & Sonja S. Singer/ Industrial Ceramic/ Chemical Publishing Co 1963

REFERENCES BOOK

1. S. Mirmira./Indian Pottery/ Published by Gramodaya Sangh Bhadrawati, MaharashtraState, India, 1993
2. W. Trinks and M. H. Macwhinney, A. Shannon, R. J. Reed and J. R. Garvey/Industrial Furnaces/6th Ed., Wiley-Interscience, 2003.
3. F. H. Norton/ Fine Ceramics: Technology and Application/McGraw Hill, NY 1970.
4. W. Ryan and C. Radford/ Whitewares: Production, Properties and Quality Control/ Pergamon Press, Oxford 1987
5. W. M. Carty, C. W. Sinton/ Science of Whitewares II/ American Ceramic Society 1999

6CR4 – 03 Ceramic Coating-Enamel and Glazes

Credit: 3
3L+0T+0P

Max. Marks: 100(IA: 30, ETE: 70)
End Term Exam: 3 Hours

Course Objectives

1. To provide and understanding of coating techniques and enameling
2. To understand the general information on Glaze and glaze raw materials
3. To able to understand the technology of glaze and classification of glazes

Course outcomes:

1. The fundamentals and analysis of different coating techniques
2. To understood the importance and types of ceramic coatings, and the process of preparing and applying the same.
3. Have a thorough knowledge about the raw materials and properties of the glaze raw materials.
4. Have a thorough knowledge about the various glazing techniques. • Have learnt the properties and defects produced by glazing.
5. Have complete understanding about the various methods of decorating the glazed article

S. No.	Contents	Hours
1	**Enameling:** Brief description of raw materials used in enamel. Batch calculations of frit making, milling and slip preparation, preparation of metal parts, and applications of slip. Firing process, colored enamels, properties and defects of enamel coating.	8
2	**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.	8
3	**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.	8
4	**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.	8
5	**Classification of Glazes:** Classification, The nature of glazes, general properties of glazes based on body to be glazed, based on glaze composition.	8
	Total	**40**

TEXT BOOKS

1.R. A. Eppler and M. Obstler/Understanding Glazes/ The American Ceramic Society 2005
2.Tailor J.R and Bull A.C, Ceramic Glaze Technology, Pergamon Press, NY, 1986.

REFERENCE BOOKS

1.R. A. Eppler and D. R. Eppler/Glazes and Ceramic Coatings/ American Ceramic Society 2000
2.Fritz /Glazes- Frits & Receipts
3.Andrew I. Andrews/ Enamels 1961

6CR4 – 04 Bioceramics

Credit: 3
3L+0T+0P

Max. Marks: 100(IA: 30, ETE: 70)
End Term Exam: 3 Hours

Course Objectives

1. To enable the students to have a sound knowledge about the applications of ceramic materials in biological field.

Course outcomes

1. To learnt Introduction and necessity of bio-ceramics.
2. To complete knowledge about bioceramics and its classification
3. Brief discussion on dental restoration and Bioactive coatings-coating techniques
4. Have studied about Hydroxyapatite and Radiotherapy glasses
5. Have studied about Calcium phosphate bio ceramics-processing, properties & applications

SN	Contents	Hours
1	Introduction and necessity of bio-ceramics. Definition of Biomaterials, biological materials, biomimetic materials. Osteoporosis and its various causes. Classification of Biomaterials. Different application of biomaterials. Physiology of human bones.	7
2	Definition of bioceramics and its classification. Different definitions of Biocompatibility. Forms, phases & functions of bio-ceramics. Different types of bioceramics-tissue interfaces. Various types of implant-tissue responses. Different bioceramic-tissue attachments. Processing techniques and microstructure of bioceramics.	8
3	Dental bioceramics-its need, brief discussion on dental restoration techniques, structure of a tooth, material composition & processing techniques along properties.	7
	Alumina and zirconia bioceramic material-its properties, uses and preparation.	
4	Bioactive coatings-coating techniques, clinical applications. Bioactive glasses & glass ceramics- composition, preparation, properties and applications.	6
5	Hydroxyapatite- differences of synthetic vs. natural HAP. Dense & porous HAP preparation, properties & applications.	6
	Radiotherapy glasses- introduction, compositions, processing, properties & uses.	
6	Biocomposite – desirable properties of bioceramics and its limitation. Different biocomposite materials, fabrication method, properties and uses.	6
	Calcium phosphate bio ceramics-processing, properties & applications.	
	Total	**40**

TEXT BOOKS

1. An Introduction to Bioceramics by Larry L. Hench & June Wilson, World Scientific publication.
2. Bioceramics Materials, properties, Applications by A. Ravaglioli, A. Krajewski, Chapman & Hall publication.

REFERENCE BOOK

1. Joon Park :Bioceramics Properties, Characterization and Application, Springer, 1995.
2. Maria valet regi: Bioceramic with Clinical Applications, Wiley, 2010.
3. W.Bonfield, G.W.Harting, K.E.Tanner: Bioceramics Vol-IV, Butterworth Heinmann, 2010.

6CR5 – 12 Oxide and Non-Oxide Ceramics

Credit: 3
3L+0T+0P

Max. Marks: 100(IA: 30, ETE: 70)
End Term Exam: 3 Hours

Course Objectives

1. To enable the students to have a thorough knowledge about the various ceramic materials used for structural applications.

Course outcomes

1. To have a studied the structural characteristics and properties of oxide, carbide, nitride, carbon and other ceramic materials used for structural applications.

SN	Contents	Hours
1	**OXIDE CERAMICS** Structural characteristics, properties and applications of silica, alumina, zirconia, Sialon, borides, silicides, magnesia, titania, thoria, mullite, uranium oxide and plutonium oxide. high temperature superconducting oxides.	**8**
2	**NON OXIDE CERAMIC** Structural characteristics, properties and applications of silicon carbide, boron carbide, tungsten carbide, titanium carbide. Structural characteristics properties and applications of silicon nitride, boron nitride, titanium nitride, aluminum nitride	**8**
3	**CERMETS** Structural characteristics, properties and applications of cermets. Types of cermets, Uses, high temperature cermets, making of cermets.	**8**
4	**ADVANCED STRUCTURAL CERAMICS** Structural characteristics, properties and applications of Carbon compounds, borides, silicides, Sialon,	**8**
5	**SINGLE CRYSTALS** Introduction, techniques for forming- Kyropolar technique. Czochralski method, edge defined- film fed growth method, Bridgman technique, floating zone method, flux technique, hydro-thermal growth technique, micro pulling down technique.	**8**
	Total	**40**

TEXT BOOKS

1. Mc Colm, Ceramic Science for Materials Technologists, Blackie & Sons Ltd.,Glasgow, 1983.
2. Handbook of Advanced Ceramics, Vol.I, Somiya.S et al (ed), Academic Press, 2003.

REFERENCES

1. Brook R.J (ed), Concise Encyclopedia of Advanced Ceramic Materials, Pergamon Press, 1991.
2. Noboru Ichinose, Introduction to Fine Ceramics, John Wiley and Sons, 1987. 3. Gernot Kostorz, High Tech Ceramics, Academic Press, NY, 1989

6CR5 – 11 Electric Properties of Materials

Credit: 2
2L+0T+0P

Max. Marks: 100(IA: 30, ETE: 70)
End Term Exam: 2 Hours

Course Objectives

1. To impart knowledge on electrical conductivity and dielectric properties of ceramic materials.
2. To know about Semiconductivity in ceramics and Electrochemical corrosion, Types, Prevention, Oxidation of metals & Refractory corrosion

Course Outcomes

1. To learn the electrical and dielectric and electrical conductivity of materials
2. To acquire knowledge of Corrosion and Oxidation and study of electrical semiconductivity properties of ceramic materials.

SN	Contents	Hours
1	Electrical Conductivity 1: 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.	8
2	Electrical Conductivity 2: 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 semiconductors, mixed conductors in poor conductors, polycrystalline ceramics.	10
3	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, Piezoelectricity.	8
4	Semiconductivity: Intrinsic Semiconduction, Extrinsic Semiconduction, The Temperature Dependence of Carrier Concentration, Factors That Affect Carrier Mobility, The Hall Effect, Semiconductor Devices	8
5	Corrosion and Oxidation: Degradation of metals – Electrochemical corrosion, Types, Prevention, Oxidation of metals, Refractory corrosion.	6
	Total	**40**

TEXTBOOKS

1. Fundamentals of Ceramics By: Michel W Barsoum, Published by Institute of Physics Publishing, The Institute of Physics, London.
2. Introduction to Ceramics by: W. D. Kingery, H. K. Brown and D. R. Uhlmann, Wiley Interscience Publication, John Wiley & Sons.
3. W. D. Calister/Material Science and Engineering/ Wiley India 2007.

REFERENCE BOOKS

1. Solid State Chemistry and its Applications By: A. R. West, John Wiley & Sons (Asia) Pte. Ltd.
2. Principles of Materials Science & Engineering – Smith.
3. Physical Properties of Materials – Lovell, Avery & Vernon.

6CR4 – 05 Polymer Science and Engineering

Credit: 2
2L+0T+0P

Max. Marks: 100(IA: 30, ETE: 70)
End Term Exam: 2 Hours

Course Objectives

1. To understand the chemistry, characterization and synthesis & Properties of polymer.
2. To know about the Polymer compounding and significance and different ingredients for rubber and plastics
3. To understand of Polymer processing and testing of polymer.

Course outcomes

1. Students have know the chemistry, characterization, properties , testing and processing of polymer
2. To know the measurements and characterization of rheological parameters
3. To understand the Thermoplastic and Thermosetting polymers and its properties and characterization

SN	Contents	Hours
1	Chemistry of high polymers: Degree of polymerizations, classification of polymers, glass transition, melting transition, criteria for rubberiness, Polymerization methods: addition, condensation and other newer techniques, copolymerization, monomer reactivity ratios and its significance, kinetics, different copolymers, random, alternating, azeotropic copolymerization, block and graft copolymers, techniques for copolymerization-bulk, solution, suspension, emulsion.	8
2	Polymer Characterization: Solubility and swelling, concept of average molecular weight, determination of number average, weight average, viscosity average and Z-average molecular weights. polymercrystallinity, analysis of polymers using IR, XRD, thermal (DSC, DMTA, TGA), microscopic (optical and electronic) techniques.	6
3	Synthesis and properties: Thermoplastics polymers: PE, PP, PS, PVC, Polyesters, Acrylic, PU polymers, Engineering Plastics: Nylon, PC, PBT, PSU, PPO, ABS, Fluor polymers, Engineering Plastics: Nylon, PC, PBT, PSU, PPO, ABS, Fluor polymers, Thermosetting polymers: PF, MF, UF, epoxy, unsaturated polyester, alkyds, natural and synthetic rubbers: recovery of NR hydrocarbon from latex, SBR, nitrile, CR, CSM, EPDM, IIR, BR, silicone, TPE.	10
4	Polymer Technology and Rheology: Polymer compounding-need and significance, different compounding ingredients for rubber and plastics, cross-linking and vulcanization. Newtonian and non-Newtonian fluids, flow equations, dependence of shear modulus on temperature, molecular/segmental deformations, Measurements of rheological parameters. Visco-elasticity-creep and stress relaxations, control of rheological characteristics, rubber curing in parallel plate viscometer, ODR and MDR.	8
5	Polymer processing and testing: Different types of molding, thermoforming, rubber processing in two-roll mill, internal mixer, Mechanical & electrical testing of polymers, surface resistivity, volume resistivity, swelling, ageing resistance, environmental stress cracking resistance.	8
	Total	**40**

TEXT BOOKS & REFERENCE BOOK:

1. Fundamentals of Polymer Science and Technology by Anshu Srivastava and Shakun Srivastava
2. Polymer Science and Technology (third edition): Plastics, Rubbers, Blends, and Compositions by Premamoy Ghosh Fundamentals of Polymer Engineering by Neil K. Petchers, Rakesh K. Gupta, Anil Kumar
3. Elements of Polymer Science and Engineering by Rudin Alfred
4. Bio related Polymers: Sustainable Polymer Science and Technology by Emo Chiellini, Helena Gil,

6CR5 – 13 Waste Management of Ceramic Industries

Credit: 2
2L+0T+0P

Max. Marks: 100(IA: 30, ETE: 70)
End Term Exam: 2 Hours

Course Objectives

1. To understand and develop an idea about the waste material generation & management associated with modern ceramic industries.
2. To develop knowledge about the scope of waste management and recycling of waste from ceramic industries

Course outcomes

1. Understand the technological/econonical/social significance of waste management and waste recyling from ceramic industries.

SN	Contents	Hours
1	Pollution and waste generation in ceramic and related industries. Kiln and stack emissions, pollution from service units like air compressor, laboratories, gas producers, storage facilities, waste water treatment plant etc	**8**
	Environmental and health impacts of pollutants and solid wastes.	
2	Indian environmental laws and WHO's norms.	**8**
	Pollution reduction measures in ceramic industries: air, sound, solid waste, water. Nature and type of industrial waste useful for ceramic industries.	
3	Use of industrial wastes in ceramic industries Utilization of fly ash, rice husk, BF slag in the production of traditional, advanced ceramics. Utilization of red mud and recovery of metals from red mud.	**8**
4	Introduction of zeolite, Application of zeolite in environment (catalytic effect, water purification). Clay as an absorbent of toxic pollutant Recycling of industrial waste. Fluorine contamination in alumina Industry disposal and recovery of refractory materials.	**10**
	Ceramics for water and air purification. Glass & glass ceramics in nuclear waste management	
	Ceramics for water and air purification. Glass & glass ceramics in nuclear waste management	**6**
	Total	**40**

TEXT BOOKS

1. P. V. Rao, A Text Book of Environmental Engineering,, Prentice Hall of India Private Limited, 2002
2. S.K. Sundaram, D. R. Spearing, and J. D. Vienna, Environmental Issues and Waste Management Technology in the Ceramic and Nuclear Industries VIII, Ceramic Transactions, Volume 143, The American Ceramic Society, 2002.

REFERENCES

1. S. M. Khopkar., Environmental Pollution: Monitoring and Control, New Age International (P) Ltd, 2004
2. C. C. Herman (Editor), S. Marra (Editor), D. R. Spearing (Editor), L. Vance (Editor) and J. D. Vienna (Editor), nvironmental Issues and Waste Management Technologies XI, Ceramic Transactions, Volume 176, John Wiley & Sons, edition, 2005

6CR4 – 20 Monolithic Refractory Lab

Credit: 1 **Max. Marks: 100 (IA: 60 ETE: 40)**
0L+0T+2P

Course Objectives

1. To have knowledge on the practicals of manufacturing and characterization of Monolithics refractory and refractory materials

Course Outcomes

1. A brief Concept & Knowledge on the practicals of Monolithics refractory and refractory materials

Contents of the Subject

1. Preparation of monolithic refractory.
2. Effect of casting parameter on the properties of cast refractories.
3. Synthesis of insulation refractory.
4. Determination of thermal conductivity of insulation refractory
5. Study of thermal shock resistance and PLCR of refractory brick
6. Determinations of chemical analysis of different types of Monolithic Refractory
7. Study the corrosion and erosion properties in Monolithic refractory.
8. Determination of packing density of monolithic refractory.
9. Study of densification and strength development in the castable with temperature.
10. Processing and casting of castable composition using planetary mixer and vibrator. Curing, drying and firing of the same.

6CR4 – 21Pottery and Heavy Clayware Lab

Credit: 1 **Max. Marks: 100 (IA: 60 ETE: 40)**
0L+0T+2P

Course Objectives

1. To have knowledge on the practicals of manufacturing and characterization of pottery and heavy clayware and ceramics materials

Course Outcomes

1. A brief Concept & Knowledge on the practicals of pottery and heavy clayware and ceramics materials

Contents of the Subject

1. Quantitative chemical analysis of tri-axial porcelain body.
2. Making of ceramic body mixes and determination of plasticity.
3. Study and operation of De-airing Pug Mill and preparation of extruded body.
4. Determination of dry linear shrinkage and fired shrinkage of ceramic body mixes.
5. Determination of tensile strength of Insulator.
6. Determination of porosity of heavy clay ware.
7. Shaping of articles by throwing.
8. Shaping of articles by jigger and jollying.
9. Shaping of articles by slip casting.
10. Shaping of articles by pressing.

6CR4 – 22 Ceramic Coating Lab

Credit: 1 **Max. Marks: 100 (IA: 60, ETE: 40)**
0L+0T+2P

Course Objectives

1. To have knowledge on the practicals of formulation, processes and characterization of Ceramic coating and its materials

Course Outcomes

1. A brief Concept & Knowledge on the practicals of pottery and heavy clayware and Ceramic coating and its materials

Contents of the Subject

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.
10. Determination of chemical analysis of glaze frit.

6CR7 – 50 Mini Project

Credit: 2
0L+0T+3P

Max. Marks: 100 (IA: 60, ETE: 40)