COURSE OUTLINE

Notation: Stat = Course Stats, CHPW = Contact Hours Per Week, L = Lecture, T = Tutorial, P = Practical/Studio, CU = Credit Unit, CR = Core, CT = Cognate, RE = Restricted Elective, UE = Unrestricted Elective, SC = Service Course by Glass and Silicates Technology Department to other Departments.

100 LEVEL FIRST SEMESTER

Course code	Title	Stat	CU	CHPW			Prerequisites
				L	T	P	
GLST101	History of Glass	CR	1	1	-	-	
GLST103	Introduction to Silicate Technology	CR	2	1	-	-	
MATH101	Sets and Number Systems	CT	2	2	1	-	
MATH103	Trigonometry & Coordinate Geometry	CT	2	2	1	-	
MATH105	Differential & Integral Calculus	CT	2	2	-	-	
PHYS111	Mechanics & Modern physics	CT	2	2	-	-	
GENS101	Nationalism	CT	1	1	-	-	
GENS103	English & Communication Skills	CT	2	2	-	-	
PHYS131	Heat & Properties of Matter	CT	2	2	-	-	
GEOL101	Physical Geology	CT	1	1	-	-	
CHEM111	Introductory General Chemistry	CT	2	2	-	-	
CHEM121	Introductory Inorganic Chemistry	CT	2	-	-	-	
CHEM161	Introductory Practical Chemistry I	RE	1	-	-	3	

	Core (CR)	Cognates (CT)	Restricted Electives (RE)	Unrestricte d (UE)
Total Credit Unit	3	18	1	0
Semester Total	22			

100 LEVEL SECOND SEMESTER

Corse Code	Title	Stat	CU	CHPW			Prerequisites
				L	T	P	
GLST102	Unit Operations in processing	CR	1	1	-	-	
GLST104	Introduction to Silicate Raw Materials	CR	2	1	-	-	
GLST106	Ceramic Workshop	CR	2	-	-	3	
STAT102	Introduction to Statistics	CT	2	2	1	-	
MATH102	Algebra	CT	2	2	1	-	
MATH104	Conic Sections & Applications of Calculus	CT	2	2	1	-	
MATH106	Vectors & Dynamics	CT	2	2	1	-	
GENS102	Environmental Health	CT	1	1	-	-	
PHYS122	Electricity, Magnetism & Modern Physics	CT	2	2	-	-	
PHYS124	Geometric & Wave Optics	CT	1	1	-	-	
CHEM112	Introductory Physical Chemistry	CT	1	1	-	-	
GEOL102	Intro. to Mineralogy & Petrology	RE	2	2	-	-	
CHEM162	Introductory Practical Chemistry II	RE	1	-	-	3	

	Core (CR)	Cognates (CT)	Restricted Elective (RE)	Unrestricted Elective (UE)
Total Credit Unit	3	15	3	0
Semester Total	19			

200 LEVEL FIRST SEMESTER

Course Code	Title	Stat	CU	CHPW			Prerequisite
				L	T	P	
GLST 201	Introduction to Silicate processing	CR	2	2	-	-	GLST102
GLST203	Chemistry of Silicates	CR	2	2	-	-	
MATH241	Calculus 1	CT	3	3	-	-	MATH 105
MATH243	Methods of Linear Algebra 1	CT	2	2	1	-	MATH 102
MMEN201	Material Science	CT	2	1	-	-	
MEEN 201	Engineering Graphics	CT	2	1	-	1	
GEOL203	Crystallography	CT	2	2	-	-	
CHEM201	General Chemistry	CT	2	2	-	-	CHEM 111
CHEM221	General Inorganic Chemistry	CT	2	2	-	-	CHEM 121
STAT 243	Statistics	CT	2	2	1	-	STAT102
GENS201	Moral Philosophy	RE	1	1	-	-	

	Core (CR)	Cognate (CT)	Restricted Elective (RE)	Unrestricted Elective (UE)
Total Credit Unit	4	17	1	0
Semester Total	22			

200 LEVEL SECOND SEMESTER

Course Code	Title	Stat	CU	CHPW			Prerequisite
				L	T	P	
GLST202	Properties of Silicate Raw Materials	CR	2	2	-	-	
GLST204	Phase Diagrams in Materials	CR	2	2	1	-	
GLST206	Silicate Fabrication Laboratory	CR	2	-	-	3	
GEOL204	Optical Mineralogy	CT	2	1	-	1	GEOL 203
MATH242	Calculus II	CT	2	2	1	-	MATH 105
CHEM212	Physical Chemistry	CT	2	2	-	-	CHEM 112
MEEN202	Engineering Drawing	CT	3	3	1	-	
BLDG208	Strength of Materials	CT	2	2	1	-	
GENS 202	Entrepreneurship & Skills Development	CT	2	2	-	-	

	Core (CR)	Cognates (CT)	Restricted Elective (RE)	Unrestrictive Elective (UE)
Total Credit Unit	6	13	0	0
Semester total	19			

300 LEVEL FIRST SEMESTER

Course Code	Title	Stat	CU	CHPW			Prerequisite
				L	T	P	
GLST301	Structure of Glass	CR	2	2	-	-	
GLST303	Properties & Applications of Glass	CR	2	2	1		
GLST303	Scientific Glass Technology I	CR	2	2	-	-	
GLST305	Whiteware Technology	CR	2	2	-	3	
GLST307	Refractory Materials	CR	2	2	-	-	
GLST309	Technology of Cement	CR	2	2	-	3	
GLST311	Batch Design in Glass	CR	2	1	-	3	
GLST313	Analytical Methods I	CR	2	-	-	3	
STAT343	Statistics	CT	2	3	-	-	STAT 102
MATH 341	Ordinary Differential Equations	CT	3	3	1	-	MATH 241

	Core (CR)	Cognates (CT)	Restricted Elective (RE)	Unrestricted Elective (UE)
Total Credit Unit	16	5	0	0
Semester Total	21			

300 LEVEL SECOND SEMESTER

Course Code	Title	Stat	CU	CHPW			Prerequisite
				L	T	P	
GLST 302	Structure & Properties of Silicates	CR	2	2	1	-	
GLST304	Scientific Glass Technology Laboratory I	CR	2	-	-	3	GLST303
GLST306	Concrete	CR	2	2	-	-	
GLST308	Material Characterization	CR	2	-	-	2	
GLST310	Introduction to Material Science	CR	2	2	-	-	
GLST312	Batch Design in Silicate s	CR	2	-	-	2	
GLST314	Refractory Applications	CR	2	2	-	-	
GLST316	Fuels and Furnaces	CR	2	2	-	-	
GLST318	Refractories Technology Laboratory	CR	2	-	-	3	
GLST320	Drawing of Refractory Lining & Joints	CR	1	-	-	2	

	Core (CR)	Cognates (CT)	Restricted Electives (RE)	Unrestricted Electives (UE)
Total Credit Unit	20	0	0	0
Semester Total	20			

400 LEVEL FIRST SEMESTER

Course Code	Title	Stat	CU	CHPW			Prerequisite
				L	T	P	
GLST401	Introduction to Research Method	CR	2	2	-	-	
GLST403	Large Scale Industrial Glass Processes	CR	2	2	-	-	
GLST405	Ceramics in Electronics	CR	2	2	-	-	
GLST407	Glass Ceramic Technology	CR	2	2	-	-	
GLST 409	Industrial Chemical Technology	CR	2	2	-	-	
GLST411	Scientific Glass Technology Laboratory II	CR	2	-	-	3	GLST304
GLST413	Advanced Ceramics Practical	CR	2	-	-	3	
MATH443	Numerical Analysis	CT	2	2	-	-	MATH 241
STAT 443	Design and analysis of experiments and quality control	CT	2	2	-	-	STAT 343

	Core (CR)	Cognates (CT)	Restricted Electives (RE)	Unrestricted Electives (UE)
Total Credit Unit	14	4	0	0
Semester Total	18			

400 LEVEL SECOND SEMESTER

Course Code	Title	Stat	CU	CHPW			Prerequisites
				L	T	P	
GLST 498	SIWES (Students Industrial Work Experience Scheme)	CR	6				

	Core (CR)	Cognates (CT)	Restricted Electives (RE)	Unrestricted Electives (UE)
Total Credit Unit	6	-	-	-
Semester Total	6			

500 LEVEL FIRST SEMESTER

Course Code	Title	Stat	CU	CHPW			Prerequisites
				L	T	P	
GLST501	Primary Sensors for Silicate Industry	CR	2	2	-	-	
GLST503	Coloration in Glass	CR	2	2	-	-	
GLST505	Bioceramics	CR	2	2	-	2	
GLST507	Sintering Technology	CR	2	2	-	-	
GLST509	Novel /Nano Silicate Materials	CR	2	2	-	3	
GLST51 1	Introduction to Inorganic Polymers	CR	2	2	-	-	
MEEN50 3	Production Management I	CT	2	2	-	-	

	Core (CR)	Cognates (CT)	Restricted Electives (RE)	Unrestricted Electives (UE)
Total Credit Unit	12	2	-	-
Semester Total	14			

500 LEVEL SECOND SEMESTER

Course Code	Title	Stat	CU	CHPW			Prerequisites
				L	T	P	
GLST502	Instrumentation & Process Control	CR	2	2	-	-	
GLST50 4	Introduction to Engineered Ceramics	CR	2	2	-	-	
GLST50 6	Composite Materials	CR	2	2	1	-	
GLST50 8	Pollution & Waste Management in Silicate Industries	CR	2	2	-	-	
GLST 510	Final Year Project	CR	6	-	-	3	
GLST512	Silicate Equipment Design Laboratory	CR	2	-	-	3	
MEEN502	Production Management II	CT	2	2	-	-	

	Core (CR)	Cognates (CT)	Restricted Electives (RE)	Unrestricted Electives (UE)
Total Credit Load	16	2	-	-
Semester Total	18			

SUMMARY OF LOAD PER SEMESTER

Level	Credit Units			
	Core and Cognate		Elective	
	1st Semester	2nd Semester	1st Semester	2nd Semester
100	22	18	1	3
200	22	19	0	0
300	21	18	0	0
400	18	6	0	0
500	14	18	0	0
TOTAL	**97**	**79**	**1**	**3**

Minimum per semester = 18 x 9 semesters = 165 + 6 SIWES = 171
Maximum per semester = 24 x 9 semester = 216 + 6 SIWES = 222
Requirement for graduation = 97 +79+ 6 SIWES = 182

B. GLASS & SILICATES TECH. 100 LEVEL

GLST 101: History of Glass (CR 1 Credit)

The long history of glass as an artifact, the dramatic changes witnessed in its application with the introduction of science to glassmaking, variety of uses spanning all aspects of human life; the phenomenal growth since the early sixties, Discussion of the twin freedom enjoyed by materials in the glassy state as factors responsible for the growth vis: freedom from the restrictions of periodicity and stoichiometry. Glass as a tool for scientific exploration and a protector of man and his inventions. Glazing applications in building and automobiles for non-structural purposes. Structural uses in deep sea diving; glass fibre reinforcements. Highlights of strengthening methods: thermal toughening, chemical toughening and lamination with particular reference to bulletproof windows. Introduction, definition and scope of ceramics. Historical perspective, classification, Ceramics and Civilization; Traditional ceramics: An overview, istory,compositions, manufacturing and application of refractories, whitewares and heavy clay wares, glass, cement, ceramic coatings.

GLST 102: Unit Operations in Processing (C R 1 credit)

Communition: different type of communition equipment and theory of size reduction. Efficiency and particle size, size reduction and size distribution. Bulk solid transport and mixing. Mixing mechanism and mixedness. Mixing equipment types and operation. Consistency, particle mechanics and deformation behaviour of powders, slurries and paste. Particle classification-screening technique, cyclone separators, centrifuge. Filtration and washing process. Plastic forming, extrusion mechanics, control of types and operations. Basic concept of drying, costs involved in drying of ceramic, drying mechanisms in particulate systems, characterization of drier operations, drier controls, drying defects and drying shrinkage, advanced drying technologies.

GLST 103: Introduction to Silicates Technology (CR 2 Credits)

The basis of glass science as related the desired properties and relative performance of the material in the various areas of application; The structure of the atoms and phases of glasses as determined by material characterization; The major determinants of the structure of the material and thus its properties: its constituent chemical elements and the way in which it is processed into its final form; These characteristics together and related through the Jaws of thermodynamics, as factor governing the material's microstructure, and thus its properties.

Basic understanding of Glass Technology, glass production: melting, forming, viscosity, annealing - glass properties: Mechanical, thermal, optical and electrical. Commercial glass grinding and polishing; process control; toxicity and personal safety in glass manufacture.

The development of modern ceramic technology, processing of ceramic powders, shape forming operations: pressing, slip casting, isostatic pressing, injection moulding, sheet forming, MLC technology. Firing of ceramics: kiln design and conveyor technology, sintering and densification, hot pressing and hot isostatic pressing. Solgel processing and monolithic ceramics. Basic glass processing, container glass, fibre glass, speciality glass products, glass-ceramics, glass microspheres, laminated glass, photochrome and photo sensitive glass Modern / high tech ceramics, high tech functions and functional ceramics, structural ceramics, electrical and electronic ceramics, chemical and nuclear ceramics, bio-ceramics, ceramic membranes, artificial gems and ceramics, aerospace and other strategic applications of ceramics, advanced

ceramic processing techniques. Energy and pollution controls.

GLST 104: Introduction to Silicate Raw Materials (CR 2 credits)

Classification of raw materials, beneficiation of raw materials, importance, use and limitations of natural raw materials: Bauxite, Limestone, Chromite, Magnesite, Dolomite, Fluorite, Graphite, Gypsum, Haematite, Kaolinite, Fireclay, Ball clay, Montmorillonite, Magnetite, Nepheline Syenite, Microcline, Feldspars (soda, potash, lime), Pyrophyllite, Quartz, Quartzite, Sillimanite, Kyanite, Andalusite, Talc, Wollastonite, Zircon, Beryl, Mica, Vermicullite, Silica sand etc; Brief idea on processing of synthetic raw materials: Bayer process, Calcined Alumina, Tabular Alumina, Fused Alumina, Sea- water Magnesia, Zircon and Zirconia, Titania, Magnesio-Aluminate Spinel, Fumed Silicaetc. The application areas and limitations of synthetic raw materials; Effect of heat on different raw materials with reference to phase transformation, thermal expansion, melting, decomposition behaviour, compound formation, stabilization.

Raw materials for introducing glass formers intermediate oxides and stabilizers or fluxing agents; Auxiliary raw materials colorants, decolourisers, opacifiers, cullet, fining and accelerating agents. Raw material storage systems: major raw material storage, minor raw material storage and the chemical additives, Quality control in batch house glass raw materials, the principle of First-In- First-Out-In the management of batch house raw materials, movement of batch house raw materials to the furnace dog house.

GLST106: Ceramic Workshop (CR 2 credits)

Sieve analysis and particle size distribution of milled product; Verification of Rittinger's Crushing Law and determination of crushing efficiency of a Jaw Crusher; Validation of Bond's Law and determination of crushing efficiency of a Roller Crusher; Determination of angle of nip and maximum feed size for a Roll Crusher; Determination of critical speed and crushing rate of a Ball Mill; Study of Filter Press and preparation of filter cake; Determination of filtration rate of ceramic slurry; Study and operation of de-airing Pug Mill and preparation of extruded body; Operation of Counter Current Mixer and determination of mix consistency; Study and operation of Hydraulic Press and determination of bulk density

B. GLASS AND SILICATES TECH. 200 LEVEL

GLST 201: Introduction to Silicate Processing (CR 2 credits)

Significance of different ceramic processing operations. Powder synthesis, Colloidal and sol-gel processing. Powder characterization: Particle size, size distribution, Shape, Surface Area, Porosity, Chemical and Phase composition. Preparation of bodies: Blending of different weight fractions and size ratios, use of binders, types of binders; clay, molecular binder, film forming binders. Plasticizers, Foaming and antifoamin, agents, granulation and spray drying. Dry pressing, Semi-dry pressing, Slip casting, Extrusion, Nontraditional shape forming: Gel casting, Tape casting, Freeze Casting, Injection moulding, Electro-phoretic deposition, Hot -pressing, Iso-static pressing; porosity, pore structure, drying defects; High temperature processing. .

Batch Materials Handling and Preparation: Intake and storage of raw Materials; Weighing and Mixing; Conveying of Batch to Dog House. Reaction occurring during glass preparation, melting phase, firing phase, Homogenizing phase, heat conditioning phase, defects in glass, phase equilibrium identification and interpretation of stones and cords in glass.

GLST 203: Chemistry of Silicates (CR 2 Credits)

Structure of crystals - atomic structure, inter-atomic bonds, atomic bonding in solids, crystal structure, grouping of ions and Pauling's rules, oxide structures, Silicates structures, silica, ortho-Silicates, pyrosilicates, framework structure, derivative structures, clay minerals, polymorphism. Structural imperfections - atomic defects, Frenkel and Schotty disorder, order-disorder transformation, association of defects, nonstoichiometric solids, dislocations. Ceramic

phase - equilibrium diagrams - Gibb's phase rule, techniques for determining phase - equilibrium diagrams. One - component and two - component phase diagrams, eutectic, incongruent melting, phase separation. Solid solutions, complex diagram, three - component phase diagrams, phase composition versus temperature, nonequilibrium phases, mestastable crystalline phases, incongruent reactions.

GLST 204: Phase Diagrams in Materials (CR 2 credits)

Crystal lattice, crystal class and crystal system. Some Real Structures: Rock Salt, Zinc Blende, Antifluorite, Rutile, Perovskite, Spinels, Wurtzite etc. Crystal imperfections: types and notations, Solid solutions, defects and dislocations Vitreous state, glasses and structural models; Condensed phase rule and single component system: Silica, Zirconia and Carbon etc. Two component systems and Lever rule. Free energy-composition diagrams, phase stability, solid solutions, Eutectic and Eutectoid, Peritectic reaction, congruently and incongruentlymelting compound. Some important binary ceramic systems SiO2-Al2O3, MgO-Al2O3, CaO-SiO2,CaO-ZrO2, MgO-SiO2, BaO-TiO2, CaO-Al2O3, CaO-MgO; Ternary System: Representation of composition on triangle, proof of the basis, Temperature, Solid models, Iso-thermal Sections, Base projection method. Ternary systems with binary and ternary Eutectic, Peritectic, congruently and incongruently melting compounds.Some important ternary ceramic systems:CaO-SiO2-Al2O3, MgO-SiO2-Al2O3,CaO-MgO-SiO2. Brief idea on the application of real system binary, ternary and quaternary phase diagrams in the processing and process control of different ceramic materials. Some important three component systems-CaOAl2O3SiO2, MgO-Al2O3-SiO2, SiO2-FeO-Fe2O3, MgO-FeO-Fe2O3, MgO-Al2O3-Cr2O3. Quaternary System-MgO-CaO-SiO2-Fe2O3, MgO-SiO2-CaO-B2O3.

The relevance of above phase diagrams in the ceramic system. Use of phase diagram in the sintering of ceramics; multiphase system containing a liquid phase, tungsten-carbide-cobalt system, porcelain, silicon nitride. Crystal growing techniques and use of phase diagrams in crystal growth; growth from stoichiometric melts, impurity distribution coefficient, constitutional supercooling and non-stoichiometric melts, single crystal growing of Yttrium-iron-garnet, cubic barium-titanate, gallium-phosphide,quartz crystal from hydrothermal solution; Phase diagrams in the development and use of refractories; Alumino-silicates, Silica and basic refractories, Fusion cast refractories. Liquid immiscibility in oxide systems. Study of dissolution of refractories in molten slag; Application of the phase diagrams in cement chemistry; calcium-alluminate cement and Portland cement Phase diagrams in glass making, iron-carbon system, in the stabilization of zirconia phases. Phase diagrams in high pressure systems, recent developments in this area.

B. GLASS AND SILICATES TECH. 300 LEVEL

GLST301: Structure of Glass (CR 2 credits)

Structural dissimilarities between glasses and non- glassy materials; Classification of glasses by structural types: Covalently bonded glasses and their examples oxides chalcogenides, organic polymers etc. ionically bonded glasses and their examples the salt glasses; Metallic glasses.

GLST 303 Properties Application of Glass (CR 2 credits)

Theoretical and Design Strength; Thermal stresses in glassware. Methods of measurement. Effects of Composition; effects of surface flaws. High strength glass surfaces; factors responsible for surface damage; The strength of glassware, determination of service stress. Simulated service stress of containers; Fracture analyses; Some aspect of the nature of inorganic glasses; Definition of the term 'Glasses', The transformation range; The chemical nature of inorganic: glasses. Viscosity: Viscosity values; Analysis of some simple problems in viscous

laminar flow - flow of glass over a horizontal plane; heat transfer from glass inside a cylindrical mould. Measurement of viscosity - high and low temperature methods, viscosity fixed points; Variation of viscosity with temperature - activation energy for viscous flow, the Fulcher equation; Flow properties in the transformation range - variation of viscosity with time, stress relation phenomena; Effect of glass composition, Surface tension; Thermal Expansion; Thermal expansion curve; Methods of measurement, Effect of glass composition; Glass to metal seals; Thermal stresses in glassware.

Refractive index- measurement effect of glass composition molar ionic refractivity; effect of heat treatment; Dispersion - the Lorentz theory relationship between dispersion and UV absorption for simple glasses; Optical glass - Terminology, history, composition and properties; Significance of properties in lens design, optical fibres and established application, optical communications. Absorption of radiation by glasses, coloured and laser glasses. Electrical properties - ironically conducting glass - main feature of conduction, effects of composition and temperature. Semi-conducting glasses - types and characteristics. Electron energy level and conduction mechanism in glasses. Dielectric loss in oxide; Glasses - the less mechanism. The frequency and temperature dependence of heat loss of alkali silicate glass.

GLST 302 Structure and Properties of Silicates (CR 2 credits)

Mechanical Properties: Concept of strength and its relation with fundamental parameters, plastic deformation, viscous flow, creep, Fracture of materials; Thermal Properties: Thermal expansion, thermal shock, annealing and chemical strengthening, specific heat and heat capacity, thermal conduction process; Electrical Properties: Electrical, electronic and ionic conduction phenomena in crystals, Fast ionic conductors, glasses and non-stoichiometric compounds. PTCR, NTCR, Varistors, thermisters etc; Dielectric Properties: Dielectric loss of crystals and glasses, dielectric strength, piezoelectric and ferroelectric ceramics; Magnetic Properties: Concept of magnetic phenomena in solids. Structure and magnetic properties of spinel ferrites, rare-earth garnets, ortho-ferrites and hexagonal ferrites with special reference to their microstructure; Optical Properties: Refractive index and dispersion, reflectance, opacity and translucency, absorption and colour from modern concepts in crystalline and vitreous ceramic systems.Characteristic of microstructure; Quantitative analysis; Properties and factors affected by microstructure; microstructural aspects of sintering and grain growth, microstructural variables; Mechanical, thermal, optical properties and the effect of microstructure; High temperature degradation; Wear behaviour; Techniques for characterizing ceramic microstructure. Resolution and its implications for routine microscopy, Optical microscopy, scanning electron microscopy, stereoscopy and stereology. Preparation of ceramic samples for microscopy. Fine powders and granulates; microstructural characterization of green bodies-sample preparation for SEM and TEM study; Dense fired ceramics, porous ceramics, microstructural maps of sintered body, polished surface and fractured surface microstructure, common pore structure in ceramic bodies, pore morphology and properties, quantitative estimation of different phases and grain size; study and interpretation of wetting behaviour, grain boundary film,crystalline interface boundaries, crystalline interphase boundaries, dislocations in the sintered body by SEM and TEM; microstructure of different types sintered ceramic bodies: Triaxial whiteware bodies, refractories, clay products,glass, glazes and enamels, glass ceramics, advanced and special ceramics.

GLST 303 Scientific Glass Technology I (CR 2 credits)

Introduction Definition, historical overviewed and the relationship that exists between Scientific Glass Technology (SGT) and glass technology, chemistry and allied fields. SGT and National Development; Obtain basic knowledge of glass and SGT, acquaint with the basic SGT operations, principles and techniques, and know the list and uses of SGT equipment, tools and or

facilities. Safety in the SGT laboratory or workshop. Physical properties, chemical properties, annealing science and technology, Identifying unknown SGT tubing, rods and glassware.

GLST 304 Scientific Glass Technology II (CR 2 credits)

List, identification and uses or SGT glass apparatus and glass systems. List, identification, operations and maintenance of SGT equipment, tools and facilities; viz: SGT universal lathe machine, polariscope, annealing lehr, fume chamber or expeller with chimney, lapping wheel, SGT super cut machine, compressor, SGT benches, bench burners, hand torches, files and glass knives, graphite rods and paddles, Tweezers, gauges, didymium goggles, flaring tools, rubber caps, sheets and stoppers, abrasives, SGT glass holders, etc SGT basic glass blowing seals: viz: fire polish tube ends, pull points, round bottoms, flat bottoms, butt seals, flare tubing, T-joints, U-joints and Y-joints, rod seals, blind seals, capillary seals, blowing bulbs and spirals.

GLST305 Whiteware Technology (CR 2 credits)

Raw materials, processing, properties, batch composition and the effect on the properties of whiteware bodies, effect of particle size distribution of kaolinite on plasticity and workability of clay. Rheology and properties of clay water system, mechanism of plasticity, additives/binders, plasticizers, flocculants and deflocculants and slip properties; Classification of whiteware bodies, batch formulation Tri-axial bodies - porcelain, stoneware, earthenware, hotel ware, majolica, terra-cotta, bone china, parian-art ware, insulator, tiles, sanitary ware etc. Body preparation including the unit operations and fabrication processes. Application of granular mechanics to slip casting. Influence of particle size distribution on properties of fired whiteware bodies. Mould materials, mould and mould design; Fundamentals of drying and shrinkage. Firing of whiteware bodies, microstructure evolution during firing of whiteware bodies. Time, temperature and atmosphere effects on firing of whitewares, special firing techniques, Glaze structure, formulation, raw materials, batch calculation, preparation, slip rheology, application. colours, decoration firing. Testing of white ware bodies.

Design and drawing of model and mould; Shaping of a pre-designed plaster model; Fabrication of pre-designed slip casting mould; Fabrication of model using Jigger and Jolly; Determination of plasticity and Plasticity Index; Determination of drying sensitivity of a green body; Study of drying curve and critical moisture content of a green body; Determination of vitrification range of a whiteware body; Determination of deffloculant demand curve of slip; Study of slip casting behavior; Study of glaze-body fit by dilatometer; Determination of flow limit of glaze; Finishing, drying and glazing of cast wares; Crazing resistance of glazed article.

GLST 306 Concrete (CR 2 credits)

Definition of concrete, aggregates: classification of aggregates. Effect of aggregates on the properties of concrete. Crushing strength of aggregate. Factors affecting the grading of aggregates. Interpretation of grading curves. Handling of aggregate. Admixture: History of admixture. Functions and classification of admixtures. Air entrainment. Damp and water proofing admixtures, etc. Properties of fresh concrete, strength of hardened concrete. Batching and mixing of concrete. Transportation and placing of concrete. Compaction of concrete, current of concrete. Properties of hardened concrete. Elasticity and creep of concrete. Concentrating index extreme environmental conditions. Testing of concrete. Quality control.

GLST307 Refractory Materials (CR 2 credits)

Classification of refractories, properties of refractories, packing of solid particles monosized particles, bimodal mixtures of spheres, bimodal mixture of non spherical particles, ternary and multiple mixtures, continuous particle size distribution, particle interaction during dry compaction; Shaped Refractories: Alumino-silicate, high alumina, magnesia, silica, doloma, carbonaceous, Refractories; raw materials, processing, process quality control, Detailed

analysis of phase diagrams with respect to the raw materials controlling the firing temperature and schedule; properties, microstructure applications; Composite refractories: alumina-carbon, magnesia-carbon, Spinel, alumina-silicon carbide- carbon, zirconia-carbon; Unshaped refractories; castables, gunning mass, ramming mixes, shot creting mass, compositions/classifications, additives, manufacturing process, quality control, properties and applications;Properties and tests: Specification of different kinds of bricks, fusion point in relation to equilibrium diagram, PCE Test, HMOR, torsional creep properties and tests, Re-heat shrinkage, Spalling resistance, slag resistance; Reaction between refractories and glasses, heat transmission, behaviour of refractories in different environments, corrosion and failure of refractories, detailed analysis and interpretation of the refractories behaviour with respect of microstructure.

GLST308 Materials characterization (CR 2 credits)

Dilatometric analysis: Studies with vitreous silica, Silica brick specimen, Whiteware samples of low thermal expansion coefficients, Interpretation of data. Differential Thermal Analysis: Studies with Ceramic Raw Materials like China clay, Ball clay, Fireclay, Pyrophyllite, Quartz, Magnesite, Dolomite, calcite, Aluminium hydroxide, Magnesium hydroxide etc. Interpretation of data. Thermo Gravimetric Analysis: Studies with some important raw materials like China clay, Ball clay, Fireclay, Pyrophyllite, Quartz, Cement samples, dolomite, calcite, magnesite, Copper sulphate etc. Interpretation of data & DTGA curves from TGA data. Particle size distribution by Andreasen pipette. Flame photometer for alkali estimation. Differential Thermal Analysis (DTA), Thermogrvimetric Analysis (TGA), Differential Scanning Calorimetry (DSC). Factors affecting the phase transformations - particle size, packing, heating rate, buoyancy effect. Thermal Conductivity, Dilatometry basic principles, instrumentations and case study in ceramic applications. Study of sintering kinetics by dilatometry; Particle Size Analysis, Surface area and porosity basic principle, data analysis; Spectroscopic method: UV-Visible, IR, FTIR and Raman Basic principle, instrumentation and analysis of data; X-Ray Methods: x-ray generation, diffraction, Bragg law, Diffraction under ideal and non-ideal conditions, Scattering and structure factor. Principles of x-ray Diffractometer (XRD), x-ray data file and its analysis, indexing of crystal type. Chemical analysis by x-ray fluorescence (XRF) Wave length and energy dispersive XR; Optical microscopy - light optics, microscope components, possibilities and limitations. Scanning Electron Microscopy - Optics and performance of a SEM, Image interpretation, crystallographic information in a SEM, analytical microscopy. Transmission Electron microscopy - construction and operation of a TEM, electron diffraction, Image interpretation. Techniques of sample preparation for TEM and SEM methods. Electron Beam Microprobe Analysis.

GLST309 Technology of Cement (CR 2 credits)

Introduction to hydraulic materials. Classification of Cement, Chemistry of hydrated and anhydrous cement compound. Manufacturing of Portland cement; Dry, Semi-dry, wet and semi-wet process, Cement grinding, Testing of cement, Cement compounds and their phase relations, Cementing qualities of cement phases, The burning of Portland cement, Constitution of Portland cement, Phase equilibrium conditions of clinker crystallization, Calcia-Alumina-Silica system, Clinker constitution and cooling process, refractories used in the rotary kiln, Role of free magnesia and free lime in the clinker, hydration of cementing phases and Portland cement, theories and mechanism of cement setting and hardening, Action of acid water and sulphate waters on Portland cement, Steam-curing of Portland cement. Special Cement and cement additives, Blast Furnace slag- and high alumina cement. Concrete: Types, Method of production and Properties of concrete, Alkali-aggregate reaction, Electrical and fire resistance of cement and concrete. Pollution control in cement industries.

Preparation of Portland cement in the laboratory; Determination of consistency of cement; Study

of initial and final setting of cement by Vicat apparatus; Determination of soundness of cement Le Chatelier method; Making and curing of cement mortar; Compressive strength of cement mortar fine with ageing time; Determination of surface area of cement by Blain Air Permeability apparatus; Determination of fineness modulus and grain size distribution of fine aggregate; Effect of casting process parameters on the properties of cement mortar; Quantitative chemical analysis of cement; Effect of admixture on cement mortar; Study of the durability of cement mortar.

GLST310 Introduction to Material Science (CR 2 credits)

Atomic Structure and Bonding. Crystal Structure, crystal class and crystal geometry: Polymorphism; crystal structure analysis, crystalline Imperfections: point defect and line defects. Diffusions in Solids and phase transformations, thermal and athermal transformations. Solid solutions. Solidification: Solidification of metals and single crystals; Brief idea of crystal growth techniques; Mechanical Properties of Metals: Stress and strain, hardness. Strengthening; Recovery and recrystallization; Strength, Fracture toughness, creep and fatigue. Engineering alloys: Fe-C phase diagram; Heat treatment of steel; Classification of steel; Polymeric Materials: Basic structure simple and network molecules; Physical states and transitions; Plasticization; Crystallinity; Polymerization, Degradation and stabilization of polymers, Vulcanization of rubber. Application of polymers, conducting polymers; Composite Materials: Definition; Types of composites, properties and applications; strength and toughness in composites, layered composites, particulate and fibre reinforced composites; Electrical, Magnetic and Optical Properties of Materials: Classification, Electrical and electronic conduction, polarization, dielectric properties, application. BCS theory and Superconducting Materials.

GLST311 Batch Design in Glass (CR 2 credits)

Glass Batch calculation methods; arithmetical approximation, simultaneous equation matrix algebra, computerized batch calculation supplementary information relating to glass composition and batch calculations. Provisions of basis for evaluating raw materials; introducing raw or modified batches into the operation; taking sample for control analysis.

Preparation of soda-lime-silicate glasses; Fabrication of plate glass and annealing; Determination of glass transition temperature of the processed glass; Effect of refining agents during preparation of glasses; Fabrication of hollow glass ware by blowing techniques; Study of chemical durability of glasses using Flame Photometer; Batch calculation and fabrication of different coloured glasses; Determination of refractive index and colour concentration of glass; Determination of density of glass by non-destructive methods; Detection of strain in glass and annealing schedule; Determination of CTE of commercial glasses; Study of Littleton softening point of glass.

GLST312 Batch Design in Silicates (CR 2 credits)

Calculations in ceramics: Dimensional change; Shrinkages (Wet-Dry and Dry-Fired), Volume Shrinkage, Moisture content, Loss on Ignition. Density and Specific gravity:: Archimedes Principles applicable to ideal solids and liquids. Effect of porosity on the function of ceramic materials, apparent porosity, Water absorption, True porosity. Calculations Relating to mixtures solid particles and water. Brongniarts Formula. "Dry" and "Wet" Measurement of materials for body mixing. Effect of Specific gravity, density of the body slip. Calculation from a recipe from a simple glaze formula. Given the recipe of a Glaze calculate the formula. Fitting Factors; Given the Recipe, calculate a formula, percentage composition of the Mill Batch. Ultimate and Rational Analysis of clays. Calculated Rational Analysis of clays, stones and feldspar. Substitution of clays in Body Recipes.

GLST313 Analytical Methods (non-instrumental) (CR 2 credits)

Glass raw material analysis by chemical methods; Proximate and ultimate analysis; Preparation of reagents and standard solutions of salts: potassium, sodium, calcium, magnesium, iron, aluminum, lead etc. for quantitative analysis; Analysis of glassmaking sand, feldspar, baryte, limestone, dolomite casiterite, gypsum, clay, etc.; Analysis of test-melted samples and comparison with standards. Determination of Ca+2 and Mg+2 in water by EDTA method; Chemical analysis of limestone/dolomite; Complete analysis of Portland cement; Chemical analysis clay/magnesite/bauxite following Na2CO3/NaOH fusion; Determination of silica in quartz by HF treatment; Determination of very low-alkali content by flame photometer; Quantitative chemical Analysis analysis of Alumino-Silicate brick; Chemical analysis of ordinary soda-lime-silicate glass; Quantitative chemical analysis of tri-axial porcelain body; Chemical analysis of glaze frit.

GLST314 Refractory Applications (CR 2 credits)

Introduction to monolithic refractories, advantages and disadvantages; Classifications based on application techniques, chemical constituents And purity; raw materials and their selection, particles size distribution,Discrete and continuous particle size distribution, Furnas, Andreassen-Andersen and Dinger-Funk model; different bonding systems, CaO-Al2O3 system, hydration of calcium aluminates, bonding mechanism of different binders, various additive systems; refractory castable and details of CCC, LCC, ULCC, NCC, SFC; other monolithics, like mortar,gunning mass, spraying mass, ramming mass, etc; machinery and equipments for making unshaped refractories,batch preparation, mixing, processing and manufacturing techniques; installation techniques and application; properties and specialties of different castable systems, like alumina, alumina - magnesia, alumina spinel, magnesia, magnesia carbon, etc.

Characteristics, manufacture and applications of carbon refractories, super refractories as zirconia, zircon, thoria, beryllia and high purity oxides like alumina, silica, magnesia. Fused and electrocast refractories. Cermets. Testing of refractories e.g. sampling, standard tests for the various refractory properties-pyrometric cone equivalent, PUL, Spalling resistance, resistance to chemical attack, cold crushing strength, apparent porosity, permeability, true specific gravity, bulk density, MOR, permanent linear change and warpage.

GLST316 Fuels and Furnaces (CR 2 credits)

Classification of natural fuels, Brief discussion on alternate and renewable energy sources, winning and washing of coal, classification of coal, proximate and ultimate analysis of coal. Storage of coal and spontaneous ignition, Carbonization and manufacture of coke, caking index and coke quality. Coking process, cokeoven and byproducts; Origin, refining and distillation of crude petroleum, properties of liquid fuel flash point, fire point, cloud point and pour point. Generation of producer gas, water gas, liquidified petroleum gas (LPG), gasifiers and gas analysis; Different types of industrial furnaces; batch and continuous furnaces and kilns, design and operation of different industrial furnaces and kilns, saggers, Fast firing technology, microwave furnaces. Fuel economy and thermal efficiency in the operation of furnaces; Sankey diagram, Regenerators and recuperators. Stack emission, chimney design, combustion calculation and environmental pollution, Measurement of temperature in furnaces- pyrometric cones, rings and bars and temperature controller; Combustion calculations of fuels; Material balance in ceramic processes. Batch and recipe calculation for refractories, glass, whitewares and cement. Energy Balance and flame temperature calculations. Combined material and energy balances.

GLST318: Refractories Technology Laboratory

Determination of packing density of one component system of various particle sizes; Determination of packing density of two component system having various size ratios; Recipe

calculation and recipe making for refractory mix; Study of compaction response behaviour of refractory mix; Shaping of refractory brick by dry pressing/hand moulding method; Determination of porosity and density of the prepared refractory brick; Determination of crashing strength of refractory bricks; Study of thermal shock resistance and PLCR of refractory brick; Determination of MOR and HMOR of refractory brick; Vibrocasting of supplied castable and study of cured property; Effect of casting parameter on the properties of cast refractories; Study of strength development of castable with temperature.

GLST320: Drawing of Refractory Lining & Joints
Study and drawing of different refractory bricks of standard shape; Study and drawing of non-standard shapes of refractory bricks; Drawing of brick wall and brick joints; Drawing of different parts of rotary kiln; Drawing of converter; Drawing of ladle; Drawing of Blast Furnace Trough Lining; Drawing of slide plates refractories; Drawing of sub entry nozzle; Drawing of monoblock stopper; Chimney calculation and drawing of chimney.

B. GLASS & SILICATES TECH. 400 LEVEL

GLST401 Introduction to Research Method (CR 2credits)
Approaches to systematic research: field and laboratory research. Instrument of research. Organization of source materials. Various forms of presentation.

GLST403 Large Scale Industrial Glass Processes (CR 2credits)
Flat glass manufacturing processes; sheet glass Foucault method, Pittsburg process. PPG ring roller process, continuous casting process. Libby Owens continuous rolling, continuous horizontal rolling grinding and polishing operations. Patterned manufacturing processes. Float glass. Hand production processes.Selection of materials for fibre glass manufacture. The processes involved in its manufacture. The use of glass and polymer fibres as flexible light guides. Fibre glass with particular reference E-glass as the most widely used reinforcement for plastics in today's world. Glass fibre, textile fibre insulating glass fibre wool.
Container glass manufacturing process; bottles and other hollowware glass articles forehearth and gob feeder, lynch blow and blow machine. Press moulds; paste moulds. Corning bulb machine (ribbon machine) tolerance in bottle manufacturing; Production of glass tubing and reds; Danner, Vello, and Schuller processes.

GLST405 Ceramics in Electronic Applications (CR 2 credits)
Introduction, elementary solid state science, electrical conduction, defect and defect chemistry, charge displacement process. Ceramic conductors: high temperature heating elements and electrodes, ohmic resistors, varistors, thermistors PTC, NTC, fuel cells and batteries, sensors, materials system, powder synthesis, processing, properties, devices and application. Fundamentals of superconductivity, theories of superconductors, materials system, synthesis, processing, properties and application; Dielectric and insulators, fundamentals of capacitors, classification of dielectric matrials, materials system, low permittivity, medium permittivity and high permittivity, Powder synthesis, processing, properties, fabrication and application. Capacitor designs, processing; Fundamentals of piezoelectricity, materials system, synthesis, processing, properties, devices and application. Fundamentals of pyroelectricity, materials system, synthesis, processing, properties, devices and application. Electro-optic fundamentals, materials system, synthesis, processing, properties, devices and application; Fundamentals of magnetism, Magnetics ceramics basic concepts, model ferrites: spinel ferrites, hexaferrites, garnets, properties influencing magnetic behavior, soft ferrites, hard ferrites, microwave ferrites, Preparation of ferrites, rawmaterials, mixing calcinations and milling, sintering, post sintered processing, applications.

GLST407 Glass Ceramic Technology (CR 2 Credits)

Fabrication and properties of Glass ceramics. Crystallization of glass: Homogeneous and heterogeneous nucleation, Growth. Binary (Mullite) and ternary (Mullite, Hexacelsian, Celsian-Rutile) glass ceramics. Phase separation. Control of mechanical, thermomechanical, electrical, optical properties through microstructure development in glass ceramics. Nanocrystalline microstructure. Surface strengthening thermal strengthening and chemical strengthening of glass ceramics. Technical application of glass ceramics: Structure, composition and properties of glass ceramic used in Radome, Photosensetaitve materials, Machinable glass ceramics, Magnetic Memory Disk. Household application of glass ceramics : Decorative glass ceramics, High Quartz and Keatite- type alumino- silicates, composition of ceramic colours glass ceramic cook top panels. Precision Optical applications: low thermal expansion glass ceramics, large casting technology, dimensional stability, transparent glass ceramic, thin walled cylinders, reflective optics, laser gyroscopes, light weight mirrors, Radiation stability technology, Refractory glass ceramics, Glass ceramics in biomedical application.

GLST409 Industrial Chemical Technology (CR 2 credits)

Fluid Flow (Momentum Transfer): Bernoulli Equation (Conservation of mass), Continuity Equation in fluid flow (conservation of mass), Flow regimes and their mechanisms, Newton's law of Viscous Flow, Fans, Blowers and pumps. Heat Transfer: Classification of heat transfer and its mechanisms- conduction, convection and radiation. Heat transfer coefficients individual and overall. Heat transfer Equipment-countercurrent and concurrent Heat Exchangers. Mass Transfer: Definition and Basic principles. Fick's First Law of molecular Diffusion. Examples of processes and equipment that involve mass transfer. Unit Operations: Process flow diagrams of unit operations, recycle and bye-pass streams. Energy and material balances. Distillation- binary mixture distillation in packed and plate columns. Evaporation- single and multiple effect evaporators as used in industry. Crystallization- types of mixtures for this separation, limitations, etc. Drying- batch and continous at industrial scale, drying chart. Filtration- types of filters, effect of operational parameters, filters aids, etc.

GLST411: Scientific Glass Technology III

SGT Glass blowing files; Basic repair of glass apparatus and systems, etc; Obtain basic knowledge of the operations of gas and oxygen cylinders with their regulators. Designing a SGT workshop or laboratory. Equipment and tools for a moderate size SGT workshop or laboratory. Review of SGT I and II. Production of specific SGT glass ware and glass systems e.g. funnels, conical flasks, round bottom flasks, flat bottom glass, pipettes, burettes, measuring cylinders, condensers, Soxhlet extractors, etc. Special projects: every graduating student must embark on design and fabrication of a glass systems apart from other miscellaneous glass apparatus produced. SGT Exhibition.

GLST413: Advanced Ceramics Laboratory (C R 2 credits)

Determination of bending strength in circular pellets; Determination of bending strength by three- and four-point bending methods; Determination of elastic modulus of bar type specimen; Determination of tensile strength of composites; Determination of fracture toughness by SENB and ISB method; Determination of hardness by Vickers Indentation; Determination of Curie temperature for ferro-electric materials; Temperature dependent conductivity of insulators/ semiconductors; Determination of frequency dependent dielectric constant and loss-factor of capacitors; Study of grain and grain boundary resistivity by Cole-Cole plot; Determination of B-H curve, permeability and magnetic loss of ferrite; Arrhenius plot for determination of activation energy of conduction.

B. GLASS & SILICATES TECH. 500 LEVEL

GLST501 Primary Sensors for Silicates Industry (CR 2 credits)

Temperature measuring devices; thermocouple, radiation pyrometers, thermometers; gas liquid and resistance thermometers. Thermometers pyrometric cones. Flow measurement; office plate, flow nozzle, venturi tube, flow laminar flow element, pilot tube. Variable area, turbine and magnetic flow meters pressure transmitter and stain gauges.

GLST502 Instrumentation and Process Control (CR 2 credits)

Instrumentation: Basic concept of instrument- idea of generalized measurement system, Functional units, Static and Dynamic characteristics of measuring device- accuracy, precision, error, hysteresis, resolution, threshold value, repeatability, etc., Calibration error and uncertainty, statistical analysis of data and error. PID diagram of process plant and Instrument specification. Transducers: Basic concept, classification and applications, Temperature measurement: Classification, mechanical temperature sensor- solid expansion liquid and vapour filled thermo electric thermocouples, Electric type-Resistance thermometer, thermistors, Optical/Radiation type, Pressure measurement: Mechanical type Manometers, Elastic type Bourdon gauge/pressure spring etc. Basic concepts of control-systems, logic analysis of systems, process control-open and closed loop system, block diagram, Transient response, system linearisation, mathematical modeling of simple physical system transfer functions. Linear closed loop system. Transient analysis of First Order, Second Order system.

Calibration of thermocouple and determination of temperature profile of the furnaces; Effect of process parameters on the response behaviour of PID controller; Calibration of PID temperature Controller; Study of isothermal sintering behaviour of ceramic materials; Study of non-isothermal sintering behaviour of ceramic materials; Study of decomposition kinetics of a material from its isothermal weight loss behavior; Study of phase transformation kinetics from differential thermal analysis; Study of the heating rate on constant rate heating densification behavior; Study of binder burnt out behaviour by TGA; Study of recystallization behaviour of materials.

GLST503 Colour in Glasses (CR 2 credits)

Introduction Transition metal colours - effects of the liquid field, effects of glass composition on colour due to CO_2 in oxide glasses. Factors affecting the equilibra of transition metal ions in glass. Effect of the composition, Redox reactions; Absorpsivity of oxide glasses in the ultraviolet. Colloidal colours. Absorption infrared. Decolourising commercial glasses.

Colours of glasses produced by non-metallic elements: Sulphur, Selenium, Tellurium, Phosphorus and certain of their compounds. Fluorescence, Thermoluminescence and solarisation of glass.

GLST504 Introduction to Engineered Ceramics (CR 2 credits)

Definition of engineering ceramic materials. Engineering ceramics generally considered in the ceramics family- natural ceramics, polycrystalline ceramics fabricated by sintering, glass, glass-ceramics, single crystals of different ceramics and artificial gems. Engineering with ceramics: high temperature applications, ceramics in metal processing, glass production, industrial processes, ceramics in heat engines, wear and corrosion resistant applications-ceramics in seals, valves, pumps, bearings, thread guides, ceramics in paper making, ceramics as cutting tool inserts, super hard abrasives; Electrical applications of ceramics- dielectric ceramics, semiconductors, conducting ceramics, ceramic superconductors. Magnetic ceramics, opotical and opto-electronic applications of ceramics. Ceramic composites-particulate, whiskers, fibre reinforced ceramics. Medical applications of ceramics, ceramics in efficient use of energy and pollution control. Design with ceramics, design considerations- reliability requirement, fabrication limitation and cost consideration. Design approaches empirical, deterministic and probabilistic design, Weibull statistics and failure analysis. Advantages and limitations of

probabilistic design, linear elastic fracture mechanics approach and combined approach

GLST505 Bioceramics (CR 2 credits)

Introduction to biomaterials, bio-ceramics as implant in human body, Physics of bone and structure of tooth, Cortical bone versus Trabecular bone structure. Different type of biomaterials: Metal and alloys, Ceramics, Polymers and composites; Bio-glass and A/W Glass ceramics, Hydroxyapatite, Bioactivity and bone bonding, porous hydroxyapatite and study of bio-compatibility; Composite implant materials: mechanics of improvement of properties by incorporating different elements. Composite theory of fiber reinforcement. Polymers filled with osteogenic fillers. Host tissue reactions; Properties of biomaterials: Bulk properties mechanical, biological and chemical properties; Surface properties Surface roughness and surface characterization. Testing of biomaterials/Implants: In vitro testing (Mechanical testing): tensile, compression, wears, fatigue, corrosion studies and fracture toughness. In-vivo testing (animals): biological performance of implants. Ex-vivo testing: in vitro testing simulating the in vivo conditions. Standards and specifications of implant materials, recent developments in this area.

GLST506 Composite Materials

Composites- Definition, Classification and Importance, design of composite materials, the concept of load transfer, Glass, ceramic and carbonfibres, silicon carbide, alumina and alumino-silicate fibres. Common ceramic matrix material and their properties, interfaces in composites, interaction at the interface. Types of reinforcement: continuous fibre, short fibre, whisker; Ceramic Matrix composites: fibre packing arrangement, fabrication, properties, interface reaction, toughness; specific examples - Alumina -silicon carbide, Mullite- Zirconia, polymer-PZT composites, metal composites, layered composites- composite processing, densification and application; properties of composites: Density, Mechanical properties, mechanism of load transferfrom matrix to fibre, elastic deformation of laminates, variation of lamina properties with orientation, tensile and compressive strength and failure mechanism of long and short fibre composites, toughness of composites and sub-critical crack growth, thermal behaviour of composites debonding, fibre pull out, delamination fracture. Application of composites. Recent advances in composite technology, recent developments in this area.

GLST507 Sintering Technology (CR 2 credits)

Diffusion: Mechanism of diffusion in solids, Fick's Laws, Nernst-Einstein equation, Random walk model, diffusion as a thermally activated process, thin film and error function solutions, diffusion distance, diffusion in ceramics, temperatures and imperfection related effects; Sintering: Driving force for sintering, solid state and liquid phase sintering, sintering models-mechanisms and kinetics. Grain growth and secondary recrystallization; Phase Transformation: Nucleation and Growth, spinodal decomposition; mechanism, thermodynamics and kinetics. Glass formation; Creep and Superplasticity: mechanisms andkinetics; Kinetics of Heterogeneous Reactions: Reactions with and between solids, calcination and dehydration reactions, particulate interactions, coarsening, nonisothermal process kinetics. Sintering technology basics; Sintering technology applications; the future of sintering. Manufacturing process metal injection moulding technology (MIM). Spark Plasma Sintering process (SPS); process ; applications. Part characteristic; benefit; Design, crystal growth systems, high temperature vacuum furnaces. Pure metals and alloys. Premixed and customized compounds. Use of mechanical and hydraulic presses. Degree of strength, resistance and dimensional accuracy achieved by hardening in the sintering heat. Finishing of the parts and component.

GLST508 Pollution & Waste Management in Silicate Industries (CR 2 credits)

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; Environmental and health impacts of pollutants and solid

wastes. Indian environmental laws and WHO's norms. Pollution reduction measures in ceramic industries: air, sound, solid waste, water. Nature and type of industrial waste useful for ceramic industries. 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. 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. Ceramics for water and air purification. Glass & glass ceramics in nuclear waste management.

GLST509 Novel/Nano Silicate Materials (CR 2 credits)

Introduction to Nanostructured materials, Low-dimensional structures: Nano clusters & Nano crystals, superparamagnetic materials, nanomagnetic composite materials, Magnetic nanostructured materials, Nanoscale magnetism of fine particles of transition metals, alloys and oxides, Survey of materials and scaling with respect to different types of nanomaterials- metals, ceramics, semiconductors, polymers, structural materials and functional materials; Rate-controlling mechanisms and diffusion. Nucleation-classical nucleation theory, clusters and nucleation rates; characterization of nanostructured materials, different synthesis techniques; Ultrafine powders and communition. Nanocomposites, Thin films and Coatings. Sol-gel processing of different types of materials and their consolidation. Monoliths, films, membranes; Gas phase synthesis, photolithography; Nanotechnology and MEMS, nano magnets for sensors and high density data storage, carbon nanotube, spin-tronic devices, nanotechnology for biological system & bio-sensor applications, recent developments in this area.

GLST510 Final Year project (CR 6 credits)

Project Topic, proposal defense, Field work and laboratory results defense- Internal and External

GLST511 Introduction to Inorganic Polymers (CR 2 credits)

Hydrocarbon and polymer molecules. Chemistry of Polymer molecules. Copolymers. Polycarbonates. Molecular weight and shape of polymers. Linear and network polymers. Crystalline, semi crystalline and amorphous polymers. When and why is a polymer amorphous? Properties and structure of amorphous polymers. Classification of polymers and inorganic polymers. First classification, second classification, third classification and fourth classification of inorganic polymers.Borazine or borazole. Substituted Borazines. Boron nitrides. Silicones. Borophosphate glasses. Polyphosphoric chlorides. Thiazyl halides. Imides of sulphur. Polyorthophosphoric acid or Polyphosphoric acid. Nitrides of sulphur. Inorganic-organic hybrid composites. Preceramic inorganic polymers.Organic and inorganic synthesis and characterization of polymers.