Ceramic Technology Syllabus

COLLEGE OF CERAMIC TECHNOLOGY
West Bengal University of Technology
B.Tech. – Ceramic Syllabus

SEMESTER – III

A. THEORY:

Sl.No.	Code No.	SUBJECTS	Contacts(Periods/Week) L	T	P	Total	Credits
1	M(CT) 301	Applied Mathematics	3	0		3	3
2.	MS(CT) 301	Solid State Physics & & Chemistry	4	0		4	4
3.	CHE(CT)301	Unit Operation-I	4	0		4	4
4.	CH(CT)301	Chem.Thermo & Kinetics	3	0		3	3
5.	CT 301	Introduction to Ceramics	4	0		4	4
6	CT 302	Geology	3	0		3	3
		TOTAL OF THEORY				**21**	**21**

A. PRACTICAL:

1.	CT 391	Physical Testing of Ceramic Raw Materials	3	3	2
2.	CS 392	Mineralogy & Microscopic Analysis	3	3	2
3.	CT 393	Chem Analysis of Cer Rawmats & Products	6	6	4
4.	CS(CT) 381	Software Lab	3	3	2
		TOTAL OF PRACTICAL		**15**	**10**
		TOTAL OF 3rd SEMESTER		**36**	**31**

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SEMESTER – IV

A. THEORY:

Sl.No.	Code No.	SUBJECTS	Contacts(Periods/Week) L	T	P	Total	Credits
1.	CS(CT) 401	Computer Sc & Operation Research	4	0		4	4
2.	CHE(CT)401	Unit Operation II	4	0		4	4
3.	CT 401	Ceramic Rawmaterials	4	0		4	4
4.	CT 402	Process Ceramics I	4	0		4	4
5.	CT 403	Energy Engg. & Furnaces	4	0		4	4
6.	CT 404	Process Calculations	3	0		3	3
		TOTAL OF THEORY				23	23
20							

B. PRACTICAL:

1.	CT 493	Energy Engg. Lab Ceramic Raw materials	3	3	2
2.	CHE(CT) 481	Unit Operation Lab	3	3	2
3.	CS(CT) 481	Software Lab	3	3	2
		TOTAL OF PRACTICAL		9	6

C. SESSIONAL

1.	HU 481	Tech. Report writing & Language Practice Lab	3	3	2
		TOTAL OF SESSIONAL			2
		TOTAL OF 4th SEMESTER		**35**	**31**

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SEMESTER – V

A. THEORY:

Sl.No.	Code No.	SUBJECTS	Contacts(Periods/Week) L	T	P	Total	Credits
1.	CT 501	Refractories I	3	0		3	3
2.	CT 502	Glass I	3	0		3	3
3.	CT 503	Whitewares I	3	0		3	3
4.	CT 504	Cement & Concrete	4	0		4	4
5.	CT 505	Metallurgy	3	0		3	3
6.	CT 506	Ceramic Coatings	3	0		3	3
		TOTAL OF THEORY				**19**	**19**

B. **PRACTICAL**:

1.	CT 591	Refractories Lab			4	4	3
2.	CT 592	Glass Lab			4	4	3
3.	CT 593	Whitewares Lab			4	4	3
4.	CT 594	Cement & Concrete Lab			4	4	3
		TOTAL OF PRACTICAL				**16**	**12**

C. SESSINALS:

1. CT 595		Plant Design & Feasibility Study**			4	4	3

TOTAL OF SESSIONAL	**4**	**3**
TOTAL OF 5th SEMESTER	**39**	**34**

**** Report Based**

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SEMESTER – VI

C. THEORY:

Sl.No.	Code No.	SUBJECTS	Contacts(Periods/Week) L	T	P	Total	Credits
1.	CT 601	Refractories II	4	0		4	4
2.	CT 602	Glass II	4	0		4	4
3.	CT 603	WhitewaresII	4	0		4	4
4.	CT 604	Advanced Ceramics II	4	0		4	4
5.	CT 605	Process Ceramics II	3	0		3	3
6.	MS(CT)601	Engg. Materials Science	4	0		4	4
		TOTAL OF THEORY				**23**	**23**

B. PRACTICALS:

1.	CT 691	Instrumental Analysis Lab	4	4	3
2.	CT 692	Ceramic Coatings Lab	3	3	2
		TOTAL OF PRACTICAL		**7**	**5**

C. **SESSIONALS**:

1.	CT 693	Furnace & Equipment Design**	4	4	4
2.	HU 694	Seminars* / Group Discussions	3	3	2

TOTAL OF SESSIONAL	**7**	**6**
TOTAL OF SEMESTER	**37**	**34**

** Report Based

*6 weeks industrial training in various industries during Summer to be credited in 7th semester.(Report Based)

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SEMESTER – VII

A. THEORY:

Sl.No.	Code No.	SUBJECTS	Contacts(Periods/Week) L	T	P	Total	Credits
1.	CT 701	Physical Ceramics	4	0		4	4
2.	CHE(CT)701	Instrumentation & Process Control	4	0		4	4
3.	CT 702	Advanced Ceramics II	3	0		3	3
4.	HU 701	Financial Management & Accounts	3	0		3	3
5.	HU(CT)702	Quality Assurance	3	0		3	3
6.	CT703(i./ii/iii/iv)	ElectiveI	3	0		0	3
		TOTAL OF THEORY				**17**	**20**

B. SESSIONALS:

1.	CT 791	Assigned Project			12	12	4
2.	CT 792	Practical Training & Evaluation					2

	TOTAL OF SESSIONALS	**12**	**6**
	TOTAL OF 6th SEMESTER	**29**	**26**

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SEMESTER – VIII

A. THEORY:

Sl.No.	Code No.	SUBJECTS	Contacts(Periods/Week) L	T	P	Total	Credits
1.	HU 801	Values & Ethics In Profession	3	0		3	3
2.	HU 802	Industrial Management	3	0		3	3
3.	HU(CT)803	Energy & Environment Management	4	0		4	4
		TOAL OF THEORY				**10**	**10**

B. SESSIONALS:

1.	CT 891	Assigned Project			18	18	8
2.	CT 892	Comprehensive Viva voce					4
		TOTAL OF SESSIONALS				**18**	**12**
		TOTAL OF 8th SEMESTER				**28**	**22**

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SUMMARY OF TOTAL CREDITS IN B.TECH IN CERAMIC TECHNOLOGY

SEMESETR I	…….	30
SEMESETR II	…….	30
SEMESTER III ……..		31
SEMESTER IV……..		31
SEMESTER V…….		34
SEMESTER VI……		34
SEMESTER VII .	……	28
SEMESTER VIII ……..		22
TOTAL		**240**

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2nd Year B. Tech. Course in Ceramic Technology

3rd SEMESTER

THEORY >>>

M(CT) - 301, Applied Mathematics, Credits = 3

a) Complex Variables: (8L)
Functions,Limits & Continuity of Complex Functions,Differentiation of Complex Functions,Analytic Functions,Cauchy-Riemann equations,Harmonic functions,Line integrals,Cauchy – Goursat Theorem(no proof reqd.),Cauchy's integral formula,Taylor's and Laurent's series.

b) Fourier's Series: (9L)
Fourier's Series associated with a function,Convergence of Fourier's Series,Dirichlet's conditions,Fourier's Series for odd & even functions,Half range Fourier series. Fourier Transform and its properties,Fourier sine and cosine transforms,Inversion formulas,Convolution Theorem.

c) Partial Differential Equations : (7L)
Formation of partial differential equations, Solution by direct integration, Lagrange's Method, Non linear equations of special types and their solutions.
Method of separation of variables and its application to Laplace and Heat conduction equations.

d) Numerical Methods: (8L)
Solution of algebraic equation: Bisection method,Regula-Falsi method,Newton-Raphson method.
Solution of a system of linear equations:- Gauss Jacobi, Gauss Seidal iterative methods, Solutions of ordinary differential equations:- Taylor series method, Euler method, Runge Kurta method, Predictor-corrector method.

e) Elements of Probability and Statistics: (9L)

Random Experiments, Events(simple and compound), Sample sources, Axioms of probability and associated results of classical definition, Conditional probability, Independent events, Baye's formula.

Random variable(discrete and continuous), Probability mass function, Probability distribution function, Distribution function, Special distribution:- Binomial, Poisson, Normal.

Statistics:- Population, sample, statistics, parameters, Estimation(point and interval estimate). Hypothesis:- Null hypothesis, alternative hypothesis, critical regions, Testing of hypothesis, Type-I error, Power of a test. Hypothesis testing for mean and standard deviation(sample drawn from N(m,)population).

MS(CT)-301 : Solid State Physics & Chemistry Credits = 4

A) Solid State Physics >>

1) Crystal Class, Symmetry, Eurain Angles, Reciprocal Lattice, Fourier Space, Electron Energy Function, X-Rays Diffraction, Structure Analysis. [2]

2) Quantum Mechanics -> Heisenberg to De Broglie, Schrodinger to Born, Wave Mechanics and Fourier Transform, Postulates of QM, Operators (Hermitian), Eigenfunction and Eigenvalue, Expectation Value, Schrodinger Time Dependent & Independent Solutions of Wave Equations with Seperation of Variables, Born Interpretation, Matrix Diagonalisation, Applications with Particle in Box and with Special Function like Hermite in Harmonic Oscillator, Legendre & Laguere polynomials for Hydrogen Wave Functions, Probality density for 1S, 2S and 3S Wave Functions. [14]

3) Interatomic Bonding, particularly Quantum Mechanical Covalent Bonding in Solids with Matrix Elements for Hamiltonian Operator and Eigenvalue Diagrams for Hydrogen Molecular Ion and Hydrogen Molecule. Molecule Orbital Calculations, Introduction to Lattice Vibrations in Solids. [3]

4) Spatial and Spin wave functions, Pauli Principle with Determinant, Anti-Symmtrization, Spin – Orbit Coupling, Para – and Dia-, Ferro-, Antiferro-, and Antiferri – magnetism. [3]

5) Theory of Dielectric and Ferroelectric Solids, Langevin Function for Dielectrics Landau-Grnzburg Thermodynamic Polynomials for Spontaneous Polarisation, Frequency Dependent Dielectric Property with Fourier Transform for Dielectric Disperson, Analyticity, Hilbert Transform for Optical Dispersion with Perseval Equlity and Quantum mechanical Sum Rules.[6]

6) Band Structure in Solids with Bloch Theorem with Periodic Boundary Conditions, E(k) vs. k diagram in Fourier Space in the First Brillouin Zone, Velocity and Effective Mass of Electrons , Basics of Semiconductors. [4]

Reference: 1) Solid State Physics - Kittel

2) Quantum Mechanics & Solid State Physics – P. C. Rakhsit and A. K. Roychowdhury
3) Solid State Physics – F. Sachs

B) Solid State Chemistry >>

1) Classification of solids>> Ionic bonding, Lattice energy, Born Haler cycle, Covalent bonding, Introduction to valence band theory, Molecular orbital theory.

2) Chemistry of solid surfaces>> Direct study of the properties of solid surfaces, Surface energy of solid surfaces, Topography of solid surfaces, Adsorption isotherms, Solid catalysts, Defects in solids, Chemistry of interfaces & grain boundaries.

3) Reactions of Solids>> Factors affecting reactivity of solids, Thermal decomposition reactions, Decomposition without melting, Powder reactants, Solid-Liquid and solid-solid reactions.

4) Effect of Chemical forces on physical properties>> Melting point, thermal expansion, Young Modulus and strength of perfect solids. M-O theory of ceramic colours, Ligand field theory of colour.

5) Atomistics of Solid state diffusion>> Diffusion in chemical, electric and electrochemical potential gradient, Ionic Conductivity in solids – an introduction, Chemistry of defects.

References: 1. Chemistry of solids – by A. K. Galwey, Chapman & Hall Publication.
2. Chemistry of the solid- by W. E. Ganner, Butterworth publication.
3. Chemistry of the Defect solid state – by A. L. G. Rees, Methuen publication.
4. An Advanced Treatise on Physical Chemistry, vol.3, The properties of Solids, Longman
5. Fundamentals of Ceramics – by Michel Barsoum, Mcgraw Hill publication.
6. Properties of Matter – by Thomas Pollack, MCGraw Hill publication.

CHE(CT)-301: Unit Operations I: Credits = 4

a) Hydrostatic equilibrium, Manometers, Newtonian & Non-Newtonian fluid, Laminar & Turbulent Flow, Reynolds stress, Boundary layers, Momentum balance & Bernoulli equation, Determination of power requirements for transportation of fluids, Friction factor & friction factor chart, Pipe fittings & valves, Pumps, Fans, Blowers & Compressors (use & construction), Flow meters.
b) Drag & friction in flow through bed of solids, Motion of particles through fluids, Fluidisation, Types of fluidisation, Application of fluidisation.
c) Heat transfer by conduction >> Fourier's law, Compound resistance in series, Unsteady state of heat conduction.

d) Heat transfer by convection >> Counter current & parallel current flows, Overall heat transfer co-efficient, Heat transfer by forced convection in turbulent flow, Analogy between transfer of heat & momentum, Natural convection.

e) Radiation heat transfer >> Emissive power, Law of radiation, Kirchoff's law, Angle of vision, Radiation between Black, Grey & Large planes.

Books:
Text : Unit Operations of Chemical Engineering_
Mc. Cabe, Smith & Harriot, Mc GrawHill
Ref: Chemical Engineering _ Coulson and Richardson. Pergemon Press.
Perry's Chemical Engineering Hand book – Perry & Green Mc Graw Hill.

CH(CT) – 301|: Chemical Thermodynamics & Kinetics: Credits = 3

A) Chemical Thermodynamics >>

a) Fundamentals: Enthalpy, Hess's Law, bond energy, Entropy & thermodynamics probability.
b) Gibb's free energy, Spontaniety and equilibrium, Partial molal volume, Chemical Potential, Gibb's Duhem equation in ceramic system, standard free energy.
c) Entropy & Third Law of thermodynamics, Ellingham diagram – Stability of Metallic oxides, Gibb's Surface excess, Gibb's adsorption equation.
d) Heterogeneous Reactions: Equilibrium constant & Free energy change, Vant Hoff equation, Applicability in different ceramic system.
e) Phase equilibria & phase transition in solid: Gibb's Phase rule – component, phases, degrees of freedom. Construction of phase diagram for one & two components system.
f) Thermal Analysis: Basic thermodynamic approach about 1^{st}-order & 2^{nd} order phase transition, Glass transition, transition of quartz – tridymite & crystobalite.

References: 1. An introduction to thermodynamics – Y.V.C. Rao.
2. Fundamental of Thermodynamics – Sonntag , Borghakke, Vanwylen.
3. Thermodynamics for chemist – Samuel Glasstone.
4. Physical Chemistry – P. C. Rahshit.
5. Hand book of ceramics (vol-I) – S. Kumar.

B) Chemical Kinetics >>

a) Rates of Reaction, order, Molecularity, Integrated rate laws, Reactions approaching equilibrium, Temperature dependence of reaction rates, consecutive elementary reactions, collision theory, activated complex theory, Steady State approximation, Parallel reactions.

Kinetics of Reactions with and between solids: Kinetics of heterogeneous reactions, Reactant transport through a planar boundary layer, Interdiffussion between solids, oxidation of a metal, Chemical diffusion in non-stoichiometric oxides, Ambipolar diffusion, Reactant transport through a fluid phase, Gas – solid reactions: vaporization, chemical vapour transport, liquid-solid reactions: refractory corrosion, reactant transport in particulate system, calcinations & dehydration reactions, coarsening of particles, precipitation in crystalline ceramics, precipitation kinetics, precipitate orientation, heterogeneous precipitation, non isothermal process.

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Reference: 1. Physical Chemistry – by Atkins.
2. Introduction to Ceramics – by W. D. Kingery.

CT – 301 : Introduction to Ceramics Credits = 4

a) General : Concepts of materials science, Definition & scope of ceramics and ceramic materials, classification of ceramic materials – conventional and advanced, Areas of applications.
b) Refractories : Classification of Refractories, Modern trends and developments, Basic raw materials, Elementary idea of manufacturing process technology, Flow diagram of steps necessary for manufacture, basic properties and areas of application.
c) Whitewares : Classification and type of Whitewares, Elementary idea of manufacturing process technology including body preparation, basic properties and application areas.
d) Ceramic Coatings : Types of glazes and enamels, Elementary ideas on compositions, Process of enameling & glazing and their properties.
e) Glass : Definition of glass, Basic concepts of glass structure, Batch materials and minor ingredients and their functions, Elementary concept of glass manufacturing process, Different types of glasses.Application of glasses.
f) Cement & Concrete : Concept of hydraulic materials, Basic raw materials, Manufacturing process, Basic compositions of OPC. Compound formation,setting and hardening.Tests of cement and concrete.

Books :- 1) Elements of Ceramics - F.H Norton
2) Fundamentals of Ceramics - Barsoum
3) Introduction to Ceramics - W.D Kingery
4) Smith - Materials Science
5) Industrial Ceramics - Singer & Singer.

CT – 302 Geology : Credits = 3

a) General & Physical Geology >> Preliminary concept of geology & its different branches, evolution of earth from solar system, Interior & exterior of the earth, Abundance of elements, Igneous & Sedimentary rocks, Concepts of petrology.
b) Origin, formation & petrology of coal & its uses.
c) Mineralogy>> Definition, classification & composition of minerals, system of crystallization, physical properties of minerals as a tool of identification, optical properties of minerals, physical & optical properties of some important minerals.
d) Structure>>Fundamental principles of silicates structure, structure of Quartz & feldspar, clay minerals, talc, alumina, sillimanite minerals, magnesia.
e) Silica & silicate minerals>> Polymorphic forms of silica & their transformation. Different natural forms of silica of industrial importance – their properties & uses – quartzite, ganister, flint, silica sand. Properties, composition, effect of heat, use & availability of pyrophyllite, talc, sillimanite minerals, zircon etc.
f) Plastic Raw Materials>> Clays, clay minerals – geology, classification, composition & properties of clays – physical & chemical properties of important clay based minerals & raw materials for ceramics.

g) Refractory Raw Materials>> General idea, composition, properties, effect of heat, occurrence & uses of Bauxite family, magnesite, dolomite, chromite, graphite etc. and their relevant geological aspects.

Books :- 1) Text book of physical geology – P.K. Mukherjee
2) Text book of Mineralogy – W. Tyrrel
3) Text book of geology – Mahapatra.

PRACTICAL >>>

CT-391, Phys. Characteristics of Ceramic Raw Materials: Credits = 2.

a) Determination of percentage Moisture content of clay.
b) Determination of % Grit content of a clay.
c) Determination of Water of Plasticity of Clays.
d) Determination of Atterberg's Plasticity of clays.
e)) Measurement of Drying Shrinkage of clays.
f)) Measurement of Dry Strength of clays.
g) Measurement of Firing Shrinkage & firing colour of clays.
h)) Determination of % Free iron content in Feldspar & Quartz powder.
h) Determination of B.D. of fired sample.
i) Determination of Vitrification Range of Clays.
h) Determination of Water Absorption of Fired Ceramic Bodies.
i) Determination of particle size by Andersen Pipette method.

CT-392: Mineralogy & Microscopic Analysis: Credits = 2

a) Study of Physical Properties of the following Minerals :
Quartz, Feldspar (Potash, Plagioclase), Pyroxene, Calcite, Magnesite, Kyanite, Sillimanite, Gypsum, Magnetite, Haematite, Galena, Biotite, Muscovite, Garnet, Chromite, Bauxite.

b) Study of rocks in hand specimens of the following rocks: Granite, Basalt, Pegmatite, Sandstone, Limestone, Schist, Gneiss, Dolomite, coal.

c) Study of optical characteristics under polarising petrological microscope: quartz, Feldspar (Orthoclase, Albite, Microcline), Kyanite, Sillimanite, Gypsum, Calcite, Garnet, Hornblende, Muscovite, Biotite, Augite.

CT-393: Chemical Analysis of Ceramic Raw Materials Credits = 4
& Products:

a) Estimation of SiO_2, Fe_2O_3, Al_2O_3, CaO and MgO in Dolomite
b) Estimation of SiO_2, Fe_2O_3, Al_2O_3, CaO and MgO in Lime stone.
d) Quantitative analysis of Bauxite.
e) Analysis of Sea-Water Magnesia.
Analysis of Fireclay.
f) Analysis of Firebrick.
g) Analysis of Kyanite.
h) Quantitative analysis of Talc.
i) Analysis of Soda-lime – silica glass.

j) Analysis of Water Glass.
k) Determination of insoluble portion in Portland cement.
l) Determination of Free Lime content in Portland Cement.
m) Complete analysis of Portland Cement.
n) Determination of $Na_2O:B_2O_3$ in Borax.
o) Rapid estimation of silica in glass sand and glass.

CS(CT) – 381: Software Lab: Credits = 2

a) Familiarity with various Operating Systems > DOS, Windows, UNIX.
b) Programming with basic language C
c) Familiarity with MS Office softwares > Word, Excel, Access
d) Presentation with MS-Power point module.

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4th SEMESTER

THEORY >>>

CS(CT)-401: Computer Science & Operation Research: Credits = 4

a) Development of Computers >> History of Development of systems, Computer generations, Digital computers, Personal computer developments.
b) Basic Anatomy of Computer >> CPU, Memory, I/O interface, ADC & DAC, Computer words, Number systems, Alphanumeric character, ALU, Logic gates with various registers.
c) Flowcharting & Programme Development >> Algorithm, Flow chart, Decision table, Machine codes, Assembly codes, High level language, Compilation process.
d) Operating Systems >> UNIX, DOS, Windows
d) Communication >> Batch processing, Multiprogramming, Time sharing, Real time, Computer networking, LAN, MAN & WAN.

Operation Research >>(To be done)

CHE(CT) 401: Unit Operation II: Credits = 4

a) Principles of diffusion and mass transfer between Phases:
Theory of diffusion, Fick's law of diffusion, equimolal diffusion, uni – component diffusion, mass – transfer co-efficients and theory. 5L

b) b) Drying of solids : Classification of dryers, principles of drying, heat and mass transfer in dryers, phase equilibria, rate of drying, drying mechanism of non porous

and porous solids, shrinkage and case hardening, through circulating and suspended bed drying, drying equipment – for solids, pastes, slurries and solution. 8L

c) Important unit operations involving particulate solids.

1) Properties & handling of particulate solids – characterization of solid particles properties of particulate masses, Pneumatic transportation of particulate materials, Storage of solid materials. 6L

2) Size Reduction >> Principles of comminution, energy and power requirement, size reduction equipment- Crushers, Grinders, ultrafine grinders and cutting machines. 8L

3) Mixing of Solids & Pastes - Mixer devices for paste & plastic masses. Mixing criteria, Mixing index, Mixer for dry powders, Rate of mixing. 6L

4)Mechanical Separation > Screening equipment, Screen equipment, screen effectiveness and capacity, Filtration equipment, Principles of filtration & clarification, Centrifugal filtration, Cross flow filtration, Gravity settling processes, Flocculation, Sedimentation, Centrifugal settlers, Principles of centrifugal sedimentation. 15 L

Books:

Text : Unit Operations of Chemical Engineering_
Mc. Cabe, Smith & Harriot, Mc GrawHill

Ref: Chemical Engineering _ Coulson and Richardson. Pergemon Press.
Perry's Chemical Engineering Hand book – Perry & Green Mc Graw Hill.

CT- 401: Ceramic Raw Materials: Credits = 4

Introduction : The range and scope of various natural minerals and inorganic non-metallic materials to be used as raw materials for ceramic products. General ideas about the characterization of natural and synthetic materials.

Group –A

Natural :

A. Fundamental principles of silicate structures, structure of clay minerals,(China clay, montmorillonite, pyrophyllite) , Structure of mica, talc, silimanite minerals.

B. Non plastic materials :

Polymorphic forms of SiO_2 and their transformations. Different natural forms of SiO_2 of industrial importance – their properties and uses. Properties, composition, effect of heat, uses and availability of pyrophillite, talc, sillimanite minerals, zircon sand etc.

C. Plastic Raw Materials :

Clays : Classification of clay, Composition and properties viz: particle shape and size, Deflocculation and flocculation, plasticity, CEC, General ideas, occurrences, important properties and uses of : China Clay, Ball clay, Fire Clay, Bentonites etc.

D. Fluxing agents:

Nepheline Syenite, Bone ash, Lepilolite, Wollastonite – their compositions, properties, availability and uses in ceramic industries.

E. Refractory Raw materials :

General idea, Composition, Properties effect of heat, availability and uses of : Bauxite family, magnesite, dolomite, chromite, graphite, Limestone.

Group – B

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Synthetically Prepared Materials:
Importance of synthetic ceramic raw materials :
Methods of powder preparation : General idea of technique of powder preparation:- Sol-gel, Co-precipitation, solvent vaporization.
Preparation, composition, characterisation and uses:
Sinter Al2O3 powders (prepared from different routes), Fused Al2O3, Mullite, Mag-Al Spinel, ZrO_2, TiO_2, Ba-titanate, ferrite, fumed silica, silicic acid sol, silica gel.

Other synthetic materials : Sea water magnesia, B/F slag, fly ash, red mud, Rice husk ash, electrolytes etc.
Synthetic abrasives : General ideas about their properties and uses.
References:

1. W.E. Worral : Clays and ceramic raw materials
2. W.Ryan : Properties of ceramic raw materials
3. S. Kumar: Hand book of ceramics ; Vol – I & II
4. D. Ganguly & M. Chatterjee : Ceramic Powder Preparation : A handbook
5. E. C. Subbarao: Advanced ceramics.

CT402: Process Ceramics I: **Credits = 4**

Material Characterization:

a) Characterization and specification of ceramic materials
b) Chemical and Phase compositions
c) Particle size and shapes
d) Density, pore structure and specific surface area.

Particle mechanics and rheology:

a) Particle packing characteristics – Models of one, two of spherical balls
b) Gap grading, continuous grading
c) Rheological behaviour of slurries and pastes:

-Newtonian fluid, plastic flow, dilatant liquid, thixotropy, Deflocculation, Zeta potential, effect of electrolytes on Zeta potentials, applications in ceramic processings.

Beneficiation Process:

Comminution – Equipments, milling, particle size distribution.

Batching and mixing: Mixing mechanism and mixing equipments.

Particle separation, concentration and washing processes – particle sizing, filtration, washing, particle concentration processes.

Granulation – direct granulation, spray granulation.

Forming processes:

Dry pressing – powder flow and die filling, compaction behaviour, ejection and transfer, die wall effects, control of compaction defects, Cold isostatic Pressing

Plastic forming – Extrusion, Jiggering, Jolleying

Casting process- Slip Casting,

Drying –drying processes, Mechanisms in drying, defects
Shaping,surface finishing, glazing.
Firing – Firing system, Pre sintering processes, sintering, vitrification and cooling.
Glass processing – selection of raw materials, effects of different oxides on glass properties, batch preparation, melting in glass tank furnace, refining of glass.

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References:

1. J. S. Reed: - Introduction to the principles of ceramic processing
2. Singer and Singer: Industrial Ceramics
3. F. Moore : Rheology of Ceramic systems
4. Onoda and Hench : Ceramic Processing before firing

Rex W. Grimshaw: The Chemistry and Physics of clays and other ceramic materials.

CT–403: Energy Engg. & Furnaces, Credits = 4

A) Energy Engg. >>

a) Energy Position in India. India's energy reserves & future scenario.

a) Solid fuel > Coal & its origin, Classification & Characterisation of Indian coal, Carbonisation of coal, wood, & other Solid fuels. Testing of various properties.
b) Liquid Fuel > Liquid fuels & other derivatives of crude petroleum and their Characteristic features & testing methods. Synthetic & other liquid fuels, Storage & handling of liquid fuels. Testing of various properties.
c) Gaseous Fuels > Natural gas, Manufacture of other commercial gaseous fuels & their use, Testing of various properties.

B) Furnaces >>

a) Historical development of furnace & kilns. Types of industrial furnaces. Components of a total furnace systems. Evolution of kilns in ceramic industries. Furnaces/kiln construction materials.
b) Heat/fuel economy > Energy audit and its necessities. Sources of heat loss in furnace. Thermal efficiency in operation of furnace. Waste heat recovery -- Recuperators & Regenerators.
c) Dynamics of gas in a furnace> Definition of Draught, its necessities, classification of draughts. Deduction of the equations for natural draught & chimney height.
d) Burners & Fire boxes> Grate firing systems, mechanical stokers, selection of burners, burner components, classification of burners.
e) Temperature Measurement > Principle, thermometric properties, heat work measurement, Resistance thermometer, Thermocouple, Radiation & Optical pyrometers. Temperature controllers.
f) Study of Different Furnaces/Kilns > Down Draft Kiln, Tunnel Kiln, Shuttle kiln, Bell type kiln, Glass Tank Furnace, Blast Furnace, LD Converters, Roller Hearth Kiln, etc.).

References:

1. Elements of Fuels, Furnaces & Refractories – O.P. Gupta.
2. Industrial Furnaces Vol. I & II – Trincs W.
3. The science of Flames and Furnaces – M.W. Thring.
4. Principles of Blast Furnaces for iron making- A.K. Biwas.

CT-404: Process Calculations: Credits : 3

a) Materials Balance :

1. Introduction to material balance
2.Gaseous System : Processes with & without chemical change
3.Gas – Liquid System : Processes with & without chemical change
4.Gas – Slid System : Processes with & without chemical chang
5. Liquid – Liquid System : Processes with & without chemical change.

B) Energy Balance >

1. Introduction to energy balance

2. Thermo Physics : Heat capacities, Mean heat capacity, Heat of solution and vapourisation.

3. Thermo Chemistry : Laws of thermo chemistry, Energy balance for Gaseous system- Non reacting and reacting system,

Gas-liquid system, Gas-solid system, Liquid-solid system.

C) Material Balance for Ceramic Process >

Ultimate, Proximate analysis of ceramic raw materials, Introduction to glaze, glass calculations, viz. Batch recipe, molecular formulae and other elementary problems.

References :

Industrial Stoichiometry – Lewis, Raddas & Lewis. Industrial Stoichiometry - Hougen & Wattson.

Ceramic Calculation - Griffithies.

PRACTICAL >>>

CT–493: Energy Engineering Lab: Credits = 2

a) Proximate analysis of coal, Caking index of coal & coke, Calorific value of coal.

b) Flue gas analysis by Orsat apparatus, Calorific value of gaseous fuel.

c) Viscosity at different temperatures and viscosity index of fuel oil / lube oil

d) Flash & fire point of fuel oil, Carbon residue of fuel oil/lube oil, Washability test of coal.

e) Cloud & pour point of fuel oil, Distillation test for petroleum products.

f) Solar radiation measurement by Pyranometer.

CHE(CT)-481: Unit Operation Lab: Credits = 2

a) Determination of the diffusivity of moisture through a supplied wooden block (wet) during its drying at (100+_10^{o}C)

b) Determination of the thermal conductivity of the supplied insulating plate by Lee's method.

c) Determination of the effectiveness of the supplied 16 mesh screen in separating the supplied clay powder mix.

d) Determination of the mixing index in blending the supplied two varieties of granular solid under tumbling action for one hour.

e) Determination of the Determination of viscosity co-efficient by falling sphere method .

f) Determination of diffusivity of 2% ethylene glycol aqueous solution.

g) Comparison of the sedimentation rate of 20% china clay aq. Suspension to that of in presence of 0.1% NaCl.

h) Determination of specific surface area , average particle size of the supplied Quartz mixture by Screen analysis.

i) Determination of the rate of drying of the supplied wet mud at (75+_10^{0}C).

j) Determination of the power requirement to crush manually the supplied rock from 4mm. Size to 0.5mm. size.
k) Determination of thermal diffusivity of the supplied metal slab.
l) Determination of the critical speed of the supplied laboratory ball mill.
m) Determination of the viscosity coefficient of the supplied liquid by capillary flow method.
n) Determination of mixing index for mixing 10% water with the supplied dried clay mass under mulling action for one hour.
o) Description with sketch the application of the supplied flow control devices for fluid flow in process plant.

CS(CT)-481: Software Lab: Credits = 2

a) Programming with advanced C.
b) Programming with C++ on real life problems.
c) Problem solving using Oracle in NT platform
d) Introduction to multimedia software.
e) Writing Programmes on Numerical Analysis Problems

SESSIONAL:

1. HU 481: Technical Report Writing & Language Practice Lab

Topics to be covered and number of hours required for it:

1. Introductory lecture is to be given to the students so that they get a clear idea of the syllabus and understand the need for having such a practice lab in the first place (3 hours).
2. Conversion practice is done on given situation topics. The students are also made to listen to pre-recorded cassettes produced by British Council and also by the Universities of Oxford and Cambridge (6 hours).
3. Group Discussions: The students are made to understand the difference between the language of conversion and group discussion. Strategies of such discussions are to teach to them. It is also helpful to use videocassettes produced by the U.G.C. on topics like group-discussion. After wards the class is divided into groups and the students have to discuss on given topics on current socio-economic-political-educational importance (12 hours).
4. Interview sessions-students are taught the do's and don'ts of facing a successful interview. They then have to face rigorous practices of mock-interviews. There simulations of real life interview sessions where students have to face an interview panel (12 hours).
5. Presentations: The secrets of an effective presentation are taught to the students. Then each and every student has to make lab presentations with the help of the overhead projector/using power point presentation and other audion-visual aids in the laboratory. They also have to face the question-answer sessions at the end of their presentation(12 hours).
6. Classes are also allotted to prepare the students for competitive examinations like the T.O.E.F.L by making the students listen to specify produced C.D. cassettes of such examinations(3 hours).

7. The overall aim of this course is to inculcate a sense of confidence in the students and help them to become good communicators in their social as well as professional lives.

Text:

1. Sharma – Business Correspondence & Report writing, TMH.
2. Prasad – Group Discussion & Interview (with Audio cassette), TMH.

Reference:

1. Sashi Kumar – Spoken English (with cassette), TMH.

3rd Year B. Tech. Course in Ceramic Technology
5th SEMESTER

THEORY >>>CT-501 : Refractories I : Credits = 3

I. Introduction : Scope of refractory Industry - Global and Domestic Market Scenario

II. Fundamentals of refractory science and engineering –

a) Brief review of raw materials –
b) gap grading, continuous grading
c) Fabrication and firing
d) Importance of Phase diagram in refractory.
e) Phase rule, Eutectic, peritectic, Two component systems – Al_2O_3 – SiO_2; Al_2O_3 – MgO; MgO – Cr_2O_3; MgO – CaO

III. Manufacturing, Properties and applications of following refractories:

1. Silica Refractories, Super duty, Semi silica refractories
2. High Alumina and Alumino Silicate Refractories: Signifiance of Phase diagram in the development of different phases – Sintered and fused alumina.
3. Basic Refractories : Magnesite, dolomite, lime, chromite: Production of Burnt refractories – Sintered and fused refractories: - Chemically bonded and Direct bonded.
4. Insulating Refractories.

IV: Testing of important properties of refractories:

a) Chemical Analysis
b) Phase analysis
c) Physical Testing:- A.P., B.D., Total Porosity, Spinel. Gravity, Pore size distribution, C.C. S, Cold MOR, Hot MOR, PCE, RUL, Compressive Strength, PLCAR, Spalling Resistance, reversible thermal Expansion, CO – disintegration, corrosion resistance.

References:

1. Refractories – Production and properties – J. H. Chester
2. High Temperature Oxides Part – I, A. M. Alper

3. The Technology of ceramics and refractories – P. P. Budnikov
4. Refractories – F. H. Norton

CT –502 Glass – I Credit – 3

a) The non-crystalline solids & the glasses. Formation from liquid phase. Formation from a gaseous phase. Formation from a solid phase. Definition of glass.
b) Vitreous transition. Phenomenological study. Thermodynamic study. Theory of vitreous transition. Relaxation behaviour of glass in the transition interval. Determination of transition temperature.
c) Conditions of vitrification. Structural theory (Zachariasen model etc.). Kinetic theory of glass (Nucleation & Growth).
d) Structure of Glass >> XRD, SAXS & SANS and other methods of determining glass structure.
e) Structural models of glass. Reaction mechanisms. Ion exchange & network breakdown processes. Glass durability controlling factors. Improvement of durability.
f) Thermodynamic basis of phase separation in glasses. Immiscibility in glasses. Kinetics of demixing. Application of immiscibility diagrams. Spinodal decomposition.
g) Density & Thermal expansion measurements & their implications and their dependence on compositions. Thermal history effects. Effect of crystallization. Additive rule.
h) Diffusion in Glasses. Electrical conductivity of glasses. Dielectric properties.
i) Optical properties of glasses. Refractive index, Molar volume & Ionic refractivity, Birefringence. Ligand field theory and ultraviolet – visible absorption. Colloidal colours. Solarisation. Infra-red absorption. Photosensitive/Photo chromic glasses. Optical applications.

Books :- 1) Glasses and The Vitreous State – J. Zarzycki
2) Chemistry of Glasses - A. Paul
3) Handbook of Glasses – R. H. Doremus
4) Spectroscopy & Structure of Glasses – C. A. Angell

CT–503: Whitewares I: Credits = 3

a) Scope of whiteware products in India & its classification and its use in various fronts.

b) Details of various types of raw materials including synthetic materials.
c) Body preparation including all the unit operations and fabrication processes ---> Transport, Storage, Batching, Body compositions, Wet-Process --->> Crushing, Grinding, Screening, Magnetic separation, Agitators, Aging, Slip treatment, Spray drying.
d) Drying >> Types of water present, Factors affecting drying (internal & external factors), Convection, Radiation, High frequency heating.
e) Glazing >> Purpose & advantages of glazing, Raw glazes, Fritted glazes, Special glazes, Fusibility of glazes, Opacity & opacifiers, Stains, Colloidal colours, Different

colouring oxides, Empirical formula of glazes, Glaze defects, Glazing techniques, Testing of glazes.

Firing : Factors determining firing schedule, Effect of heat on whiteware bodies, Formation of different phases at different temperatures, Final phases of porcelain bodies, Analysis of microstructure. Brief description about various types of kiln, Kiln furniture & Loading.

References:

1. Ceramic Whitewares – Sudhir Sen
2. Industrial Ceramics – Singer & Singer
3. Fine Ceramics – F.H. Norton.
4. The Technology of Ceramics and Refractories – P.P. Budnikov.

CT - 504, Cement & Concrete: Credits = 4

1.Pozzolana Cement:

Definition, classifications, Pozzolanic activity and its influencing factors, Lime – Pozzolana reaction and products fomation, Applications.

2. Portland Cement:

Definition, Raw materials and their physico – chemical characteristics, manufacturing process, cement making kilns viz, Rotary and shaft kiln. Refractory used in Rotary kiln, reactions occurred in different zones of rotary kiln, Hydration of cement, Setting and hardening of Portland cement, Heat of Hydration, Action of acid & sulphate water on cement, Flash set and False set of cement, Alkali – Aggregate reaction in Portland cement., Applications.

3. Special Cements:

Rapid hardening Portland cement, Quick setting cement, White Portland Cement, coloured cement, Sulphate resisting cement, Low heat Portland cement, Oil – well cement, Waterproofed Portland cement, Hydrophobic cement, sorel cement, Blended Cement, Macro defect Free (MDF) Cement, Sur – Sulphated Cement, Refractory Cement, Cement paints.

4. Testing of Cements : Insoluble residue in cement, estimation of free lime in cement, fineness of cement, standard consistency of cement, Initial and Final setting of cement, soundness of cement, slump test of concrete, Flow table test of mortar , Heat of hydration of cement .Vee Bee consistometer test.

5. High Alumina Cement:

Introduction to Refractory cement, Raw Materials used, classification and composition of HAC, manufacturing process, Mineralogical phases of HAC, Hydration of HAC on the basis of CaO-Al_2O_3-H_2O Phase diagram, Strength Development, HAC castables asd uses.

6. Concrete:

Introduction, Admixture, Gap Grade concrete, continuous grade concrete, light, normal and heavy concrete, properties of concrete, installation technique of concrete, uses of various concretes.

Books:

5. Chemistry of cement by F.M. Lea
6. Cement Chemistry by F.W. H. Taylor
7. High Alumina Cement by T. D. Robson
8. Concrete Technology by Neville.

CT – 505: Metallurgy: Credits = 4

Ceramic Technology Syllabus

Scope & Relevance in relation to Ceramics .

a) Ferrous Metals > Pig iron, Blast furnace, Cast iron, Sponge iron, Corex & Mandrex process, Effect of chemical elements on iron & steel, Steel making process, Classification of steels, Application of carbon steel, Influence of the constituents on steel, Alloy steel, Effect of alloying elements on steel.
b) Non-Ferrous Metals & alloys > **Aluminium**, Its extraction, alloys & applications, **Copper**, Its extraction , alloys & applications, **Zinc**, Its extraction , alloys & applications , **Lead**, Its extraction , alloys & applications . Alloys for high temperature service conditions, Metals for nuclear energy.
c) Powder Metallurgy > process description, Maintenance of metal powders, Blending of powders, Compaction, Pre-sintering, Sintering, Secondary operation, Products of powder metallurgy, Advantage of the process, Disadvantages & limitation, Design consideration.

d) Forming Process > Casting, Mechanical working process, Welding, Brazing, Soldering, Machining of metals.
e) Mechanical Tests > Tensile test, Compression test, Hardness test, Impact test, Fatigue test, Creep & stress-rupture test.
f) Phase Transformation in Metals > Nucleation & Growth, Solidification, Allotropic transformation, Cooling Curve for Pure Iron, Inverse rate curve for steel, Isothermal transformation, Transformation upon continuous cooling, Martensitic transformation, TTT curve, Phase transformation in alloy steel, Effect on transformation points, Isothermal decomposition of Austenite, Alloyed Austenitic transformation upon continuous cooling.
Binary Diagrams of systems with simple eutectic , partial & complete solubility , intermetallic compound formation & mixed . Ternary diagrams - elementary ideas . Equilibrium & Non-equilibrium phases .
g) Heat Treatment > Iron-carbon phase diagram - salient features . Heat treatment programmes & products. Carbon - steels , Cast Irons , Alloy Steels . Normalizing, Mar tempering, Austempering, Harden ability, Theory of tempering, Case hardening, Carburising, Cyaniding, Nitriding, Induction hardening, Flame hardening, Diffusion coating.
Books :- 1) Elements of Metallurgy- Swarup & Saxena.
2) Physical Metallurgy - Avner.
3) Metallurgy - Lakhtin.

CT–506: Ceramic Coatings : Credits = 3

a) Advantages of ceramic coating w.r.t. organic coatings.
b) Different types of ceramic coatings : i) Thermal barrier coating,
ii) High emissivity refractory coating.
c) Characteristics of different types of ceramic coating.
d) Raw Materials, Composition of different types of coating, Processing of the raw materials, Frit preparation, Milling, Preparation of enamel slip.
e) Metal surface preparation before coating.
g) Wetting of metal by glass, Different theories of adherence.
h) Theory of opacity and treatment of opacifying agents.

i) Application of coatings on metal surfaces.
j) Drying and firing of coating.
k) Different coating defects and remedial measures.
l) Special types of coatings.

Testing & quality control of coating.

Books :- 1) Technology of enamels – V. V. Vargin
2) Vitreous Enamel : A guide to modern enameling practice – K. A. Maskall & D. White.

PRACTICAL >>>

CT–591: Refractories Lab: Credits = 3

a) Powder Preparation -- Crushing fireclay grog. Size separation of grog.

b) Characteristion of different clays -- Ball clay, Plastic clay etc. grain's B.D., Grain porosity, Grain Sp. Gr., Tap density, Body preparation, Temporary binders (Dextrin, Starch etc.). Ceramic binders.
c) Study of effect of Composition, Forming pressure & Firing temperature on some properties of refractory bricks.
d) Fabrication of some high alumina & basic bricks.
e) Testing of various important properties of refractories as per IS.
f) Refractory corrosion test.

CT–592: Glass Lab: Credits = 3

a) Preparation of Soda-Lime-Silica glass with different colouring oxides, e.g. CoO, FeO etc.
b) Preparation of Boro-silicate glass with alkali & alkaline earth oxides.
c) Preparation of Opal glass with different opacifying agents -- Fluoride & Phosphate opal.
d) Preparation of low melting Phosphate glass in various systems.
e) Determination of Alkali resistance of glass.
f) Determination of alkalinity of glass
g) Thermal shock test on glass wares.
h) Determination of density of glass.
i) Determination of strain in glass wares by polariscope.
j) Demonstration of cord viewers.

CT–593: Whitewares Lab: Credits = 3

a) Preparation of Whiteware Body >> Milling of raw materials, measurement of slip properties, green body preparation, slip casting, pressing, drying & firing.
b) Preparation of glazes & application of glaze on body, and firing.
c) Determination of water absorption, True density, Bulk density & Modulus of rupture of various fired whiteware bodies.
d) Determination of thermal shock resistance of fired whiteware bodies
e) Measurement of glaze thickness by Penetrometer.
f) Determination of acid solubility of ceramic body & glaze.
g) Determination of alkali solubility of ceramic body & glaze.

CT-594: Cement & Concrete Lab: Credits = 3

a) Tests like Consistency of cement, Setting time, Hardening, CCS as per standard specification,
b) Study of strength properties both as a function of composition and setting time of cement-sand mortars & concrete.
c) Setting time of various grades of cements.
d) Slump test of concrete.
e) Vee- Bee consistometer test of concrete.
f) Compaction factor test of concrete.
g) NDT of cement-sand mortars/concrete blocks by Schmidt test hammer.
h) Soundness of cement.

i) Flow table test of mortar. Heat of hydration of cement, Water permeability of mortar. Air entrainment of concrete.

SESSIONAL:

CT – 595: Plant Design & Feasibility Study: Credits : 3

Development of process flow sheet, material balance, energy balance, equipment sizing, plant site selection, plant layout, equipment costing, Capital cost estimation, financial analysis of project etc.

3rd Year B. Tech. Course in Ceramic Technology

6th SEMESTER

THEORY >>>

CT–601: Refractories I I : Credits = 4

I) Monolithics

a) Introduction of Monolithic Refractories, Shaped and Unshaped Refractories — Advantages and Disadvantages, Classification of Unshaped Refractories
b) Aggregates used in monoliths.
c) Refractory cement and other additives, Additives for ramming and gunning materials.
d) Classification of Castables: Conventional, Low cement, Ultra low cement No or zero cement, Gel bonded and self floor castables, Silica free and Basic castables.
e) Manufacture of Castables/Monoliths, Installation techniques, Applications.
f) RefractoryCement,Morters,Concrete,Ramming Mass, Fettling,Guncrete.

II. Non Oxide Refractories :

i) Silicon Carbide, Boron Carbide, Fabrication Properties and applications.
ii) Nitride refractories – Silicon nitride, boron nitride, Fabrication, properties and application
iii) Pure oxide refractories :- Alumina, Magnesia, and zirconia based refratories.
iv) Special refractories : - Flow control refractories, continuous casting etc.

III) Carbon bearing refractories: Importance of carbon bearing refractories. Advantages of these refractories, Properties variation with the amount of carbon in basic refractories, Properties of pitch, tar and resin used in brick manufacturing, tempering of these bricks, application of antioxidants, wear mechanism in LD converter.

References:

1. Steel Plant Refractories :- J. H. Chester
2. High temperature oxides , Part I to IV – A. M. Alper
3. Recent Trend in Refractory Monolithics by Dr. Subrata Banerjee.

CT–602: Glass II : Credits = 4

a) Rheological properties of glasses, Notion of rheology, Viscosity, Elastic & Visco-elastic properties of glasses.
b) Thermal Properties of glasses, Specific heat, Thermal conductivity, Thermal expansion.
c) Mechanical properties of glasses, Mechanical resistance,
d) Fatigue, Fracture, Reinforcement of glasses .
e) Surface properties of glasses, Formation of artificial layer,
f) Methods of modifying surfaces.
d) Glass-ceramics, Controlled crystallization, Examples of some
g) systems, Special applications.
e) Glass production, Basic processes of glass making, Batch process, Continuous process, Raw materials selection, Batch house & mixing, Batch transportation, Tank furnace, Batch feeding, Melting & refining, Bottle glass, Sheet glass, Other glasses, Annealing, Thermal treatment, Chemical treatment, Production control & planning, Optical fibre glass production & processes.

Books :- 1) Handbook of Glass Manufacture - F.V. Tooley
2) Glass Engineering Handbook – E. B. Shand.
4) 3) Handbook of Glass Properties – G. W. Morey.
4) Handbook of Glasses – R. H. Doremus

CT–603: Whitewares I I : Credits = 4

Manufacturing of the following whiteware bodies with process flowcharts & Body Composition:

i) Electrical Porcelain ii) Wall & floor tiles
iii) Sanitary wares iv) Wear resistant ceramics.
v) Low Loss bodies vi) Grinding media
vii) Chemical porcelain viii) Spark plug Insulators
ix) Mullite porcelain

a) Drying> Different types of dryers and their operations & maintenance, sources of heat for drying & Drying schedule, defects at green stage (before firing) causes & remedies.
b) Firing> Firing schedule, factors for determination of firing schedule, pressure curve, kilns and their operation techniques, atmosphere of firing, reactions at different temperatures with firing conditions, phase formation, microstructure, different energy conservation practices.
Firing defects – causes & remedies.
c) Kiln Furniture> Application, Properties, working life, Type & temp. of use, Low mass and low expansion kiln furniture, Strong nitride bonded SiC kiln furniture for special applications.
d) Testing:
Incoming test: Testing of different rawmaterials;
Physical Test: Residue, fired colour, M.O.R. (Gr&Fr), Particle size distribution, drying shrinkage, firing shrinkage, casting rate, plasticity, free iron, button test etc.
Chemical Test: L.O.I., SiO_2, Al_2O_3, Fe_2O_3, Al_2O_3, TiO_2, Na_2O, K_2O, CaO, MgO etc.

In process Test: pH, viscosity, Particle size distribution, sp. Gr., glaze thickness, thixotropy, casability, plasticity, dry & fired strength, dry & firing shrinkage, glaze colour & flow etc.

Final Test: Dimension, firing shrinkage, Fired strength (glazed & unglazed), B.D., porosity, Abrasion resistance test, Mechanical strength, thermal shock resistance test, Electrical puncture test, Dielectric test, flash over test, creepage distances, wet power frequency voltage withstand test, impulse voltage withstand test.

References:

4. Ceramic Whitewares – Sudhir Sen
5. Industrial Ceramics – Singer & Singer
6. Fine Ceramics – F.H. Norton.

4. The Technology of Ceramics and Refractories – P.P. Budnikov.

CT – 604: Advanced Ceramics I: Credits = 4

a) Engineering Ceramics : Carbides : Boron carbide, Silicon carbide, Titanium carbide, Zirconium carbide, Hafnium carbide & Uranium carbide. Nitrides : Boron, Silicon & Aluminium nitrides. Silicides : Molybdenum disilicide. Borides. Sialon. Graphites. Cermets & Composites.
b) Ceramics used in advanced applications: Nuclear energy, Magneto- hydrodynamic generation, Gas turbine blades, Abrasives, Aerospace, Diesel engines, Heat Exchangers,Cutting Tools,Wear Applications
c) Ceramics for Medical and Scientific products:

Tissue attachment mechanism, Bio- active materials, nearly inert crystalline ceramics, porous ceramics, bioactive glass and glass ceramics, calcium phosphate ceramics, carbon base implant materials, ceramics for dental applications.

d) Ceramics for optical applications : CRT and TV picture tubes, Telecommunication and related uses , Information display , Laser , Fibre optics , Electromagnetic windows .
e) Ceramics in Electrochemical cells : Sodium sulphate cell (with β – alumina) , Electrical ceramics for fuel cell and high energy batteries .

Books :- 1) Ceramic Materials for Electronics R.C Buchanon
2) Electronic Ceramics B.C.H Steele
3)Ceramics & Glass(vol 4) ASM International.

CT-605: Process Ceramics II: Credits = 3

I) Concept of Mono-size and Mono-dispersed submicron ceramic powder . Powder preparation of high performance ceramics , Powders from chemical solutions , Powders from vapour phase reactions , Co-precipitation , Sol-gel techniques . Preparation of mono-dispersed and mono-size submicron alumina powder .

II) Advanced Forming Processes , Hot pressing , Isostatic pressing , Injection moulding , Tape casting , Gel casting , Chemical vapour deposition , Coating processing , Plasma processing and plasma synthesis .

III) Consolidation of solid powders by heat , Sintering , Driving force of sintering , Different types of solid state sintering , Mass transport mechanism during sintering ,

Different sintering models , Factors controlling sintering kinetics , Recrystallisation and grain growth , Pressure associated with sintering . Hot pressing and hot isostatic pressing (HIP) .

IV) Ceramic processing related to development of microstructure . Development of fine grain alumina body of high theoretical density .

References/Books :-

1) Ceramic processing before firing - Onada and Hench .
2) Introduction to the principles of ceramic processing - J.S.Reed .
3) Advances in Ceramics - Vol 9 . Forming of ceramics. Eds:- John A. Mangels and G.L Messing.

MS(CT)-601: Engineering Materials Science : Credits = 4

Scope and Objective .

a) Introduction > Structure, Properties, Relevance of materials science & engineering, Structure – Property relationship.

b) Structure of Crystals & X-ray Diffraction >> Ideas on lattice, Inhomogeneous bonds, Crystal structures, Symmetry & periodicity . Grouping of ions & Pauling's rule, Crystal class, Space lattice, Symmetry elements, Bravais lattice , unit cell , Crystal systems , Planes , directions and positions in crystals, Miller indices. Oxide structures, Silicate structures & others. Polymorphism & Polytypism. Packing of crystals. Elements of X-ray diffraction.Bragg's law.

c) Structural Imperfections >> Notations used for atomic defects. Formation of reaction equations. Solid Solutions. Point Defects -- Frenkel & Schottky defects. Line defects - Edge & Screw dislocations. Elucidation of their properties. Order - Disorder transformation. Association of defects. Non-stoichiometry. Grain boundaries. Twining, Stacking faults.

d) Reaction with and between solids>> Kinetics of heterogeneous reactions, Reactant transport through a planar boundary layer, through a fluid phase, in particulate systems. Precipitation in crystalline materials, Non isothermal process.

e) Mechanical Properties of materials >> Types of materials based on mechanical behaviour . Position of ceramics and glasses . Tensile testing , Explanation of typical Stress-Strain behaviours .
Deformation by slip . Plastic deformation . Slip by dislocation movement, Cottrell's views , Shear strain rate, Peierls stress, Critical Resolved Shear Stress for Slip, Twinning deformation, Fracture behaviour. Brittle & ductile, Brittle fracture & crack propagation, Elasticity, Anelasticity, Strength, Creep.

f) Strengthening Mechanisms > General concepts, Cold working, Yield point, Yield stress, Strain (Work) hardening, Solute strengthening, Strengthening by grain boundaries, Second phase strengthening, Dispersion , Toughening .

g) Annealing of Metals >Objectives & Methods . Fundamental concepts, Recovery, Recrystallisation & grain growth, Factors affecting them, Effect of annealing on mechanical behaviour of metals(Microstructural changes on Annealing).

h) Visco-elastic deformation>>Typical viscoelastic behaviour , Voight & Kelvin models , Viscoelastic Materials . Models of visco-elastic behaviour.

i) Electron Theory of Solids > The electron gas, Quantised electron gas, Free electron theory of metals, Electrons in periodic potential, Band/Zone Theory of metals Brillouin zones, Conduction process.

j) Thermoelectric Properties > Basic concepts, seebeck, Peltier & Thomson effects, Application, Figure of merit, Thermoelectric refrigerators & generators.

k) Chemical Properties>>
i)Corrosion & its prevention > Galvanic theory, Half cell potentials, Electrochemical corrosion, Rate, Types, Corrosion prevention methods.
ii) Oxidation of metals, Pilling – Bed worth Ratio, Oxidation kinetics , Films & properties ..

l) Macromolecules >> Different types of polymers, Elementary structural features & properties, Control of structures and crystallization. Polymeric reactions, Formation of various polymers, Polyethylene & Rubber, Glass transition temperature. Implications of important properties.Thermoplasts and thermosets.

Books :- 1) Principles of Materials Science & Engineering - Smith.
2) Corrosion Engineering Handbook - Fontana.
3) Materials Science - Raghavan.
4) Mechanical Metallurgy - Dieter
5) Introduction to Ceramics - W.D Kingery.
6) Materials Science - Van Vlack.

PRACTICAL >>>

CT- 691: Instrumental Analysis Lab: Credits = 3

a) Dilatometric analysis : Studies with vitreous silica, Silica brick specimen, Whiteware samples of low thermal expansion coefficients, Interpretation of data.

b) 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.

c) 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.

d) Particle size distribution by Andreasen pipette.

e) Flame photometer for alkali estimation.

f) Spectrophotometric Analysis/Colorimetric Analysis.

g) XRD analysis - Interpretation of Diffractograms.

h) SEM analysis (Analysis of microstructure).

CT–692: Ceramic Coatings Lab: Credits = 2

1.Metal surface preparation – cleaning, pickling, Ni dipping and neutralization.
2.Formation and melting of enamel frits, compounding of a recipe of enamel slip with frit, opacifiers and other additions, melting.
3.Sieve analysis of wet milled and dry milled enamels, determination of consistency of enamel slip.
4.Aplication of enamel by dipping, spraying
5. Firing of enamel wares.
6.Study of defects of enameled ware
7. Testing of vitreous enamel wares:
a) Test of resistance to Acid and Alkali
b) Test of resistance to boiling water
c) Test for resistance to Thermal shock

d) Test for resistance to impact
e) Test for warpage
f)Test for abrasion resistance
g)Test for adherence of enameled specimens by Adherence meter method.

C. SESSIONAL:

CT-693: Furnace & Equipment Design: Credits : 4

A) Process Design of a Furnace/Kiln :-

1) Shuttle Kiln
2) Rotary Kiln
3) Tunnel Kiln
4) Shaft Kiln
5) Glass Melting Tank Furnace
6) Roller Hearth Furnace etc.

B) Process Design of an equipment used in Ceramic Industries from the following group :-

1) Comminution Equipment
2) Drying Equipment
3) Mechanical Separation Equipment.

CT-694: Seminars & Group Discussion: Credits : 2

To be decided by the teachers.

4th Year B. Tech. Course in Ceramic Technology

7th SEMESTER
THEORY >>>

CT – 701: Physical Ceramics: Credits = 4

Scope & Objective .

a) Ceramic crystal structures : Corrundum , Wurtzite , Zinc blende , Rocksalt , Perovskite and Spinel structure etc.

b)Atomic Mobility >> Diffusion & Diffusivity, Laws of Diffusion , Diffusion in solids , Controlling diffusivity . Nernst-Eistein equation. Diffusion as thermally activated process. Nomenclature & concepts of atomistic process. Temperature & impurity dependence of diffusion. Diffusion in crystalline oxides. Dislocation. Boundary & surface diffusion.

c)Phase Transformations >> Formal theory of transformation kinetics with examples. Spinodal decomposition. Thermodynamics & kinetics of nucleation & growth.

d) Grain Growth, Sintering & Vitrification >>Sintering - Single & multiphase . Study of sintering - Kinetics , mechanisms of mass transport , Sintering variables , Sintering aids .

Recrystallisation & grain growth. Abnormal grain growth. Sintering vis-à-vis Vitrification. Sintering with a reactive liquid. Pressure sintering & hot pressing. Secondary phenomena. Firing shrinkage.

m) Microstructure & Characterisation>> Features in microstructures. Microstructural observations - Optical & Electron Microscopy . Techniques of sample preparation .

f) Ceramic Phase Equilibrium Diagrams >> Techniques of determining phase diagrams. One - , two - , and three - components phase diagrams. Examples. Phase composition versus temperature. Non-equilibrium phases. Typical ceramic systems like zirconia - calcium oxide / magnesium oxide / ceria , calcia - silica , magnesia - silica , soda - lime - silica , lime - alumina - silica etc.

g)Electrical Properties >> Electrical conduction in materials, Electron mobility, Drift velocity, Relaxation time, Electrical resistivity, Energy band model ---> Insulators, Conductors, Semiconductors diagrams, Mechanism of electrical conduction in intrinsic and extrinsic semiconductors, Charge transport in pure silicon, Quantitative relationship of electrical conduction in intrinsic elemental semiconductors, Effect of temperature on intrinsic semiconductors, N - type and P - type semiconductors, Doping. Mass action law, Charge densities in intrinsic semiconductors.Electronic & Ionic conduction, Ceramic conductors like varistors, thermistors, resistors etc. Piezoelectricity, Ferroelectricity.

h) Magnetic Properties >> Diamagnetism , Paramagnetism , Pauli paramagnetism , Ferromagnetism , Antiferromagnetism & Ferri magnetism - Ferrites .Soft & Hard magnetic materials- Ferrites, Mixed ferrites, Origin of interactions in ferro - and antiferro - and antiferri - magnetic materials ---> direct, super and double exchange interactions. Exchange energy, Magnetostatic energy, Magnetocrystalline anisotropy energy, Domain wall energy, Magnetostrictive energy.Properties & applications of ferrites.

i)Dielectric Properties >> Introduction, Basic properties of dielectrics & theory ---> D.C., Capacitance, Dielectric strength, Loss factor. Equivalent circuit description of linear dielectrics, Power factor, Dielectric polarisation, Polarisation mechanisms, Polarisation Vs. frequency, Dielectric loss & breakdown, Ceramic capacitors and insulators.

j)Optical Properties >> Introduction. Light & electromagnetic spectrum, Electromagnetic waves in ceramics, Refractive index, Dispersion, Reflection and refraction. Transmission & reflection of light. Luminescence ---> Photo & Cathodes. Lasing action. Scattering of light. Boundary reflectance and surface gloss. Opacity & translucency. Absorption & colour. Stress-optic effect. Comparative optical properties , Structural correlations , Optical fibres .

k)Thermal Properties >> Thermal conductivity , Specific heat , Thermal expansion , Thermal stress . Comparative thermal behaviour of ceramics .

Books :- 1) Introduction to Ceramics - W.D.Kingery
2) Fundamentals of Ceramics - Barsoum
3) Physical Ceramics for Engineers - Van Vlack
7) Principles of Materials Science & Engineering - Smith
8) Handbook of Ceramics - Editor S. Kumar

CHE(CT)-701: Instrumentation & Process Control: Credits = 4

Ceramic Technology Syllabus

A) Instrumentation >>

Basic concept of measurement :- Idea of generalized measurement system, Functional units, Static and dynamic characteristics of measuring device – accuracy , precision , error , hysterisis , resolution , threshold value , repeatability etc.. Calibration error and uncertainty , Statistical analysis of data and error . PID diagram of Process Plant and Instrument specification . [6L]

Transducers : Basic concept , classification and applications . [2L]

Temperature measurement: Classification, mechanical temperature sensor – solid expansion , liquid and vapour filled thermo , Thermo electric thermocouples , Electric type – Resistance thermometer , Thermistors, ,Optical/ Radiation type .

Pressure measurement : Mechanical type – Manometers , Elastic type Bourdon gauge/pressure spring , Bellows and Diaphram , Bell gauges . Electrical type- potentiometric device , strain gauge , LVDT and capacitative . Solid state device – piezo junction and piezo-resistance . [4L]

Flow Measurement :- Classification of flow meters , head , area , mass flow , positive displacement flow meters . Electric type – turbomagnetic , electromagnetic , ultrasonic and hotware . Digital , open channel and solid flowmeters etc..

Level measurement :- Mechanical , thermal effect , electrical, ultrasonic and γ-radiation types. [4L]

Process Control:-

Basic concepts of control – system , logic analysis of system , process control – open and closed loop system , block diagram , Transient response , system linearisation , Mathematical modeling of simple physical system , transfer functions .

Linear open-loop system – Transient analysis of First order , Second order system , Analysis of first order systems in series . [6L]

Linear closed – loop system – Negative and positive feedback , servo and regular control , transfer function of measurement , controller and final control element .

Mode of control – P , PI , PD , & PID . Transient responses of closed-loop system , stability of control system . [6L]

Industrial Controller – Cascade controller , Metered , Ratio , Time variable , Limit , Dual agent controls , Engineered control systems . [6L]

References :-

1) Principles of Industrial Instrumentation - D. Patranabis. Tata Mcgraw Hill (2^{nd} Ed).
2) Industrial Instrumentation Fundamentals - Fribance. Mcgraw Hill.
3) Process System Analysis & Control - Coughnour. Mcgraw Hill (2^{nd} Ed).
4) Chemical Process Control - Stephanopoulos. Prentice Hall India.
5) Process Instrument and Control Handbook - Considine & Considine. Mcgraw Hill.

Ceramic Technology Syllabus

CT-702: Advanced Ceramics II: Credits = 3

1. Electronic Ceramics :

a) A. Ceramic substrates > (Al_2O_3 , BeO , AlN , Glass Ceramic) , Processing of Thick Film , Thin Film , Multilayer Packages.
b) Properties of Ceramic Insulators.
c) Ceramic Capacitor Dielectrics > Barium titanate, Other titanate based dielectrics ,Composition with high Pb content, Processing of thick & thin film capacitors, Integrated capacitors. Relaxor Dielectrics.

d) Piezoelectric Ceramics > Piezoelectric & electrostrictive materials, Powders & Processes , Piezoelectric ceramic applications.

e) Electro-optic Ceramics & Devices > Different Materials , PLZT compositional systems , Powders & Processes , Hysteresis loop , Electro optic properties , Applications.
d) Sensors > Oxygen Sensors , Principles of operation, Solid electrolyte sensors, Semiconductor sensors, Thermistors and related sensors .
e) Magnetic Ceramics : Spinel Ferrites , Hexagonal Ferrites , Garnet , Processing , Single crystal ferrite , Applications .

Critical parameters, Powder synthesis,

f) Ceramic Superconductors : High T_c Superconductors , Structure of Y-Ba-Cu oxide system , Powder synthesis, Theory of Superconductivity , Applications .
f) Nano Ceramics : Different Compositions , Synthesis , Applications .
g)Ceramic Membranes.

Suggested Readings :

1) Ceramic Materials for Electronics : R.C.Buchanon.
2) Electronic Ceramics : B.C.H Steele.
3) Adv. Ceram. Materl. Vol I By K Furuta & K Uchino.
4) Ceramics and Glass(vol I) ASM International.
5) Science & Technology of Ceramics (vol 4) Advances in Ceramics A.H.Heuer and L.W Hobbs
6) Handbook of Properties of Technical & Engineering Ceramics,part I . An Introduction For the Engineer & Designer , R. Morrel .
7) Ceramics for high performance applications : J Burke , A.E.Gowan & R.N Kalz , Ed.

Encyclopedia of Chemical Technology Kirk Othmer.

HU–701: Financial Management & Accounts: Credits = 3

Financial Management & Accounts

Code: HU 701

Ceramic Technology Syllabus

Contact: 3L
Credits: 3
Allotted Hrs: 45L

Introduction [3L]
Financial Management, Financial Planning and Capitalization- definitions, objectives, changing roles and functions, Financial Decision.

Capital Budgeting [7L]
Nature of Investment decision, Importance of Capital Budgeting, The Capital. Budgeting Process - Investment Criterion, Pay-back period, Accounting, ROR (Rate of Return) Method, Discounting Cash flow method, Net - present value method, IRR (Internal Rate of Return) method, The benefit-Cost Ratio method.

Management of Working Capital [7L]
Various concepts, Elements, Classification, Financing and importance of working capital, Investment analysis, Cash flow determination, cost of capital, capital budgeting methods.

Budgeting Control Technique [5L]
Concepts of Budget, budgeting and budgetary control, Objectives, Functions, Uses, Advantages, Limitations; Master Budget and Report.

Cost - Volume - Profit Analysis [8L]
Classification of costs, Allocation, apportionment and absorption, Cost centers, different costing systems, Cost analysis for managerial decisions, Meaning of Linear CVP analysis, Objectives, Assumptions, Break - Even analysis, determining the Break-Even point profit, Volume graph profit, Volume ratios margin of Safety.

Introduction to Accounting [8L]
Basic accounting concepts, important definitions, uses, limitations, advantages; types of Accounting, Financial statements, introduction to Journal Accounting; different types of Vouchers, double entry bookkeeping, different types of transactions related to Financial Accounting.

Financial Control [7L]
Posting of Ledgers and preparation of Trial Balance; preparation of Balance Sheet and Profit and Loss Accounts; Controlling other departments by Financial Accounting (A practical Approach).

Books:

1. Financial Management and Accounting - P. K. Jain, S. Chand & Co.
2. Management & Accounting: Principles and Practice - R. K. Sharma & Shashi Kumar Gupta, Kalyani Publishers.
3. Advanced Management Accounting - Kaplan & Atkinson, PHI.
4. Fundamentals of Financial Management - Van Home, PE.
5. Financial Mgmt Accounting, Gupta,Pearson
6. Financial Mgmt, I.M. Pandey, Vikas
7. Financial Mgmt., Khan & Jain, TMH

8. Financial Mgmt , Mcmenamin, OUP
9. Financial Mgmt & Policy, Van Horne, PHI
10. Financial Mgmt,Kulkarni & Satyaprasad, Himalaya

HU(CT)706: Quality Assurance : Credits = 3

A) Quality Assurance >>

a) Definition of quality, Quality control, Quality assurance, TQM, Quality circle. Importance of quality control activities in an organization, Quality loop in an organization, Stages of quality control activities in an organization, Type of quality characteristics, Advantages & disadvantages of different quality characteristics.

b) Statistical Process Control >> Definition, Chance causes, Assignable causes, Difference between two causes

g) Cost of Quality >> Elements of quality cost, Assessing cost of quality, Cost of appraisal, Prevention & failure cost, Optimum cost of quality control, Quality cost awareness

h) ISO - 9000 / Quality System >> Introduction, Definition of ISO, Its development, Series of ISO - 9000 standards, Selection of standards, Classes of ISO - 9000 quality system, Benefits of ISO - 9000 quality system

i) Seven Tools of quality Control >> Cause & effect diagram, Scatter diagram, Control charts, Pareto diagram, Histogram, Flow charts, Graph check sheets.

j) Process Capability Study >> Definition, Needs of process capability study, Derivation of standard deviation, Concept of USL & LSL, Six sigma, Accuracy & precision, Calculation of Cp & Cpk indices, Implication of Cp & Cpk on process control.

k) Control Charts >> Definition & its uses, Different types of control charts, Derivation of control charts.

l) Process of Continuous Improvement >> Quality circle -- Definition, Basis of Q. C. circle, Starting of a Q. C. circle, Kanban system, PDCA cycle, Brain storming, Cause & effect diagram, Gantt chart.

References:

1. TQM and ISO-14000 – Dr. K. C. Arora.

SESSIONAL:

CT–791: Assigned Project: Credits = 6

To be decided by the Teachers in consultation with the students.

Ceramic Technology Syllabus

CT-792: Practical Training Evaluation: Credits = 3

To be decided by the Teachers in consultation with the students .

CT-793: Seminar on Assigned Topic: Credits = 2

To be decided by the Teachers in consultation with the students in an open house.

4th Year B. Tech. Course in Ceramic Technology

8th SEMESTER

Ceramic Technology Syllabus

THEORY >>>

Values & Ethics in profession

Code: HU 801
Contact: 3L
Credits: 3

Allotted Hrs: 39L

Science, Technology and Engineering as Knowledge and as Social and Professional Activities **[2L**

Effects of Technological Growth: [15L

Rapid Technological growth and depletion of resources. Reports of the Club of Rome. Limits to growth; sustainable development. Energy Crisis; Renewable Energy Resources.
Environmental degradation and pollution. Eco-friendly Technologies. Environmental Regulations. Environmental Ethics. Appropriate Technology Movement of Schumacher: later developments. Technology and developing nations. Problems of Technology transfer. Technology assessment/ impact analysis; Industrial hazards and safety, safety regulations safety engineering. Politics and technology, authorization versus democratic control of technology; Human Operator in Engineering projects and industries. Problems of man machine interaction. Impact of assembly line and automation. Human centred Technology

Ethics of Profession:
[8L

Engineering profession: Ethical issues in engineering practice. Conflicts between business demands and professional ideals. Social and ethical Responsibilities of Technologists. Codes of professional ethics. Whistle blowing and beyond. Case studies.

Profession and Human Values
[14L

Value Crisis in contemporary society. Nature of values: Value Spectrum of a ‘good’ life

Psychological values: Integrated personality; mental health. Societal values: The modern search for a 'good' society, justice, democracy, secularism, rule of law; values in Indian Constitution. Aesthetic values: Perception and enjoyment of beauty, simplicity, clarity

Moral and ethical values: Nature of moral judgments; canons of ethics; Ethics of virtue; ethics of duty; ethics of responsibility. Work ethics, professional ethics.

Books:

1.Blending the best of the East & West, Dr. Subir Chowdhury, EXCEL
2.Ethics & Mgmt. & Indian Ethos, Ghosh, VIKAS
3.Business Ethics,Pherwani,EPH
4.Ethics,Indian Ethos & Mgmt., Balachandran,Raja,Nair, Shroff Publishers
5.Business Ethics: concept and cases, Velasquez, Pearson

Industrial Management

Code: HU 802

Contact: 3L

Credits: 3

Allotted Hrs: 39L

Human Resource Management: **[8L**

Recruitment and selection, Performance appraisal, Industrial Relations, Trade Union, Collective Bargaining

Organizational Behaviour: **[8L**

Different Schools of Management Thought : Scientific Management, Administrative Theory, Theory of Bureaucracy, Human Relations Theory(Elton Mayo).

Motivation: Concept, Different Theories (Maslow, ERG, Herzberg,)

Communication: Purpose, process, Barriers to effective communication, Guidelines to make communication effective.

Perception: Process, Importance, Factors influencing perception, Shortcuts for judging people- Halo effect, Stereotyping, Projection.

Quality Management: **[6L**

Concept, Dimensions for goods and services, Cost of Quality, Statistical Quality Control, Control Charts, Acceptance Sampling (single).

Total Quality Management: Concept, benefits, Criticism.

New Quality Tools: Kaizen, Six Sigma, Quality Circles.

Productions Management: [5L

Concept. Difference from Operations Management, Types of Production(Mass, Batch, Project), Functions of Production Management.

Productivity: Concept, Different Inputs and Productivity Measures, Effeciency and Effectiveness, Measures to increase Productivity.

Marketing Management: [6L

Basic Concepts of Marketing, Difference between Selling and Marketing, Elements of Marketing Mix- the 4 P's.

Marketing Environment: Mega Environment, Micro Environment, Internal Environment, Relevant Environment.

Simple Marketing Strategies: SWOT Analysis, BCG Matrix, Industry Matrix.

Materials Management: [6L

Concept, Functions, EOQ Models- Wilson model, model with shortage, model with quantity discount, model without shortage , Selective Inventory Control—ABC, VED, FSN analysis

Books:

1. Industrial Management, Vol.1 L.C. Jhamb, EPH
2. Industrial Relations, Trade Unions & Labour Legislation - Sinha, Pearson Education Asia
3. Organizational Behaviour, S.P. Robbins, Prentice Hall
4. Productions and Operations Management, S. N. Chary, TMH
5. Marketing Management, Phillip Kotler, Prentice Hall/Pearson Education.
6. Productions and Operations Management, Joseph Monks,TMH

HU (CT)-803: Energy & Environment Management: Credits =4

A) Energy Management : Objectives of Energy Management

Energy Scenario - Global and National

The Energy Crisis; Ceramic Industry and Energy

Areas and levels of Energy Management

Energy Monitoring and Control

Energy Conservation - Principles and Techniques

Energy Audit - Principles of

Less Energy Intensive Processes and Conditions . Automatic fixing of numbers is not being done

B) Objectives of Environment Management

Waste Minimization, Life Cycle Assessment.
Standards , Regulations and Monitoring of Environmental Programmes .
Standards for Environmental Requirements - Country wise Variation .
Environmental Impact Assessment (EIA),
Air Quality and Water Quality Modelling
Environmental Auditing
Multidisciplinary Team Management
Case Studies.

Books/Readings :

1. C.D Grant: Energy Conservation in Chemical & Process Industries - I. Chem E , George Godwin Ltd. Rugby 1979.
2. B Linnhoff et al: User Guide on Process Jutegration for the Efficient use of Energy. - I Chem E , Rugby , 1982 .
3. Uhlmann's Encyclopedia of Chem Technology - Vol B7.
4. Env. Engg. G. Kiely , McGraw Hill (1998).
5. Uhlmann's Encyclopedia of Chem Technology - Vol B8.
6. Envtl. Auditing - International Chamber of Commerce Pub,486 , ICC Publishing(1989).

SESSIONAL:

CT-891: Assigned Project: Credits = 8

CT-892: Comprehensive Vivavoce: Credits = 4