B. Tech in Ceramic Technology
West Bengal University of Technology
SEMESTER III

Sl. No.		Subjects	Codes	Lect	Tut	Pract	TOT	Credits
	A. THEORY SUBJECTS							
1	**HU-301**	Values & Ethics in Profession		2	0	0	2	2
2	**CH(CT)-302**	Chemistry II		3	1	0	4	4
3	**CH-301**	Basic Environmental Engg. & Elementary Biology		3	0	0	3	3
4	**CH(CT)-303**	Chemical & Engg. Thermodynamics		3	1	0	4	4
5	**CHE(CT)-301**	Unit Operation I		3	1	0	4	4
6	**CT-301**	Earth Sciences & ceramic Raw Materials		3	0	0	3	3
		TOTAL OF THEORY					**20**	**20**
	B. PRACTICALS							
7	**CT-391**	Chemical Analysis Lab		0	0	3	3	2
8	**CS(CT)-391**	Software Lab		0	0	3	3	2
9	**CHE(CT)-392**	Unit Operation Lab		0	0	3	3	2
10	**CT-392**	Physical Testing of Ceramic Raw materials		0	0	3	3	2
		TOTAL OF PRACTICALS					**12**	**8**
		TOTAL OF THIRD SEMESTER					**32**	**28**

B. Tech in Ceramic Technology
West Bengal University of Technology
SEMESTER IV

Sl. No.		Subjects	Codes	Lect	Tut	Pract	TOT	Credits
	A. THEORY SUBJECTS							
1	**Basic Sc.**	Numerical Methods		2	0	0	2	2
2	**Basic Sc.**	Mathematics III		3	1	0	4	4
3	**Engg. Sc.**	Energy Resource & Elements of Furnaces		3	0	0	3	3
4	**Prof. core I**	Unit Operation II		3	1	0	4	4
5	**Prof. core II**	Process Ceramics		3	1	0	4	4
		TOTAL OF THEORY					**17**	**17**
	B. PRACTICALS							
6	**HU**	Comm. Skill & Report writing		0	0	3	3	2
	Basic Sc	Numerical Methods		0	0	2	2	1
7	**Engg. Sc**	Fuel Testing Lab		0	0	3	3	2
8	**Prof. Core I**	Geology Lab		0	0	3	3	2
9	**Prof. Core II**	Instrumental Analysis Lab		0	0	3	3	2
		TOTAL OF PRACTICALS					**14**	**9**
		TOTAL OF FOURTH SEMESTER					**31**	**26**

B. Tech in Ceramic Technology
West Bengal University of Technology

THIRD YEAR FIFTH SEMESTER

Sl. No.		Subjects	Codes	Lect	Tut	Pract	TOT	Credits
	A. THEORY SUBJECTS							
1.	**HU 501**	**Economics for Engineers**		3	0	0	3	3
2.	**(P.C)CT 501**	**Refractories Technology**		3	1	0	4	4
3.	**(P.C)CT 502**	**Glass Science & Technology**		3	1	0	4	4
4.	**(P.C)CT 503**	**Whitewares Technology**		3	0	0	3	3
5.	**Free Elective** **CT 504A (**IT 504D) **CT 504B** (CS 601) **CT 504C** (CS504D)	**Operation Research** **DBMS** **Object Oriented Prog.**		3	0/1	0	3/4	3/4
		TOTAL OF THEORY					17/18	17/18
	B. PRACTICALS							
6.	**CT 591**	**Refractories Lab**		0	0	3	3	2
7.	**CT 592**	**Glass Lab**		0	0	3	3	2
8.	**CT 593**	**Whitewares Lab**		0	0	3	3	2
9	**Free Elective** **CT 594A(**IT 594D) **CT 594B**(CS 691) **CT 594C**(CS504D)	**Operation Research Lab** **DBMS Lab** **Object Oriented Programming Lab**		0	0	3	3	2
		TOTAL OF PRACTICALS					12	8
		TOTAL OF FIFTH SEMESTER					**29/30**	**25/26**

B. Tech in Ceramic Technology
West Bengal University of Technology

THIRD YEAR SIXTH SEMESTER

Sl. No.		Subjects	Codes	Lect	Tut	Pract	TOT	Credits
	A. THEORY SUBJECTS							
1.	**HU 601**	Principles of Management		2	0	0	2	2
2.	**CT 601**	Cement and Concrete Tech		3	0	0	3	3
3.	**CT 602**	Engg. Materials Sc.		3	0	0	3	3
4.	**CT 603**	Ceramic Coating & Process Calculations		4	0	0	4	3
5.	**CT 604**	Metallurgy		3	0	0	3	3
6.	**CT605A or CT605B**	Instrumentation or Process Control		3/3	0/0	0/0	3/3	3/3
		TOTAL OF THEORY					**18**	**18**
	B. PRACTICALS							
7.	**CT 691**	Cement & Concrete Lab		0	0	3	3	2
8.	**CT 692**	Materials Characterization Lab		0	0	3	3	2
9.	**CT 693**	Metal & Ceramic coating Lab		0	0	3	3	2
10.	**CT 681**	**Seminar**		0	0	3	3	2
		TOTAL OF PRACTICALS					**12**	**8**
		TOTAL OF SIXTH SEMESTER					**30**	**26**

B. Tech in Ceramic Technology
West Bengal University of Technology
Fourth Year –Seventh Semester

Sl. No.		Subjects	Codes	Lect	Tut	Pract	TOT	Credits
	A. THEORY SUBJECTS							
1.	**CT701**	Advanced Ceramics		3	0	0	3	3
2.	**CT702**	Physical Ceramics		3	0	0	3	3
3.	**CT703**	Monolithic Refractories		3	0	0	3	3
4.	**CT704A**	Nano-technology		3/3	0	0	3/3	3
	CT704B	Composites						
5.	**CT 705**	Quality Management		3	0	0	3	3
		TOTAL OF THEORY					**15**	**15**
	B. PRACTICALS							
6.	**HU 781**	Group Discussion		0	0	0	3	2
7.	**CT 791**	Plant Design-I		0	0	4	4	2
10.	**CT 782**	Industrial Training	**4 wks during 6^{th}-7^{th} sem-break**					2
11.	**CT 781**	Project Part I					6	2
12.	**CT 793**	Monolithic Lab		0	0	3	3	2
13.	**CT 795**	Quality Management Lab		0	0	3	3	2
		TOTAL OF PRACTICALS					**19**	**12**
		TOTAL OF SEVENTH SEMESTER					**34**	**27**

Fourth Year – Eighth Semester

Sl. No.		Subjects	Codes	Lect	Tut	Pract	TOT	Credits
	A. THEORY SUBJECTS							
1.	**HU801A** **HU801B**	Organizational Behaviour / Project Management		2	0	0	2	2
2.	**Prof. Elective** **CT 801A** **CT 801B**	Bio-Ceramics Electrical & Electronic Ceramics		3/3	0	0	3/3	3
3.	**Free Elective** **CT 802A** **CT 802B**	Energy Management Environment Management		3	0	0	3/3	3
		TOTAL OF THEORY					**8**	**8**
	B. PRACTICALS							
4.	**CT891**	Plant Design-II		0	0	6	6	4
5.	**CT 881**	Project II		0	0	12	12	6
6.	**CT 882**	Grand Viva						3
		TOTAL OF PRACTICALS					**18**	**13**
		TOTAL OF EIGHTH SEMESTER					**26**	**21**

B. Tech in Ceramic Technology
West Bengal University of Technology
Syllabus
Third Semester
Chemistry 11 – Credit 3
Code- CH(CT)302

1. **Chemical Bonding:**
   (i) **Ionic Bond** – Types of ionic solids, radius ratio effect and coordination number, limitations of radius ratio, lattice defects, lattice energy and Born-Haber cycle, solvation energy and solubility of ionic solids, polarizing power and polarizability, Fajan's rules. 3

   (ii) **Covalent Bond:** Valence bond theory and its limitations, directional characteristics of covalent bond, various types of hybridization and shapes of simple inorganic molecules and ions. Valence shell electron pair repulsion (VSEPR) theory, linear combination of atomic orbitals (LCAO), bonding, nonbonding and antibonding molecular orbitals. Applications of MO theory to explain the stability of homo and hetero dinuclear diatomic molecules, multi-centre bonding in electron-deficient molecules. 6

   (iii) **Coordination Compounds:** Werner's theory, nomenclature, chelates, stereo-chemistry of coordination numbers 4, 5 and 6. Various types of isomerism in coordination complexes. Important applications of coordination compounds. Sidgwick effective atomic number concept, valence bond theory of coordination compounds. 5

   (iv) **Theories of Metal-Ligand bonding:** Limitations of valence bond theory; Crystal-field theory and crystal-field splitting in octahedral and tetrahedral complexes; factors affecting the crystal-field parameters. Different applications. J.T. distortion. Demerits. Ligand field theory. 8

2. **Magnetic Properties of Transition Metal Complexes:** Types of magnetic behaviour, methods of determining magnetic susceptibility, L-S and J-J coupling, orbital contribution to magnetic moments. Correlation of magnetic moment data and stereochemistry of Co(II) and Ni(II) complexes; anomalous magnetic moments. 2

3. **Electronic Spectra of Transition Metal Complexes:** Types of electronic transitions, selection rule for d-d transitions, spectroscopic ground states. Explanation of electronic spectra on the basis of Orgel energy level diagram. C.T Spectra. 4

4. **Surface and Colloids Chemistry:** Adsorption- Langmuir and Freundlich isotherms. Multi layer adsorption-BET equation (no derivation) and its application to surface area measurement. Sols (reversible and irreversible), emulsions and emulsifiers, association colloids (micelles), gels. Applications of colloids. Qualitative idea of electrokinetic phenomena. Zeta potential. 4
5. **Molecular Spectroscopy*:*** Emission and absorption spectra. Transition probabilities and selection rules. Pure rotational spectra. Normal modes of vibration. Infrared spectra of linear and bent AB_2 molecules. Examples. Electronic spectra of diatomic molecules. Vibrational structure. Franck-Condon principle. 4
6. **Magnetic Resonance Spectroscopy:** Nuclear Magnetic Resonance spectroscopy. Chemical shifts. Spin spin splittings. Relaxation times. Electron Spin Resonance. Nuclear hyperfine splitting. Examples. 2

References:

1. General Inorganic Chemistry (I and II) – by R. P. Sarkar.
2. *"Physical Chemistry"*, **P. C. Rakshit,** 5th Edition (1985), 4th Reprint (1997), Sarat Book House,Calcutta.
3. *"Inorganic Chemistry"*, **D. F. Shriver and P. W. Atkins**, 3rd Edition (1999), ELBS, London.
4. *"Concise Inorganic Chemistry"*, **J. D. Lee**, 5th Edition (1996), Chapman & Hall, London.

B. Tech in Ceramic Technology
West Bengal University of Technology
Chemical and Engineering Thermodynamics
SEM-3
Paper Code – **CH(CT) – 303**

Syllabus of Chemical Thermodynamics

1. Enthalpy and Free energy : 5L
   Enthalpy, Different types of heat of reactions, Heat Hess's Law, Bond Energy, Gibb's Free energy and Work function, Spontaneity of a process , Standard state, Standard free energy of formation, Partial molar volume, Partial molar thermal properties, Chemical potential, Gibb's Duhem equations and its application, Helmoltz equation

2. Free energy and Chemical Reactions: 6L
   Chemical Equilibrium and Equilibrium Constant, Reaction Isotherm, Temperature dependence of equilibrium constant, Van't Hoff equation and its application, Change of thermal properties in Heterogeneous chemical reactions

3. The properties of Solutions: 5L
   Properties of Ideal solution, Rault's Law, Duhem –Margules equation, Vapour pressure curves for ideal and nonideal so0lution , Solid liquid equlibria

4. Phase equlibria: 5L
   Clapeyron equation in Solid-liquid, liquid-vapour equilibria, Gibb's phase rule, Phase diagram in one and two component system, Simple Eutectic and peritectic system

5. Statistical Thermodynamics: 4L
   Thermodynamic probability and entropy, Boltzman distribution law, partition function and thermodynamics quantities.

B. Engineering Thermodynamics

1. Thermodynamic System and Control Volume; Thermodynamic Properties, Processes and Cycles; Thermodynamic Equilibrium: Zeroth Law of Thermodynamics; Heat and Work 4L

2. First Law of Thermodynamics; First Law for Closed System; Energy; Specific heat and Enthalpy; First Law applied to Flow Process; Steady Flow Process; Mass Balance and Energy Balance; Examples of Steady flow Processes; Variable flow Process 6L

3. 2nd Law of Thermodynamics; Difference between heat and work; Cyclic Heat Engine; Heat reservoirs; Kelvin-Planck and Clausius Statement of 2nd Law; Refrigerator and Heat Pump; Reversibility and Irreversibility; Causes of Irreversibility; Carnot Theorem; Absolute Thermodynamic Temperature Scale 8L

4. Entropy; Clausius' Theorem; Property of Entropy; Entropy Principle; Causes of Entropy Increase; Entropy and Disorder 4L

Books and References:
1) Engineering Thermodynamics – P. K. Nag
2) A Textbook of Chemical Engineering Thermodynamics – K.V.Narayanan
3) Thermodynamics – P.C.Rakshit
4) Thermodynamics for Chemists – S.Glasstone

Unit Operation –I
Code: **CHE(CT)-301**

Units and dimensions, dimensional analysis 2L

Hydrostatic Equilibrium, Manometer 2L

Newtonian & non-Newtonian fluid, Laminar & turbulent flow, Reynold's stress, Boundary layers, Momentum balance and Bernoulli equation,Friction factor and friction factor charts 8L

Pipe, Fittings and Valves, Pumps, Fans and Compressors, Flowmeters 5L

Drag and friction in flow through bed of solids, Motion of particles through fluids 4L

Heat Transfer by conduction, Fourier's law, Compound resistance in series, Heat transfer through hollow cylinder and spheres 3L

Unsteady state heat conduction, Semi infinite solid, Penetration distance 2L

Principles of heat flow in fluids, Countercurrent and parallel flows and related temperature profiles, Overall heat transfer co-efficient, Logarithmic mean temperature difference, Individual heat transfer coefficients, Calculation of overall co-efficients , Heat transfer by forced convection, Empirical equations 7L

Heat exchanger equipments 3L

Fundamental concepts of radiation, Emissivity, Blackbody radiation, Planck's law, Wein's displacement law, Stefan-Boltzman Law, Kirchoff's law, Gray body, Angle of vision
Radiation intensity of blackbody, View factor, Radiation between two black surfaces, Heat exchange between parallel gray surfaces 7L

Earth Sciences & Ceramic Raw Materials

Paper Code – CT 301

GR.-A (Earth Sciences & Natural Raw Materials)

1. Idea about Earth Science or Geology. Its different branches and its importance in Ceramic Technology. Evolution of the earth from the solar system. Interior and exterior of the earth. Global Tectonics and its bearing on the global pattern of distribution of geomorphic features as well as of rocks and minerals. The Geological Time Scale.
(06 Lectures)

2. Rocks and Minerals: Characterisation and Classification of rocks and minerals. Petrology and Mineralogy. Igneous, Sedimentary and Metamorphic Rocks. Physical and optical properties of minerals as tools of mineral identification. Elements of Crystallography. Physical and optical properties of some important ceramic minerals. Rocks useful for the ceramic industry. (06 Lectures)

3. Silicate Minerals and Silica: Fundamentals of silicate structures. Structural and/or compositional characteristics of Quartz, Tridymite, Cristobalite; Feldspars; Sillimanite group of minerals; Zircon, etc. Polymorphic transformation of silica minerals and aluminosilicate minerals. Different natural forms of silica of industrial importance and their properties and uses – Quartzite, Ganister, Flint, Silica sand, etc. Properties, composition, effect of heat, use and Indian availability of silica minerals, Feldspars, Pyrophyllite, Talc, Sillimanite minerals, Zircon, etc.

(06 Lectures)

4. Plastic Raw Materials: Definition and classification of clay minerals. Structure of clay minerals (Kaolinite, Pyrophyllite, Montmorillonite, Chlorite etc.) and its comparison to the structure of micas. Composition, properties, uses, particle size, plasticity, cation exchange capacity (CEC), effect of heat treatment, etc. of the clay minerals.

(05 Lectures)

5. Fluxing Raw Materials: Nepheline Syenite, Bone Ash and Wollastonite – their compositions, properties, Indian availability and uses in ceramic industries.

(03 Lectures)

8. Refractory Raw Materials: General idea, composition, properties, effect of heat, Indian availability and uses of – Bauxite group of minerals, Magnesite, Dolomite, Chromite and Limestone.

(04 Lectures)

GR.-B (Synthetic Ceramic Raw Materials)

1. Scope & Application of Synthetic Ceramic powder: 3L

   Purpose /Advantage of synthetic ceramic raw materials, idea about crystal, crystallite, grain, particle, Particle size, shape and agglomerate, Application areas of synthetic ceramic powder

2. Methods of Ceramic Powder preparation: 6L

   Precipitation and co-precipitation technique, Sol-Gel process (SGP), Hydrothermal synthesis, Solvent vaporization technique

3. Alumina : 4L

   Phases of Alumina and its structure, Bayer alumina and its purification, Calcined Alumina, Tabular alumina, Fused alumina, Synthesis of oxide and hydroxide Powder from solution routes & their Characterization

4. Zirconia: 4L

   Polymorphic transformation of ZrO_2 , Partially stabilized and fully stabilized zirconia (PSZ & FSZ), Synthesis of stabilized ZrO_2 powder (with Y_2O_3 , CeO_2 etc.) from solution routes & its Characterization , Monodisperse spherical ZrO_2 powder

5. Magnesio aluminates Spinal: 4L

Synthesis of Magnesio aluminate hydrate (MAH) from solution route by using different precursor used, Seeding effect on crystallization and spnelisation, Magnasia rich and alumina rich spinel

6. Mullite, Silica Gel and Precipitated Silica: 4L
   Synthesis from different precursors in solution routes & their Characterization

7. Barium Titanate and Ferrite: 4L
   Temperature dependent structural stability of $BaTiO_3$, Normal and inverse spinel ferrites, Hexagonal ferrite and gernet ferrites, Synthesis from different precursors in solution routes & their Characterization. Pechini process and modified Pechini process, Co-precipitation techniques of Ni, Zn and Mn ferrite

Recommended readings

1. A Text-book of Geology – P.K. Mukherjee (1964). World Press, Kolkata. 539p.
2. Introduction to Physical Geology – A.K. Datta (1983). Kalyani Publishers, New Delhi. 261p.
3. A Text-book of Geology – G.B. Mahapatra (1997). CBS Publishers, New Delhi. 366p.
4. Rutley's Elements of Mineralogy (26th Edition) – H.H. Read (1970). Thomas Murby & Co. (George Allen & Unwin), London. 560p.
5. Manual of Mineralogy (21st Edition) – C. Clein & C.S. Hurlbut, Jr. (1993) [After, J.D. Dana]. John Wiley & Sons, New York. 692p.
6. Mineralogy (2nd Edition, First Indian Reprint) – L.G. Berry & B. Mason (1985). CBS Publishers, New Delhi. 561p.
7. An introduction to the rock-forming minerals (ELBS Edition) – W.A. Deer, R.A. Howie & J. Zussman (1978). English Language Book Society (ELBS) & Longman, London. 528p.
8. (In Bengali) *Kristalmurti vidya O Alokranto Mineral Vijnan* [English Translation: Morphologic Crystallography and Optical Mineralogy] – S. Ray (1974). W. Bengal State Book Board, Kolkata. 349p.
9. Ceramic Raw Materials (2nd Revised Edition) – W. E. Worrall (1982). Pergamon Press, Oxford. 111p.
10. Properties of Ceramic Raw Materials (2nd Edn. in SI/Metric Units) – W. Ryan (1978). Pergamon Press, Oxford. 113p.
11. Ceramic Raw Materials of India: A Directory – S.K Guha (Editor) (1982). Indian Institute of Ceramics, Kolkata. 202p.
12. Ceramic Powder preparation : A Hand Book, Dibyendu Gangully & Minati Chatterjee, Kluwer Academic Publishers
13. Sol-Gel Processing of Advanced Ceramics, Editor by F. D. Gnanam, Oxford & IBH Publishing Co. Pvt. Ltd. New Delhi
14. Advanced Technical Ceramics Edited by Shigeyuki Somiya

PRACTICAL

for 3rd semester.

Chemical Analysis of Ceramic Raw Materials & Products:
Paper Code – CT 391

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.
c) Quantitative analysis of Bauxite.
d) Analysis of Sea-Water Magnesia.
f) Analysis of Fireclay.
g). Analysis of Kyanite.
h) Determination of insoluble portion in Portland cement.
i) Determination of Free Lime content in Portland Cement.
k) Complete analysis of Portland Cement.

l) Analysis of Water Glass.
m) Analysis of Soda-lime – silica glass.
n) Analysis of Firebrick.
o) Rapid estimation of silica in glass sand and glass.
p) Quantitative analysis of Talc.
q) Quantitative analysis of Blast Furnace Slag.
r) Quantitative analysis of Fly Ash.

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-Powerpoint module.

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.

Phys. Characteristics of Ceramic Raw Materials: Credits = 2.
Paper Code- CT 392

a) Determination of percentage Moisture content of clay.
a) Determination of % Grit content of a clay.
a) Determination of Water of Plasticity of Clays.
d) Determination of Atterberg's Plasticity of clays.
e)) Measurement of Drying Shrinkage of clay.
f)) Measurement of Dry Strength of clays.
g) Measurement of Firing Shrinkage & firing colour of clays and feldspar.
h)) Determination of % Free iron content in Feldspar & Quartz powder.

i) Determination of Vitrification Range of Clays.
j) Determination of Water Absorption of Fired Ceramic Bodies.
k) Determination of particle size distribution by Sedigraph.

Fifth Semester
THEORY PAPERS

HU 501 (Economics for Engineers):

B. Tech in Ceramic Technology
West Bengal University of Technology

Contracts: 3L **Credits- 3**

Module-I

1. Economic Decisions Making – Overview, Problems, Role, Decision making process.
2. Engineering Costs & Estimation – Fixed, Variable, Marginal & Average Costs, Sunk Costs, Opportunity Costs, Recurring And Nonrecurring Costs, Incremental Costs, Cash Costs vs Book Costs, Life-Cycle Costs; Types Of Estimate, Estimating Models - Per-Unit Model, Segmenting Model, Cost Indexes, Power-Sizing Model, Improvement & Learning Curve, Benefits.

Module-II

3. Cash Flow, Interest and Equivalence: Cash Flow – Diagrams, Categories & Computation, Time Value of Money, Debt repayment, Nominal & Effective Interest.
4. Cash Flow & Rate Of Return Analysis – Calculations, Treatment of Salvage Value, Annual Cash Flow Analysis, Analysis Periods; Internal Rate Of Return, Calculating Rate of Return, Incremental Analysis; Best Alternative Choosing An Analysis Method, Future Worth Analysis, Benefit-Cost Ratio Analysis, Sensitivity And Breakeven Analysis. Economic Analysis In The Public Sector - Quantifying And Valuing Benefits & drawbacks.

Module-III

5. Inflation And Price Change – Definition, Effects, Causes, Price Change with Indexes, Types of Index, Composite vs Commodity Indexes, Use of Price Indexes In Engineering Economic Analysis, Cash Flows that inflate at different Rates.
6. Present Worth Analysis: End-Of-Year Convention, Viewpoint Of Economic Analysis Studies, Borrowed Money Viewpoint, Effect Of Inflation & Deflation, Taxes, Economic Criteria, Applying Present Worth Techniques, Multiple Alternatives.
7. Uncertainty In Future Events - Estimates and Their Use in Economic Analysis, Range Of Estimates, Probability, Joint Probability Distributions, Expected Value, Economic Decision Trees, Risk, Risk vs Return, Simulation, Real Options.

Module-IV

8. Depreciation - Basic Aspects, Deterioration & Obsolescence, Depreciation And Expenses, Types Of Property, Depreciation Calculation Fundamentals, Depreciation And Capital Allowance Methods, Straight-Line Depreciation Declining Balance Depreciation, Common Elements Of Tax Regulations For Depreciation And Capital Allowances.
9. Replacement Analysis - Replacement Analysis Decision Map, Minimum Cost Life of a New Asset, Marginal Cost, Minimum Cost Life Problems.
10. Accounting – Function, Balance Sheet, Income Statement, Financial Ratios Capital Transactions, Cost Accounting, Direct and Indirect Costs, Indirect Cost Allocation.

Readings

1. James L.Riggs,David D. Bedworth, Sabah U. Randhawa : Economics for Engineers 4e , Tata McGraw-Hill
2. Donald Newnan, Ted Eschembach, Jerome Lavelle : Engineering Economics Analysis, OUP
3. John A. White, Kenneth E.Case,David B.Pratt : Principle of Engineering Economic Analysis, John Wiley
4. Sullivan and Wicks: Engineering Economy, Pearson
5. R.Paneer Seelvan: Engineering Economics, PHI
6. Michael R Lindeburg : Engineering Economics Analysis, Professional Pub

CT 501 (Refractories Technology): **Credits = 3**

1. Introduction: Scope of Refractory Industry, Definition and classification of refractories. (2)
2. Binary phase diagrams related to refractory oxide systems eg. $Al_2O_3 – SiO_2$, $Al_2O_3 – MgO$, $MgO – Cr_2O_3$, $MgO – CaO$. (6)
3. Manufacturing, Properties and applications of the following refractories:

a) Silica Refractories: Super duty, Moderate heat duty and Low heat duty silica refractories. (2)

b) Alumino-silicate Refractories: Signifiance of Phase diagram in the development of different phases –High alumina refractories. (6)

c) Basic Refractories : Magnesite, dolomite, lime, Chemically bonded and Direct bonded refractories. (7)

d) Chromite and mullite refractories. (4)

e) Carbon bearing refractories – $MgO – C$ and $Al_2O_3 – MgO – C$ etc. (6)

f) Refractories for non-ferrous metallurgical industries like Al, Cu, Pb, Zn etc. (5)

4. Testing of important properties of refractories: A.P., B.D., Total Porosity, Sp. 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. (8)
5. Monolithic Refractories

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
5. Monolithic Refractories – Subrata Banerjee

CT 502 (Glass Science & Technology): **Credits = 3**

1. The non-crystalline solids & the glasses. Formation from liquid phase. Formation from a gaseous phase. Formation from a solid phase. Definition of glass. 2L
2. Rheological properties of glasses, Viscosity, Elastic & Visco-elastic properties of glasses.
3. Vitreous transition. Phenomenological study. Thermodynamic study. Theory of vitreous transition. Relaxation behaviour of glass in the transition interval. Determination of transition temperature. 05L
4. Conditions of vitrification. Structural theory (Zachariasen model etc.). Kinetic theory of glass (Nucleation & Growth). 04L
5. Structural models of glass. Reaction mechanisms. Ion exchange & network breakdown processes. Glass durability controlling factors. Improvement of durability. 04L
6. Thermodynamic basis of phase separation in glasses. Immiscibility in glasses. Spinodal decomposition.
7. Density & Thermal expansion measurements & their implications and their dependence on compositions. Thermal history effects. Effect of crystallization. Additive rule. 04L
8. Diffusion in Glasses. Electrical conductivity of glasses. Dielectric properties;
9. Thermal Properties of glasses, Specific heat, Thermal conductivity, Thermal expansion.
10. 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. 08
11. Batch calculation of the glass and determination of the oxide composition of the glass.

Reference:
1) Handbook of Glass Manufacture - F.V. Tooley
2) Glass Engineering Handbook – E. B. Shand.
3) Handbook of Glass Properties – G. W. Morey.
4) Handbook of Glasses – R. H. Doremus
5) Chemistry of Glasses - A. Paul
6) Inorganic Glass - Arun K. Varsheneya

CT 503 (Whitewares Technology): **Credits = 3**

1. Scope & Application of Whiteware product, Characteristics of Whiteware product, Earthenware, Stoneware, China & Porcelain 2L
2. Raw Materials used in Whiteware industry : Clay, Quartz, Feldspar, Wollastonite, Pyrophyllite, Talc, Bone ash, 3L
3. Body Preparation & Fabrication process: 5L
   Crushing and Grinding, Screening, Magnetic separation, Transport, Storage, Batching and body composition, Aging, Slip casting, properties of slip, plastic forming
4. Drying: 5L Types of water present, Factors affecting drying (internal & external factors), Different types of dryers and its operations & maintenance, sources of heat for drying & Drying schedule, Defects of dried body at green stage, its causes & remedies.
5. Glazing: 7L
   Purpose & advantages of glazing, Raw glazes, Fritted glazes, Semiconducting Glaze, Fusibility of glazes, Glaze Opacifiers, Stains, Colloidal colours, Different colouring oxides, Adherence and Flow properties of glaze slip, Glaze defects, Glazing techniques, Testing of glazes.
6. Firing: 5L Firing schedule of whiteware bodies, Reactions at different temperatures, Microstructure development and phase formation of porcelain bodies, Firing defects – causes & remedies, Different types of kilns and operation techniques.
7. Kiln Furniture: 4L

Characteristics, Different types of Kiln Furniture, Cordierite, SiC based Kiln Furniture, Silicon nitride bonded SiC kiln furniture, Low thermal mass Kiln car.

8. Production of the following whiteware bodies with process flowcharts, Body Composition & properties:
   (i) Electrical Porcelain 1L (ii) Wall & floor tiles 3L (iii) Sanitary wares 2L
   (iv) Spark plug Insulators 1L (v) Bone China 3L

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.

FREE ELECTIVE (One to be chosen from the following)

Operation Research
Code: IT504D **(CT 504A)**
Contact: 3L + 1T **Credits: 4**
Module I
Linear Programming Problems (LPP):
Basic LPP and Applications; Various Components of LP Problem Formulation.
Solution of Linear Programming Problems:
Solution of LPP: Using Simultaneous Equations and Graphical Method;
Definitions: Feasible Solution, Basic and non-basic Variables, Basic Feasible Solution, Degenerate and Non-degenerate Solution, Convex set and explanation with examples.
5L
Solution of LPP by Simplex Method; Charnes' Big-M Method; Duality Theory. Transportation Problems and Assignment Problems. **12L**
Module II
Network Analysis:
Shortest Path: Floyd Algorithm; Maximal Flow Problem (Ford-Fulkerson); PERT-CPM (Cost Analysis, Crashing, Resource Allocation excluded). **6L**
Inventory Control:
Introduction to EOQ Models of Deterministic and Probabilistic ; Safety Stock; Buffer Stock.
3L
Module III
Game Theory:
Introduction; 2-Person Zero-sum Game; Saddle Point; Mini-Max and Maxi-Min Theorems (statement only) and problems; Games without Saddle Point; Graphical Method; Principle of Dominance.
5L
Module IV
Queuing Theory:
Introduction; Basic Definitions and Notations; Axiomatic Derivation of the Arrival & Departure (Poisson Queue). Poisson Queue Models: (M/M/1): (∞ / FIFO) and (M/M/1: N / FIFO) and problems.
5L
Text Books:
1. H. A. Taha, "Operations Research", Pearson
2. P. M. Karak – "Linear Programming and Theory of Games", ABS Publishing House
3. Ghosh and Chakraborty, "Linear Programming and Theory of Games", Central Book Agency
4. Ravindran, Philips and Solberg - "Operations Research", WILEY INDIA
References:
1. Kanti Swaroop — "Operations Research", Sultan Chand & Sons
2. Rathindra P. Sen—"Operations Research: Algorithms and Applications", PHI
3. R. Panneerselvam - "Operations Research", PHI
4. A.M. Natarajan, P. Balasubramani and A. Tamilarasi - "Operations Research", Pearson
5. M. V. Durga Prasad – "Operations Research", CENGAGE Learning
6. J. K. Sharma - "Operations Research", Macmillan Publishing Company

Database Management System

B. Tech in Ceramic Technology
West Bengal University of Technology

Code: CS-601**(CT 504B)**
Contact: 3L+1T **Credits: 4**

Introduction [4L]
Concept & Overview of DBMS, Data Models, Database Languages, Database Administrator, Database Users, Three Schema architecture of DBMS.

Entity-Relationship Model [6L]
Basic concepts, Design Issues, Mapping Constraints, Keys, Entity-Relationship Diagram, Weak Entity Sets, Extended E-R features.

Relational Model [5L]
Structure of relational Databases, Relational Algebra, Relational Calculus, Extended Relational Algebra Operations, Views, Modifications Of the Database.

SQL and Integrity Constraints [8L]
Concept of DDL, DML, DCL. Basic Structure, Set operations, Aggregate Functions, Null Values, Domain Constraints, Referential Integrity Constraints, assertions, views, Nested Subqueries, Database security application development using SQL, Stored procedures and triggers.

Relational Database Design [9L]
Functional Dependency, Different anamolies in designing a Database., Normalization using funtional dependencies, Decomposition, Boyce-Codd Normal Form, 3NF, Nomalization using multi-valued depedencies, 4NF, 5NF

Internals of RDBMS [7L]
Physical data structures, Query optimization : join algorithm, statistics and cost bas optimization. Transaction processing, Concurrency control and Recovery Management : transaction model properties, state serializability, lock base protocols, two phase locking.

File Organization & Index Structures [6L]
File & Record Concept, Placing file records on Disk, Fixed and Variable sized Records, Types of Single-Level Index (primary, secondary, clustering), Multilevel Indexes, Dynamic Multilevel Indexes using B tree and B+ tree .

Text Books:
1. Henry F. Korth and Silberschatz Abraham, “Database System Concepts”, Mc.Graw Hill.
2. Elmasri Ramez and Novathe Shamkant, “Fundamentals of Database Systems”, Benjamin Cummings Publishing. Company.
3. Ramakrishnan: Database Management System , McGraw-Hill
4. Gray Jim and Reuter Address, “Transaction Processing : Concepts and Techniques”, Moragan Kauffman Publishers.
5. Jain: Advanced Database Management System CyberTech
6. Date C. J., “Introduction to Database Management”, Vol. I, II, III, Addison Wesley.
7. Ullman JD., “Principles of Database Systems”, Galgottia Publication.

Reference:
1. James Martin, “Principles of Database Management Systems”, 1985, Prentice Hall of India, New Delhi
2. “Fundamentals of Database Systems”, Ramez Elmasri, Shamkant B.Navathe, Addison Wesley Publishing Edition
3. “Database Management Systems”, Arun K.Majumdar, Pritimay Bhattacharya, Tata McGraw Hill

Object Oriented Programming
Code: CS504D **(CT 504C)**
Contact: 3L + 1T **Credits: 4**

Object oriented design [10 L]
Concepts of object oriented programming language, Major and minor elements, Object, Class, relationships among objects, aggregation, links, relationships among classes-association, aggregation, using, instantiation, meta-class, grouping constructs.

Object oriented concepts [4 L]
Difference between OOP and other conventional programming – advantages and disadvantages. Class, object, message passing, inheritance, encapsulation, polymorphism

Basic concepts of object oriented programming using Java [22 L]
Implementation of Object oriented concepts using Java.

Language features to be covered:

Class & Object proprieties [6L]
Basic concepts of java programming – advantages of java, byte-code & JVM, data types, access specifiers, operators, control statements & loops, array, creation of class, object, constructor, finalize and garbage collection, use of method overloading, this keyword, use of objects as parameter & methods returning objects, call by value & call by reference, static variables & methods, garbage collection, nested & inner classes, basic string handling concepts- String (discuss charAt() , compareTo(), equals(), equalsIgnoreCase(), indexOf(), length() , substring(), toCharArray() , toLowerCase(), toString(), toUpperCase() , trim() , valueOf() methods) & StringBuffer classes (discuss append(), capacity(), charAt(),

delete(), deleteCharAt(), ensureCapacity(), getChars(), indexOf(), insert(), length(), setCharAt(), setLength(), substring(), toString() methods), concept of mutable and immutable string, command line arguments, basics of I/O operations – keyboard input using BufferedReader & Scanner classes.

Reusability properties[6L] – Super class & subclasses including multilevel hierarchy, process of constructor calling in inheritance, use of super and final keywords with super() method, dynamic method dispatch, use of abstract classes & methods, interfaces.

Creation of packages, importing packages, member access for packages.

Exception handling & Multithreading [6L] – Exception handling basics, different types of exception classes, use of try & catch with throw, throws & finally, creation of user defined exception classes. Basics of multithreading, main thread, thread life cycle, creation of multiple threads, thread priorities, thread synchronization, interthread communication, deadlocks for threads, suspending & resuming threads.

Applet Programming (using swing) [4L] – Basics of applet programming, applet life cycle, difference between application & applet programming, parameter passing in applets, concept of delegation event model and listener, I/O in applets, use of repaint(),

getDocumentBase(), getCodeBase() methods, layout manager (basic concept), creation of buttons (JButton class only) & text fields.

Textbooks/References:

1. Rambaugh, James Michael, Blaha – "Object Oriented Modelling and Design" – Prentice Hall, India
2. Ali Bahrami – "Object Oriented System Development" – Mc Graw Hill
3. Patrick Naughton, Herbert Schildt – "The complete reference-Java2" – TMH
4. R.K Das – "Core Java For Beginners" – VIKAS PUBLISHING
5. Deitel and Deitel – "Java How to Program" – 6th Ed. – Pearson
6. Ivor Horton's Beginning Java 2 SDK – Wrox
7. E. Balagurusamy – " Programming With Java: A Primer" – 3rd Ed. – TMH

PRACTICAL PAPERS

CT–591: Refractories Lab: Credits = 2

a) Powder Preparation -- Crushing fireclay grog. Size separation of grog.
b) Determination of Packing Density of refractory raw materials
c) Fabrication of refractory bodies using best packed refractory raw materials.
c) Firing of refractory bodies at different temperatures
d) Study of effect of Composition, Forming pressure & Firing temperature on some properties of refractory bodies.
e) Testing of various important properties of refractories as per IS.
f) Refractory corrosion test.
g) Spalling Resistance Test (Thermal Shock Resistance) of refractory bodies.

CT–592: Glass Lab: Credits = 2

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) determination of Chemical durability of different types of glasses
h) Thermal shock test on glass wares.
i) Determination of density of glass.
j) Determination of strain in glass wares by polariscope.
k) Demonstration of cord viewers.

CT–593: Whitewares Lab: Credits = 2

a) Preparation of Whiteware Body >> Milling of raw materials, measurement of slip properties, green body preparation, slip casting/plastic forming/pressing.
b) Preparation of glazes & application of glaze on body, drying 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.

Free Elective (Any one of the following)
Operation Research Lab
CT- 594A (IT594D**), Contact: 3P, Credits: 2**
Software based lab using C /C++
1. Assignment on Tranportation problem.
2. Assignment on Assignment problem
3. Assignment on Duality
4. Assignment on Simplex method (Including Charns' Big-M Method)
5. Assignment on Shortest Path by using Dijkstra's or Floyd's Algorithm
6. Assignment on Maximal Flow Problem (Ford-Fulkerson Method).
7. Assignment on PERT/CPM
8. Familiarization with O.R package: TORA

Database Management System Lab
Code: CS691 **(CT 594B)**
Contact: 3P, Credits: 2
Structured Query Language
1. **Creating Database**
□□Creating a Database
□□Creating a Table
□□Specifying Relational Data Types
□□Specifying Constraints
□□Creating Indexes
2. **Table and Record Handling**
a. INSERT statement
b. Using SELECT and INSERT together
c. DELETE, UPDATE, TRUNCATE statements
d. DROP, ALTER statements
3. **Retrieving Data from a Database**
□□The SELECT statement
□□Using the WHERE clause
□□Using Logical Operators in the WHERE clause
□□Using IN, BETWEEN, LIKE, ORDER BY, GROUP BY and HAVING
Clause
□□Using Aggregate Functions
□□Combining Tables Using JOINS
□□Subqueries
4. **Database Management**
□□Creating Views
□□Creating Column Aliases
□□Creating Database Users
□□Using GRANT and REVOKE
Cursors in Oracle PL / SQL
Writing Oracle PL / SQL Stored Procedures

OOP Lab
Code: CS594D **(CT 594C)**
Contact: 3P Credits: 2
1. Assignments on class, constructor, overloading, inheritance, overriding
2. Assignments on wrapper class, arrays
3. Assignments on developing interfaces- multiple inheritance, extending interfaces
4. Assignments on creating and accessing packages

5. Assignments on multithreaded programming
6. Assignments on applet programming

Note: Use Java for programming

Preferably download "**java_ee_sdk-6u4-jdk7-windows.exe**" from
http://www.oracle.com/technetwork/java/javaee/downloads/java-ee-sdk-6u3-jdk-7u1-downloads-523391.html

Sixth Semester

CT 601 Cement & Concrete Technology Credits = 3.

1. Pozzolana Cement:
Definition, classifications, Pozzolanic activity and its influencing factors, Lime – Pozzolana reaction and products fomation, Applications. 2L

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. 10L 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, sorel cement, Blended Cement, Macro defect Free (MDF) Cement, Sur – Sulphated Cement, Refractory Cement, Cement paints. 6L

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 , 6L

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 and uses. 8L

6. Concrete:
Introduction,Gap Grade concrete, continuous grade concrete, light, normal and heavy concrete, properties of concrete, installation technique of concrete, uses of various concretes. 8L

Books:

a) Chemistry of cement by F.M. Lea
b) Cement Chemistry by F.W. H. Taylor
c) High Alumina Cement by T. D. Robson
d) Concrete Technology by Neville.

CT - 602: Engineering Materials Science: Credits = 3

1. Structure of solids: Introduction – Atomic bonding – ionic, covalent, metallic, Van der Waals; Crystal structure, Lattice planes and directions.
2. Lattice imperfections – point defects, line defects, plane defects etc.
3. Practical determination of Structure: Introduction, Theoretical and Practical X-ray diffraction – Powder technique, other applications.
4. Mechanical Properties: Introduction, Deformation by slip. Plastic deformation. Slip by dislocation movement, Cottrell's views, Shear strain rate, Peierl's stress, Critical Resolved Shear Stress for Slip, Twinning deformation,
5. Fracture behaviour. Brittle & ductile fracture, Brittle fracture & crack propagation, Griffith's theory. Modifications. Critical Stress Intensity Factor, Fracture Toughness etc.
6. Strengthening Mechanisms > General concepts, Cold working, Yield point, Yield stress, Strain (Work) hardening, Solid solution strengthening, Strengthening by grain boundaries, Second phase strengthening, Dispersion hardening, Precipitation or age hardening.
7. 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).
8. 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.
9. Corrosion & its prevention: Galvanic theory, half cell potentials. Electrochemical corrosion, Corrosion rate, Types of corrosion, Corrosion prevention methods. Corrosion polarization & Passivation. High temperature corrosion: Oxidation of metals, Pilling – Bed worth Ratio, Oxidation kinetics.

10. Electrical Properties: Electrical conduction in materials, Electron mobility, Drift velocity, Relaxation time, Electrical resistivity, Energy band model: Insulators, Conductors, Semiconductors, Band 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 & extrinsic semiconductors.

Books: 1) Principles of Mat. Sc. & Engg. – Smith
2) Introduction to Ceramics – W. D. Kingery
3) Physical Props. of Materials - Lovell, Avery, Vernon
4) Materials Science – Callister

CT–603: Ceramic Coatings & Process Calculations Credits = 4

A. Ceramic Coatings

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.

B. Process Calculations

A) Materials Balance :
1. Combustion Calculations : Liquid and Gaseous Fuels, Excess Air, Flue Gas Volume etc.
2.Evaporator & Dryer : Weak liquor, Strong Liquor, Evaporated vapor
3.Calculation on processes with or without Chemical Changes
B) Energy Balance >
1.Calculations on Heat capacities, Mean heat capacity, Heat of Formation, Heat of Reaction, Heat of solution and vapourisation.
2. Energy balance for various Reacting and non-Reacting systems.
C) Material Balance for Ceramic Process >
Introduction to Glaze, Glass calculations, viz. Batch recipe, Molecular formulae and other elementary problems.

References :

1) Industrial Stoichiometry – Lewis, Radasch & Lewis.
2) Chemical Process Principles - Hougen & Wattson.
3) Calculation in Ceramics – R. Griffithies.
4) Basic Principles and Calculations in Chemical Engineering – D.M.Himmelblau

CT – 604: Metallurgy: Credits = 3

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.

ELECTIVE
CT 605A Instrumentation **Credits = 3**

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 .
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]

References :-
1) Principles of Industrial Instrumentation - D. Patranabis. Tata Mcgraw Hill (2nd Ed).
2) Industrial Instrumentation Fundamentals - Fribance. Mcgraw Hill.
3) Process Instrument and Control Handbook - Considine & Considine. Mcgraw Hill.

ELECTIVE
CT 605B Process Control **Credits = 3**

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 .
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) Process System Analysis & Control - Coughnour. Mcgraw Hill (2nd Ed).
2) Chemical Process Control - Stephanopoulos. Prentice Hall India.
3)Process Instrument and Control Handbook - Considine & Considine. Mcgraw Hill.

PRACTICALS:

CT 691 Cement & Concrete Lab: Credits = 2

a) Tests like Consistency of cement, Initial Setting time, Final Setting Time, 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.

CT 692 Material Characterization Lab (B. Tech.) Credit = 2

1. **General techniques of characterization of Nano and Micron ceramic materials**: Scope and Application.

2. **Particle size Analysis :** (Nano and Micron) Theory of working principle, Case study of ceramic materials

3. **FTIR spectroscopic Analysis :** Theory of working principle, Case study of ceramic materials

4. **Phase Analysis by XRD :** Theory of working principle, Case study of ceramic materials

5. **Crystallite Size Determination by XRD techniques:** Theory of working principle, Case study of ceramic materials

6. **Micro structural Analysis by SEM / TEM :** Theory of working principle, Case study of ceramic materials

CT–693: Metal & 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.

CT 681 Seminar Credit = 2

Topics & contents decided by the concerned teacher

Theory: 7th Semester, B. Tech. In Ceramic Technology

CT-701: Advanced Ceramics: Credits = 3

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, Gas turbine blades, Abrasives, Aerospace, 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: 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.

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.

f) Sensors > Oxygen Sensors, Principles of operation, Solid electrolyte sensors, Semiconductor sensors, Thermistors and related sensors.

g) Magnetic Ceramics: Spinel Ferrites, Hexagonal Ferrites, Garnet, Processing, Single crystal ferrite, Applications.
Critical parameters, Powder synthesis,

h) Nano Ceramics: Different Compositions, Synthesis, Applications.

i) Ceramic Membranes.

j) Brief introduction of non – oxide ceramics, difference between oxide and non-oxide ceramics regarding bonding

k) Carbides – Boron carbide, Silicon carbide, Titanium carbide, Zirconium carbide, Tungsten carbide, Hafnium carbide – their methods of preparation, bonding / structure, properties and applications both in refractory and advanced application.

l) Nitrides:- Boron nitride, Silicon nitride, Aluminium nitride, Uranium nitride – Their fabrication/ preparation methods, structure, properties and application both as refractory and advanced ceramics

m) Graphite – Fabrication, structure, properties and applications

n) Borides – Fabrication, Structure, properties and applications

o) Silicides – Fabrication, Structure, properties and applications

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,
8) Introduction to Technical ceramics by B. E. Waye.
9) Ceramics for Advanced Technologies by J. E. Hove.
10) Encyclopedia of Chemical Technology Kirk Othmer.

CT – 702: Physical Ceramics: Credits = 3

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.

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

k) 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.

l) 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
4) Principles of Materials Science & Engineering - Smith
5) Handbook of Ceramics - Editor S.

CT-703 Monolithic Refractories Credits: 3

a) Introduction of Refractories and Monolithic Refractories/Castable Refractories, Shaped and Unshaped Refractories — Advantages and Disadvantages of Monolithic/Castable Refractories, Classification of Unshaped Refractories.
b) Aggregates used in monoliths/Castables Refractories.
c) Refractory cement and other additives, Additives for ramming and gunning materials.
d) Refractory Cement,Morters,Concrete,RammingMass,Fettling, Gunning Mass, Spray Mass.
e) Type of bonding in Castable Refractories e.g. Hydraulic Bonding, Chemical Bonding and Quagulation Bonding
f) Classification of Castables: Conventional Castables, Low cement Castables, Ultra low cement castables, No or zero cement Castables, Gel bonded and self floor castables, Silica free and basic castables, Nano material incorporated Castables.
g) Carbon Bonded Refractory Castables,
h) Manufacture of Castables/Monoliths, Installation techniques, Applications.
i) Different areas of application of Monolithics/ Castable Refractories.

Reference Books:-
1. Recent Trend in Refractory Monolithics by Dr. Subrata Banerjee.
2. Refractories Hand Book Edited by Charles A. Schacht.

CT-704A Nano Technology Credits: 3

1. Introduction of Nano scale and Micron scale materials in nature, Idea on Nano technology in different branches, Application of NSM, Theories of formation of NSM and future challenge. 3L

2. Quantum Mechanics: Application of Quantum mechanics in Nano structured materials, Electronic behavior and Nano material behavior, Wave particle duality, Schrodinger wave equation and its solution, Eigen value and Eigen function, Operator, particle in 3D box and Well, Linear harmonic oscillator 6L

3. Physical and Chemical route for preparation of NSM : Milling, Physical vapour deposition, Chemical vapour deposition, Sol-Gel method, Combustion techniques, Precipitation and Co-precipitation techniques. 6L

4. Synthesis and characterization of Nano-ceramic materials (a) Nano Al_2O_3 (b) Nano SiO_2 (c) Nano ZrO_2 (d) Nano $BaTiO_3$ (e) Nano Ferrite (MFe_2O_4 , M = Ni, Cu, Zn, Co etc.) (f) Nano TiO_2 10L

5. Properties and Characterization of Nano structured materials: (a) X-ray diffraction (Crystallite size and strain, Williamson-Hall plot, lattice parameter) (b) Particle size (c) Scanning electron microscope and Transmission electron microscope. 6L

Recommended Books & Journals:
1. Hand Book of Nano Structure materials & Nano Technology edited by Hari singh Nalwa.
2. Nano Materials edited by H. Hosona, Y. Mishima,H. Takezoe & K.J.D. Makenzie
3. Nano powder to Functional Materials edited by Radu Robert Piticescu, W. Lojkowski & J.R. Blizzard.
4. Journal of Sol-Gel Science and Technology

CT-704B Composite: Credits: 3

Definition, Historical Background, Classification and applications

Mechanical behaviour and failure of materials

Strengthening and reinforcing – Analyses and prediction of strength of composites

Fibre reinforcement – Fibre and matrix types.

Brittle matrix composites, Inorganic matrix composites, CMC, MMC, Polymer matrix composites

Characterization and analyses of composite interfaces

Composite Fabrication

Books, proceedings etc.

1. Mechanical behaviour of ceramics- R.W.Davidge
2. Concise encyclopedia of composite Materials – Anthony Kelly Ed. Pergaurdn Pr.
3. Proc. Am. Ceram. For composites – 1986 onwards
4. High performance fibre composites – Morley (Acad press)

CT-705A **Quality Management** **Credits = 3**

SL. NO.	TOPIC	No. of Lecture
1	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.	7
2	Statistical Process Control >> Definition, Chance causes, Assignable causes, Difference between two causes along with practical application	2
3	Cost of Quality >> Elements of quality cost, Assessing cost of quality, Cost of appraisal, Prevention & failure cost, Optimum cost of quality control	3
4	ISO - 9001 Quality System - Introduction, Definition of ISO, Its development. Clauses of ISO - 9001 quality system.Benefits of ISO - 9000 quality system, ISO-14001 ENV. Mgt. System, ISO 18001 OHSAS, SA 8001	4
5	Cause & effect diagram, Control charts, Pareto diagram, Histogram, Brain storming, PDCA cycle, Gantt Chart, Kaizen,TPM, 5S	8
6	Process Capability Study - Definition, Needs of process capability study, Derivation of standard deviation, Concept of USL & LSL, Accuracy & precision, Calculation of Cp & Cpk indices, Implication of Cp & Cpk on process control.	4
7	Six sigma- Concept, Definition, Process, Methodology, benefits	5

References:

1. TQM and ISO-14000 – Dr. K. C. Arora.
2. Introduction to Statistical Quality Control – Douglas C. Montgomery
3. Statistical Methods for Six sigma in R&D and manufacturing- Anand M. Joglekar.
4. Quality Control and Application – Bertrand L. Hansen, Prabhakar M. Ghare

Theory: 8th Semester B. Tech. in Ceramic Technology

Organisational Behaviour

HU801A

Contracts: 2L

Credits- 2

1. Organizational Behaviour: Definition, Importance, Historical Background, Fundamental Concepts of OB, Challenges and Opportunities for OB. **[2]**
2. Personality and Attitudes: Meaning of personality, Personality Determinants and Traits, Development of Personality, Types of Attitudes, Job Satisfaction. **[2]**
3. Perception: Definition, Nature and Importance, Factors influencing Perception, Perceptual Selectivity, Link between Perception and Decision Making. **[2]**
4. Motivation: Definition, Theories of Motivation - Maslow's Hierarchy of Needs Theory, McGregor's Theory X & Y, Herzberg's Motivation-Hygiene Theory, Alderfer's ERG Theory, McClelland's Theory of Needs, Vroom's Expectancy Theory. **[4]**
5. Group Behaviour: Characteristics of Group, Types of Groups, Stages of Group Development, Group Decision Making. **[2]**
6. Communication: Communication Process, Direction of Communication, Barriers to Effective Communication. **[2]**
7. Leadership: Definition, Importance, Theories of Leadership Styles. **[2]**
8. Organizational Politics: Definition, Factors contributing to Political Behaviour. **[2]**
9. Conflict Management: Traditional vis-a-vis Modern View of Conflict, Functional and Dysfunctional Conflict, Conflict Process, Negotiation – Bargaining Strategies, Negotiation Process. **[2]**
10. Organizational Design: Various Organizational Structures and their Effects on Human Behaviour, Concepts of Organizational Climate and Organizational Culture. **[4]**

References:

1. Robbins, S. P. & Judge, T.A.: Organizational Behavior, Pearson Education, 15th Edn.
2. Luthans, Fred: Organizational Behavior, McGraw Hill, 12th Edn.
3. Shukla, Madhukar: Understanding Organizations – Organizational Theory & Practice in India, PHI
4. Fincham, R. & Rhodes, P.: Principles of Organizational Behaviour, OUP, 4th Edn.
5. Hersey, P., Blanchard, K.H., Johnson, D.E.- Management of Organizational Behavior Leading Human Resources, PHI, 10th Edn.

Or

Project Management

HU801B

Contracts: 2L

Credits- 2

1. Project Management Concepts: Concept and Characteristics of a Project, Importance of Project Management.**[1]**
2. Project Planning: Project Evaluation, Financial Sources, Feasibility Studies. **[4]**
3. Project Scheduling: Importance of Project Scheduling, Work Breakdown Structure and Organization Breakdown Structure, Scheduling Techniques – Gantt Chart and LOB, Network Analysis – CPM/PERT. **[6]**
4. Time Cost Trade-off Analysis – Optimum Project Duration. **[2]**
5. Resource Allocation and Leveling. **[2]**
6. Project Life Cycle. **[2]**
7. Project Cost – Capital & Operating Costs, Project Life Cycle Costing, Project Cost Reduction Methods. **[2]**

8. Project Quality Management: Concept of Project Quality, TQM in Projects, Project Audit. **[1]**
9. Software Project Charateristics and Mangement **[2]**
10. IT in Projects: Overview of types of Softwares for Projects, Major Features of Project Management Softwares like MS Project, Criterion for Software Selection. **[2]**

References

1. Gopalkrishnan P. and Rama Mmoorthy: Text Book of Project Management, Macmillan
2. Nicholas John M.: Project Management for Business and Technology – Principles and Practice, Prentice Hall India, 2nd Edn.
3. Levy Ferdinand K., Wiest Jerome D.: A Management Guide to PERT/CPM with GERT/PDM/DCPM and other networks, Prentice Hall India, 2nd Edn.
4. Mantel Jr., Meredith J. R., Shafer S. M., Sutton M. M., Gopalan M. R.: Project Management: Core Text Book, Wiley India, 1st Indian Edn.
5. Maylor H.: Project Management, Pearson, 3rd Edn.
6. Nagarajan K.: Project Management, New Age International Publishers, 5th Edn.
7. Kelkar. S.A, Sotware Project Management: A concise Study, 2nd Ed., PHI

Prof. Elective
CT-801A **Bio- Ceramics** **Credits: 3**

I. Need for bio ceramics
II. Physiology of human bones
III. Stress distribution on some important joints of the human body
IV. Types of bio ceramics – tissue attachment
V. Types of bio ceramic materials:
   (a) Almost inert crystalline bio ceramics
   (b) Porous Bio Ceramics
   (c) Bioactive Glasses & Glass – Ceramics
   (d) Bio Ceramic Coatings
VI. Interfacial Reaction Kinetics
VII. Relation of surface kinetics to the rate bone bonding
VIII. Present uses pf bio ceramics
IX. Processing of bio ceramic materials and their characterization

Reference:

Bio Ceramics – Material, Properties, Applications

A. Ravaglili & A. Krajewski , Chapman & Hall

CT-801B **Electrical and Electronics Ceramics:** **Credits: 3**

Dielectric Properties: Dielectric constant and loss, Dielectric strength and break down voltage, Ceramic insulators.

Ferro electric Ceramics: Crystal structure, perovskite structure, barium titanate – hysteresis and Curie Point. Effect of isovalent and hetero valent doping. Vacancy and non stoichiometry doped Barium titanate as semiconductor. Role of grain boundary. Potential barriers as grain boundary. Interfacial polarization, Effect of grain size.

Ceramic Capacitors – Barium titanate based capacitors, High dielectric constant and losses, ageing, single and multilayered capacitors.

Piezoelectric properties of ceramics:

Sensors- NTC and PTC effects, Barium titanate based thermistors, role of grain boundary and doping, electroding, Semiconducting gas sensors

Solid electrolytes – SOFC.

Free Elective:

CT-802A Energy Management Credits: 3

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

CT-802B Environment Management Credits: 3

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 Modeling
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).