Curriculum for B.Tech. in Ceramic Technology

(Applicable from the academic session 2018-2019)

(Department of Ceramic Technology)

Government College of Engineering & Ceramic Technology

73, A.C Banerjee Lane

Kolkata-700010

Definition of Credit:

1 Hr. Lecture (L) per week	1 credit
1 Hr. Tutorial (T) per week	1 credit
1 Hr. Practical (P) per week	0.5 credits

MOOCs for B. Tech Honours:

Additional 20 credits are to be acquired through MOOCs for obtaining B. Tech. with Honours.

Guidelines for completing MOOCs (Courses of 8-12 weeks' duration): -

In 1st year: 8 credits

In 2nd year: 4 credits

In 3rd year: 4 credits

In 4th year: 4 credits

In the first year of study, students have to earn a total of 8 credit points, taking ONE course from Science and Engineering Group and ONE course from Humanities Group.

For the subsequent three years of study, students have to earn a total of 12 credit points by successfully completing one course in each year of study.

FIRST YEAR FIRST SEMESTER

1st Semester B. Tech Ceramic Technology							
Sl. No.	Type of course	Course Code	Course Title	Hours per week			Credits
				Lecture	Tutorial	Practical	
Theory							
1	Basic Science course	BS(CT) 101	Mathematics – I	3	1	0	4
2	Basic Science course	BS(CT) 102	Chemistry	3	0	0	3
3	Basic Science course	ES(CT) 101	Programming for Problem solving	3	0	0	3
Sessional/Practical							
1	Basic Science course	BSL(CT) 103	Chemistry Lab	0	0	3	1.5
2	Engineering Science Course	ESL(CT) 102	Programming for Problem solving Lab	0	0	4	2
3	Engineering Science Course	ESL(CT) 102	Engineering Graphics & Design	1	0	4	3
4		CLA(CT)-1	Comprehensive Laboratory Assessment	-	-	-	1
				Total credits			**17.5**

The course teacher shall assess the students for Serial Nos. 1, 2, 3 under Sessional/Practical before commencement of Semester End Examination. A student has to secure at least 50% marks in Serial Nos. 1, 2, 3 under Sessional/Practical, failing which the student would be debarred from sitting in the Semester End Examination.

A student has to secure at least 50% marks in rest of the courses (Theory papers and CLA), failing which he/she would carry backlog(s).

Name of the course		**MATHEMATICS I**	
Course Code: BS(CT) 101		**Semester: 1st**	
Duration: 6 months		**Maximum Marks: 100**	
Teaching Scheme		**Examination Scheme**	
Theory: 3 hrs./week		Mid Term Exam I: 15 Marks	
Tutorial: 1		Mid Term Exam II: 15 Marks	
Practical: 0		Assignment & Quiz etc.: 20 Marks	
Credit Points: 4		Semester End Exam: 75 Marks (Two third weightage for final reckoning i.e., 50 marks)	
Objective:			
1.	To learn evaluation techniques of evolute, involute and can use concept of improper integrals.		
2.	To explain the meaning of Mean value theorem, Rolle's theorem and can recognize when to apply L'Hospital rule.		
3.	To Understand the definitions of limits and convergence in the context of sequences and series of real numbers.		
4.	To understand multivariate calculus, Divergence and curl which is used in many fields of natural and social science and engineering.		
5.	To identify a critical point as a local maximum, local minimum or a saddle point for a function of two variable		
6.	To learn the concept of eigen values, eigen vectors, diagonalisation of matrices for understanding engineering problems.		
Pre-Requisite			
1.	Class 12th standard knowledge of Mathematics		
Module	**Content**	**Hours**	**Marks.**
1	***Calculus (Integration):*** Evolutes and involutes; Evaluation of definite and improper integrals; Beta and Gamma functions and their properties; Applications of definite integrals to evaluate surface areas and volumes of revolutions.	8	
2	***Calculus (Differentiation):*** Rolle's Theorem, Mean value theorems, Taylor's and Maclaurin's theorems with remainders; Indeterminate forms and L'Hospital's rule; Maxima and minima.	6	
3	***Sequence and Series:*** Convergence of sequence and series, tests for convergence; Power	11	

	series, Taylor's series, series for exponential, trigonometric and logarithm functions; Fourier series: Half range sine and cosine series, Parseval's theorem.		
4	***Multivariate Calculus:*** Limit, continuity and partial derivatives, Directional derivatives, Total derivative; Tangent plane and normal line; Maxima, minima and saddle points; Method of Lagrange multipliers; Gradient, Curl and Divergence.	9	
5	***Matrices:*** Inverse and rank of a matrix, Rank-nullity theorem; System of linear equations; Symmetric, Skew-symmetric and Orthogonal matrices; Determinants; Eigenvalues and Eigenvectors; Diagonalization of matrices; Cayley-Hamilton Theorem, and Orthogonal transformation.	8	

Course outcomes	
After completion of the course, a student would be able to:	
CO 1	apply the concept and techniques of differential and integral calculus to determine curvature and evaluation of different types of improper integrals.
CO 2	relate the domain of applications of mean value theorems to engineering problems.
CO 3	apply the tools of power series and Fourier series to analyze engineering problems and the concept of convergence of infinite series in many approximation techniques in engineering disciplines.
CO 4	apply the knowledge for solving the real-life problems by using several variables and extremum points.
CO 5	analyze different types of matrices, their eigen values, eigen vectors, rank and also their orthogonal transformations which are essential for understanding physical and engineering problems.
Learning Resources:	
1.	Erwin Kreyszig, Advanced Engineering Mathematics, John Wiley & Sons.
2.	Michael Greenberg, Advanced Engineering Mathematics, Pearson.
3.	B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers.
4.	Kanti B. Dutta, Mathematical Methods of Science and Engineering, Cenage Learning.
5.	Veerarajan T., Engineering Mathematics for first year, Tata McGraw-Hill, New Delhi.

<table>
<tr><td colspan="2">Name of the course</td><td colspan="2">Chemistry</td></tr>
<tr><td colspan="2">Course Code: BS(CT) 102</td><td colspan="2">Semester: 1st</td></tr>
<tr><td colspan="2">Duration: 6 months</td><td colspan="2">Maximum Marks: 100</td></tr>
<tr><td colspan="2">Teaching Scheme</td><td colspan="2">Examination Scheme</td></tr>
<tr><td colspan="2">Theory: 3 hrs./week</td><td colspan="2">Mid Term Exam I: 15 Marks</td></tr>
<tr><td colspan="2">Tutorial: Nil</td><td colspan="2">Mid Term Exam II: 15 Marks</td></tr>
<tr><td colspan="2">Practical: Nil</td><td colspan="2">Assignment & Quiz etc.: 20 Marks</td></tr>
<tr><td colspan="2">Credit Points: 3</td><td colspan="2">Semester End Exam: 75 Marks (Two third weightage for final reckoning i.e., 50 marks)</td></tr>
<tr><td colspan="4">Objective:</td></tr>
<tr><td>1.</td><td colspan="3">The objective of the course is to provide an exposure to the atomic bonding, atomic and crystal structure, crystalline defects and various properties of chemistry.</td></tr>
<tr><td>2.</td><td colspan="3">This course also provides an understanding of practical problem-solving techniques for the chapters covered in the course.</td></tr>
<tr><td colspan="4">Pre-Requisite</td></tr>
<tr><td>1.</td><td colspan="3">This course also provides an understanding of practical problem-solving techniques for the chapters covered in the course.</td></tr>
<tr><td>Module</td><td>Content</td><td>Hours</td><td>Marks.</td></tr>
<tr><td>1</td><td>Chemical bonding in molecules

MO theory, Structure, bonding and energy levels of bonding and shapes of many atom molecules,

Chemistry of coordination compounds reactivity and stability: Determination of configuration of cis- and trans- isomers by chemical methods. Labile and inert complexes, substitution reaction on square planer complexes, trans effect (example and applications). Structure and bonding: VB description and its limitations.

Elementary Crystal Field Theory: Splitting of d^n configurations in octahedral, square planar and tetrahedral fields, crystal field stabilization energy in weak and strong fields; pairing energy. JahnTeller distortion.</td><td>6</td><td></td></tr>
<tr><td>2</td><td>Spectroscopic techniques and applications

Principles of spectroscopy and selection rules. Electronic spectroscopy. Fluorescence and its applications in medicine. Vibrational and rotational spectroscopy of diatomic molecules. Applications. Nuclear magnetic resonance and magnetic resonance imaging, surface characterization techniques. Diffraction and scattering. d-d transitions; selection rules for electronic spectral transitions; spectrochemical series of ligands; charge</td><td>2</td><td></td></tr>
</table>

	transfer spectra (elementary idea).		
3	**Periodic properties** Effective nuclear charge, penetration of orbitals, variations of s, p, d and f orbital energies of atoms in the periodic table, electronic configurations, atomic and ionic sizes, ionization energies, electron affinity and electronegativity, polarizability, oxidation states, coordination numbers and geometries, hard soft acids and bases, molecular geometries.	4	
4	**Chemical Thermodynamics** Concept of Thermodynamic system: Definition with example of diathermal wall, adiabatic wall, isolated system, closed system, open system, extensive property, intensive property. Introduction to first law of thermodynamics: different statements, mathematical form. Internal energy: Definition, Example, Characteristics, Physical significance, Mathematical expression for change in internal Energy, Expression for change in internal energy for ideal gas. Enthalpy: Definition, Characteristics, Physical significance, Mathematical expression for change in Enthalpy, Expression for change in enthalpy for ideal gas. Heat Capacity: Definition, Classification of Heat Capacity (Cp and C_V): Definition and General expression of Cp - C_V. Expression of Cp - C_V for ideal gas. Reversible and Irreversible processes: Definition, Work done in Isothermal Reversible and Isothermal Irreversible process for Ideal gas, Adiabatic changes: Work done in adiabatic process, Interrelation between thermodynamic parameters (P, V and T), slope of P-V curve in adiabatic and isothermal process. Application of first law of thermodynamics to chemical processes: exothermic, endothermic processes, law of Lavoisier and Laplace, Hess's law of constant heat summation, Kirchoff's law. 2^{nd} law of thermodynamics: Statement, Mathematical form of 2nd law of thermodynamics (Carnot cycle). Joule Thomson and throttling processes; Joule Thomson coefficient for Ideal gas, Concept of inversion temperature. Evaluation of entropy: characteristics and expression, entropy change in irreversible cyclic process, entropy change for irreversible isothermal expansion of an ideal gas, entropy change of a mixture of gases. Work function and free energy: Definition, characteristics, physical significance, mathematical expression of ΔA and ΔG for ideal gas, Maxwell's Expression (only the derivation of 4 different forms), Gibbs Helmholtz equation. Condition of spontaneity and equilibrium reaction.	6	
5	**Surface and Colloid Chemistry** Adsorption, absorption and sorption, Physical and Chemisorption, Langmuir and Freundlich isotherm, Multilayer adsorption, BET isotherm and its application to surface area measurement, Sols (reversible and irreversible), emulsion and emulsifier, micelle, gels,	3	

	application of colloids, qualitative idea of electro-kinetic phenomena, Zeta potential.		
6	**Solid state Chemistry** Introduction to stoichiometric defects (Schottky & Frenkel) and non – stoichiometric defects (Metal excess and metal deficiency). Role of silicon and germanium in the field of semiconductor.	3	
7	**Stereochemistry** Representations of 3 dimensional structures, structural isomers and stereoisomers, configurations and symmetry and chirality, enantiomers, diastereomers, optical activity, absolute configurations and conformational analysis. Isomerism in transitional metal compounds	6	
8	**Organic reactions and synthesis of a drug molecule** Introduction to reactions involving substitution, addition, elimination, oxidation, reduction, cyclization and ring openings. Synthesis of a commonly used drug molecule.	6	

Course outcomes	
After completion of the course, a student would be able to:	
CO 1	describe various types of bonding and connectivity in a molecular system.
CO 2	use various tools to analyze different linkages present in a molecular system to determine exact structure of a molecule.
CO 3	estimate the energy change of a chemical reaction using thermodynamic parameters.
CO 4	apply knowledge of surface phenomena and colloidal properties of solids in assessing particulate behaviour.
CO 5	identify different imperfections in solids based on understanding of the ideal crystal structures.
CO 6	Identify three-dimensional structures of different isomeric molecules and their participation in different chemical reactions like addition, substitution, elimination reaction etc.
Learning Resources:	
1.	P. C. Rakshit, Physical Chemistry, Sarat Book House (7th Edition).
2.	S. Glasston, Text Book of Physical Chemistry, Macmillan India Limited.
3.	S. Pahari, Physical Chemistry, New Central Book Agency.
4.	R. P. Sarkar, Inorganic Chemistry (Vol-1 & II)
5.	J.D .Lee, Concise Inorganic Chemistry(5th Edition) Chapman & Hall
6	I. L. Finar,(Vol-I) Organic Chemistry, Addison Wesley Longman, Inc.
7	Physical Chemistry, Atkins, 6th Edition, Oxford Publishers.
8	Organic Chemistry,G Mark Loudon, 4th Edition, Oxford Publishers.

9	Basic Stereochemistry of Organic Molecules, Subrata Sengupta, Book syndicate Pvt. Ltd.

Name of the course		**PROGRAMMING FOR PROBLEM SOLVING**	
Course Code: ES(CT)101		**Semester: 1st**	
Duration: 6 months		**Maximum Marks: 100**	
Teaching Scheme		**Examination Scheme**	
Theory: 3 hrs./week		Mid Term Exam I: 15 Marks	
Tutorial: Nil		Mid Term Exam II: 15 Marks	
Practical: Nil		Assignment & Quiz etc.: 20 Marks	
Credit Points: 3		Semester End Exam: 75 Marks (Two third weightage for final reckoning i.e., 50 marks)	
Objective:			
1.	To understand the various steps in Program development and basic concepts in C Programming Language.		
2.	To learn how to write modular and readable C Programs in C to solve problems.		
Pre-Requisite			
1.	Basic fundamental knowledge of Mathematics.		
2.	Knowledge of arithmetic and logical reasoning		
Module	**Content**	**Hours**	**Marks.**
1.	**Introduction to Computing** Computer Systems-Hardware and Software, Different components, Computer Languages, Algorithm, Flowchart, Representation of Algorithm and Flowchart with examples.	4	
2.	**Introduction to C** History of C, Features of C, Structure of C Program, Character Set, C Tokens-Keywords, Identifiers, Constants, Variables, Data types, Operators.	4	
3.	**Statements** Selection statements (Decision Making)- if and switch statements with examples, Repetition statements (loops)- while, for, do-while statements with examples, Unconditional statements- break, continue, goto statements with examples.	4	
4.	**Arrays** Declaration and Initialization, One dimensional Arrays, Two dimensional Arrays, Searching, Basic Sorting Algorithms.	4	
5.	**Strings** Declaration and Initialization, String Input / Output functions, String manipulation functions.	4	

6.	**Function** Designing Structured Programs, Types of Functions-User defined functions, Standard functions, Categories of functions, Parameter Passing techniques, Storage classes, Dynamic Memory Allocation, Recursion.	8	
7.	**Pointers** Introduction, Definition and Declaration of pointers, address operator, Pointer variables, Pointers with Arrays.	5	
8.	**Structures and Unions** Introduction, Declaration and Initialization, Array of Structures, Unions.	5	

Course outcomes

After completion of the course, a student would be able to:

CO 1	explain different components of computers
CO 2	formulate simple algorithms for arithmetic and logical problems
CO 3	translate the algorithms to programs (in C language).
CO 4	test and execute the programs
CO 5	implement branching, iteration and recursion
CO 6	use arrays, pointers and structures to formulate algorithms and programmes

Learning Resources:

1.	Byron Gottfried, Schaum's Outline of Programming with C, McGraw-Hill
2.	E. Balaguruswamy, Programming in ANSI C, Tata McGraw-Hill
3.	Brian W. Kernighan and Dennis M. Ritchie, The C Programming Language, Prentice Hall of India
4.	Programming with C by T Jeyapoovan, Vikas Publishing House Pvt Ltd

Name of the course	**CHEMISTRY LAB**		
Course Code: BSL(CT) 103	**Semester: 1^{st}**		
Duration: 6 months	**Maximum Marks: 100**		
Teaching Scheme	**Examination Scheme**		
Theory: Nil	Attendance: 10		
Tutorial: Nil	Preparation of Lab Report: 30		
Practical: 3 hrs./week	Experimental data/ Precision of work done: 30		
Credit Points: 1.5	Presentation/ analysis of the result: 10		
	Viva Voce: 20		
Objective:			
1.	To develop laboratory practice and safety.		
2.	To develop laboratory skills and instrumentation.		
3.	To deepen the understanding of concepts.		
4.	To provide scientific skills and chemical knowledge.		
Pre-Requisite			
1.	Class 12^{th} standard knowledge in Practical Chemistry		
Module	**Content**	**Hours**	**Marks.**
1	Qualitative analysis of an inorganic sample salt.	6	
2	Estimation of Fe(II) present in a solution permanganometrically	3	
3	Estimation of Fe(II) present in a solution dichromatometrically.	3	
4	Determination of hardness of water in ppm unit complexometrically.	6 (any two from Module 4-9)	
5	Determination of surface tension of a given liquid.		
6	Determination of viscosity of a given liquid.		
7	Determination of rate constant of a reaction.		
8	Determination of cell constant and conductance of a solution.		
9	Potentiometry: determination of redox potential and emf.		
Course outcomes			

After completion of the course, a student would be able to:	
CO 1	analyze qualitative parameters (basic and acid radicals) of inorganic salts.handle stalagmometer and Ostwald’s viscometer to determine surface tension and viscosity of liquid.
CO 2	estimate quantities of Fe (II) permanganetometrically and dichromatometrically.
CO 3	estimate hardness of water complexometrically.
CO 4	handle stalagmometer and Ostwald’s viscometer to determine surface tension and viscosity of liquid.
CO 5	develop perception about safety standards to be maintained inside the laboratory.
CO 6	develop skill to work in a team.
Learning Resources:	
1.	Practical Chemistry, Prof Sachin Dutta, Bharati Book Stall
2.	Practical Chemistry , R Mukhopadhyay & P Chatterjee, Books and Allied (p) Ltd.
3.	Practical Chemistry, Pandey, Bajpai, Giri, S Chand Publication
4.	Vogel's Qualitative Inorganic Analysis, G Svehla, B Shivasankar (7th Edition), Pearson
5.	Vogel's Quantitative Chemical Analysis, J Mendham, R C Denney, J D Barnes, M Thomas, B Shivasankar (6th Edition), Pearson

Name of the course	PROGRAMMING FOR PROBLEM SOLVING LAB		
Course Code: ESL(CT) 102	**Semester: 1^{ST}**		
Duration: 6 months	**Maximum Marks: 100**		
Teaching Scheme	**Examination Scheme**		
Theory: Nil	Attendance: 10		
Tutorial: Nil	Preparation of Lab Report: 30		
Practical: 4 hrs./week	Experimental data/ Precision of work done: 30		
Credit Points: 2	Presentation/ analysis of the result: 10		
	Viva Voce: 20		
Objective:			
1.	To understand the various steps in Program development.		
2.	To understand the basic concepts in C Programming Language.		
3.	To learn how to write modular and readable C Programs		
4.	To learn to write programs (using structured programming approach) in C to solve problems.		
Pre-Requisite			
1.	knowledge of Mathematics.		
2.	knowledge of arithmetic and logical operations.		
3.	knowledge of reasoning.		
Module	**Content**	**Hours**	**Marks.**
1	Familiarization with programming environment	2	
2	Simple computational problems using arithmetic expressions	3	
3	Problems related to Branching and logical expressions	3	
4	Iterative problems using loops e.g., sum of series	3	
5	1D Array manipulation, searching, sorting related problems	3	
6	Problems related to 2D arrays and Strings manipulation	3	
7	Problems related to Functions, call by value, call by reference and dynamic memory allocation	8	

8	Problems regarding Recursion	3	
9	Pointers related problems	6	
10	Problems on structures and Unions	6	

Course outcomes

After completion of the course, a student would be able to:

CO 1	formulate algorithms for simple problems and translate given algorithms to a working and correct program
CO 2	identify and correct logical errors and syntax errors encountered at run time.
CO 3	write iterative as well as recursive programs.
CO 4	represent data in arrays, strings and structures and manipulate them through a program
CO 5	declare pointers of different types and use them in defining self-referential structures.
CO 6	work effectively in a team.

Learning Resources:

1.	E. Balaguruswamy, Programming in ANSI C, Tata McGraw-Hill
2.	Programming with C by T Jeyapoovan, Vikas Publishing House Pvt Ltd
3.	Programming in C by J.B. Dixit, Laxmi Publications Pvt Ltd

Name of the course	**ENGINEERING GRAPHICS AND DESIGN**
Course Code: ESL(CT) 103	**Semester: 1ST**
Duration: 6 months	**Maximum Marks: 100**
Teaching Scheme	**Examination Scheme**
Theory: 1 hr./week	Attendance: 10
Tutorial: Nil	Preparation of Lab Report: 30
Practical: 4 hrs./week	Experimental data/ Precision of work done: 30
Credit Points: 3	Presentation/ analysis of the result: 10
	Viva Voce: 20

Module	**Content**	**Hours**	**Marks.**
1	**Introduction to Engineering Drawing** Principles of Engineering Graphics and their significance, Drawing instruments and their uses; Different types of lines and their uses; Lettering; Dimensioning; Drawing standards and codes; Scales: concept of R.F, plain and diagonal scales.	2L+8P	
2	**Geometrical Construction and Curves used in Engineering Practice** Construction of polygons, conic sections including the rectangular hyperbola (General method only); Cycloidal curves: cycloid, epicycloid, hypocycloid; Involute.	1L+4P	
3	**Orthographic Projections of Points, Lines, Planes** Principles of orthographic projections, conventions; Projections of points; Projections of lines inclined to both reference planes; Projections of planes like circle, polygons etc.	1L+4P	
4	**Projections of Regular Solids** Projections of regular solids like cone, pyramids, prisms etc.	1L+4P	
5	**Sections of Right Regular Solids and Development of Surfaces** Section of solids like cylinder, prism, pyramid, cone etc. Development of surfaces of right regular solids: cylinder, prism, pyramid and cone.	1L+4P	
6	**Isometric Projections** Principles of isometric projection, isometric scale, isometric views, conventions; Isometric views of planes, simple and compound solids; Conversion of isometric views to orthographic views and vice-versa.	1L+4P	
7	**Overview of Computer Graphics, Customisation & CAD Drawing** Listing the computer technologies that impact on graphical communication; Demonstrating knowledge of the theory of CAD software [such as: the menu system, toolbars (standards, object properties, draw, modify and dimension), drawing area (background, crosshairs, coordinate system), dialog boxes and windows, shortcut menus (button bars), the command line (where applicable), the status bar,	1L+4P	

	different methods of zoom as used in CAD, select and erase objects. Setting up of the drawing page and the printer, including scale settings; Setting up of units and drawing limits; ISO and ANSI standards for coordinate dimensioning and tolerancing; Orthographic constraints, Snap to objects manually and automatically; Producing drawings by using various coordinate input entry methods to draw straight lines, Applying various ways of drawing circles.		
8	**Annotations, Layering & Other Functions** Applying dimensions to objects; Applying annotations to drawings; Setting up and use of layers, layers to create drawings; Create, edit and use customized layers; Changing line lengths through modifying existing lines (extend/lengthen); Printing documents to paper using the print command; Orthographic projection techniques; Drawing sectional views of composite right regular geometric solids and project the true shape of the sectioned surface; Drawing annotation, Computer-Aided Design (CAD) software modelling of parts and assemblies. Parametric and non-parametric solid, surface, and wireframe models. Part editing and two-dimensional documentation of models. Planar projection theory, including sketching of perspective, isometric, multi view, auxiliary, and section views. Spatial visualization exercises. Dimensioning guidelines, tolerancing techniques; dimensioning and scale multi views of dwelling.	2L+8P	
9	**Demonstration of a Simple Team Design Project** Geometry and topology of engineered components: creation of engineering models and their presentation in standard 2D blueprint form and as 3D wire frame and shaded solids; meshed topologies for engineering analysis and tool-path generation for component manufacture; geometric dimensioning and tolerancing; Use of solid-modelling software for creating associative models at the component and assembly levels; floor plans that include: windows, doors, and fixtures such as WC, bath, sink, shower, etc. Applying colour coding according to building drawing practice; Drawing sectional elevation showing foundation to ceiling; Introduction to Building Information Modelling (BIM).	2L+8P	

Course outcomes	
After completion of the course, a student would be able to:	
CO 1	apply basics of Engineering Graphics standards for interpreting Engineering Drawing
CO 2	apply features of Engineering Graphics to create working drawings
CO 3	draw and explain plan and elevation of different solid objects
CO 4	develop solid model with Computer Aided Design (CAD) software
CO 5	communicate to other engineering personnel via engineering graphics language
Learning Resources:	
1.	Bhatt N.D., Panchal V.M. & Ingle P.R., (2014), Engineering Drawing, Charotar Publishing House
2.	Shah, M.B. &Rana B.C. (2008), Engineering Drawing and Computer Graphics, Pearson Education
3.	Agrawal B. &Agrawal C. M. (2012), Engineering Graphics, TMH Publication

4.	Narayana, K.L. & P Kannaiah (2008), Text book on Engineering Drawing, Scitech Publishers
5.	(Corresponding set of) CAD Software Theory and User Manuals

Following is the list of drawing instruments that required for making engineering drawings on paper with perfection.

Sl. No.	Name of the instrument	Sl. No.	Name of the instrument
1	Drawing Board	8	Compass (Small and Large)
2	T-Scale	9	Divider (Small and Large)
3	Set-squares (45°–45° & 60°–90°)	10	French Curves
4	Protractor	11	Sharpener
5	Scales (Plain, Diagonal)	12	Eraser
6	Drawing paper (A1 Size)	13	Drawing pins & clips
7	Drawing pencil (H, HB, B)	14	Duster or handkerchief etc.

FIRST YEAR SECOND SEMESTER

2nd Semester B. Tech Ceramic Technology							
Sl. No.	Type of course	Course Code	Course Title	Hours per week			Credits
				Lecture	Tutorial	Practical	
Theory							
1	Basic Science course	BS(CT) 204	Mathematics-II	3	0	0	3
2	Basic Science course	BS(CT) 205	Physics	3	1	0	4
3	Engineering Science Course	ES(CT) 204	Basic Electrical Engineering	3	1	0	4
4	Humanities & Social Sciences including Management	HS(CT/IT/CS) 201	English	2	0	0	2
Sessional/Practical							
1	Basic Science course	BSL(CT) 206	Physics Lab	0	0	3	1.5
2	Engineering Science Course	ESL(CT) 205	Basic Electrical Engineering Lab	0	0	2	1
3	Engineering Science Course	ESL(CT) 206	Workshop /Manufacturing Practices	1	0	4	3
4	Humanities & Social Sciences including Management	HSL(CT/IT/CS) 202	Language Lab	0	0	2	1
5		CLA(CT) 2	Comprehensive Laboratory Assessment	-	-	-	1
				Total credits			**20.5**

The course teacher shall assess the students for Serial Nos. 1, 2, 3,4 under Sessional/Practical before commencement of Semester End Examination. A student has to secure at least 50% marks in Serial Nos. 1, 2, 3,4 under Sessional/Practical, failing which the student would be debarred from sitting in the Semester End Examination.

A student has to secure at least 50% marks in rest of the courses (Theory papers and CLA), failing which he/she would carry backlog(s).

Name of the course		**MATHEMATICS –II**	
Course Code: BS(CT) 204		**Semester: 2ND**	
Duration: 6 months		**Maximum Marks: 100**	
Teaching Scheme		**Examination Scheme**	
Theory: 3 hrs./week		Mid Term Exam I: 15 Marks	
Tutorial: Nil		Mid Term Exam II: 15 Marks	
Practical: Nil		Assignment & Quiz etc.: 20 Marks	
Credit Points: 3		Semester End Exam: 75 Marks (Two third weightage for final reckoning i.e., 50 marks)	
Objective:			
1.	To learn integral of a function of more than one variable		
2.	To create mathematical models using first order differential equation.		
3.	To learn analytical technique for finding solution of higher order differential equation.		
4.	To study complex power series, classification of singularities, calculus of residues and its applications in the evaluation of integrals, and other concepts and properties.		
5.	To study the techniques of complex variables and functions together with their derivatives, Contour integration and transformations.		
Pre-Requisite			
1.	Class 12th standard knowledge of Mathematics		
Module	**Content**	**Hours**	**Marks.**
1	**Multivariate Calculus (Integration)** Multiple Integration: Double integrals (Cartesian), change of order of integration in double integrals, change of variables (Cartesian to Polar), Applications: Areas and volumes, Center of mass and Gravity (constant and variable densities); Triple integrals (Cartesian), Orthogonal curvilinear coordinates, Simple applications involving cubes, sphere and rectangular parallelepipeds; Scalar line integrals, vector line integrals, scalar surface integrals, vector surface integrals, Theorems of Green, Gauss and Stokes.	11	
2	**First order ordinary differential equations** Exact, linear and Bernoulli's equations, Equations not of first degree: equations solvable for p, equations solvable for y, equations solvable for x and Clairaut's type.	5	
3	**Ordinary differential equations of higher orders** Second order linear differential equations with constant coefficients, Use of D-operators, Second order linear differential equations with variable coefficients, method of variation of parameters, Cauchy-Euler equation;	9	

	Power series solutions; Legendre polynomials, Bessel functions of the first kind and their properties.		
4	**Complex Variable – Differentiation** Differentiation of complex functions, Cauchy-Riemann equations, Analytic functions, Harmonic functions, determination of harmonic conjugate, elementary analytic functions (exponential, trigonometric, logarithmic) and their properties; Conformal mappings, Mobius transformations and their properties.	6	
5	**Complex Variable – Integration** Contour integrals, Cauchy-Goursat theorem (without proof), Cauchy integral formula (without proof), Liouville's theorem and Maximum-Modulus theorem (without proof); Taylor's series, Zeros of analytic functions, Singularities, Laurent's series; Residues, Cauchy residue theorem (without proof), Evaluation of definite integral involving sine and cosine, Evaluation of certain improper integrals using the Bromwich contour.	9	

Course outcomes	
After completion of the course, a student would be able to:	
CO 1	apply the concept of multiple integrals for solving different physical problems.
CO 2	apply different techniques to solve first and second order ordinary differential equations with its formulation to address the modelling of systems and problems of engineering sciences.
CO 3	apply different tools of differentiation and integration of functions of a complex variable that are used with various other techniques for solving engineering problems.
CO 4	apply different types of transformations between 2- dimensional planes for analysis of physical or engineering problems.
CO 5	apply complex integration technique to find residue of any complex function.
Learning Resources:	
1.	Erwin Kreyszig, Advanced Engineering Mathematics, John Wiley & Sons.
2.	Michael Greenberg, Advanced Engineering Mathematics, Pearson.
3.	B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers.
4.	Kanti B. Dutta, Mathematical Methods of Science and Engineering, Cenage Learning.
5.	Veerarajan T., Engineering Mathematics for first year, Tata McGraw-Hill, New Delhi.
6.	E. L. Ince, Ordinary Differential Equations, Dover Publications.
7.	J. W. Brown and R. V. Churchill, Complex Variables and Applications, Mc-Graw Hill.

Name of the course	**PHYSICS**
Course Code: BS(CT) 205	**Semester: 2^{ND}**
Duration: 6 months	**Maximum Marks: 100**
Teaching Scheme	**Examination Scheme**
Theory: 3 hrs./week	Mid Term Exam I: 15 Marks
Tutorial: Nil	Mid Term Exam II: 15 Marks
Practical: Nil	Assignment & Quiz etc.: 20 Marks
Credit Points: 3	Semester End Exam: 75 Marks (Two third weightage for final reckoning i.e., 50 marks)

Objective:	
1.	The objective of the course is to provide an exposure to the conservative force field, motion under conservative force, moment of inertia, development and various laws of electromagnetism, familiarizing the students with different wave phenomena of light like interference, diffraction, polarization and the evolution of quantum mechanics.
2.	This course also provides an understanding of practical problem-solving techniques for the chapters covered in the course.
Pre-Requisite	
1.	Class 11^{th} and 12^{th} standard knowledge of Physics and Mathematics.

Module	**Content**	**Hours**	**Marks.**
1	**Mechanics**: Use of vectors in particle mechanics, Unit vectors in spherical and cylindrical polar coordinates, Conservative vector fields and their potential functions - gravitational and electrostatic examples, Gradient, Divergence and Curl. Gauss' Divergence Theorem and Stoke's Theorem. States of equilibrium, Work and Energy, Conservation of energy, Motion in a central field and conservation of angular momentum. Angular momentum of a system of particles, Torque, Moment of inertia, Parallel and Perpendicular axes theorem, Calculation of moment of inertia for (i) thin rod, (ii) disc, (iii) cylinder and (iv) sphere. Rotational dynamics of rigid body (simple cases).	10	
2	**Electricity & Magnetism**: Overview of Coulomb"s law, Gauss's law, dielectric polarization, Displacement vector, permeability and dielectric constant, polar and non-polar dielectrics, applications of	10	

	dielectrics. Electric current and the continuity equation. Overview of Biot-Savart law and Ampere‘s Circuital law. Magnetisation, permeability and susceptibility, classification of magnetic materials, ferromagnetism, magnetic domains and hysteresis, applications. Generalization of "Ampere’s circuital law, —Maxwell‘s equations. Maxwell's wave equation in free space and its solution.		
3	**Optics**: Interference of light waves, Young's experiment, Interference in thin film, Newton's rings. Diffraction of light waves, Fraunhoffer diffraction due to single slit and plane diffraction grating, Polarisation of light waves, Polarisation by reflection, Brewster's law.	8	
4	**Quantum Mechanics**: Introduction to quantum physics, Black body radiation, Photoelectric Effect and Compton Effect and their explanation using the photon concept. de Broglie hypothesis, wave-particle Duality. Born’s interpretation of the wave function, verification of matter waves, uncertainty principle, Schrodinger wave equation, particle in box, quantum harmonic Oscillator, hydrogen atom.	14	

Course outcomes

After completion of the course, a student would be able to:

CO 1	explain different coordinate systems, conservative force field, gradient, divergence and curl of a field.
CO 2	solve problems on electrostatics on the basis of knowledge of motion in a central force field.
CO 3	explain basics of electromagnetism including Biot-Savart law and Ampere’s circuital law.
CO 4	apply the concepts of wave theory of light to different phenomena like interference, diffraction and polarization.
CO 5	solve numerical problems on interference, diffraction and polarization.
CO 6	analyze the dual nature of any particle on the basis of Schrodinger theory of wave function in particular application to particle in a box problem.

Learning Resources:

1.	J. Singh, Semiconductor Optoelectronics: Physics and Technology, McGraw-Hill Inc. (1995)
2.	B. E. A. Saleh and M. C. Teich, Fundamentals of Photonics, John Wiley & Sons, Inc., (2007)
3.	S. M. Sze, Semiconductor Devices: Physics and Technology, Wiley (2008).

4.	A. Yariv and P. Yeh, Photonics: Optical Electronics in Modern Communications, Oxford University Press, New York (2007)
5.	P. Bhattacharya, Semiconductor Optoelectronic Devices, Prentice Hall of India (1997)

Name of the course	BASIC ELECTRICAL ENGINEERING		
Course Code: ES(CT) 204	**Semester: 2^{ND}**		
Duration: 6 months	**Maximum Marks: 100**		
Teaching Scheme	**Examination Scheme**		
Theory: 3 hrs./week	Mid Term Exam I: 15 Marks		
Tutorial: 1 hr./week	Mid Term Exam II: 15 Marks		
Practical: Nil	Assignment & Quiz etc.: 20 Marks		
Credit Points: 4	Semester End Exam: 75 Marks (Two third weightage for final reckoning i.e., 50 marks)		
Objective:			
1.	Impart a basic knowledge of several electrical quantities such as current, voltage, power, energy, frequency etc. to the students		
2.	Provide the basic difference between DC and AC and provide basic principles to solve DC and AC circuits used in electrical devices		
3.	Explain the working principle, construction, characteristics and applications of transformer and different DC and AC rotating electrical machines		
4.	Explain the working principles of different power converters and other low tension switchgear and protective devices; as well as, make the students acquainted with the calculations for energy consumption, especially for household applications		
Pre-Requisite			
1.	Class 12th standard knowledge of Mathematics and Physics		
Module	**Content**	**Hours**	**Marks.**
1	**DC Circuits** Electrical circuit elements (R, L and C), voltage and current sources, Kirchoff current and voltage laws, analysis of simple circuits with dc excitation. Super position, Thevenin and Norton Theorems. Time-domain analysis of first-order RL and RC circuits.	**8**	
2	**AC Circuits** Representation of sinusoidal waveforms, peak and rms values, phasor representation, real power, reactive power, apparent power, power factor. Analysis of single-phase ac circuits consisting of R, L, C, RL, RC, RLC combinations (series and parallel), resonance. Three phase balanced circuits, voltage and current relations in star and delta connections.	8	
3	**Transformers** Magnetic materials, BH characteristics, ideal and practical transformer, equivalent circuit, losses in transformers, regulation and efficiency. Auto-transformer and three-phase transformer connections.	6	
4	**Module 4: Electrical Machines** Generation of rotating magnetic fields, Construction and working of a three-phase induction motor, Significance of torque-slip characteristic. Loss components and efficiency, starting and speed control of induction	8	

	motor. Single-phase induction motor. Construction, working, torque-speed characteristic and speed control of separately excited dc motor. Construction and working of synchronous generators.		
5	**Power Converters** DC-DC buck and boost converters, duty ratio control. Single-phase and three-phase voltage source inverters; sinusoidal modulation.	6	
6	**Electrical Installations** Components of LT Switchgear: Switch Fuse Unit (SFU), MCB, ELCB, MCCB, Types of Wires and Cables, Earthing. Types of Batteries, Important Characteristics for Batteries. Elementary calculations for energy consumption, power factor improvement and battery backup.	6	

Course outcomes

After completion of the course, a student would be able to:

CO 1	explain the overall electrical power system, its different parameters, components, protective elements and power converters.
CO 2	solve problems of DC and AC circuits using different methods and network theorems.
CO 3	derive different expressions to evaluate performance of electrical machines.
CO 4	analyze electric machines and circuits using equivalent circuits, phasor analysis etc.
CO 5	identify different electric machines with the help of different characteristics and parameters for appropriate applications.
CO 6	calculate energy consumption in an electrical circuit.

Learning Resources:

1.	D. P. Kothari and I. J. Nagrath, “Basic Electrical Engineering”, Tata McGraw Hill, 2010.
2.	D. C. Kulshreshtha, “Basic Electrical Engineering”, McGraw Hill, 2009.
3.	L. S. Bobrow, “Fundamentals of Electrical Engineering”, Oxford University Press, 2011.
4.	E. Hughes, “Electrical and Electronics Technology”, Pearson, 2010.
5.	V. D. Toro, “Electrical Engineering Fundamentals”, Prentice Hall India, 1989.

<table>
<tr><td colspan="2">Name of the course</td><td colspan="2">ENGLISH</td></tr>
<tr><td colspan="2">Course Code: HS(CT/IT/CS) 201</td><td colspan="2">Semester: 2ND</td></tr>
<tr><td colspan="2">Duration: 6 months</td><td colspan="2">Maximum Marks: 100</td></tr>
<tr><td colspan="2">Teaching Scheme</td><td colspan="2">Examination Scheme</td></tr>
<tr><td colspan="2">Theory: 2 hrs./week</td><td colspan="2">Mid Term Exam I: 15 Marks</td></tr>
<tr><td colspan="2">Tutorial: Nil</td><td colspan="2">Mid Term Exam II: 15 Marks</td></tr>
<tr><td colspan="2">Practical: Nil</td><td colspan="2">Assignment & Quiz etc.: 20 Marks</td></tr>
<tr><td colspan="2">Credit Points: 2</td><td colspan="2">Semester End Exam: 75 Marks (Two third weightage for final reckoning i.e., 50 marks)</td></tr>
<tr><td colspan="4">Objective:</td></tr>
<tr><td>1.</td><td colspan="3">To develop and integrate the use of the four language skills i.e. Reading, Listening, Speaking and Writing.</td></tr>
<tr><td>2.</td><td colspan="3">To revise and reinforce structure already learnt</td></tr>
<tr><td>3.</td><td colspan="3">To enable the learner to communicate effectively and appropriately in real life situations.</td></tr>
<tr><td colspan="4">Pre-Requisite</td></tr>
<tr><td>1.</td><td colspan="3">Basic English Grammar knowledge of class 12th standard</td></tr>
<tr><td>Module</td><td>Content</td><td>Hours</td><td>Marks.</td></tr>
<tr><td>1</td><td>Vocabulary building and new words concept:
• Concept of Word formation
• Collection of five new words everyday (from Oxford Dictionary & English Newspapers)
• Synonyms & Antonyms
• Masculine & Feminine
• Singular & Plural</td><td>4</td><td></td></tr>
<tr><td>2</td><td>Basic Writing Skill – Written English
• Sentence construction
• Use of Phrases, idioms and clauses in sentences
• Importance of proper punctuation
• Techniques for writing precisely
• Paragraph writing</td><td>4</td><td></td></tr>
<tr><td>3</td><td>Avoiding mistakes & errors in English
• Subject – Verb agreement
• Noun – Pronoun agreement
• Misplaced Modifiers
• Articles
• Prepositions</td><td>4</td><td></td></tr>
</table>

<table>
<tr><td>4</td><td>Practice of Writing English – Form
Precis writing
Essay writing
Letter writing
Comprehension
English Translation – Mother tongue to English & vice versa</td><td>6</td><td></td></tr>
<tr><td>5</td><td>Communication Skill – incorporation of presentation skill & negotiation skill
Listening comprehension
Spoken English
Comprehension, intonation, accent, stress and rhythm
Conversation and dialogues
Manoeuvring sentences – replacing words
Interview – personal interview / Group Discussion
Public speaking</td><td>6</td><td></td></tr>
<tr><td colspan="4">Course outcomes</td></tr>
<tr><td colspan="4">After completion of the course, a student would be able to:</td></tr>
<tr><td>CO 1</td><td colspan="3">develop a minimum repository of English words to use for making meaningful sentences.</td></tr>
<tr><td>CO 2</td><td colspan="3">write correct sentences using phrases, idioms, clauses with proper punctuation marks.</td></tr>
<tr><td>CO 3</td><td colspan="3">identify the common mistakes and grammatical errors in sentence construction.</td></tr>
<tr><td>CO 4</td><td colspan="3">write letters, essays, precis etc. in proper format.</td></tr>
<tr><td>CO 5</td><td colspan="3">able to speak English with correct pronunciation.</td></tr>
<tr><td>CO 6</td><td colspan="3">communicate effectively in public forum and in professional field</td></tr>
<tr><td colspan="4">Learning Resources:</td></tr>
<tr><td>1.</td><td colspan="3">Technical Education: Raman and Sharma</td></tr>
<tr><td>2.</td><td colspan="3">Effective Technical Communication: Ashraf Rizvi</td></tr>
<tr><td>3.</td><td colspan="3">Effective Communication and Soft Skills: Nitin Bhatnagar & Mamta Bhatnagar</td></tr>
</table>

Name of the course	**PHYSICS LAB**
Course Code: BSL(CT) 206	**Semester: 2ND**
Duration: 6 months	**Maximum Marks: 100**
Teaching Scheme	**Examination Scheme**
Theory: Nil	Attendance: 10
Tutorial: Nil	Preparation of Lab Report: 30
Practical: 3 hrs./week	Precision of work done: 30
Credit Points: 1.5	Presentation/ analysis of the result: 10
	Viva Voce: 20

Module	Content	Hours	Marks.
1	Determination of an unknown resistance using Carey Foster Bridge	3	
2	Determination of energy band gap by four-probe method	3	
3	Determination of Planck's constant using photocell	3	
4	Verification of Stefan's law of blackbody radiation	3	
5	Verification of Bohr's atomic orbital theory through Frank-Hertz experiment	3	
6	Determination of wavelength of light by Newton's ring method	3	

Course outcomes

After completion of the course, a student would be able to:

CO 1	identify different equipment and accessories as per specification needed to conduct a particular experiment.
CO 2	calibrate very small resistance using Carey Foster Bridge.
CO 3	estimate the band gap of any semiconductor using four probe method.
CO 4	estimate the temperature of an approximate black body.
CO 5	apply Einstein equation of Photoelectric effect to evaluate Planck constant.
CO 6	estimate the radius of curvature of a curved surface using Newton's Ring experiment.
CO 7	validate Bohr's hypothesis using Frank-Hertz experiment.

CO 8	develop skill to work in a team.
Learning Resources:	
1.	Separate manuals associated to each experiment are provided to students

Name of the course	**BASIC ELECTRICAL ENGINEERING LAB**
Course Code: ESL(CT) 205	**Semester: 2ND**
Duration: 6 months	**Maximum Marks: 100**
Teaching Scheme	**Examination Scheme**
Theory: Nil	Attendance: 10
Tutorial: Nil	Preparation of Lab Report: 30
Practical: 2 hrs./week	Experimental data/ Precision of work done: 30
Credit Points: 1	Presentation/ analysis of the result: 10
	Viva Voce: 20

Module	Content	Hours	Marks.
1	First activity: Introduction to basic safety precautions and mentioning of the do's and Don'ts. Noting down list of experiments to be performed, and instruction for writing the laboratory reports by the students. Group formation. Students are to be informed about the modalities of evaluation.		
2	Introduction and uses of following instruments: (a) Voltmeter (b) Ammeter (c) Multimeter (d) Oscilloscope Demonstration of real-life resistors, capacitors with color code, inductors and autotransformer.		
3	Demonstration of cut-out sections of machines: DC machine, Induction machine, Synchronous machine and single-phase induction machine.		
4	Calibration of ammeter and Wattmeter.		
5	Determination of steady state and transient response of R-L, R-C and R-L-C circuit to a step change in voltage.		
6	Determination of steady state response of R-L and R-C and R-L-C circuit and calculation of impedance and power factor.		
7	Determination of resonance frequency and quality factor of series and parallel R-L-C circuit.		
8	(a) Open circuit and short circuit test of a single-phase transformer (b) Load test of the transformer and determination of efficiency and regulation		
9	Demonstration of three phase transformer connections. Voltage and current relationship, phase shifts between the primary and		

	secondary side.		
10	Measurement of power in a three-phase unbalanced circuit by two wattmeter method.		
11	Determination of Torque –Speed characteristics of separately excited DC motor.		
12	Determination of Torque speed characteristics and observation of direction reversal by change of phase sequence of connection of Induction motor.		
13	Determination of operating characteristics of Synchronous generator.		
14	Demonstration of operation of (a) DC-DC converter (b) DC-AC converter (c) DC-AC converter for speed control of an Induction motor.		
15	Demonstration of components of LT switchgear.		

Course outcomes

After completion of the course, a student would be able to:

CO 1	identify different equipment and accessories as per specification needed to conduct a particular experiment.
CO 2	set up an electric wiring for household application.
CO 3	calibrate of different measuring instruments viz ammeter, voltmeter, wattmeter.
CO 4	verify three network theorems (Thevenin, Norton and Superposition) using different combination of circuits.
CO 5	determine the steady & transient response of AC networks.
CO 6	determine different operating characteristics viz load characteristics of motors and generators.
CO 7	estimate parameters of transformers by open circuit and short circuit tests.
CO 8	develop skill to work in a team.

Learning Resources:

1.	S. K. Bhattacharya and K. M. Rastogi, “Experiments in Basic Electrical Engineering”, New Age International (P) Limited, Publishers, 2003
2.	A. Chakrabarti, S. Debnath and C. K. Chandra, “Basic Electrical Engineering”, Tata McGraw Hill, 2009
3.	D. P. Kothari and B. S. Umre, “Laboratory Manual for Electrical Machines”, I.K. International Publishing House Pvt. Limited, 2017

Name of the course		**WORKSHOP/ MANUFACTURING PRACTICES**	
Course Code: ESL(CT) 206		**Semester: 2ND**	
Duration: 6 months		**Maximum Marks: 100**	
Teaching Scheme		**Examination Scheme**	
Theory: 1 hr./week		Attendance: 10	
Tutorial: Nil		Preparation of Lab Report: 20	
Practical: 4 hrs./week		Experimental data/ Precision of work done: 30	
Credit Points: 3		Presentation/ analysis of the result: 20	
		Viva Voce: 20	
Module	**Content**	**Hours**	**Marks.**
1	Manufacturing methods: casting, forming, machining, joining and advanced manufacturing methods	1L	
2	CNC machining, Additive manufacturing	1L+4P	
3	Fitting operations & power tools	2L+8P	
4	Electrical & Electronics	1L+4P	
5	Carpentry	2L+8P	
6	Plastic moulding, glass cutting	1L+4P	
7	Metal casting	1L+4P	
8	Welding (arc welding & gas welding), brazing	1L+4P	
9	Machine shop	2L+8P	
10	Smithy	1L+4P	
Course outcomes			
After completion of the course, a student would be able to:			
CO 1	explain different manufacturing processes which are commonly employed in industry to fabricate components using different materials including CNC machining, additive manufacturing.		
CO 2	complete a defined job in different sections of mechanical workshop e.g., carpentry, fitting etc.		
CO 3	find out dimensional accuracies and dimensional tolerances possible with different		

	manufacturing processes.
CO 4	assemble different components to produce small devices.
CO 5	make electrical wiring for household applications.
Learning Resources:	
1.	Hajra Choudhury S.K., Hajra Choudhury A.K. and Nirjhar Roy S.K., "Elements of Workshop Technology", Vol. I 2008 and Vol. II 2010, Media promoters and publishers private limited, Mumbai.
2.	Kalpakjian S. And Steven S. Schmid, "Manufacturing Engineering and Technology",4thedition, Pearson Education India Edition, 2002.
3.	Gowri P. Hariharan and A. Suresh Babu," Manufacturing Technology – I" Pearson Education, 2008.
4.	Roy A. Lindberg, "Processes and Materials of Manufacture", 4th edition, Prentice Hall India, 1998.
5.	Rao P.N., "Manufacturing Technology", Vol. I and Vol. II, Tata McGraw Hill House, 2017.

Name of the course	LANGUAGE LAB
Course Code: HSL(CT/IT/CS) 202	**Semester: 2ND**
Duration: 6 months	**Maximum Marks: 100**
Teaching Scheme	**Examination Scheme**
Theory: Nil	
Tutorial: Nil	
Practical: 2hrs./week	
Credit Points: 1	

Module	Content	Hours	Marks.
1	**LISTENING** Listening to pre-recorded short episodes, conversations, passages, stories, news bulletin, speeches by famous personalities – Listening for general and specific information etc.	4	
2	**READING:** Reading aloud – by students individually – reading rhymes – proverbs – passages on various topics of interest – Newspaper reading – Reading humorous passages – Anecdotes – Stories – tricky sounds (conditioners) – Reading manuals – Reading individual sentences with articulation, pronunciation, Tones, Punctuation, pauses etc. - Reading the titles of popular books, movies and poems.	4	
3	**SPEAKING:** Self-introduction – introducing one self, one's family – one's friends and relatives, one's country etc. Welcome Address, Vote of thanks. Extempore speeches. Short speech on simple topics on simpler themes for about one minute. Role play – Group Discussion – Debate – Seminars – Machine Descriptions (depending upon branches) – Compering – Interviewing others by Asking Questions – Interview Techniques – Conversational Practice – Telephonic Conversation – Telephonic Interviews – How to establish conversation / dialogues – Entry Attempts/Admissions.	6	
4	**WRITING:** Writing Resume, preparing Curriculum Vitae, Converting newspaper headlines into sentences. Formation of Sentences – Using the table of Sentence-making and producing multiple sentences. Framing Questions for the responses given. Tips for better performance in interviews. Describing Objects. Describing Situations; Project report writing (outline): significant features of Project report writing – Organization – Presentation – Use of Impersonal Passives – Acknowledgements.	6	
5	**PROFESSIONAL ETHICS & ORGANISATIONAL BEHAVIOUR:** Different kinds of Ethics – Ethics in different fields – Engineering Ethics – Senses of Engineering Ethics – Moral Values – Integrity & Loyalty – Work Ethics – Respect for others and authority – Empathy – Caring and Sharing – Honesty – Courage and Commitment – Valuing Time – Co-operation & Teamwork – Safety and Risk – Right Action – Professional ideals and virtues – Individual's Ambition – Conflict Resolution – Self-	4	

	Confidence – Customs and Manners – General Behaviour – Etiquettes to be followed – Professional Responsibility – Accountability – Leadership Quality – Effective Communication skills.		

Course outcomes	
After completion of the course, a student would be able to:	
CO 1	develop listening skill with proper comprehension.
CO 2	read aloud fluently various topics with proper pronunciation and articulation and necessary pauses.
CO 3	able to speak English fluently with correct pronunciation during Group Discussions, Seminar presentations, Telephonic conversations etc.
CO 4	write Resume, prepare Curriculum Vitae and Convert newspaper headlines into sentences etc.
CO 5	develop self-confidence and leadership quality through effective communication skills.
CO 6	develop skill to write project reports in impersonal passive voice.

SECOND YEAR FIRST SEMESTER

3rd Semester B. Tech Ceramic Technology							
Sl. No.	Type of course	Course Code	Course Title	Hours per week			Credits
				Lecture	Tutorial	Practical	
Theory							
1.	Basic Science Course	BS(CT) 307	Engineering Mathematics	3	1	0	4
2.	Engineering Science Course	ES(CT) 307	Basic Mechanical Engineering	3	0	0	3
3.	Professional Core Course	PC(CT) 301	Ceramic Raw Materials	3	1	0	4
4.	Professional Core Course	PC(CT) 302	Unit Operation I	3	1	0	4
5.	Professional Core Course	PC(CT) 303	Energy Resources & Furnaces	4	0	0	4
6.	Engineering Science Course	ES(CT) 308	Chemical & Engineering Thermodynamics	3	1	0	4
Sessional/Practical							
1.	Professional Core Course	PCL(CT) 304	Powder Preparation & Chemical Analysis of Ceramic Raw Materials and Products Lab	0	0	3	1.5
2.	Professional Core Course	PCL(CT) 305	Fuels Testing Lab	0	0	3	1.5
3.	Basic Science Course	BSL(CT)308	Numerical Methods Lab	0	0	2	1
4.	Comprehensive Laboratory Assessment	CLA(CT) 3	All Labs	-	-	-	1
Mandatory Course							
1.	Mandatory course	MC(CT) 301	Environmental Sciences	2	0	0	0
				Total credits			**28**

The course teacher shall assess the students for Serial Nos. 1, 2, 3 under Sessional/Practical before commencement of Semester End Examination. A student has to secure at least 50% marks in Serial Nos. 1, 2, 3 under Sessional/Practical, failing which the student would be debarred from sitting in the Semester End Examination.

A student has to secure at least 50% marks in rest of the courses (Theory papers, Mandatory Course and CLA), failing which he/she would carry backlog(s).

Name of the course	**ENGINEERING MATHEMATICS**
Course Code: BS(CT) 307	**Semester: 3RD**
Duration: 6 months	**Maximum Marks: 100**
Teaching Scheme	**Examination Scheme**
Theory: 3 hrs./week	Mid Term Exam I: 15 Marks
Tutorial: 1 hr./week	Mid Term Exam II: 15 Marks
Practical: Nil	Assignment & Quiz etc.: 20 Marks
Credit Points: 4	Semester End Exam: 75 Marks (Two third weightage for final reckoning i.e., 50 marks)

Objective:	
1.	To understand Fourier series representation of Periodic signals.
2.	To understand the concept of Laplace transformation, Inverse Laplace transformation, solution of ordinary differential equations using Laplace transform.
3.	To understand fundamental concepts of Ordinary and Partial differential equation.
4.	To learn the tools of interpolation to estimate and predict for unknown functional value.
5.	To learn proper numerical methods to deal with specific problems of definite integrals and ODE.
Pre-Requisite	
1.	10+2 Mathematics
2.	Mathematics-I [BS(CT) 101] & Mathematics-II [BS(CT) 204]

Module	**Content**	**Hours**	**Marks.**
1	**<u>Integral Transforms:</u>** **Laplace Transforms:** Laplace transform, properties of Laplace Transform, Laplace transform of periodic functions. Finding inverse Laplace transform by different methods, convolution theorem. Solution of ODE using L.T. **Fourier Transforms:** Fourier transforms properties, Sine & Co-Sine Fourier transforms, convolution, inverses and Parseval's Identity.	14	
2	**Partial Differential Equation:** Introduction to PDE, Formation of PDE. First Order Partial differential equations, solutions of first	8	

	order linear PDEs. **Partial Differential Equation of second Order:** Solution of Wave Equation, Heat Conduction equation and Laplace's equation by a) Laplace transform b) Fourier transforms and c) Method of separation of variables.		
3	**<u>Numerical Analysis:</u>** **Approximation in numerical computation:** Absolute error, Relative error, Percentage error, Truncation and rounding errors, Fixed and floating-point arithmetic, Propagation of errors. **Interpolation:** Newton forward & backward interpolation, Lagrange's and Newton's divided difference Interpolation. **Numerical integration:** Trapezoidal rule, Simpson's 1/3 rule, Weddle's rule, expression for corresponding error terms.	10	
4	**<u>Numerical Analysis (Contd.):</u>** **Numerical Solution of a System of linear equation:** Gauss elimination method, Matrix inversion, Gauss Jordan, Gauss-seidel iterative method. **Numerical Solution of Algebraic equation:** Bisection method, Regula-Falsi method, Newton Raphson method. **Numerical Solution of Ordinary Differential Equation:** Euler's method, Modified Euler's & Runge-Kutta (4^{th} Order) method.	10	

Course outcomes

After completion of the course, a student would be able to:

CO 1	explain different approximation in numerical computation such as Absolute error, Relative error, Percentage error, Truncation and rounding errors, Fixed and floating-point arithmetic, Propagation of errors.
CO 2	apply the concept and techniques of integral transforms for spectral analysis and solutions of ODE and PDE relevant to the field of Ceramic science.
CO 3	solve initial value problems for linear ODE by Laplace transformation.
CO 4	solve diffusion and heat conduction problems by modelling as PDE.
CO 5	apply appropriate approximation techniques to solve real world problems.
CO 6	apply different numerical techniques to solve algebraic, linear and non-linear equations.

Learning Resources:

1.	Lokenath Debnath, Dambaru Bhatta, Integral Transform and their applications, CRC Press
2.	Larry C. Andrews, Bhimsen K. Shivamoggi, Integral Transforms for Engineers, Macmillan.
3.	Erwin Kreyszig, Advanced Engineering Mathematics, John Wiley & Sons.
4.	B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers.
5.	S. S. Sastry, Introductory Methods of Numerical Analysis, PHI
6.	S. A. Mollah, Numerical Analysis and Computational Procedure, Books and Allied (P) Ltd.

Name of the course	**BASIC MECHANICAL ENGINEERING**
Course Code: ES(CT) 307	**Semester: 3RD**
Duration: 6 months	**Maximum Marks: 100**
Teaching Scheme	**Examination Scheme**
Theory: 3 hrs./week	Mid Term Exam I: 15 Marks
Tutorial: Nil	Mid Term Exam II: 15 Marks
Practical: Nil	Assignment & Quiz etc.: 20 Marks
Credit Points: 3	Semester End Exam: 75 Marks (Two third weightage for final reckoning i.e., 50 marks)

Objective:

1.	The objective of this course is to provide a good foundation for taking up advanced courses of the subsequent semesters. A working knowledge of statics with emphasis on force equilibrium and free body diagrams is provided. This course provides an understanding of the kinds of stress and deformation and how to determine them in a wide range of simple, practical structural problems, and an understanding of the mechanical behavior of materials under various load conditions. This course also provides the basic understanding of different machine elements and joints like cam-follower, power screw, belt drives, gear drives, riveted and welded joints.

Pre-Requisite

1.	Class 12th standard physics knowledge
2.	Class 12th standard knowledge in differential and integral calculus

Module	Content	Hours	Marks.
1	**Introduction to statics** Two-dimensional force systems: Principle of transmissibility, Resolution of force into rectangular components, Moment, Varignon's theorem, Couple, Equivalent couples, Force couple systems. Equilibrium of forces in two dimensions: Concept of free body diagram, Equilibrium conditions.	8	
2	**Strength of materials** Concept of stress: Normal stress and shearing stress, Tension and compression within the elastic limit: Definition of elasticity, plasticity, ductility, malleability, hardness, fatigue, creep, brittleness; Hooke's law, Stress-strain diagram for ductile and brittle material, working stress, factor of safety, stress and strain in composite bar, Thermal stress. Torsion of circular shafts, angle of twist, torque and power developed in hollow and circular shafts. Shear Force and Bending Moment: Relation between shear force and bending moment, Sign convention, Shear force and bending moment diagrams for simply supported beam, overhanging beam	12	

	and cantilever subjected to point loads & uniformly distributed load, location of point of contra-flexure.		
3	**Theory of machine elements** Cams and followers: Classification of cams and followers, Different follower motions and their displacement diagrams like uniform velocity, SHM. Drawing of profile of radial cam with knife-edge follower without offset with reciprocating motion (graphical method only). Power screws: Forms of threads, Terminology of power screw, Torque requirement while lifting and lowering load, self-locking screw, efficiency of square threaded screw. Belt drives: Types of belt and belt drives, action of belts on pulleys, velocity ratio. Gear drives: Friction wheels, Advantages and disadvantages of gear drive, classification of gears, terminology used in gears, simple and compound gear train. Riveted Joints: Types of riveted joints, Failure, strength and efficiency of a riveted joint. Welded joints: Welding processes, butt joints, lap joints, strength of butt welds, stress relieving of welding joints.	12	

Course outcomes

After completion of the course, a student would be able to:

CO 1	apply knowledge of force, moment and couple in solving problems.
CO 2	illustrate equilibrium of forces in two dimensional systems.
CO 3	apply concepts of simple stress, strain and thermal stress in mechanical systems.
CO 4	calculate torsional forces, shear force and bending moment of beams to illustrate the state of deformable bodies.
CO 5	solve numerical problems on power screw, belt drives, riveted and welded joints.
CO 6	design gear drives and cam-follower systems.

Learning Resources:

1.	Engineering mechanics- Timoshenko and Young
2.	Engineering mechanics- Mariam and Kraige
3.	Strength of materials- Timoshenko and Young
4.	Theory of machines- S S Rattan
5.	Design of machine elements- V B Bhandari

Name of the course	**Ceramic Raw Materials**
Course Code: PC(CT) 301	**Semester: 3RD**
Duration: 6 months	**Maximum Marks: 100**
Teaching Scheme	**Examination Scheme**
Theory: 3 hrs./week	Mid Term Exam I: 15 Marks
Tutorial: 1 hr./week	Mid Term Exam II: 15 Marks
Practical: Nil	Assignment & Quiz etc.: 20 Marks
Credit Points: 4	Semester End Exam: 75 Marks (Two third weightage for final reckoning i.e., 50 marks)

Objective: The objective of the course is to acquire

1.	knowledge on the structure, classification, properties and application of different natural ceramic raw materials.
2.	knowledge on different processing technique of ultrapure synthetic ceramic materials and their properties / characterization.
3.	knowledge on the different properties, structure in relation with application field of ceramic raw materials.
4.	knowledge on the different characteristics of different natural materials applicable in relation with application oriented ceramic product manufacturing.

Pre-Requisite

1.	Class 12th standard knowledge of chemistry
2.	Class 12th standard knowledge in basic chemical calculation and Stoichiometric relations

Module	Content	Hours	Marks.
1	Natural Raw Materials		
1.1	Structure and properties of ceramic minerals: (i) Structure of ionic compound (ii) Structure of covalent ceramic minerals	**2**	
1.2	Identification of minerals: (i) Physico-chemical properties (ii) Optical mineralogical properties	3	
1.3	Silica and silicate minerals: Polymorphic forms of silica, their transformation, different applications in ceramic industries; different natural forms of silica of industrial importance, their properties, uses: e.g. quartzite, ganister, flint, silica sand. Other forms of silica and their applications: silica gel, vitreous silica.	4	
1.4	Plastic ceramic raw materials: clay minerals, classification of clays, structure, properties and application.	5	

	(i) Important properties of clay: plasticity, CEC, drying strength, shrinkage, vitrification, effect of heat on clay. (ii) Important clay minerals: china clay, ball clay, fireclay, bentonite, mica etc.		
1.5	Fluxing agent: feldspar, nephelene syenite, bone ash, lepidolite and wollastonite- their composition, properties, availability and uses in relevant ceramic industries.	4	
1.6	Refractory raw materials: bauxite, magnesite, dolomite, chromite, graphite, sillimanite group of minerals, limestone: their composition, properties, effect of heat, occurrence and applications.	4	
1.7	Other important raw materials: Laterite, rutile, gypsum, garnet, fluorspar, borax.	2	
2.	Synthetic Ceramic raw Materials		
2.1	Scope, Application & Basic background of Synthetic Ceramic Powder: Purpose /Advantage of synthetic Ceramic Raw Materials, Ultra-pure Synthetic ceramic raw materials, Industrially used synthetic ceramic raw materials, Idea about crystal, crystallite, grain, particle, Particle size and shape, Agglomerated & Mono dispersed particle, Application areas of synthetic ceramic powder in different Engineering field.	3	
2.2	Methods of Ceramic Powder preparation: Sol-Gel process (SGP), Sol-Gel-Auto combustion & Low temperature Solution Combustion process (LCS), Precipitation and co-precipitation technique, Hydrothermal synthesis, Solvent vaporization technique	6	
2.3	Characterization of Synthetic Ceramic powder: Particle size distribution of nano and micron range particles, Decomposition and crystallization study by DTA, TGA and DTGA, Phase analysis by XRD, Debye Scherer equation for crystallite size determination. SEM and TEM.	3	
2.4	Alumina: 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/combustion routes & powder Characterization	4	
2.5	Zirconia: Polymorphic transformation of ZrO_2, Partially stabilized and fully stabilized zirconia (PSZ & FSZ), Synthesis of stabilized ZrO2 powder (with Y_2O_3 , CeO_2 etc.) from solution routes & powder Characterization , Monodisperse spherical ZrO2 powder spinel	4	

2.6	Mullite, Silica Gel and Precipitated Silica: Synthesis from different precursors in solution routes & their Characterization	4	
2.7	Barium Titanate and Ferrite: Temperature dependent structural stability of $BaTiO_3$, Synthesis of $BaTiO_3$ by Pechini and modified Pechini process, Normal and inverse spinel ferrites, Synthesis of Ni, Zn and Mn ferrite powder by sol-gel-auto combustion, co-precipitation techniques & powder Characterization.	4	

Course outcomes

After completion of the course, a student would be able to:

CO 1	identify the suitability of different types of ceramic materials in different ceramic industries.
CO 2	characterize the different types of ceramic raw materials (natural and synthetic) and products for industrial uses.
CO 3	determine suitability of synthetic raw materials vis-à-vis natural raw materials for the preparation of value-added products.
CO 4	use the structure-property relationship to decide the manufacturing process of industrial ceramic products.
CO 5	synthesize the different types of pure and ultrapure ceramic materials for structural applications.
CO 6	apply the structural properties of ceramic materials in relation to their different applications.

Learning Resources:

1.	W.E. Worrall, “Clays and Ceramic Raw materials”: Applied Sc. Publishers
2.	Properties of Ceramic Raw materials: W. Ryan, Pergamon Press
3.	The Chemistry and Physics of Clays and other Ceramic Materials: R. W. Grimshaw, Ernest Benn Ltd
4.	Ceramic Raw Materials (2nd Revised Edition) – W. E. Worrall (1982). Pergamon Press, Oxford. 111p.
5.	Ceramic Raw Materials of India: A Directory – S.K Guha (Editor) (1982). Indian Institute of Ceramics, Kolkata. 202p.
6.	Ceramic Powder preparation: A Hand Book, Dibyendu Gangully & Minati Chatterjee, Kluwer Academic Publishers
7.	Sol-Gel Processing of Advanced Ceramics, Editor by F. D. Gnanam, Oxford & IBH Publishing Co. Pvt. Ltd. New Delhi

Name of the course	**Unit Operation I**
Course Code: PC(CT) 302	**Semester: 3RD**
Duration: 6 months	**Maximum Marks: 100**
Teaching Scheme	**Examination Scheme**
Theory: 3 hrs./week	Mid Term Exam I: 15 Marks
Tutorial: 1 hr./week	Mid Term Exam II: 15 Marks
Practical: Nil	Assignment & Quiz etc.: 20 Marks
Credit Points: 4	Semester End Exam: 75 Marks (Two third weightage for final reckoning i.e., 50 marks)

Objective:

1.	The objective of the course is to provide an exposure to the engineering application of the physical principles involved in various unit operations related to processing of ceramic materials. Familiarizing the students with the major physical features and the working principles of the equipment for handling various kinds of fluid and transport of heat through conduction, convection and radiation is also a part of the objective. This course also provides an understanding of practical problem-solving techniques for the processes as described in Module 1, 2, 3 & 4.

Pre-Requisite

1.	Class 12th standard knowledge of Physics
2.	Class 12th standard knowledge in differential & integral calculus

Module	Content	Hours	Marks.
1	Fluid Mechanics Introduction to unit operations for ceramic processes, Units and dimensions, dimensional analysis, Hydrostatic Equilibrium, Manometer, Newtonian & non-Newtonian fluid, Laminar & turbulent flow, Reynold's stress, Boundary layers, Momentum balance and Bernoulli equation, Friction factor and friction factor charts, Pipe, Fittings and Valves, Pumps, Fans and Compressors, Flowmeters, Drag and Friction in flow.		
2	Heat Transfer by Conduction Steady State Heat Transfer by conduction, Fourier's law, Compound resistance in series, Heat transfer through hollow cylinder and spheres, Unsteady state heat conduction, Semi-infinite solid, Penetration distance		
3	Heat Transfer by convection 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, Application of Empirical Equations, Heat exchanger equipments.		
4	Heat Transfer by Radiation 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.		

Course outcomes	
After completion of the course, a student would be able to:	
CO 1	distinguish the basic features of moving fluids at low and high velocities through pipes in order to determine the frictional losses and suitable materials of construction for a pipeline.
CO 2	select machineries for transportation of fluids with special emphasis on ceramic processes.
CO 3	develop a pipeline layout complete with fittings, valves and flow meters for a flow of fluid with certain flow rate.
CO 4	apply the laws of heat conduction to calculate heat flow through successive layers of furnace wall.
CO 5	apply the principles of heat flow in fluids to calculate the heat transfer area and the type of heat exchanger
CO 6	apply concepts of radiation to determine the amount of heat transfer by radiation in furnaces.
Learning Resources:	
1.	Unit Operations of Chemical Engineering – W. M. McCabe., J. C. Smith., P. Harriot., McGraw Hill
2.	Chemical Engineering – Coulson, Richardson, Backhurst and Harker, Pergamon Press
3.	Heat Transfer – B. K. Datta., Prentice Hall of India, New Delhi

Name of the course	**Energy Resource & Furnaces**
Course Code: PC(CT) 303	**Semester: 3RD**
Duration: 6 months	**Maximum Marks: 100**
Teaching Scheme	**Examination Scheme**
Theory: 4 hrs./week	Mid Term Exam I: 15 Marks
Tutorial: Nil	Mid Term Exam II: 15 Marks
Practical: Nil	Assignment & Quiz etc.: 20 Marks
Credit Points: 4	Semester End Exam: 75 Marks (Two third weightage for final reckoning i.e., 50 marks)

Objective:

1.	The objective of the course is to provide the knowledge on basic characteristics and the sources of the energy resources being used for processing ceramic materials at high temperature furnaces. Familiarising the students with the major physical features and the working principles of those furnaces as well as the accessories forms a major part of the objective. This course also provides some important clues for solving practical numerical problems related to fuel combustion and furnace efficiency.

Pre-Requisite

1.	Class 12th standard knowledge of physics and chemistry
2.	Class 10th standard knowledge of basic mathematics

Module	**Content**	**Hours**	**Marks.**
1	Energy Resources		
1.1	Basic Definitions Calorific value, Primary and Secondary Air, Inflammability limits, Flame temperature etc.		
1.2	Solid Fuel Origin of Coal, Proximate & Ultimate Analysis, Stages of Coal, Coal Petrography, Storage of Coal & Spontaneous combustion; Carbonisation of coal, Low Temperature & High Temperature Carbonization, Coke Making & By-product Recovery, Salient features of LTC & HTC		
1.3	Liquid Fuel Origin of Petroleum, Classification of Petroleum, Products from Petroleum Distillation, General Scheme of Petroleum Distillation, Cracking, Visbreaking, reforming, sweetening, viscosity index, flash point & fire point, Cloud Point & Pour point, Carbon Residue, Aniline Point & Diesel Index, Octane & Cetane no., Coal-Tar Fuel		
1.4	Gaseous Fuel Natural gas, Liquefied Petroleum Gas, Producer Gas & water gas		
2	Furnaces		
2.1	General Features of Industrial Furnaces Introduction, Classification of Industrial Furnaces, Components of total Furnace System, Furnaces/Kiln Construction materials.		

2.2	Efficient Utilization of Energy Heat/Fuel Economy, Energy Audit and its Necessity, Sources of Heat Losses, Factors affecting Fuel Economy, Thermal Efficiency in operation of Furnace, Techniques of waste heat recovery, Recuperators & Regenerators, Operation of different type of Recuperators & Regenerators		
2.3	Dynamics of Flue Gas Movement in a furnace Definition of Draught; its necessity, Classification of Draught, Deduction of Equations for Calculation of Natural Draught & Chimney Height		
2.4	Study of Typical Furnaces/Kilns and useful Heating Elements Down Draft Kiln, Tunnel Kiln, Shuttle kiln, Bell type kiln, Glass Tank Furnace, Blast Furnace, BOF, EAF, Roller Hearth Kiln, Rotary Kiln, Induction Furnaces, Electrical Furnaces, SiC, $MoSi_2$ & Lanthanum Chromate heating Element		

Course outcomes	
After completion of the course, a student would be able to:	
CO 1	specify right kind and quantity of fuel on the basis of properties of solid, liquid and gaseous fuels for use in industrial and other furnaces.
CO 2	apply carbonization techniques of coal for preparation of coke for metallurgical and domestic purpose.
CO 3	assess the properties of various petroleum fractions and coal tar fuels for their suitable use as automobile fuel/furnace fuel or as lubricants.
CO 4	apply different energy conservation techniques to enhance furnace efficiency.
CO 5	apply dynamics of gas movement and techniques of heat recovery using heat exchangers for overall conservation of energy in ceramic industry.
CO 6	select suitable furnaces & kilns for different ceramic & glass making processes.

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

Name of the course	**Chemical & Engineering Thermodynamics**
Course Code: ES(CT) 308	**Semester: 3^{RD}**
Duration: 6 months	**Maximum Marks: 100**
Teaching Scheme	**Examination Scheme**
Theory: 3 hrs./week	Mid Term Exam I: 15 Marks
Tutorial: 1 hr./week	Mid Term Exam II: 15 Marks
Practical: Nil	Assignment & Quiz etc.: 20 Marks
Credit Points: 4	Semester End Exam: 75 Marks (Two third weightage for final reckoning i.e., 50 marks)

Objective:

1.	Chemical Thermodynamics: The objective of the course is to provide the knowledge on thermodynamic and kinetic parameters of solid state reactions including third Law of thermodynamics and its application in crystalline solids. Imparting knowledge on stability of domain in different oxides, configurational entropy of crystalline solid oxides, phase equilibria and phase diagram of binary oxide system, congruent and incongruent melting of oxide ceramics also constitute a major part of the objective.
2.	Engineering Thermodynamics The objective of the course is to provide an exposure to the engineering application of the basic concepts of thermodynamics. Providing major clues as to how the energy balance equation, concept of second law, entropy change and availability can be applied for solving practical problems is also a part of the objective. This course also provides an understanding of practical problem solving techniques for Carnot vapour cycle, Rankine cycle, Diesel cycle and auto cycle by applying the knowledge on properties of pure substance in all three phases and their behaviour in power cycles

Pre-Requisite

1.	Class 12th standard knowledge of physics, physical Chemistry & basic chemical thermodynamics
2.	Class 12th standard knowledge in differential & integral calculus
3.	Basic concepts of thermodynamics as contained in the syllabus of BS(CT) 102

Module	Content	Hours	Marks.
1	Chemical Thermodynamics		
1.1	Thermodynamics of Solid metallic oxide: Thermodynamically controlled and Kinetically controlled product, Free energy diagram of polymorphic transformation of solid metallic oxide, Chemical potential and Electrode potential of solid oxides, Gibbs-Duhem relation and its application, Gibbs Helmoltz equation and its applicability in ceramic system.		
1.2	Thermodynamics of Solid State reactions: Free energy diagram for solid state reactions like calcination, dehydroxylation etc. Stability of domain in different oxides phases, Ellingham Diagram, Chemical equilibrium and equilibrium constant, Reaction isotherm, Temperature dependence of equilibrium constant,		

	Van't Hoff equation and its application		
1.3	Statistical Thermodynamics: Thermodynamics probability and Configurational entropy of crystalline solid, Third Law of thermodynamics and its application in ceramic compounds, Specific entropy of solid metallic oxides, Boltzman distribution Law, Partition function and its application		
1.4	Phase Equilibrium: Phase, Component, Degree's of Freedom, Gibb's phase rule, Phase diagram of one and two component oxide system, Construction of different types of phase diagram, Eutectic and Peritectic reactions with examples. Congruent melting and incongruent melting of solid metallic oxides		
2.	Engineering Thermodynamics		
2.1	Concept of energy and various forms of energy, first law applied to elementary processes, Control volume, steady flow process, mass and energy balance in simple steady flow process, application of steady flow process to nozzle, throttling device and turbine/compressor, variable flow processes.		
2.2	Carnot cycle, efficiency of reversible heat engine, inequality of Clausius, entropy change in irreversible process, principle of increase of entropy, applications of entropy principle, available and unavailable energy, decrease in unavailable energy when heat is transferred through finite temperature difference, available energy from finite energy source, quality of energy, law of degradation of energy, maximum work in a reversible process		
2.3	Thermodynamic properties of pure substance, P-V-T behaviour of simple compressible substance, ideal and real gas,		
2.4	Carnot vapour cycle, Ideal Rankine cycle, Reheat Rankine cycle, Air-standard Otto and Diesel cycle.		

Course outcomes	
After completion of the course, a student would be able to:	
CO 1	apply thermodynamic concepts to predict the stability of metal and metallic oxides and the possibility of solid-state reactions.
CO 2	apply the concept of configurational entropy and third Law of thermodynamics to detect imperfections in crystalline solids.
CO 3	identify different reactions viz eutectic, peritectic etc. in different phase equilibrium systems for Ceramics and metals.
CO 4	apply thermodynamic properties and mass and energy balance equations to closed and open systems including various thermal devices such as nozzles, diffusers, turbines and compressors, for solving representative numerical problems.
CO 5	evaluate the performance of energy conversion devices using the concept of second law, entropy

	change and availability.
CO 6	solve problems involving different practical power cycles using the properties of pure substances like water and changes in properties of substances in various processes.
Learning Resources:	
1.	Introduction to Ceramics— W. D. Kingery, H. K. Bowen & D. R. Uhlmann
2.	Solid State Phase Transformation— V. Raghavan
3.	Fundamentals of Ceramics—M. W. Barsoum
4.	Physical Chemistry—P. C. Rakshit
5.	Engineering Thermodynamics – P.K.Nag
6.	Thermodynamics: An engineering approach- Yunus A Cengel; Michael A Boles

Name of the course	**Powder Preparation & Chemical Analysis of Ceramic Raw Materials and Products Lab.**
Course Code: PCL(CT) 304	**Semester: 3RD**
Duration: 6 months	**Maximum Marks: 100**
Teaching Scheme	**Examination Scheme**
Theory: Nil	Attendance: 10
Tutorial: Nil	Preparation of Lab Report: 20
Practical: 3 hrs./week	Experimental data/ Precision of work done: 30
Credit Points: 1.5	Presentation/ analysis of the result: 20
	Viva Voce: 20

Module	**Content**	**Hours**	**Marks.**
1	Synthesis of ultrapure silica powder by sol gel method	3	
2	Synthesis of Alumino hydrogel and alumina powder by Precipitation technique in relation with particle size	3	
3	Synthesis of nano metal ferrite (MFe_2O_4 : M = Zn, Mg and Co) powder by solution combustion technique	3	
4	Synthesis of MAH gel and $MgAl_2O_4$ powder by co-precipitation technique	3	
5	Synthesis of $ZnFe_2O_4$ powder by co-precipitation technique	3	
6	Primary Characterization of Synthesized Ceramic powder by Tap density, DTA / TGA / DTGA, FTIR and PSD	3	
7	Estimation of SiO_2, Fe_2O_3, Al_2O_3, CaO and MgO in Lime stone / Dolomite.	3	
8	Quantitative analysis of Bauxite.	3	
9	Analysis of Sea-Water Magnesia.	3	
10	Analysis of Fireclay.	3	
11	Determination of insoluble portion in Portland cement band free lime in cement	3	
12	Complete analysis of Portland cement.	3	

13	Complete Analysis of Water Glass.	3	
14	Complete Analysis of Soda-lime – silica glass.	3	
15	Quick estimation of silica in glass sand and glass.	3	
16	Quantitative analysis of Blast Furnace Slag/ Fly Ash.	3	
Course outcomes			
After completion of the course, a student would be able to:			
CO 1	synthesize different types of ultra-pure ceramic powders like silica, alumina, MAH, $MgAl_2O_4$, $ZnFe_2O_4$.		
CO 2	prepare micron and nano ceramic powder.		
CO 3	characterize ceramic powders with different tools.		
CO 4	determine chemical composition of various ceramic raw materials & products, e.g. dolomite, limestone, cement, Water-glass, soda-lime-silica glass.		
CO 5	estimate free lime & insoluble residue content in cement		
CO 6	determine the chemical composition of Slag, Fly Ash.		
CO 7	develop skill to work in a team		
Learning Resources:			
1.	**Lab Manuals**		

Name of the course	Fuel Testing Lab
Course Code: PCL(CT) 305	**Semester: 3RD**
Duration: 6 months	**Maximum Marks: 100**
Teaching Scheme	**Examination Scheme**
Theory: Nil	Attendance: 10
Tutorial: Nil	Preparation of Lab Report: 20
Practical: 3 hrs./week	Experimental data/ Precision of work done: 30
Credit Points: 1.5	Presentation/ analysis of the result: 20
	Viva Voce: 20

Module	Content	Hours	Marks.
1	Proximate Analysis of coal: Determination of Moisture, Volatile Matter, Ash and Fixed Carbon content of coal		
2	Determination of Calorific Value of Coal/Oil		
3	Studying the nature of change in Viscosity of lube oil at different temperatures		
4	Determination of Flash Point and Fire Point of Fuel oils		
5	Determination of Carbon Residue of Fuel Oil/Lube Oil		
6	Performing Distillation Test for Petroleum Products		

Course outcomes

After completion of the course, a student would be able to:

CO 1	identify different equipment and accessories as per specification needed to conduct a particular experiment.
CO 2	determine industrially important properties like calorific value and proximate analysis of solid fuel.
CO 3	determine industrially important properties of liquid fuel like calorific value, flash point & fire point, boiling range etc.
CO 4	determine industrially important properties of lubricants like Carbon Residue, Viscosity and Temperature Relationship etc.
CO 5	develop skill to work in a team

Learning Resources:

1.	Respective IS manuals and the manuals provided in the fuel testing laboratory

Name of the course			Numerical Methods Lab	
Course Code: BSL(CT) 308			**Semester: 3RD**	
Duration: 6 months			**Maximum Marks: 100**	
Teaching Scheme			**Examination Scheme**	
Theory: Nil			Attendance: 10	
Tutorial: Nil			Preparation of Lab Report: 20	
Practical: 2 hrs./week			Experimental data/ Precision of work done: 30	
Credit Points: 1			Presentation/ analysis of the result: 20	
			Viva Voce: 20	
Module	**Content**		**Hours**	**Marks.**
1	Apply Newton forward, backward and Lagrange's interpolation to solve problem on function.			
2	Apply numerical integration by using Trapezoidal rule, Simpson's 1/3 rule, Weddle's rule.to find area under a curve.			
3	Apply Gauss elimination and Gauss –seidel iterations. methods to solve system of linear equations.			
4	Apply Regular-Falsi and Newton-Raphson-methods.to solve algebraic equations.			
5	Apply Euler's and Runge-Kutta.methods.to solve ordinary differential equations.			
6	Draw an algorithm and write C-programme to solve problems with Euler and Runge-Kutta methods.			
Course outcomes				
After completion of the course, a student would be able to:				
CO 1	Measure different types of errors in numerical computations.			
CO 2	Solve interpolation problems for equal and unequal nodes using different methods.			
CO 3	Solve numerical integration problems using different techniques.			
CO 4	solve linear and non-linear equations using different numerical methods.			
CO 5	write C programme for different numerical problems			
CO 6	draw algorithm on different mathematical problems.			
Learning Resources:				
1.	**Lab Manual**			

Name of the course		**ENVIRONMENTAL SCIENCES**	
Course Code: MC(CT) 301		**Semester: 3RD**	
Duration: 6 months		**Maximum Marks: 100**	
Teaching Scheme		**Examination Scheme**	
Theory: 2 hrs./week		Mid Term Exam I: 15 Marks	
Tutorial: Nil		Mid Term Exam II: 15 Marks	
Practical: Nil		Assignment & Quiz etc.: 20 Marks	
Credit Points: 0		Semester End Exam: 75 Marks (Two third weightage for final reckoning i.e., 50 marks)	
Objective:			
1.	to understand the importance of study of environmental science.		
2.	to learn various types of pollution (anthropogenic and natural).		
3.	to understand "Sustainable development", i.e., meeting human goals along with sustaining the ability of natural systems to provide resources and services for mankind to survive.		
4.	to learn how to manage environmental hazards in the events of natural and anthropogenic calamities.		
5.	to learn Environmental Impact Assessment (EIA), mandatory for setting up new industries, and various Acts related to environmental protection.		
Pre-Requisite			
1.	Chemistry, BS(CT)102		
2.	Physics, BS(CT) 205		
3.	Mathematics I, BS(CT) 101		
Module	**Content**	**Hours**	**Marks.**
1	The Multidisciplinary nature of environmental studies: Definition, scope and importance, Need for public awareness.	**2**	
2	The Natural Resources Renewable and non-renewable resources: a) Natural resources and associated problems • Forest resources: Use and over-exploitation, deforestation, mining, dams and their effects on forests and tribal people. • Water resources: Use and over-utilization of surface and ground water, floods, drought, conflicts over water, dam's benefits and problems. • Mineral Resources: Use and exploitation, environmental effects of extracting and using mineral resources. • Food Resources: World food problems, changes caused by agriculture and over grazing, effects of modern agriculture, fertilizers- pesticides problems, water logging, salinity. • Energy Resources: Growing energy needs, renewable and non-renewable energy sources, use of alternate energy sources. • Land Resources: Land as a resource, land degradation, man induced landslides, soil erosion, and desertification.	5	

	b) Role of individual in conservation of natural resources. c) Equitable use of resources for sustainable life styles.		
3	Eco Systems a) Concept of an eco-system: Understanding ecosystems, Ecosystem degradation, Resource utilization b) Structure and function of an eco-system. c) Producers, consumers, decomposers. d) Energy flow in the eco systems: Water cycle, Carbon cycle, Oxygen cycle, Nitrogen cycle, Energy cycle, Integration of cycles in nature e) Ecological succession. f) Food chains, food webs and ecological pyramids. g) Introduction, types, characteristic features, structure and function of (i) Forest ecosystem (ii) Grass land ecosystem (iii) Desert ecosystem (iv) Aquatic eco systems (ponds, streams, lakes, rivers, oceans, estuaries)	5	
4	Biodiversity and its Conservation (a) Introduction, Definition: genetic diversity, species diversity and ecosystem diversity. (b) Biogeographically classification of India. (c) Value of biodiversity: consumptive, productive, social, ethical (d) Biodiversity at global, national and local level. (e) India as a mega diversity nation. (f) Hot-spots of biodiversity. (g) Threats to biodiversity: habitats loss, poaching of wild life, man wildlife conflicts. (h) Endangered and endemic species of India. (i) Conservation of biodiversity: in-situ and ex-situ conservation of biodiversity.	5	
5	Environmental Pollution (a) Definition, (b) Causes, effects and control measures of: (1) Air pollution, (2) Water pollution, (3) Soil pollution, (4) Marine pollution, (5) Noise pollution, (6) Thermal pollution, (7) Nuclear hazards (c) Solid waste Management: Causes, effects and control measures of urban and industrial wastes. (d) Role of an individual in prevention of pollution. (e) Disaster management: Floods, earth quake, cyclone and landslides, industrial safety.	6	
6	Social issues and the Environment (a) Urban problems related to energy (b) Water conservation, rain water harvesting, water shed management	4	

	(c) Resettlement and rehabilitation of people; its problems and concerns, (d) Climate change, global warming, acid rain, ozone layer depletion, nuclear accidents and holocaust (e) Wasteland reclamation (f) Consumerism and waste products (g) Environment protection Act (h) Air (prevention and control of pollution) Act (i) Water (prevention and control of pollution) Act (j) Wildlife protection act (k) Forest conservation act (l) Issues involved in enforcement of environmental legislations (m) Public awareness		

Course outcomes	
After completion of the course, a student would be able to:	
CO 1	explain how human beings should make a sustainable living using the Earth's finite resources.
CO 2	apply scientific methods judiciously in preventing causes which damage natural ecosystems.
CO 3	explain how to protect endangered species and endemic species for conserving biodiversity.
CO 4	explain the causes and effects of various types of pollution and their prevention.
CO 5	apply disaster management techniques in the events of natural and anthropogenic calamities.
CO 6	follow various environment protection acts, "Environment Impact Assessment" (EIA) as and when required in setting up of new industries.
Learning Resources:	
1.	Textbook of Environmental studies, Erach Bharucha, UGC
2.	Fundamental concepts in Environmental Studies, D D Mishra, S Chand & Co Ltd
3.	Environmental chemistry, A. K. Dey

SECOND YEAR SECOND SEMESTER

4th Semester B. Tech Ceramic Technology							
Sl. No.	Type of course	Course Code	Course Title	Hours per week			Credits
				Lecture	Tutorial	Practical	
Theory							
1.	Basic Science Course	BS(CT) 409	Biology	2	0	0	2
2.	Professional Core Course	PC(CT) 406	Unit Operation II	3	0	0	3
3.	Engineering Science Course	ES(CT) 409	Engineering Materials Science	3	0	0	3
4.	Professional Core Course	PC(CT) 407	Processing of Ceramics	3	0	0	3
5.	Engineering Science Course	ES(CT) 410	Fundamentals of Metallurgy	3	0	0	3
6.	Professional Elective Course	PE(CT) 401	Process Calculations(A)/ Introduction to Industrial Ceramics (B)	2	0	0	2
7.	Humanities & Social Sciences including Management Courses	HS(CT) 403	Economics & Statistics	3	0	0	3
Sessional/Practical							
1.	Professional Core Course	PCL(CT)408	Physical Testing & Instrumental Methods of Analysis of Raw Materials & Products Lab	0	0	3	1.5
2.	Professional Core Course	PCL(CT)409	Unit Operation Lab	0	0	3	1.5
3.	Comprehensive Laboratory Assessment	CLA(CT) 4	All Labs	-	-	-	1
				Total credits			**23**

The course teacher shall assess the students for Serial Nos. 1, 2 under Sessional/Practical before commencement of Semester End Examination. A student has to secure at least 50% marks in Serial Nos. 1, 2 under Sessional/Practical, failing which the student would be debarred from sitting in the Semester End Examination.

A student has to secure at least 50% marks in rest of the courses (Theory papers and CLA), failing which he/she would carry backlog(s).

Name of the course	**BIOLOGY**
Course Code: BS(CT) 409	**Semester: 4TH**
Duration: 6 months	**Maximum Marks: 100**
Teaching Scheme	**Examination Scheme**
Theory: 2 hrs./week	Mid Term Exam I: 15 Marks
Tutorial: Nil	Mid Term Exam II: 15 Marks
Practical: Nil	Assignment & Quiz etc.: 20 Marks
Credit Points: 2	Semester End Exam: 75 Marks (Two third weightage for final reckoning i.e., 50 marks)

Objective:

1.	To understand cell, the unit of life, different types of cells and classification of living organisms.
2.	To understand Biomolecules, their structure and functions, their role in a living organism. and applications of certain biomolecules in industry.
3.	To understand human physiology which is essential in bioengineering field
4.	To apply in different technology for production of medicines to transgenic plants and animals for designing new biotechnological products in our daily life.

Pre-Requisite

1.	Chemistry: BS(CT) 102

Module	Content	Hours	Marks.
1	**I**ntroduction to cell biology: cell definition and types, cell theory, structure of a cell, cell cycle, tissue and its types, basic introduction to five kingdom of classification	**4**	
2	Introduction to Biomolecules: carbohydrate, protein, fat, amino acid, nucleic acid (DNA and RNA), Enzymes and their application in industry.	4	
3	Human physiology: digestion, respiration and its types (aerobic and anaerobic), excretion.	4	
4	Genes and introduction to recombinant DNA Technology: prokaryotic and eukaryotic gene structure, gene replication, transcription and translation, recombinant DNA technology and introduction to cloning.	6	
5	Application of Biology: Brief introduction to production of vaccines, cloning in microbes, plants and animals, Basics to	6	

	Biosensors, Biochips, Biofuels, Tissue engineering and its application, Transgenic plants and animals, Bioengineering (production of artificial limbs, joints and other parts of body)		

Course outcomes	
After completion of the course, a student would be able to:	
CO 1	explain cells, its structure and function, and basis for classification of living organisms.
CO 2	explain Biomolecules, its structure and function and their role in living organism and usefulness in industry.
CO 3	explain mechanisms of digestion, respiration and excretion in human physiology.
CO 4	demonstrate the concept of biology and its uses in combination with different technologies for production of medicines and production of transgenic plants and animals.
CO 5	illustrate genes and genetic materials (DNA and RNA) present in living organisms.
Learning Resources:	
1.	Cell and Molecular Biology-P.K.Gupta
2.	Biology for Engineers, T.Johnson
3.	Genetic Engineering-Sandhya Mitra
4.	Introductory Microbiology –Trevor Gross
5.	Introduction to Biomedical Engineering –John Enderle and Joseph Bronzino

Name of the course	**UNIT OPERATION II**
Course Code: PC(CT) 406	**Semester: 4TH**
Duration: 6 months	**Maximum Marks: 100**
Teaching Scheme	**Examination Scheme**
Theory: 3 hrs./week	Mid Term Exam I: 15 Marks
Tutorial: Nil	Mid Term Exam II: 15 Marks
Practical: Nil	Assignment & Quiz etc.: 20 Marks
Credit Points: 3	Semester End Exam: 75 Marks (Two third weightage for final reckoning i.e., 50 marks)

Objective:

1.	To provide an exposure to the engineering application of the physical principles involved in various unit operations related to processing of ceramic materials.
2.	To familiarize with the major physical features and the working principles of the equipment for handling particulate solids, mechanical separation processes like filtration/sedimentation and drying
3.	To provide an understanding of practical problem-solving techniques for the physical processes.

Pre-Requisite

1.	Class 12th standard knowledge of physics
2.	Class 12th standard knowledge in differential & integral calculus

Module	Content	Hours	Marks.
1	**Properties and handling of particulate solids** Characterization of solid particles, Average particle sizes, Specific surface of mixture, screen analysis, Properties of masses of particles, Storage and conveying of solids, Mixing of solids, Performance of mixers, Mixers for Non cohesive and cohesive solids, Mixer extruders, Muller Mixer, Pug mill, Mixing performance, Axial mixing; Size reduction, characteristics of comminuted products, Energy and power requirement in comminution, Efficiency, Crushing law and work index, Equipment for size reduction, Jaw crusher, Gyratory crusher, Roll crushers, Grinders, Hammer mill and impactors, Roller mills, Attrition mill, Tumbling mill, Ball mill, Critical speed of Ball mill, Ultrafine grinders, Classifying hammer mill, Fluid energy mill, agitated mill, Colloid mill, Cutting machine, Open circuit and	14	

	closed circuit operation.		
2	**Mechanical Separation** Screening equipment, Material balances over screen, Screen efficiency; Filtration, Cake filter: Filter press, Shell and leaf filter, Vacuum filter: rotary drum filter, Precoat filter, Centrifugal filters, Filter media, Filter aids, Principles of cake filtration, Pressure drop through filter cake, Compressible and incompressible filter cakes, Filter medium resistance, Constant pressure filtration, Continuous filtration, constant rate filtration Clarifying filter, Cross flow filtration, Gravity sedimentation, Gravity thickener, Centrifugal sedimentation	8	
3	**Drying of solids** Basic definitions on humidification; Dry and wet bulb temperature, Relative humidity, Absolute humidity, Dew point, Humid volume, Psychrometric chart and its use, Bound moisture, Unbound moisture, Equilibrium moisture, Drying rate curve, Calculation of drying time, Classification of dryer, Type of dryers: Tray dryer, Tunnel dryer, Drum/ roller dryer, Spray dryer. Cross circulation and through circulation drying.	14	

Course outcomes	
After completion of the course, a student would be able to:	
CO 1	apply principles of handling & storing of particulate solids for selection of machineries for processing ceramic raw materials found naturally in the form of rocks & minerals.
CO 2	apply the principles of comminution process to make rough estimate of energy requirement for crushing and grinding
CO 3	apply principles of mechanical separation processes to separate bulk solid from ceramic slurry
CO 4	apply principles of mechanical separation processes to separate solids from liquid medium taking help of gravitational pull and centrifugal force without using filtering media.
CO 5	apply principles of drying to determine drying rates, drying time etc. for ceramic body.
CO 6	select suitable equipment for drying various kind of wet ceramic materials by using principles of drying.
Learning Resources:	
1.	W. M. McCabe., J. C. Smith., P. Harriot., Unit Operations of Chemical Engineering, McGraw Hill.
2.	B. K. Datta., Principles of Mass Transfer and Separation Process, Prentice Hall of India, New Delhi.
3.	C. J. Geankoplis., Transport Processes and Unit Operations, Prentice Hall.

Name of the course		**Engineering Materials Science**	
Course Code: ES(CT) 409		**Semester: 4^{TH}**	
Duration: 6 months		**Maximum Marks: 100**	
Teaching Scheme		**Examination Scheme**	
Theory: 3 hrs./week		Mid Term Exam I: 15 Marks	
Tutorial: Nil		Mid Term Exam II: 15 Marks	
Practical: Nil		Assignment & Quiz etc.: 20 Marks	
Credit Points: 3		Semester End Exam: 75 Marks (Two third weightage for final reckoning i.e., 50 marks)	
Objective:			
1.	To provide an exposure to the atomic bonding, atomic and crystal structure, crystalline defects of metallic materials etc.		
2.	To familiarize with properties viz. mechanical, electrical, magnetic etc. and structure-property correlations of metallic materials		
3.	To provide scope of problem-solving techniques for the topics covered		
Pre-Requisite			
1.	Mathematics-I: BS(CT) 101		
2.	Mathematics-II: BS(CT) 204		
3.	Physics: BS(CT) 205		
4.	Chemistry: BS(CT)102		
5.	Ceramic Raw materials: PC(CT)301		
Module	**Content**	**Hours**	**Marks.**
1	Introduction: Scope and Importance of the subject	1	
2	Classification of Engineering Materials: Metals & alloys, Ceramics, polymers and composites – basic characteristics and important properties	2	
3	Structure of solids: atomic bonding – ionic, covalent, metallic, Van der Waals; Crystal structures-crystal systems, Bravais lattice, Lattice planes and directions. Mathematical calculations of	4	

	different parameters, Numerical problems		
4	Lattice imperfections – point defects, line defects, planar and volume defects, substitutional and interstitial solid solutions, Hume Rothery rules, Intermetallic compounds, Numerical problems	3	
5	Mechanical Properties: Stress strain, Elastic and plastic deformation. Deformation by dislocation movement, Critical Resolved Shear Stress for Slip, Cottrell's views, Shear strain rate, Peierl’s stress, Deformation by twinning. Comparison, Numerical problems	4	
6	Fracture: Ductile & brittle fracture, critical stress intensity factor, crack propagation, Griffith’s theory, fracture toughness etc. Numerical problems	4	
7	Strengthening Mechanisms: General concepts, Cold working, Yield point, Yield stress, Strain (Work) hardening, Solid solution strengthening, Hall-Petch equation - Strengthening by grain boundaries, second phase strengthening, Dispersion hardening, Precipitation or age hardening. Fatigue, creep and stress-rupture behaviour. Annealing of metals – Recovery, Recrystallization, Grain growth. Numerical problems	4	
8	Corrosion & its prevention in metals: 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. Numerical problems	6	
9	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; Dielectric polarization – capacitance, ferro-electricity and piezoelectricity, Numerical problems	4	
10	Magnetic Properties of metals and ceramics: different types of magnetism, hysteresis loop of ferro- and ferri-magnetic materials and their applications, magneto-striction, Magneto crystalline anisotropy, Magnetostatic energy, Domain wall energy, Magnetic exchange energy, Direct, Super and Double exchange interaction,	4	

	Soft and Hard magnets, Numerical problems		

Course outcomes	
After completion of the course, a student would be able to:	
CO 1	identify different classes of bonding and crystal structures of solids
CO 2	identify various types of lattice imperfections responsible for development of beneficial properties for its applications in engineering materials
CO 3	explain mechanical, electrical and and magnetic properties of solids
CO 4	solve problems on bonding, crystal structure, defects, elastic & plastic deformation and fracture behaviour, electrical and magnetic properties of engineering materials
CO 5	identify limits of various strengthening mechanisms and annealing of metals for engineering applications
CO 6	design metallic structures of engineering importance giving due importance to electrochemical corrosion and oxidation of metals and its kinetics
Learning Resources:	
1.	Principles of Mat. Sc. & Engg. – Smith
2.	Physical Properties of Materials - Lovell, Avery & Vernon
3.	Materials Science & Engineering – An Introduction - W D Callister, Jr.

Name of the course	**Processing of Ceramics**
Course Code: PC(CT) 407	**Semester: 4TH**
Duration: 6 months	**Maximum Marks: 100**
Teaching Scheme	**Examination Scheme**
Theory: 3 hrs./week	Mid Term Exam I: 15 Marks
Tutorial: Nil	Mid Term Exam II: 15 Marks
Practical: Nil	Assignment & Quiz etc.: 20 Marks
Credit Points: 3	Semester End Exam: 75 Marks (Two third weightage for final reckoning i.e., 50 marks)

Objective:	
1.	To gain the knowledge about the science of ceramic processing
2.	To learn different characterization techniques and rheological behavior of raw materials
3.	To gain knowledge on different processing techniques for preparation of ceramic bodies
4.	To learn the fundamentals of different shape forming operations and thermal treatment of ceramic bodies.
5.	To learn fundamentals of glass processing.

Pre-Requisite	
1.	Ceramic Raw Materials PC(CT)301
2.	Unit Operation I: PC(CT) 302

Module	**Content**	**Hours**	**Marks.**
1	Introduction & Science in Ceramic Processing	1	
2	Material Characterization: a) Characterization and specification of ceramic materials b) Chemical and Phase compositions c) Particle size and shape d) Density, pore structure and specific surface area.	3	
3	Rheological behaviour of slurries and pastes: Newtonian fluid, plastic flow, dilatant liquid, thixotropy, Deflocculation, Flocculation, Zeta potential, effect of electrolytes on Zeta potentials, applications in ceramic processing.	6	

4	Beneficiation process: Comminution – Equipment, milling, particle size distribution. Batching and mixing: Mixing mechanism and mixing equipment. Particle separation, concentration and washing processes – particle sizing, filtration, washing, particle concentration processes. Granulation – direct granulation, spray granulation.	5	
5	Particle packing: Particle packing characteristics – Models of one, two of spherical balls, Different types of pores present in ceramic body. measurement of porosity, formation of porosity. Gap grading, continuous grading	4	
6	Forming processes: Dry pressing, Semidry 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, casting defects.	6	
7	Drying –drying processes, Mechanisms in drying, defects Firing: Firing system, Pre-sintering processes, sintering, vitrification and cooling.	6	
8	Preliminary ideas of Glass processing – selection of raw materials, effects of different oxides on glass properties, batch preparation, melting in glass tank furnace, refining of glass.	5	

Course outcomes

After completion of the course, a student would be able to:

CO 1	select suitable raw materials for different ceramic and glass industries based on characterization of the materials
CO 2	apply techniques of size reduction, mixing and compaction in preparing a green product
CO 3	analyze rheological behavior of different Ceramic and glass systems for industrial usage
CO 4	apply different forming processes to shape ceramic green products.
CO 5	apply techniques of melting, refining and annealing in glass manufacturing

CO 6	apply techniques of drying and firing for processing of ceramic products
Learning Resources:	
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
5.	Rex W. Grimshaw: The Chemistry and Physics of clays and other ceramic materials.

Name of the course		**FUNDAMENTALS OF METALLURGY**	
Course Code: ES(CT) 410		**Semester: 4TH**	
Duration: 6 months		**Maximum Marks: 100**	
Teaching Scheme		**Examination Scheme**	
Theory: 3 hrs./week		Mid Term Exam I: 15 Marks	
Tutorial: Nil		Mid Term Exam II: 15 Marks	
Practical: Nil		Assignment & Quiz etc.: 20 Marks	
Credit Points: 3		Semester End Exam: 75 Marks (Two third weightage for final reckoning i.e., 50 marks)	
Objective:			
1.	To provide an exposure of ores, mineral beneficiation and metal extraction process		
2.	To provide knowledge on iron, steel making and nonferrous metal extraction process		
3.	To provide knowledge on heat treatment process to distinguish different graded iron and alloy steel		
4.	To provide knowledge on metallurgical testing		
Pre-Requisite			
1.	Energy Resources and Furnaces PC(CT) 303		
2.	Chemistry BS(CT) 102		
Module	**Content**	**Hours**	**Marks.**
1	**Scope, Application & Basic background of Extractive and Physical Metallurgy:** Minerals, Ore, Gangue and Fluxes, Occurrence of Minerals and Ore in India, Goldschmidt classification, Mineral beneficiation and ore dressing, Metal refining process, Purity of metal	3	
2	**Different Metallurgical Process:** Basic principle, applications and processing techniques of (a) Pyrometallurgy (b) Hydrometallurgy (c) Electro metallurgy (d) Powder Metallurgy	8	
3	**Iron making Process:** Production of Cast Iron, pig Iron and Sponge iron, Description of	4	

	Blast furnace and Chemistry of Blast Furnace Reactions, Nodular Cast Iron, Malleable Cast Iron		
4	**Steel making process:** Primary steelmaking (Basic oxygen steelmaking, BOF , Electric arc furnace, EAF) Bessemer converter Secondary steelmaking (L-D converter, Ladle metallurgy operation including deoxidation, desulphurization, inert gas ringing and vacuum reactors, AOD, VOD), Continuous casting, Production of ferroalloys, Stainless steel	6	
5	**Non-ferrous metal extraction:** Different steps of extraction of Copper, Lead, Zinc, Aluminum, Gold and Silver	6	
6	**Heat treatment & Phase transformation of Metal:** Iron-Carbon equilibrium diagram & its salient features, Phase transformation in metal, Cooling curve for pure iron, Inverse rate curve for steel, Isothermal transformation, Transformation upon continuous cooling, Martensitic transformation, TTT diagram, Heat treatment of steel, Effect of alloying elements & Alloy steel, Normalizing, Tempering and hardening	5	
7	**Metallurgical Testing:** Tensile test, Compression test, Hardness test, Impact test, fatigue test, Creep and Stress rupture test	3	

Course outcomes

After completion of the course, a student would be able to:

CO 1	explain mineral, ore, gangue, flux, mineral beneficiation and metal refining process used in metallurgical industries
CO 2	explain basic principles used in ferrous and non-ferrous metal extraction.
CO 3	explain Cast iron and steel making process
CO 4	interpret different phases of Iron-Iron carbide phase equilibrium system
CO 5	identify suitable heat treatment process with special reference to microstructural features in alloy steels
CO 6	Describe different Metallurgical Testing methods

Learning Resources:

1.	Elements of Metallurgy- Swarup & Saxena.

2.	Principles of Extractive Metallurgy -A. Ghosh and H. S. Ray
3.	Extractive Metallurgy, -Joseph Newton
4.	Chemical Metallurgy - -R. H. Parkar

<table>
<tr><td colspan="2">Name of the course</td><td colspan="2">Process Calculations</td></tr>
<tr><td colspan="2">Course Code: PE(CT) 401A</td><td colspan="2">Semester: 4TH</td></tr>
<tr><td colspan="2">Duration: 6 months</td><td colspan="2">Maximum Marks: 100</td></tr>
<tr><td colspan="2">Teaching Scheme</td><td colspan="2">Examination Scheme</td></tr>
<tr><td colspan="2">Theory: 2 hrs./week</td><td colspan="2">Mid Term Exam I: 15 Marks</td></tr>
<tr><td colspan="2">Tutorial: Nil</td><td colspan="2">Mid Term Exam II: 15 Marks</td></tr>
<tr><td colspan="2">Practical: Nil</td><td colspan="2">Assignment & Quiz etc.: 20 Marks</td></tr>
<tr><td colspan="2">Credit Points: 2</td><td colspan="2">Semester End Exam: 75 Marks (Two third weightage for final reckoning i.e., 50 marks)</td></tr>
<tr><td colspan="4">Objective:</td></tr>
<tr><td>1.</td><td colspan="3">To use basic theories and quantitative formulations of chemistry, fuels and combustion for quantitative assessment of raw materials and air requirement for furnaces.</td></tr>
<tr><td>2.</td><td colspan="3">To use mass and energy balance equations for ceramic processes.</td></tr>
<tr><td colspan="4">Pre-Requisite</td></tr>
<tr><td>1.</td><td colspan="3">Chemistry BS(CT) 102</td></tr>
<tr><td></td><td colspan="3">Energy resources and Furnaces PC(CT) 303</td></tr>
<tr><td></td><td colspan="3">Ceramic Raw Materials PC(CT) 301</td></tr>
<tr><td>Module</td><td>Content</td><td>Hours</td><td>Marks.</td></tr>
<tr><td>1</td><td>Calculations on combustion of fuel in furnaces

Basic calculations on mole %, avg. mol. weight, density of mixture of gas; Calculation of molecular formula of fuel gas, flue gas volume, ratio of Flue gas/Fuel gas from given data on flue gas composition, excess air etc.</td><td>10</td><td></td></tr>
<tr><td>2</td><td>Heat balance calculation of processes with or without Chemical Changes

Calculations of heat capacities, mean heat capacity, heat of formation, heat of Reaction, heat of solution and vaporization; Energy balance for various reacting and non-reacting systems</td><td>04</td><td></td></tr>
<tr><td>3</td><td>Material Balance for Ceramic Process

Calculation of requirement of air for dryer; Calculations of percentage composition of glaze in terms of oxides, recipe for glazes; Calculations on percentage raw materials needed for making various kinds of glass;</td><td>10</td><td></td></tr>
</table>

	Calculations on oxide composition of glass		
Course outcomes			
After completion of the course, a student would be able to:			
CO 1	determine mole%, avg. mol. weight, density etc. of mixture of gases		
CO 2	determine fuel/air ratio, percentage of excess air, combustion efficiency etc. on the basis of stack gas. analysis.		
CO 3	determine heat capacity, mean heat capacity, heat of formation, heat of solution etc of a system comprising various chemical constituents.		
CO 4	calculate air requirement for drying ceramic green body maintaining controlled residual water content.		
CO 5	prescribe the composition of the mix of available raw materials for preparation of glaze and glass.		
CO 6	calculate the oxide composition of a glass from raw material batch description.		
Learning Resources:			
1.	Industrial Stoichiometry- Lewis, Radasch & Lewis; McGraw-Hill		
2.	Chemical Process Principles - Hougen & Wattson. McGraw-Hill		
3.	Basic Principles and Calculations in Chem. Engg.- David M. Himmelblau		
4.	Calculation in Ceramics- R.Griffiths & C. Radford; Maclaren and sons Limited		

Name of the course	**Introduction to Industrial Ceramics**		
Course Code: PE(CT)401B	**Semester: 4TH**		
Duration: 6 months	**Maximum Marks: 100**		
Teaching Scheme	**Examination Scheme**		
Theory: 2 hrs./week	Mid Term Exam I: 15 Marks		
Tutorial: Nil	Mid Term Exam II: 15 Marks		
Practical: Nil	Assignment & Quiz etc.: 20 Marks		
Credit Points: 2	Semester End Exam: 75 Marks (Two third weightage for final reckoning i.e., 50 marks)		
Objective:			
1.	To understand the characteristics, classification and applications of important refractories.		
2.	To acquire knowledge of triaxial ceramics, their classification, properties and applications		
3.	To understand how glass differs from other ceramic materials, their composition, properties and applications.		
4.	To get preliminary knowledge on cement, ceramic abrasives and cermet materials.		
Pre-Requisite			
1.	Chemistry BS(CT) 102		
2.	Ceramic Raw Materials PC(CT) 301		
Module	**Content**	**Hours**	**Marks.**
1	Refractories: Definition of refractories, Basic properties requirement, history of refractory development, different method of classification, applications of different types of refractories, different important properties, preliminary ideas of un-shaped refractories.	5	
2	Whitewares: Definition of whiteware, different classification of whiteware, their composition and applications, raw materials and their role, basic processing flow diagram, whiteware at home, in construction, in electrical, as substrate, in dental application	3	
3	Definition of glass, different types of glass, their composition and applications, important raw materials and their basic roles, glass manufacturing process flow diagram, Viscosity vs temperature diagram, important properties of glass, industrial glass products	5	

4	Inorganic Cement History of calcareous cement, classification and composition and application of different inorganic cements, Different raw materials used and manufacturing process flow diagram, different chemical reactions occurred during cement burning, different phases and their roles in setting and strength development of cement paste, hydration reactions of cement paste, different properties of cement.	5	
5	Cermet: What are special characteristics of cermet, different types of cermet, their composition and properties, manufacturing methods, applications.	2	
6	Ceramic Abrasives History ceramic abrasive development, different types of abrasives, natural and synthetic, their composition and manufacturing process flow diagram, important synthetic abrasive manufacturing, types of bond used, abrasive grains preparation, different applications of ceramic abrasives	3	

Course outcomes	
After completion of the course, a student would be able to:	
CO 1	explain basic differences between different industrial ceramic products.
CO 2	classify refractory materials based on their chemical characteristics, application areas etc.
CO 3	correlate compressive strength with the development of different hydrated phases of the Portland cement.
CO 4	apply different bonding agents for synthetic ceramic abrasives.
CO 5	describe the formulation of different types of glass with desirable properties
CO 6	correlate composition with the properties for different triaxial ceramic bodies.
Learning Resources:	
1.	Ritwik Sarkar Refractory Technology: Fundamentals & Application
2.	Lea's chemistry of cement and concrete
3.	F Singer and S.S Singer Industrial Ceramics:
4.	J E Shelby: Introduction to glass Sc & Technology

Name of the course		**Economics & Statistics**	
Course Code: HS(CT) 403		**Semester: 4TH**	
Duration: 6 months		**Maximum Marks: 100**	
Teaching Scheme		**Examination Scheme**	
Theory: 3 hrs./week		Mid Term Exam I: 15 Marks	
Tutorial: Nil		Mid Term Exam II: 15 Marks	
Practical: Nil		Assignment & Quiz etc.: 20 Marks	
Credit Points: 3		Semester End Exam: 75 Marks (Two third weightage for final reckoning i.e., 50 marks)	
Objective:			
1.	To understand the various concepts of Economics		
2.	To develop proficiency to apply various methods for evaluation of projects		
3.	To understand the concept of random variable and probability distribution		
Pre-Requisite			
1.	Class 12th standard knowledge of Mathematics.		
Module	**Content**	**Hours**	**Marks.**
1	ECONOMICS		
1.1	Concept of Economics and Economic Decision Making. Engineering Costs & Estimation: Fixed, Variable, Marginal & Average Costs, Step Cost, Product and Period Cost, Direct and Indirect Cost, Sunk Costs, Shutdown Cost, Opportunity Costs, Recurring and Non-recurring 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, Learning Curve Model, Benefits and difficulties in estimation.	4	
1.2	Cash Flow, Interest and Equivalence: Cash Flow – Diagrams and Cash Flow Statement, Time Value of Money, Real, Nominal & Effective Interest, Different Interest Formulae. Cash Flow & Rate of Return Analysis: Net Present Worth Analysis, Future Worth Analysis, Internal Rate of Return, Benefit-Cost Ratio Analysis, Sensitivity analysis and Breakeven Analysis.	9	
1.3	Inflation and Index Numbers: Definition, Stages, Causes and Effects of inflation; Price Change with Indexes, Types of Index Numbers, Tests of Index Numbers. Depreciation: Basic Aspects, Different methods of Depreciation Calculation.	6	

2	STATISTICS		
2.1	Basic Statistics: Measures of Central Tendency and Dispersion. Basic Theory of Probability: Random variable, Probability distributions- discrete and continuous. Expectation and variance. Binomial, Poisson and Normal distributions and related problems.	7	
2.2	Sampling Theory: Random sampling: parameter, statistic and its sampling distribution. Standard error of statistic. Sampling distribution of sample mean and variance in random sampling from a normal distribution (statement only). Testing of Hypothesis: Simple and composite hypothesis. Critical region. Level of significance. Type I and Type II errors. One sample and two sample tests for mean and proportions. Chi-square test for goodness of fit.	9	

Course outcomes	
After completion of the course, a student would be able to:	
CO 1	explain the various concepts of Economics, Cost estimation, Inflation, Depreciation etc.
CO 2	apply different cost estimation techniques to solve different problems on cost estimation.
CO 3	apply various analytical methods like net present worth analysis, internal rate of return analysis, future worth analysis, benefit –cost ratio analysis, break-even analysis, to evaluate different engineering projects.
CO 4	solve problems for depreciation, inflation. and interest related problems.
CO 5	explain the concept of measures of central tendency, dispersion, skewness and kurtosis, random variable and probability distribution.
CO 6	Analyze data samples with statistical tools.
Learning Resources:	
1.	H.L. Bhatia & S.N. Maheswari: Economics for Engineers, Vikas Publishing House Pvt. Ltd.
2.	R. Paneer Seelvan: Engineering Economics, PHI.
3.	James L. Riggs, David D. Bedworth, Sabah U. Randhawa: Economics for Engineers 4e, Tata McGraw-Hill
4.	Donald Newnan, Ted Eschembach, Jerome Lavelle: Engineering Economics Analysis, OUP
5.	Sullivan and Wicks: Engineering Economy, Pearson.
6.	Partha Chatterjee: Economics for Engineers, Vrinda Publications.
7.	N.G. Das: Statistical Methods (combined volume), Tata McGraw-Hill

Name of the course	**Physical Testing & Instrumental methods of Analysis of Raw materials & Products Lab**		
Course Code: PCL(CT) 408	**Semester: 4^{TH}**		
Duration: 6 months	**Maximum Marks: 100**		
Teaching Scheme	**Examination Scheme**		
Theory: Nil	Attendance: 10		
Tutorial: Nil	Preparation of Lab Report: 20		
Practical: 3 hrs./week	Experimental data/ Precision of work done: 30		
Credit Points: 1.5	Presentation/ analysis of the result: 20		
	Viva Voce: 20		

Module	**Content**	**Hours**	**Marks.**
1	Determination of percentage of Moisture content of clay.	3	
2	Determination of % Grit content of clay.	3	
3	Determination of Water of Plasticity of Clays.	3	
4	Measurement of Drying Shrinkage of clay	3	
5	Measurement of Firing Shrinkage & firing colour of clays and feldspar.	3	
6	Determination of vitrification range of Clays.	3	
7	Determination of Water Absorption of Fired Ceramic Bodies	3	
8	Determination of particle size distribution by Sedigraph	3	
9	Dilatometric Analysis: Studies with vitreous silica, Silica brick specimen, Whiteware samples of low thermal expansion coefficients, Interpretation of data.	3	
10	Differential Thermal Analysis: Studies with Ceramic Raw Materials like China clay, Ball clay, Fireclay, Pyrophyllite, Quartz, Magnesite, Dolomite, calcite, Aluminum hydroxide, Magnesium hydroxide etc. Interpretation of data.	3	
11	Thermo Gravimetric Analysis: Studies with some important raw materials like China clay, Ball clay, Fireclay, Pyrophyllite, Quartz, Cement samples, dolomite , calcite, magnesite, Copper sulphate	3	

	etc. Interpretation of data & DTGA curves from TGA data.		
12	XRD analysis - Interpretation of Diffractograms. SEM analysis (Analysis of microstructure).	3	
13	Particle size distribution by Particle Size Analyzer.	3	
Course outcomes			
After completion of the course, a student would be able to:			
CO 1	identify different equipment and accessories as per specification needed to conduct a particular experiment.		
CO 2	determine the % of moisture content, grit content, drying, firing shrinkage and firing colour of clays and feldspar.		
CO 3	determine the water of plasticity and vitrification range of fired clay bodies.		
CO 4	determine the linear thermal expansion co-efficient of different ceramic product (green and fired) samples.		
CO 5	determine the thermal behavior of different ceramic raw materials like clays, magnesites, dolomites, calcites etc. by Differential Thermal Analysis and Thermo Gravimetric Analysis.		
CO 6	analyze particle size distribution of ceramic powders.		
CO 7	analyze different phases present in the samples and also their microstructure.		
CO 8	develop skill to work in a team.		
Learning Resources:			
1.	**Lab manuals**		

Name of the course	**UNIT OPERATION LAB**
Course Code: PCL(CT) 409	**Semester: 4TH**
Duration: 6 months	**Maximum Marks: 100**
Teaching Scheme	**Examination Scheme**
Theory: Nil	Attendance: 10
Tutorial: Nil	Preparation of Lab Report: 20
Practical: 3 hrs./week	Experimental data/ Precision of work done: 30
Credit Points: 1.5	Presentation/ analysis of the result: 20
	Viva Voce: 20

Module	Content	Hours	Marks.
1	Drawing and labeling different parts of a lay-out of pipeline consisting of various pipes, fittings, and valves	3	
2	Drawing and labeling different parts of dismantled centrifugal and positive displacement pumps	3	
3	Determination of viscosity coefficient of fluid by falling sphere method using Stoke's Law.	3	
4	Determination of specific surface area and average particle size of a comminuted solid mixture by screen analysis	3	
5	Determination of sedimentation rate of solid-liquid mixture	3	
6	Determination of mixing index of solid particulates mixture	3	
7	Determination of viscosity of a liquid by capillary flow method	3	

Course outcomes

After completion of the course, a student would be able to:

CO 1	identify different equipment and accessories as per specification needed to conduct a particular experiment.
CO 2	set up a pipeline layout.
CO 3	identify different parts of pumps for assembling them to perfectly working machines.
CO 4	determine the coefficient of viscosity of a liquid by maintaining low velocity of a falling sphere through it.

CO 5	determine the surface area of comminuted solid particles through screen analysis.
CO 6	evaluate the performance of a solid-solid mixer by comparing theoretical and practically determined standard deviations.
CO 7	develop skill to work in a team.
Learning Resources:	
1.	McCabe, Smith, Harriott: Unit Operations of Chemical Engineering; Mc Graw Hill
2.	Respective IS manuals provided in the Unit Operation Laboratory

THIRD YEAR FIRST SEMESTER

5th Semester B. Tech Ceramic Technology							
Sl. No.	Type of course	Course Code	Course Title	Hours per week			Credits
				Lecture	Tutorial	Practical	
Theory							
1.	Professional Core Course	PC(CT) 510	Refractories	3	0	0	3
2.	Professional Core Course	PC(CT) 511	Glass Science &Technology	3	0	0	3
3.	Professional Core Course	PC(CT) 512	Whitewares	3	0	0	3
4.	Professional Elective Course	PE(CT) 502	Bio Ceramics (A) / Nano Ceramics (B)	3	0	0	3
5.	Open Elective Course	OE(CT) 501	DBMS (A) / Object Oriented Programming (B) / Operation Research (C)	3	0	0	3
Sessional/Practical							
1.	Professional Core Course	PCL(CT) 513	Refractories Lab	0	0	3	1.5
2.	Professional Core Course	PCL (CT) 514	Glass Lab	0	0	3	1.5
3.	Professional Core Course	PCL(CT) 515	Whitewares Lab	0	0	3	1.5
4.	Open Elective Course	OEL(CT)502	DBMS Lab (A) / Object Oriented Programming Lab (B) / OR Lab (C)	0	0	2	1
5.	Comprehensive Laboratory Assessment	CLA(CT) 5	All Labs	-	-	-	1
				Total credits			**21.5**

The course teacher shall assess the students for Serial Nos. 1, 2, 3,4 under Sessional/Practical before commencement of Semester End Examination. A student has to secure at least 50% marks in Serial Nos. 1, 2, 3,4 under Sessional/Practical, failing which the student would be debarred from sitting in the Semester End Examination.

A student has to secure at least 50% marks in rest of the courses (Theory papers and CLA), failing which he/she would carry backlog(s).

Name of the course		**Refractories**	
Course Code: PC(CT)510		**Semester: 5TH**	
Duration: 6 months		**Maximum Marks: 100**	
Teaching Scheme		**Examination Scheme**	
Theory: 3 hrs./week		Mid Term Exam I: 15 Marks	
Tutorial: Nil		Mid Term Exam II: 15 Marks	
Practical: Nil		Assignment & Quiz etc.: 20 Marks	
Credit Points: 3		Semester End Exam: 75 Marks (Two third weightage for final reckoning i.e., 50 marks)	
Objective:			
1.	To provide an exposure to various Refractories, their classification, nature of raw materials, manufacturing techniques.		
2.	To familiarize with the properties/characteristics, testing of refractories and applications in ferrous and non-ferrous industries.		
Pre-Requisite			
1.	Ceramic Raw Materials: PC(CT) 301		
2.	Energy Resources & Furnaces: PC(CT) 303		
3.	Unit Operation-II: PC(CT) 406		
4.	Processing of Ceramics: PC(CT) 407		
Module	**Content**	**Hours**	**Marks.**
1	**Introduction:** Scope of Refractory Industry, Definition and classification of refractories.	2	
2	Binary phase diagrams related to refractory oxide systems e.g. $Al_2O_3 – SiO_2$, $Al_2O_3 – MgO$, $MgO – Cr_2O_3$, $MgO – CaO$.	4	
3	Raw materials – impurity effect on sintering & properties, Manufacturing techniques, Properties/characteristics and applications of the following refractories: Silica Refractories: Super duty, Moderate heat duty and Low heat duty silica refractories. Alumino-silicate Refractories: Significance of Phase diagram in the development of different phases –High alumina refractories. mullite refractories Basic Refractories: Magnesite, dolomite, lime, chemically bonded and Direct bonded refractories (Mag-chrome and chrome-mag),	18	

	Chromite refractories. Synthetic spinel – Magnesium aluminate Fusion cast, thermal insulating, Zirconia, Oxide, Non-oxide composite refractories (Al2O3/ZrO2-Si3N4/SiAlON/BN)		
4	Carbon bearing refractories – MgO – C and Al_2O_3 – MgO – C, Al2O3-SiC-C etc.	4	
5	Testing of refractories as per BIS: A.P., B.D., Total Porosity, Sp. Gravity, Pore size distribution, C.C.S., Cold MOR., Hot MOR., PCE., RUL., Compressive Strength, PLCAR, Thermal shock Resistance (Spalling)., Reversible Thermal Expansion., CO – disintegration, Corrosion resistance. Thermal Conductivities.	4	
6	Introduction to selection and application of refractories for Ferrous (Iron & Steel) and Non-ferrous (Al, Cu, Pb, Zn) industries	4	
Course outcomes			
After completion of the course, a student would be able to:			
CO 1	explain the scopes of refractory materials in ceramic industry		
CO 2	apply phase equilibrium diagrams for the formulation of batch compositions and assessment of properties of different refractories systems.		
CO 3	explain effect of composition of refractory raw materials on fabrication techniques.		
CO 4	explain usage of different refractories and their applications in ferrous and non-ferrous metallurgical industries.		
CO 5	characterize different refractories using standard testing methodologies.		
CO 6	recommend appropriate application of refractories for different industries		
Learning Resources:			
1.	J. H. Chester, Refractories – Production and properties.		
2.	A. M. Alper, High Temperature Oxides, Part – I,		
3.	P. P. Budnikov, The Technology of ceramics and refractories –		
4.	F. H. Norton, Refractories.		

Name of the course		**Glass Science and Technology**	
Course Code: PC(CT)511		**Semester: 5TH**	
Duration: 6 months		**Maximum Marks: 100**	
Teaching Scheme		**Examination Scheme**	
Theory: 3 hrs./week		Mid Term Exam I: 15 Marks	
Tutorial: Nil		Mid Term Exam II: 15 Marks	
Practical: Nil		Assignment & Quiz etc.: 20 Marks	
Credit Points: 3		Semester End Exam: 75 Marks (Two third weightage for final reckoning i.e., 50 marks)	
Objective:			
1.	To understand the difference between glass and crystalline ceramic material.		
2.	To acquire knowledge of different types of glass, their properties and applications		
3.	To acquire knowledge on processing and quality control in glass industry.		
4.	To get knowledge on measurement techniques of viscosity, density, COE and mechanical properties of different glass samples.		
Pre-Requisite			
1.	Ceramic Raw Materials: PC(CT) 301		
2.	Energy Resources & Furnaces: PC(CT) 303		
3.	Unit Operation-II: PC(CT) 406		
4.	Processing of Ceramics: PC(CT) 407		
Module	**Content**	**Hours**	**Marks.**
1	Introduction a. Definition of glass b. Enthalpy / temperature diagram Glass families of interest	3	
2	Glass formation principles: a. Structural theories of glass formation b. Kinetic theory of glass formation i. Nucleation rate ii. Crystal growth rate iii. T-T-T diagram	9	

3	Structure and properties of different glasses: silica glass; borate glass; alkali silicate glass; alkali borate glass; alkali boro silicate glass; alkali-alkaline-silicate glass; alkali alumino silicate glass; phosphate glass; germanate glass; chalcogenide glass etc.	9	
4	Properties of glass and measurement techniques: a. Viscosity b. Density and molar volume c. Thermal expansion; thermal conductivity d. Electrical conductivity e. Chemical durability f. Mechanical properties g. Strengthening of glass h. Optical properties	9	
5	Inorganic glass making: a. Basic process of glass making- batch and continuous process. b. Raw material selection c. Batch mixing d. Melting reaction e. Glass tank furnace i. Different parts of glass tank furnace ii. Refractories in glass tank furnace f. Refining g. Forming of glass products: container glass; flat glass, fibre glass h. Annealing i. Defects in glass products	9	
6	a. Batch calculations of different oxide glasses b. Calculation of co-ordination number and fraction NBO/BO of silicate/borate glass c. Calculation of network connectivity of silicate glass	6	

Course outcomes

After completion of the course, a student would be able to:

CO 1	explain the principles of glass formation based on kinetic theory and different structural models
CO 2	describe the physical and chemical properties of glass with respect to composition and structure
CO 3	calculate oxide composition or batch composition from natural /synthetic raw materials.
CO 4	describe the formulation of different types of glass with desirable properties
CO 5	calculate the fraction of NBO /network connectivity of a given glass composition to correlate

	with the properties of the glass.
CO 6	make commercial glass with tailor made properties starting from raw material selection and processing parameters.
Learning Resources:	
1.	Introduction to glass science and technology, 2^{nd} Edition, J.E.Shelby , RSC; NY, USA.
2.	Fundamentals of inorganic glasses, A.K. Varshneya, Academic press, Inc.
3.	P J Doyle: Glass making Today
4.	F V Tooley: Handbook of glass Manufacture vol I & II
5.	Harold Rawson: Properties and applications of glass
6.	Amal Pal: Chemistry of Glass
7.	Samuel R Scholes: Modern Glass Practice

Name of the course	**Whiteware**
Course Code: PC(CT)512	**Semester: 5^{TH}**
Duration: 6 months	**Maximum Marks: 100**
Teaching Scheme	**Examination Scheme**
Theory: 3 hrs./week	Mid Term Exam I: 15 Marks
Tutorial: Nil	Mid Term Exam II: 15 Marks
Practical: Nil	Assignment & Quiz etc.: 20 Marks
Credit Points: 3	Semester End Exam: 75 Marks (Two third weightage for final reckoning i.e., 50 marks)

Objective:

1.	To provide knowledge on the classification of whiteware products and uses of raw materials along with various body preparation techniques, with special emphasis on. forming, drying, glazing & firing.
2.	To familiarize with the uses of different kiln furniture
3.	To acquire knowledge on causes and remedies of various green and fired defects.
4.	To gain knowledge on manufacturing techniques of different whiteware products.

Pre-Requisite

1.	Ceramic Raw Materials: - PC(CT) 301
2.	Energy Resources & Furnaces: -PC(CT) 303
3.	Unit Operation: - PC(CT) 302 & PC(CT) 406
4.	Processing of Ceramics: - PC(CT) 407

Module	Content	Hours	Marks.
1	Scope & Application of Whiteware product, Characteristics of Whiteware product, Earthenware, Stoneware, China & Porcelain. Raw Materials used in Whiteware industries: Clay, Quartz, Feldspar, Wollastonite, Pyrophyllite, Talc, Bone ash	5	
2	Body Preparation & Fabrication process: Crushing and Grinding, Screening, Magnetic separation, Transport, Storage, Batching and body composition, Aging, Slip casting, properties of slip, plastic forming.	5	
3	Drying: 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	

4	Glazing: 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	
5	Firing: Firing schedule of whiteware bodies, Reactions at different temperatures, Microstructure development and phase formation of porcelain bodies, Firing defects – causes & remedies, Different type of kilns and operation techniques.	5	
6	Kiln Furniture: Characteristics, Different types of Kiln Furniture, Cordierite, SiC based Kiln Furniture, Silicon nitride bonded SiC kiln furniture, Low thermal mass Kiln car.	4	
7	Production of the following whiteware bodies with process flowcharts, Body Composition & properties: (i) Electrical Porcelain (ii) Wall & floor tiles (iii) Sanitary wares 2L (iv) Spark plug Insulators (v) Bone China.	6	

Course outcomes

After completion of the course, a student would be able to:

CO 1	formulate body compositions of whitewares and glazes with the knowledge of raw materials.
CO 2	explain slip house operation along with shaping methodology, drying techniques for whiteware body making.
CO 3	choose appropriate glazing techniques for application in whiteware bodies
CO 4	select appropriate kiln and kiln furniture for firing of different types of whiteware bodies.
CO 5	determine drying and firing schedules of bodies and glazes corelating causes & remedies of drying and firing defects.
CO 6	explain manufacturing processes of different whiteware products.

Learning Resources:

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

Name of the course	**Bio-ceramics**
Course Code: PE(CT) 502A	**Semester: 5TH**
Duration: 6 months	**Maximum Marks: 100**
Teaching Scheme	**Examination Scheme**
Theory: 3 hrs./week	Mid Term Exam I: 15 Marks
Tutorial: Nil	Mid Term Exam II: 15 Marks
Practical: Nil	Assignment & Quiz etc.: 20 Marks
Credit Points: 3	Semester End Exam: 75 Marks (Two third weightage for final reckoning i.e., 50 marks)

Objective:

1.	To understand the need of biomaterials and advantages of bio-ceramics over polymer and metals
2.	To classify bio-ceramics on the basis of response of tissue in presence of bio material
3.	To acquire knowledge on the different processing methods of various types of bio-ceramic materials.
4.	To characterize the bio-ceramic materials.

Pre-Requisite

1.	Ceramic Raw Materials: PC(CT)301
2.	Fundamentals of Biology: BS(CT) 409
3.	Processing of Ceramics: PC(CT) 407

Module	Content	Hours	Marks.
1	Need of Biomaterials; classification of biomaterials; properties and application of different biomaterials	**3**	
2	Physiology of human bones; stress distribution of some important joints of human body; osteoporosis and its various causes.	3	
3	Advantages of ceramic materials over other biomaterial; need of bio ceramics; classification of bio ceramic materials.	3	
4	Types of bio ceramic –tissue interface response; types of tissue attachment of bio ceramic prosthesis. Different processing techniques of bio ceramic; preparation and	9	

	properties of alumina and zirconia based surgical implants. Hydroxyapatite-Synthetic versus natural HAP, preparation of dense and porous HAP; their properties and application.		
5	Bioactive glass and glass-ceramics: Preparation, properties and application; reaction steps of bioactive glass implant – simulated body fluid.	8	
6	Bio ceramic composites: limitations of different biomaterials; Fabrication methods; different types and their applications.	5	
7	Characterization of bio ceramics:	5	

Course outcomes

After completion of the course, a student would be able to:

CO 1	explain the need of biomaterials, their classification and advantages of bio-ceramics over polymer and metals.
CO 2	explain physiology of human bone and stress distribution of important joints.in human body.
CO 3	explain the tissue-response and attachments on the different types of bio-ceramic materials.
CO 4	synthesize different types of bio-ceramic materials such as bioinert, porous, bioactive and resorbable bio-ceramics
CO 5	correlate the processing methods and properties developed in different types of bio-ceramic materials.
CO 6	characterize the bio-ceramic materials with respect to their structure, bioactivity and mechanical properties.

Learning Resources:

1.	L.L.Hench and June Wilson, An Introduction to Bioceramics- World Scientific Publisher
2.	A. Ravaglioli and A.Krajewski , Bioceramics: Materials; Properties-Application- Chapman & Hall
3.	J.R. Jones and A. G. Clare, Bio-glasses: An Introduction- Wiley Publisher

Name of the course	**Nano-Ceramics**		
Course Code: PE(CT) 502B	**Semester: 5TH**		
Duration: 6 months	**Maximum Marks: 100**		
Teaching Scheme	**Examination Scheme**		
Theory: 3 hrs./week	Mid Term Exam I: 15 Marks		
Tutorial: Nil	Mid Term Exam II: 15 Marks		
Practical: Nil	Assignment & Quiz etc.: 20 Marks		
Credit Points: 3	Semester End Exam: 75 Marks (Two third weightage for final reckoning i.e., 50 marks)		
Objective:			
1.	To learn the versatile applications of different nano materials.		
2.	To corelate the fundamentals of quantum mechanics with nanotechnology.		
3.	To learn synthesis various nanomaterials by different processes		
4.	To understand the properties and characterization of nanomaterials		
Pre-Requisite			
1.	Chemistry BS(CT)102		
2.	Ceramic raw materials PC(CT)301		
3.	Process Ceramics PC(CT)407		
Module	**Content**	**Hours**	**Marks.**
1	**Scope, Application & Basic background of nano materials:** Nano science and nano technology, Nano structured materials (NSMs), Dimension of nano and micron materials, nano-revolution in science and technology – a few exciting natural phenomena and real-life situation, Size dependent properties in relation with band structure of nano and micron materials, Versatile unique applications of nanostructured material in different branches of science and technology.	5	

2	**Quantum Mechanics & Namo technology** Basics of Quantum Mechanics: Wave particle duality, Schrodinger wave equation and its solution of particle in a 1D and 3D box, Eigen value and Eigen function, particle in finite well, Quantum confinement, linear harmonic oscillator and its solution - application of quantum mechanics in nano structured materials.	8	
3	**Synthesis of Nano structured materials:** Top-down and bottom up approach in different physical and chemical methods (Spray pyrolysis, physical and Chemical Vapour Deposition , Inert gas , sputtering , High-energy ball milling, Sol gel processing, precipitation and co-precipitation, low temperature solution combustion synthesis, gel combustion, solvothermal and hydrothermal synthesis, reverse micelles/ microemulsion method, sonochemical process, laser ablation etc.	10	
4	Properties and Characterization of Nano structured materials: Mechanical, optical, electrical, magnetic and electrochemical properties of NSM's, Characterisation of nano materials: XRD (phase present, Crystallite size and strain, Williamson-Hall plot, lattice parameter), Emission Scanning Electron Microscope (FESEM)- High Resolution Transmission Electron Microscope (HETEM), surface topography by AFM, particle size by laser diffraction – surface area by multipoint BET, FTIR, Raman, Auger and plasmonic spectroscopy etc.	10	
5	Important nanomaterials, their structure, properties and applications: Quantum dot, Nano Al_2O_3, Nano SiO_2, Nano ZrO_2, Nano $BaTiO_3$, Nano Ferrite, Nano TiO_2 , Nano ZnO, Nano Fe_2O_3, Fullerene, carbon nanotube and grapheme	6	
Course outcomes			
After completion of the course, a student would be able to:			
CO 1	explain the versatile applications of NSMs.		

CO 2	correlate Quantum Mechanical principles with nanotechnology
CO 3	synthesize different nano structured materials using different processing techniques for advanced applications.
CO 4	characterize the properties of nano structured materials for its applications
CO 5	explain structure, properties and applications of Nano Structured Materials.
CO 6	correlate processing techniques of NSMs with its particle size.
Learning Resources:	
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.	Nano Materials- A.K.Bandyopadhyay/ New Age Publishers.
5.	Nano Essentials- T.Pradeep/TMH
6.	Quantum Physics – A. Ghatak.

Name of the course	**DBMS**
Course Code: OE(CT)501A	**Semester: 5^{TH}**
Duration: 6 months	**Maximum Marks: 100**
Teaching Scheme	**Examination Scheme**
Theory: 3 hrs./week	Mid Term Exam I: 15 Marks
Tutorial: Nil	Mid Term Exam II: 15 Marks
Practical: Nil	Assignment & Quiz etc.: 20 Marks
Credit Points: 3	Semester End Exam: 75 Marks (Two third weightage for final reckoning i.e., 50 marks)

Objective:

1.	To understand the different issues involved in the design and implementation of a database system.
2.	To learn the physical and logical database designs, database modeling, relational, hierarchical, and network models.
3.	To develop an understanding of essential DBMS concepts such as: database security, integrity, and concurrency.
4.	To understand the different issues involved in the design and implementation of a database system.

Pre-Requisite

1.	Programming for Problem Solving: ES(CT)101
2.	Mathematics I: BS(CT)101

Module	Content	Hours	Marks.
1	**Database system architecture**: Data Abstraction, Data Independence, Data Definition Language (DDL), Data Manipulation Language (DML). **Data models**: Entity-relationship model, network model, relational and object oriented data models, integrity constraints, data manipulation operations.	6	
2	**E/R Model:** Conceptual Data Modeling – motivation, entities, entity types, various types of attributes, relationships, relationship types, Entity set types, Participation constraints, E/R diagram	6	

	notation, Extended E/R Model, Examples		
3	**Relational Data Model:** Concepts of relations, schema-instance distinction, keys, referential integrity & foreign keys, converting the database specification in E/R notation to the relational schema, Relational algebra operators: selection, projection, cross product, various types of joins, division, set operations, example queries, tuple relational calculus, domain relational calculus, Fundamentals of SQL.	6	
4	**Relational Database Design:**:Importance of a good schema design, problems encountered with bad schema designs, motivation for normal forms, dependency theory - functional dependencies, Armstrong's axioms for FD's, closure of a set of FD's, minimal covers, Normalization, Normal Forms - 1NF, 2NF, 3NF and BCNF, decompositions and desirable properties of them, multi-valued dependencies and 4NF, join dependencies and 5NF, Concept of De-normalization.	8	
5	**Transaction Processing:** Transaction processing and Error recovery - Concepts of transaction processing, ACID properties, concurrency control, Serializability, locking based protocols, Timestamp based protocols, recovery and logging methods.	6	
6	Data Storage and indexing: Single level and multi-level indexing, Dynamic Multi level indexing using B Trees and B+ Trees, Query processing and Query Optimization, Introduction to database security.	4	

Course outcomes	
After completion of the course, a student would be able to:	
CO 1	describe the fundamental elements of relational database management systems
CO 2	design a database system using ER diagram.
CO 3	explain the basic concepts of relational data model, entity-relationship model, relational database design, relational algebra and SQL.
CO 4	develop an efficient database design by normalization.
CO 5	justify the consistency of the transactions in order to maintain its integrity.
CO 6	explain the concepts of different database storage structures and access techniques.
Learning Resources:	
1.	Abraham Silberschatz, Henry F. Korth, S. Sudarshan, Database System Concepts (6th Edition) McGraw-Hill.

2.	Ullman JD., “Principles of Database Systems”, Galgottia Publication.
3.	R.P. Mahapatra, Khanna, Database Management Systems Publishing House, New Delhi (AICTE Recommended Textbook – 2018)
4.	Ramez and Novathe Shamkant, “Fundamentals of Database Systems”, Benjamin Cummings Publishing. Company.
5.	Ramakrishnan: Database Management System, McGraw-Hill
6.	Gray Jim and Reuter Address, “Transaction Processing: Concepts and Techniques”, Moragan Kauffman Publishers.
7.	Jain: Advanced Database Management System CyberTech 6. Date C. J., “Introduction to Database Management”, Vol. I, II, III, Addison Wesley.
8.	James Martin, “Principles of Database Management Systems”, 1985, Prentice Hall of India, New Delhi

Name of the course	**OBJECT ORIENTED PROFRAMMING**
Course Code: OE(CT)501B	**Semester: 5TH**
Duration: 6 months	**Maximum Marks: 100**
Teaching Scheme	**Examination Scheme**
Theory: 3 hrs./week	Mid Term Exam I: 15 Marks
Tutorial: Nil	Mid Term Exam II: 15 Marks
Practical: Nil	Assignment & Quiz etc.: 20 Marks
Credit Points: 3	Semester End Exam: 75 Marks (Two third weightage for final reckoning i.e., 50 marks)

Objective:

1.	To construct models for object-oriented software development
2.	To write java programmes with abstraction, code reusability and data security features
3.	To handle different run time exception cases in a java programme
4.	To build concurrent processing scenarios with java multithread programming

Pre-Requisite

1.	Programming for Problem Solving: ES(CT)101

Module	Content	Hours	Marks.
1	**Concept of Object-Oriented Programming** Object Oriented Programming (OOP) features, comparison between OOP and procedural programming languages, Object Oriented Modelling concepts- class diagram, linking, association, aggregation, generalization and specialization.	04	
2	**Introduction to Java programming** Basic data types, compilation and execution of a java programme, role of JDK & JVM, class & object creation, class member access protection, idea of constructor, method overloading, array of objects, call by value and call by reference concept with object passing as method argument, garbage collection, utility of this and final keyword, concept of static variables, methods and static blocks, string handling methods- length(), equals() and charAt(), command line arguments, keyboard input operations, concept of	10	

	nested/inner classes.		
3	**Code Reusability Aspect of Java Programming** Concept of inheritance, possible types of inheritances in java, member accessing rules for superclass and subclass, superclass constructor calling from subclass constructor, method overriding, dynamic method dispatch or dynamic binding, prevention of inheritance, concept of abstract class and interface with their implementation, inheritance aspect of interface, concept of package– package creation, importing of package, member accessing rules for packages.	12	
4	**Exception Handling in Java** Need for exception handling, different types of exceptions, concept of try & catch block, nested try statements, use of multiple catch clauses, throw & throws clause and their differences, use of finally block, idea of user defined exception	06	
5	**Multithread Programming with Java** advantage of multithreading, concept of main thread and child thread, thread life cycle, creation of multiple child threads, idea of setName(), getName(), sleep(), isAlive() and join() method, basic concept of thread synchronization.	04	

Course outcomes	
After completion of the course, a student would be able to:	
CO 1	describe object-oriented modelling features for object-oriented software development.
CO 2	develop java programmes with incorporation of string handling operations and data security features
CO 3	apply abstractions and code reusability features of java for dynamic resolving of method calls
CO 4	explain java run time exceptions and their handling procedures
CO 5	develop multi thread programme in Java for parallel processing.

Learning Resources:	
1.	James Rambaugh- Michael, Blaha, Object Oriented Modelling and Design, Prentice Hall, India, ISBN: 978-0130159205
2.	Herbert Schildt, The Complete Reference Java, McGraw Hill, ISBN: 978-0-07-163177-8
3.	Herbert Schildt, Java A Beginner's Guide, Kindle Edition, Oracle press, ISBN-13978-

	0071809252
4.	Cay S Horstmann and Gary Cornell, Core Java Volume I Fundamentals, Pearson, ISBN: 9780137082346
5.	Harvey Deitel and Paul Deitel, Java How to Program, Early Objects, Global Edition, Pearson Education, ISBN-13: 9781292223902

Name of the course		**Operation Research**	
Course Code: PE(CT)401B		**Semester: 5TH**	
Duration: 6 months		**Maximum Marks: 100**	
Teaching Scheme		**Examination Scheme**	
Theory: 3 hrs./week		Mid Term Exam I: 15 Marks	
Tutorial: Nil		Mid Term Exam II: 15 Marks	
Practical: Nil		Assignment & Quiz etc.: 20 Marks	
Credit Points: 3		Semester End Exam: 75 Marks (Two third weightage for final reckoning i.e., 50 marks)	
Objective:			
1.	To understand Simplex method for Linear Programming problems		
2.	To use dynamic programming to solve problems.		
3.	To learn network model e.g., short path, minimum spanning tree, maximum flow problems.		
4.	To understand the principles of zero sum, 2 player game.		
5.	To learn different techniques of Operation Research for mathematical formulation of complex decision making problems.		
Pre-Requisite			
1.	Mathematics I:BS(CT) 101		
2.	Economics & Statistics: HS(CT) 403		
Module	**Content**	**Hours**	**Marks.**
1	**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. Solution of LPP by Simplex Method; Charnes' Big-M Method; Duality Theory. Transportation Problems and Assignment Problems.	17	

2	**Network Analysis**: Shortest Path: Floyd Algorithm; Maximal Flow Problem (Ford-Fulkerson); PERT-CPM (Cost Analysis, Crashing, Resource Allocation excluded). **Inventory Control:** Introduction to EOQ Models of Deterministic and Probabilistic ; Safety Stock; Buffer Stock.	9	
3	**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.	5	
4	**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.	5	
Course outcomes			
After completion of the course, a student would be able to:			
CO 1	solve Linear Programming Problems using appropriate technique and optimization.		
CO 2	analyze network models e.g., short paths, minimum spanning tree, maximum flow problem.		
CO 3	solve duality theory problems, transportation and assignment problems.		
CO 4	solve zero sum, 2 player game.		
CO 5	model a dynamic system as a queuing model to measure its performance.		
CO 6	explain sensitivity analysis and the prime-dual relationship.		
Learning Resources:			
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		
5.	Kanti Swaroop — “Operations Research”, Sultan Chand & Sons		
6.	Rathindra P. Sen—“Operations Research: Algorithms and Applications”, PHI		
7.	R. Panneerselvam - “Operations Research”, PHI		

8.	A.M. Natarajan, P. Balasubramani and A. Tamilarasi - “Operations Research”, Pearson
9.	M. V. Durga Prasad – “Operations Research”, CENGAGE Learning
10.	J. K. Sharma - “Operations Research”, Macmillan Publishing Company

Name of the course	**REFRACTORY LAB**
Course Code: PCL(CT) 513	**Semester: 5^{TH}**
Duration: 6 months	**Maximum Marks: 100**
Teaching Scheme	**Examination Scheme**
Theory: Nil	Attendance: 10
Tutorial: Nil	Preparation of Lab Report: 20
Practical: 3 hrs./week	Experimental data/ Precision of work done: 30
Credit Points: 1.5	Presentation/ analysis of the result: 20
	Viva Voce: 20

Module	Content	Hours	Marks.
1	Determination of Packing Density of refractory raw materials(aggregate)/grog using different size fractions	3	
2	Fabrication of refractory bodies using best packed refractory raw materials (aggregate)/grog.	3	
3	Firing of the fabricated refractory bodies at different temperatures.	3	
4	Study of the effect of Composition, Forming pressure & Firing temperature on some properties of fired refractory bodies.	3	
5	Various types of important tests like AP, BD, CCS, spalling resistance, corrosion test of the fired refractory bodies as per BIS.	3	
6	Determination of Pyrometric Cone Equivalent (PCE) and Refractoriness Under Load (RUL)	3	

Course outcomes	
After completion of the course, a student would be able to:	
CO 1	Equipment recognition
CO 2	estimate packing density of refractory raw materials/aggregate.
CO 3	fabricate refractory bodies with appropriate packing density of the raw materials.
CO 4	correlate compositions of refractory bodies with maturing temperatures to sinter the products.
CO 5	characterize refractory materials through different standard testing methods.

CO 6	select application temperatures of refractory products based on PCE and RUL values.
CO 7	Team work
Learning Resources:	
1.	Lab Manuals

Name of the course	**Glass Lab**
Course Code: PCL(CT) 514	**Semester: 5TH**
Duration: 6 months	**Maximum Marks: 100**
Teaching Scheme	**Examination Scheme**
Theory: Nil	Attendance: 10
Tutorial: Nil	Preparation of Lab Report: 20
Practical: 3 hrs./week	Experimental data/ Precision of work done: 30
Credit Points: 1.5	Presentation/ analysis of the result: 20
	Viva Voce: 20

Module	Content	Hours	Marks.
1	Glass batch calculation and preparation of glass by melting route	3	
2	Measurement of density of different glass samples	3	
3	Alkali resistance test of different glass samples	3	
4	Alkalinity test of different glass samples	3	
5	Acid resistance test of different glass samples	3	
6	Determination of thermal shock resistance of different glass samples	3	
7	Determination of Tg and Tc by DTA (Differential Thermal Analysis)	3	
8	Stress of glass sample by Polari analysis -meter	3	

Course outcomes

After completion of the course, a student would be able to:

CO 1	prepare a glass batch and glass article after melting, casting and annealing.
CO 2	determine the different physical and chemical resistance properties of glass articles following NDT and destructive testing.
CO 3	determine glass transition temperature and crystallization temperature by DTA.
CO 4	evaluate the stress/strain in glass articles by Polarimeter

Learning Resources:	
1.	Lab Manuals

Name of the course	**Whiteware LAB**
Course Code: PCL(CT) 515	**Semester: 5TH**
Duration: 6 months	**Maximum Marks: 100**
Teaching Scheme	**Examination Scheme**
Theory: Nil	Attendance: 10
Tutorial: Nil	Preparation of Lab Report: 20
Practical: 3 hrs./week	Experimental data/ Precision of work done: 30
Credit Points: 1.5	Presentation/ analysis of the result: 20
	Viva Voce: 20

Module	Content	Hours	Marks.
1	Calculation & Batching of a whiteware body composition	3	
2	Grinding of the batch in a pot mill	3	
3	Characterization of slip properties, like- solid content, sp. Gr. & litre weight	3	
4	Measurement of variation of fluidity with electrolyte concentration	3	
5	Measurement of casting rate	3	
6	Perform shaping of ceramic product in a plaster of paris mould	3	
7	Perform the trimming, natural drying, finishing and drying in an electric dryer	3	
8	Calculation & batching, grinding of glaze in a pot mill.	3	
9	Perform application of glaze in a dried product.	3	
10	Perform firing of the glazed product in an electric furnace	3	
11	Perform visual inspection of fired products	3	
12	Perform characterizations of fired product, like A.P., B.D.	3	

Course outcomes	
After completion of the course, a student would be able to:	
CO 1	prepare slip with the natural raw materials

CO 2	characterize the slip prior to casting.
CO 3	correlate casting rate, fluidity with electrolyte concentration.
CO 4	perform different processes viz forming, drying and firing.
CO 5	apply glaze after preparation of glaze slip.
CO 6	characterise final product
CO 7	Team work
Learning Resources:	
1.	Lab Manual
2.	Corresponding IS specifications
3.	Industrial Ceramics-Singer & Singer

Name of the course	**DBMS Lab**
Course Code: OEL(CT) 502A	**Semester: 5TH**
Duration: 6 months	**Maximum Marks: 100**
Teaching Scheme	**Examination Scheme**
Theory: Nil	Attendance: 10
Tutorial: Nil	Preparation of Lab Report: 20
Practical: 2 hrs./week	Experimental data/ Precision of work done: 30
Credit Points: 1	Presentation/ analysis of the result: 20
	Viva Voce: 20

Module	**Content**	**Hours**	**Marks.**
1	Creating a Database , Creating a Table Specifying Relational Data Types Specifying Constraints ,INSERT statement ,SELECT ,DELETE, ,RENAMEUPDATE, TRUNCATE ,DROP and ALTER statements	6	
2	The SELECT statement Using the WHERE clause Using Logical Operators in the WHERE clause Using IN, BETWEEN, LIKE, ORDER BY, GROUP BY and HAVING	6	
3	Using Aggregate Functions Combining Tables Using JOINS Sub queries	6	
4	Creating Views, Creating Column Aliases, Creating Database Users Using GRANT and REVOKE.PL/SQL	6	

Course outcomes

After completion of the course, a student would be able to:

CO 1	construct queries using SQL.
CO 2	apply typical data definitions and manipulation commands
CO 3	design applications to test Nested and Join Queries
CO 4	apply “Views” for maintaining data security.
CO 5	write queries with DCL commands for access protection.
CO 6	Apply PL/SQL.for creation and manipulation of database.

Learning Resources:

1.	Lab Manuals

Name of the course	**OBJECT ORIENTED PROFRAMMING LAB**
Course Code: OEL(CT) 502B	**Semester: 5TH**
Duration: 6 months	**Maximum Marks: 100**
Teaching Scheme	**Examination Scheme**
Theory: Nil	Attendance: 10
Tutorial: Nil	Preparation of Lab Report: 20
Practical: 2 hrs./week	Experimental data/ Precision of work done: 30
Credit Points: 1	Presentation/ analysis of the result: 20
	Viva Voce: 20

Module	Content	Hours	Marks.
1	Writing java programmes with class member access specifiers, constructors, method overloading concepts, I/O operations, static block, static variables and methods, this and final keyword.	03	
2	Java programming with array of objects, object passed as method arguments, object returned from method, string handling functions like length (), equals (), charAt(), keyboard input operations, command line arguments.	03	
3	Writing java programmes with nested/inner classes, handling name conflict resolving issues in java nested/inner classes.	03	
4	Writing java programmes for implementation of inheritances, superclass member accessing from the subclass, dynamic resolving of method calls with overriding.	03	
5	Writing java programmes for implementation of abstract class, interface, extended interface, combined inheritance of both abstract class and interface with handling of dynamic method dispatch scenarios.	06	
6	Modular programming with java packages- its creation, importing and accessing of member components.	03	
7	Handling of java run time exceptions with try, catch and finally block. Implementation of throw and throws clause in the aspect of user defined exception objects.	06	

8	Implementation of java multithread programming in the aspect of parallel processing- controlling of main thread, creation of multiple child threads.	03	
Course outcomes			
After completion of the course, a student would be able to:			
CO 1	write java programmes with data protection, method overloading, and object independent accessing features along with string handling operations.		
CO 2	apply various abstractions and code reusability features of java in the aspect of dynamic binding scenarios.		
CO 3	construct effective modular progamming in java using the package concept.		
CO 4	solve different run time and user defined exceptional cases that may occur within a java programme code		
CO 5	apply multi thread programming in java for parallel processing.		
Learning Resources:			
1.	Herbert Schildt, The Complete Reference Java, McGraw Hill, ISBN: 978-0-07-163177-8		
2.	Cay S Horstmann and Gary Cornell, Core Java Volume I Fundamentals, Pearson, ISBN: 9780137082346		
3.	Harvey Deitel and Paul Deitel, Java How to Program, Early Objects, Global Edition, Pearson Education, ISBN-13: 9781292223902.		

Name of the course	**Operation Research LAB**
Course Code: OEL(CT) 502C	**Semester: 5TH**
Duration: 6 months	**Maximum Marks: 100**
Teaching Scheme	**Examination Scheme**
Theory: Nil	Attendance: 10
Tutorial: Nil	Preparation of Lab Report: 20
Practical: 2 hrs./week	Experimental data/ Precision of work done: 30
Credit Points: 1	Presentation/ analysis of the result: 20
	Viva Voce: 20

Module	Content	Hours	Marks.
1	**Software based lab using C /C++** a) Application of Transportation problem to solve LPP. b) Application of Assignment problem to solve LPP. c) Application of Duality theory to solve LPP. d) Application of Simplex method to solve LPP. e) Application of Dijkstra's or Floyd's Algorithm to solve problems on Network Analysis. f) Application of Ford-Fulkerson method to solve Maximal Flow Problem. g) Application of PERT/CPM to solve problem. h) Familiarization with O.R package: TORA.		

Course outcomes

After completion of the course, a student would be able to:

CO 1	solve LPP using Transportation and Assignment problem.
CO 2	solve LPP using Simplex method and Duality theory.
CO 3	solve problems on Network analysis using Floyd's Algorithm.
CO 4	solve Maximal Flow Problem using Ford-Fulkerson method
CO 5	solve dynamical programming using .PERT/CPM
CO 6	use TORA to solve problems.

Learning Resources:

1.	Lab manuals

THIRD YEAR SECOND SEMESTER

6th Semester B. Tech Ceramic Technology							
Sl. No.	Type of course	Course Code	Course Title	Hours per week			Credits
				Lecture	Tutorial	Practical	
Theory							
1.	Professional Core Course	PC(CT) 616	Cement, Concrete & Monolithic Refractories	4	0	0	4
2.	Professional Core Course	PC(CT) 617	Physical Ceramics	3	0	0	3
3.	Professional Core Course	PC(CT) 618	Advanced Ceramics	3	0	0	3
4.	Professional Elective Course	PE(CT) 603	Refractories for Ferrous Industries (A) / Refractories for Non -ferrous & Other Industries (B)	3	0	0	3
5.	Open Elective Course	OE(CT) 603	Total Quality Management (A) / Environment Engg. & Management (B)	3	0	0	3
6.	Professional Core Course	PC(CT) 619	Instrumentation & Process Control	4	0	0	4
Sessional/Practical							
1.	Professional Core Course	PCL(CT) 620	Cement, Concrete & Monolithics Lab	0	0	3	1.5
2.	Comprehensive Laboratory Assessment	CLA(CT) 6	All Labs	-	-	-	1
3.	Humanities & Social Sciences including Management Courses	HSL(CT).604	Group Discussions	0	0	2	1
Mandatory Course							
1.	Mandatory Course	MC(CT) 602	Indian Constitution	*3*	*0*	*0*	*0*
				Total credits			**23.5**

The course teacher shall assess the students for Serial No. 1 under Sessional/Practical before commencement of Semester End Examination. A student has to secure at least 50% marks in Serial No. 1 under Sessional/Practical, failing which the student would be debarred from sitting in the Semester End Examination.

A student has to secure at least 50% marks in rest of the courses (Theory papers, Group Discussions, mandatory course and CLA), failing which he/she would carry backlog(s).

Students would undergo 8-12 weeks' internship after 6th Semester

Name of the course	Cement, Concrete and Monolithic Refractories
Course Code: PC(CT)616	**Semester: 6TH**
Duration: 6 months	**Maximum Marks: 100**
Teaching Scheme	**Examination Scheme**
Theory: 4 hrs./week	Mid Term Exam I: 15 Marks
Tutorial: Nil	Mid Term Exam II: 15 Marks
Practical: Nil	Assignment & Quiz etc.: 20 Marks
Credit Points: 4	Semester End Exam: 75 Marks (Two third weightage for final reckoning i.e., 50 marks)

Objective:

1.	To learn classification, manufacturing techniques and usage of different types of cements, concretes and monolithic refractories.
2.	To acquire knowledge on cement used for high temp. applications and as binders in unshaped refractories.
3.	To learn hydration setting and hardening of different types of cements.
4.	To learn the properties and testing methods of cement, concrete and monolithic refractories.

Pre-Requisite

1.	Chemistry: BS(CT)-102
2.	Refractories: PC(CT)-510

Module	Content	Hours	Marks.
1	**Introduction** Pozzolanic materials, domestic cement, high temp. refractory cement and Monolithic Refractories/Castable Refractories their properties at room temp. as well as high Temperatures, The selection of cements for specific use and monolithic refractories for specific service condition.	**2**	
2	Pozzolana Cement: Definition, classifications, Pozzolanic activity and its influencing factors, Lime – Pozzolana reaction and products formation, Applications.	2	

3	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, different areas of applications.	6	
4	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. And their applications	4	
5	Testing of Cements, mortar and concrete as per BIS: 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.	3	
6	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 $CaO\text{-}Al_2O_3\text{-}H_2O$ Phase diagram, Strength Development, HAC castables and applications.	3	
7	Concrete: Introduction, Gap Grade concrete, continuous grade concrete, light, normal and heavy concrete, workability and bleeding of concrete, properties of concrete, installation technique of concrete, various uses of concretes.	3	
8	Monolithic Refractories: Advantages and disadvantages of monolithic/castable refractories, classification of unshaped refractories, aggregate used ,binders and other additives used in ramming, gunning, fettling, spray mass etc.Types of bonding(e.g. hydraulic, chemical, gel &	4	

	Quagulation bonding) in monolithic refractories		

Course outcomes	
After completion of the course, a student would be able to:	
CO 1	explain pozzolanic materials, its classification, lime-pozzolana reactions and their applications.
CO 2	explain classification of cements and concretes, their manufacturing processes and testing methodologies.
CO 3	explain the mechanisms of hydration, setting and hardening of different kinds of cements & concretes and their applications.
CO 4	correlate WC ratio with workability, bleeding of concrete, consistency and strength development in cement and concrete mixes.
CO 5	classify unshaped refractories based on CA cement content, additives used and installation techniques.
CO 6	Select areas of applications of castables in different industries based on its formulations.
Learning Resources:	
1.	F.M.LEA, Chemistry of cement
2.	F.W.H. Taylor, Cement Chemistry
3.	T.D.Robson, High Alumina Cement
4.	W.E. Neville, Concrete Technology
5.	Dr. Subrata Mukherjee, Recent Trend in Refractory Monolithics
6.	Charles A. Schacht, Refractories Hand Book Edited.

Name of the course		**Physical Ceramics**	
Course Code: PC(CT)-617		**Semester: 6th**	
Duration: 6 months		**Maximum Marks: 100**	
Teaching Scheme		**Examination Scheme**	
Theory: 3 hrs./week		Mid Term Exam I: 15 Marks	
Tutorial: Nil		Mid Term Exam II: 15 Marks	
Practical: Nil		Assignment & Quiz etc.: 20 Marks	
Credit Points: 3		Semester End Exam: 75 Marks (Two third weightage for final reckoning i.e., 50 marks)	
Objective:			
1.	To provide an exposure to the atomic bonding, atomic and crystal structure, crystalline defects of ceramic materials.		
2.	To familiarize with diffusion, sintering mechanisms and binary and ternary phase equilibrium systems		
3.	To familiarize with properties viz. electrical, magnetic etc. and structure-property correlations of ceramic materials		
4.	To provide scope of problem-solving techniques for the topics covered		
Pre-Requisite			
1.	Engg. Materials Science: ES(CT)409		
Module	**Content**	**Hours**	**Marks.**
1	Introduction: Scope and Importance of the subject	1	
2	Atomic arrangement in solids: Octahedral and tetrahedral sites in a close-packed structure- number of sites per atom- stacking of close-packed layers- coordination number and radius ratio-Pauling's Rules of formation of ionic solids.	2	
3	Important structures in ceramic systems: Rock-salt, Cesium Chloride, Fluorite and antifluorite, Zinc blende, Wurtzite, Rutile, Corundum and Ilmenite, Perovskite, Spinel, Ferrites and Garnets, Silicate structure- orthosilicate – pyro silicate- amphibole-pyroxene- layered and networked silicate structures etc..	5	
4	Point Defects – different types – non-stoichiometry – defect	4	

	reactions and defect equations in ionic solids – thermodynamics of defect formation and calculation of defect concentration.		
5	Atomic Mobility: Diffusion & diffusivity, laws of diffusion, solution of Fick's second law under different initial and boundary conditions- concept of error function – Kirkendall effect – Experimental determination of diffusion coefficient; diffusion as a thermally activated process - Nernst-Eistein equation.; atomistic mechanism of diffusion, temperature & impurity dependence of diffusion. Diffusion in crystalline oxides; dislocation, grain boundary & surface diffusion.	4	
6	Ceramic Phase Equilibrium Diagrams: Derivation of "Phase Rule" and basic concepts of drawing and interpretation of "phase diagrams" – one-, two- , and three– component systems; application of "lever rule in each case; techniques of determining the phase diagrams; non-equilibrium phases; typical ceramic systems like pure silica, silica –alumina, calcia - silica , magnesia - silica etc., Gravity Center Principle for calculation of phases in ternary mixtures, Typical cases in ternary systems with binary compound formation without solid solution formation, few examples	6	
7	Sintering and micro-structure development in ceramic systems: Basic concepts of sintering and its driving force, different atomistic models of sintering and their kinetics- evaporation condensation, solid state sintering, effects of point, line and surface defects, liquid phase and reactive sintering, grain growth and exaggerated grain growth	6	
8	Different properties of ceramic materials: electrical (including dielectric, ferroelectric, piezoelectric etc), optical, magnetic etc.	8	

Course outcomes	
After completion of the course, a student would be able to:	
CO 1	classify ceramic materials based on atomic arrangement in solids and ceramic crystal structures including various silicates.
CO 2	identify different defects in crystalline ceramics.
CO 3	solve problems on steady and non-steady state diffusion processes in different systems.
CO 4	analyze a ceramic.phase equilibrium diagram for prediction of its behaviour.
CO 5	apply sintering mechanisms in ceramic manufacturing processes

CO 6	justify application of typical ceramics on the basis of their functional properties.
Learning Resources:	
1.	Introduction to Ceramics - W.D.Kingery
2.	Fundamentals of Ceramics – Barsoum
3.	Physical Ceramics for Engineers - Van Vlack
4.	Handbook of Ceramics - Editor S. Kumar
5.	Principles of Materials Science & Engineering – Smith
6.	Physical Properties of Materials (ELBS) – Lovell, Avery and Vernon

Name of the course	Advanced Ceramics
Course Code: PC(CT)618	**Semester: 6^{TH}**
Duration: 6 months	**Maximum Marks: 100**
Teaching Scheme	**Examination Scheme**
Theory: 3 hrs./week	Mid Term Exam I: 15 Marks
Tutorial: Nil	Mid Term Exam II: 15 Marks
Practical: Nil	Assignment & Quiz etc.: 20 Marks
Credit Points: 3	Semester End Exam: 75 Marks (Two third weightage for final reckoning i.e., 50 marks)

Objective:

1.	To learn membrane separation process and classifications, application and properties, inorganic membrane, sol-gel process, membrane modification, porous and non-porous membrane, concept of osmosis and reverse osmosis, application of ceramic membrane.
2.	To learn the surface engineering of the materials, surface dependent engineering properties like mechanical, chemical, electrical, optical, thermal etc., different surface coating technologies like physical vapour deposition (thermal evaporation and sputtering), electron beam evaporation, chemical vapour deposition (LPCVD, PECVD, APCVD), spin coating, dip coating, spray pyrolysis etc. through sol-gel technique, criteria for selection of a surface coating technology.

Pre-Requisite

1.	Engineering Materials Sciencs: ES(CT)409

Module	Content	Hours	Marks.
1	**Introduction:**	1	
2	Ceramics used in advanced applications: Nuclear energy, Gas turbine blades, Abrasives, Aerospace, Heat Exchangers, Cutting Tools, Wear Applications	4	
3	a) 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.	4	
4	Ceramics for optical applications: Telecommunication and related uses, Information display, Laser, Fibreoptics , Electromagnetic windows	3	
5	Ceramics in Electrochemical cells: Sodium sulphate cell (with β –alumina), Electrical ceramics for fuel cell and high-energy	4	

	batteries. 1. Electronic Ceramics: Ceramic substrates > (Al_2O_3 , BeO , AlN , Glass Ceramic) , Processing of Thick Film , Thin Film , Multilayer Packages. Properties of Ceramic Insulators. Ceramic Capacitor Dielectrics > Barium titanate, other titanate based dielectrics, Composition with high Pb content, Processing of thick & thin film capacitors, Integrated capacitors. Relaxor Dielectrics. Piezoelectric Ceramics > Piezoelectric & electro strictive materials, Powders &Processes, Piezoelectric ceramic applications.		
6	Electro-optic Ceramics & Devices > Different Materials , PLZT compositional systems , Powders & Processes , Hysteresis loop , Electro optic properties , Applications. Sensors > Oxygen Sensors, Principles of operation, Solid electrolyte sensors, Semiconductor sensors, Thermistors and related sensors. Magnetic Ceramics: Spinel Ferrites, Hexagonal Ferrites, Garnet, Processing, Single crystal ferrite, Applications. Critical parameters, Powder synthesis, Nano Ceramics: Different Compositions, Synthesis, Applications.	4	
7	Ceramic Membranes. Separation processes, membrane separation, advantages and disadvantages of membrane, Historical development, definition and types of membrane, applications.	2	
8	Membrane separation processes and classifications, gradient of chemical potential – concentration gradient, pressure gradient, temperature gradient, electrochemical potential gradient; feed and permeate; selectivity and flow through rate or permeation rate; retention and separation factor; mass concentration and mole concentration; benefit of membrane technology; membrane fouling; back-flush; flux vs time relation; flux-force relation; Micro-filtration; Ultra-filtration; Nano-filtration; Osmosis, Reverse osmosis.	3	
9	Classifications of membrane based on nature, structure, application, mechanism; membrane charge; driving forces – pressure driven,	3	

	concentration driven, potential driven; dead end filtration; cross flow filtration; cation and anion exchange membrane, bipolar membrane; seven aspects for commercialized membrane separation process; Inorganic membrane: advantageous properties over polymeric membrane, classifications – porous (microporous, mesoporous and microporous layers) and non-porous; ceramic membranes made of silica, titania, zirconia, alumina; zeolite membrane; ceramic membrane preparation steps; roll of binder, plasticizer, pore former, pore generator, types of membrane depending on permeate and retentate; industrial applications.		
10	Advanced Ceramic Coating Technology: Thin film technology; advantages of thin film over thick film; surface engineering of the materials, surface dependent engineering properties like mechanical, chemical, electrical, optical, thermal etc.; techniques of depositions (gas and liquid phase)	2	
11	Physical vapour deposition process: evaporation and sputtering; evaporation system requirements; modeling of evaporation; Clausius-Clapeyron equation; ideal gas laws; equation of rate of evaporation; Hertz-Knudsen equation; Knudsen cell; mean free path; evaporation sources – resistive heating and e-beam heating. Sputtering: what is sputtering; sputter yield; angle of incident; sticking coefficient; energy of incident ion; Reactive sputtering; DC sputtering; RF sputtering; Magnetron sputtering; applications of nitrides, carbides etc.	3	
12	Chemical vapour deposition: introduction, steps involved in CVD, preparation of coating of silicon, silica, silicon carbide, silicon nitride, alumina, titanium carbide etc.; APCVE, LPCVD, PECVD, Hot wall reactor, Cold wall reactor etc.; applications.	3	
13	Liquid phase deposition: sol-gel technique; reaction involved in sol-gel synthesis; different ways of drying gel; schematic representation of sol-gel process; advantages and disadvantages; application of coating of titania, zirconia, barium titanate etc. by sol-gel technique. Spin coating: steps involved, defects arise, film thickness vs spin time and spin speed relation. Dip coating: steps involved parameters to be controlled, applications; Spray pyrolysis.	3	
Course outcomes			

After completion of the course, a student would be able to:	
CO 1	explain structure and properties of electrical and electronic ceramic materials and their applications.
CO 2	explain principles, processing and applications of Solid Oxide Fuel Cells, Lithium Ion Batteries etc.
CO 3	explain principles of Electro-optic ceramics, magnetic ceramics, multiferroics and their applications.
CO 4	explain the principles of membrane separation processes and classification of. membranes.
CO 5	select the best membrane module and manufacturing process for different applications.
CO 6	explain the significance and importance of surface engineering, role of surface coating, surface modification techniques and advanced coating methods.
Learning Resources:	
1.	R.C.Buchanon.,Ceramic Materials for Electronics:
2.	B.C.H Steele ,Electronic Ceramics:.
3.	K Furuta& K Uchino Adv. Ceram. Materl. Vol I
4.	ASM International ,Ceramics and Glass(vol I) .
5.	A.H.Heuer and L.W Hobbs ,Science & Technology of Ceramics (vol 4) Advances in Ceramics .
6.	R. Morrel, Handbook of Properties of Technical & Engineering Ceramics, part I. An Introduction For the Engineer & Designer,
7.	J Burke, A.E.Gowan& R.N Kalz, Ceramics for high performance applications:
8.	J. E. Hove, Ceramics for Advanced Technologies.
9.	Kirk Othmer ,Encyclopedia of Chemical Technology.
10.	Hugh O. Pierson.,Handbook of Chemical Vapour Deposition, 2nd Edition,
11.	Richard W. Baker, Membrane Technology and Applications, 2nd Edition, Willey
12.	https://www.walshmedicalmedia.com/open-access/nanofiltration-and-ultrafiltration-ceramic-membranes-for-food-processing-a-mini-review-2155-9589-1000140.pdf
13.	https://www.atech-innovations.com/fileadmin/downloads/pub050302.pdf

Name of the course	Refractories for Ferrous Industries
Course Code: PE(CT)603A	**Semester: 6TH**
Duration: 6 months	**Maximum Marks: 100**
Teaching Scheme	**Examination Scheme**
Theory: 3 hrs./week	Mid Term Exam I: 15 Marks
Tutorial: Nil	Mid Term Exam II: 15 Marks
Practical: Nil	Assignment & Quiz etc.: 20 Marks
Credit Points: 3	Semester End Exam: 75 Marks (Two third weightage for final reckoning i.e., 50 marks)

Objective:

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

Pre-Requisite

1.	Fundamentals of Metallurgy: ES(CT)-410
2.	Refractories: PC(CT)510

Module	Content	Hours	Marks.
1	Overview of different routes of steel making in integrated and special steel plants, Importance of refractory materials in iron & steel making process from the point of view of clean steel making, Undesirable impact of refractory inclusions in finished steel product, Concept of specific refractory consumption (kg/tcs*) and specific cost (Rs/tcs)	3	
2	**(A) Refractory in Iron Zone:** **I. Coke Oven:** Role of coke in iron making process, Importance of silica, fireclay refractory in wall and doors of coke oven battery, Desirable properties of coke oven refractory for high campaign life, concept of average battery life in Indian and global scenario. **II. Sinter Plant:** Role of sinter in iron making process, Application of refractory in ignition hood of sinter plant. **III. Calcination Plant:** Role of calcined limestone and dolomite in steel making process, Types of refractory in lime and dolomite	15	

	kilns. **IV. Blast Furnace:** Application of refractory in different zones of blast furnace stove and cast house area. Role of carbon block in the hearth of blast furnace, Concept of grouting for periodic repair of tap hole. **V. Corex Process:** Application of refractory in reduction shaft and gasifier, DC Arc Furnace. **VI. Torpedo Ladle/Transfer Ladle:** Usage of torpedo ladle in steel plant, lining pattern of torpedo ladle, Concept of average life of torpedo ladle in Indian and global scenario.		
3	**(B) Refractory in Steel Zone:** **I. Basic Oxygen Furnace/LD Converter:** BOF steel making process and slag formation.Necessity of using basic refractory in converter; Concept of requirement of different types of refractory in impact zone, metal zone, slag zone and taphole area; Concept of heat size; Role of gunning in increasing the service life of converter. Slag coating/ slag splashing practice to improve converter life. **II. Electric Arc Furnace:** Lining pattern and type of refractory used in EAF steel making. **III. Steel Ladle:** Lining pattern of steel ladle refractory, Concept of Ladle Metallurgy, Role of operational parameters in service life, Purging refractory and slide gate mechanism, Role of gunning and patching mass for hot repair. **IV. Argon Rinsing Station and RH Degasser:** Types of refractory used in these processes. **V. Continuous Casting:** Importance of tundish refractory (spray mass, back up castable, impact pad, turbo stop, cover flux , insulating materials, dams and weirs) in continuous casting, Concept of open and closed casting, Concept of sequence casting, Analysis of black refractory (ladle shroud, mono block stopper, sub entry nozzle, sub immersion ladle) in billet, slab and bloom caster; An overview of manufacturing process of black refractory. **VI. Burner Cover:** Application of ceramic fibre blankets and modules in the burner cover of ladle preheater and tundish preheater.	15	
4	**(C) Refractory in Mill Zone:** Overview of different refractory used in mill zone	1	
5	**(D) Failure Analysis of Refractory:** **I.** Consequences of refractory failure: plant shut down, loss of property, loss of steel, fatal accidents. **II.** Microstructure and phase analysis of failed part. **III.** Preventive measure: visual inspection, intermediate hot & cold repair (gunning, patching), shell thermography, Laser measurement to estimate residual refractory lining thickness.	3	

Course outcomes

After completion of the course, a student would be able to:

CO 1	Differentiate different steel making route and different unit associated for making steel.
CO 2	Identify the importance of refractories for making clean steel and its specific consumption and cost
CO 3	Find out the suitability of refractories for basic iron and steel making practice.
CO 4	Select suitable refractories for coke oven, sinter plant, blast furnace, Corex process and ladle used in iron making processes.
CO 5	Identify refractories suitable for BOF/LD, EAF etc. and mill zone
CO 6	Select the refractories used in continuous casting process
Learning Resources:	
1.	O.P Gupta: Elements of Fuels Furnaces & Refractories, Khanna Publishers
2.	Ahindra Ghosh and Amit Chatterjee: Iron making & Steel making: Theory & Practice, PHI Learning
3.	J. H. Chesters: Steel Plant Refractories:
4.	P.P.Budnikov: The Technology of Ceramics and Refractories. The MIT press, 4^{th} Ed,2003
5.	C. A. Schacht: Refractory Linings: Thermo-mechanical Design and Applications, CRC Press, 1995.
6.	Refractories Hand Book, The Technical Association of refractories, Japan, a Funding Member of UNITCER

Name of the course	**Refractories for Non-Ferrous and other Industries**
Course Code: PE(CT)603B	**Semester: 6TH**
Duration: 6 months	**Maximum Marks: 100**
Teaching Scheme	**Examination Scheme**
Theory: 3 hrs./week	Mid Term Exam I: 15 Marks
Tutorial: Nil	Mid Term Exam II: 15 Marks
Practical: Nil	Assignment & Quiz etc.: 20 Marks
Credit Points: 3	Semester End Exam: 75 Marks (Two third weightage for final reckoning i.e., 50 marks)

Objective:

1.	To familiarize with the furnaces used in non-ferrous metallurgical processes like Aluminum industries, Copper industries, Zinc industries, Lead industries and other ceramic industries like Glass, Cement and Pottery..
2.	To provide an exposure to the refractories application in the non-ferrous and other Ceramic industries.

Pre-Requisite

1.	Refractories:- PC(CT)-510
2.	Fundamentals of Glass ,Cement & Pottery Processing Techniques

Module	Content	Hours	Marks.
1	**Introduction:** Refractories and their properties at high Temperatures, The selection of refractories for specific conditions of the service of the furnace- the temperature, working cycle, interaction with aggressive melts and gases, mechanical interaction of the material in the furnace	**2**	
2	**Aluminium Industry:** i).Furnaces used in Aluminium Industries- Electrolysis furnace, Refining Blast Furnace, Melting Furnace, Rapid Melting Furnace, Holding furnace, ii). Refractories used of those furnaces iii). Wear mechanism of Refractories and composition.	6	
3	**Copper Industries:**i). Copper Smelting Process: Self Melting (Flash) Furnace method, Reverberatory furnace	6	

	smelting method, Blast furnace method, M.I.(Mitsubishi material & Ishikawajima Heavy Industries) method, ii). Converter iii). Refining furnaces iv). Melting furnace for Electrolytic Copper. v) Refractories used of those furnaces		
4	**Zinc Industries:** i). Dry melting Method: Electrothermal Distillation method, I.S.P. smelting method ii). Wet Electrolytic method iii). Refractories used of those furnaces	4	
5	**Lead Industries:** I) Blast furnace for lead smelting II) Refractories used of this furnace	3	
6	**Other Ceramic Industries:** **A) Glass Industry:** i). Glass tank Furnaces ii). Refractories used in glass tank furnace iii) Mechanism of refractories corrosion iv) Wear of glass contact area v) Damage of refractories at upper structure vi) damage of refractories in regenerater & applied refractories	6	
7	**B) Cement and Lime industries** i) Cement Rotary kiln ,Lime Calcining kiln ii) Refractories used in those kiln	4	
8	**C) Pottery Industries** Types of kiln I) Tunnel Kiln ii) Shuttle Kiln iii) Refractories used of those kiln	4	

Course outcomes
After completion of the course, a student would be able to:

CO 1	provide exposure on the properties of refractories and their specific uses in severe service conditions of the furnaces.
CO 2	Learn manufacturing processes of different non-ferrous metals like aluminium, copper ,zinc, lead and types of furnace used.
CO 3	choose suitable refractories for different non-metal producing furnaces under specific service condition.
CO 4	Get an idea of the mechanism of corrosion/damage of refractories in different non-ferrous furnaces.
Learning Resources:	
1.	Ritwik Sarkar, Refractory Technology.
2.	R. H. Tupkary, Modern Steel making Practice,
3.	Andrey Yurkov, Refractories for Aluminium
4.	Refractories Handbook-The Technical Association of Refractories, Japan

Name of the course	**Total Quality Management**
Course Code: OE(CT)603A	**Semester: 6TH**
Duration: 6 months	**Maximum Marks: 100**
Teaching Scheme	**Examination Scheme**
Theory: 3 hrs./week	Mid Term Exam I: 15 Marks
Tutorial: Nil	Mid Term Exam II: 15 Marks
Practical: Nil	Assignment & Quiz etc.: 20 Marks
Credit Points: 3	Semester End Exam: 75 Marks (Two third weightage for final reckoning i.e., 50 marks)

Objective:

1.	To learn the concept of quality and its importance
2.	To learn the uses of different SPC & SQC techniques in problem solving.
3.	To familiarize with ISO 9001 QMS, Quality circle, Five S, Five Whys' analysis, Kaizen, Six sigma.
4.	To acquaint with Total Quality Management practices.

Pre-Requisite

1.	Economics & Statistics: HS (CT) 403

Module	**Content**	**Hours**	**Marks.**
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	**6**	
2	Statistical Process Control >> Definition, Chance causes, Assignable causes, Difference between two causes along with practical application. Steps for continual improvements- Pareto analysis, Brain storming, Cause & effect diagram. PDCA cycle	6	
3	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.	5	
4	Cost of Quality >> Elements of quality cost, Assessing cost of	4	

	quality, Cost of appraisal, Prevention & failure cost, Optimum cost of quality control		
5	Five S, Five Whys analysis, Kaizen, Kanban, 7 QC tools, Quality circle. Gantt Chart	5	
6	ISO - 9001 Quality System - Introduction, Definition of ISO, Its development. Clauses of ISO - 9001 quality system. Benefits of ISO - 9000 quality system	5	
7	Six sigma- Concept, Definition, Process, Methodology, benefits, TQM & TPM, Control charts	5	

Course outcomes

After completion of the course, a student would be able to:

CO 1	identify types of quality characteristics and their usefulness.
CO 2	relate reason(s) for variation(s) along with stepwise corrective measures.
CO 3	identify condition of the process by calculating process capability indices with the initiation of corrective actions to bring back process under control.
CO 4	assess cost of quality relating overall product cost.
CO 5	apply techniques of TQM, Six Sigma, 5S, Kanban, RCA, QC, Gantt chart for productivity improvement, project scheduling and problem solving.
CO 6	implement ISO-9001in an organisation

Learning Resources:

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

Name of the course		**Environment Engineering & Management**	
Course Code: OE(CT)603B		**Semester: 6TH**	
Duration: 6 months		**Maximum Marks: 100**	
Teaching Scheme		**Examination Scheme**	
Theory: 3 hrs./week		Mid Term Exam I: 15 Marks	
Tutorial: Nil		Mid Term Exam II: 15 Marks	
Practical: Nil		Assignment & Quiz etc.: 20 Marks	
Credit Points: 3		Semester End Exam: 75 Marks (Two third weightage for final reckoning i.e., 50 marks)	
Objective:			
1.	To identify the air pollutants, their dispersion characteristics, and their adverse effects on environment especially on human health		
2.	To identify the water pollutants and their adverse effects on environment especially on human health		
3.	To study and classify the nature of various solid wastes produced by industrial, agricultural and urban population activities.		
4.	To get familiar with technological clues and equipments required to manage and mitigate the problem of environmental pollution.		
Pre-Requisite			
1.	Class 12th standard knowledge of physics and chemistry		
2.	Class 12th standard knowledge in differential & integral calculus		
Module	**Content**	**Hours**	**Marks.**
1	**Air Pollution** Classification and properties of air pollutants; Major sources of air pollutants; Particulate matter; Photochemical smog; Effects of air pollutants on vegetation & human health; Methods of removal of air pollutants; Air pollution laws	4	
2	**Air Pollutant Dispersion** Temperature Lapse Rates and Atmospheric Stability: Inversions	3	
3	**Air Pollutant control methods and equipments** Calculation of particulate collection efficiency; Gravitational Settling Chambers; Cyclone Separators; Mechanisms of particle separation in Fabric Filters; Fabric Characteristics; Fabric Filter Systems; Electrostatic Precipitators; Wet Scrubbers- its advantages and disadvantages; Selection of particulate collector	6	
4	**Water Pollution** Water resources; Origins of wastewater; Classification of water pollutants; Biochemical Oxygen Demand and Chemical Oxygen Demand; Measurement of BOD & COD; Disease causing agents; Synthetic organic compounds (pesticides, detergents,); Plant nutrients; Inorganic chemicals and minerals; Thermal discharges and oil: Water	6	

	pollution laws		
5	**Waste Water Treatment** Stages of treatment-primary, secondary & tertiary; Physical, chemical & other processes; Primary treatment- Removing FOG, grits & settleable materials; Secondary (Biological) treatment – Activated sludge process, Trickling filter & lagooning; Sludge treatment and disposal; Tertiary treatment- Chlorination,UV radiation, ozonation, reverse osmosis, ion exchange & electrodialysis	6	
6	**Solid Waste Management** Sources & classification of solid waste; Public health aspects; Methods of collection; Role of transfer station; Disposal methods- Open dumping, sanitary landfill, incineration, composting; New solid waste management techniques- Recovery & recycling	5	

Course outcomes	
After completion of the course, a student would be able to:	
CO 1	Identify the common pollutants in the air, their distinguishing features and major health effects.
CO 2	Predict the possibility of dispersion of air pollutants by studying the temperature lapse rates of local atmosphere and by examining the local conditions for temperature inversion.
CO 3	Suggest equipments needed to discharge considerably pollution free air from industry, especially ceramic industry.
CO 4	Identify the pollutants present in water and classify them according to their nature keeping in view the oxygen demand of the polluted water.
CO 5	Suggest equipments needed to produce clean water based on the analysis of polluted water discharged from industry.
CO 6	Classify various solid wastes produced by industry, agriculture & municipal towns and suggest suitable methods for their disposal and reuse.
Learning Resources:	
1.	Environmental Pollution Control Engineering, C.S.Rao, Wiley Eastern Ltd.
2.	Environmental Engineering & Management, Suresh K Dhameja, S.K.Kataria & Sons.
3.	Introduction to Environmental Engineering & Science, Gilbert M. Masters & Wendell P. Ela, Prentice Hall India.
4.	Handbook of Environmental Engineering, Myer Kutz, Wiley

<table>
<tr><td colspan="2">Name of the course</td><td colspan="2">Instrumentation & Process Control</td></tr>
<tr><td colspan="2">Course Code: PC(CT)619</td><td colspan="2">Semester: 6TH</td></tr>
<tr><td colspan="2">Duration: 6 months</td><td colspan="2">Maximum Marks: 100</td></tr>
<tr><td colspan="2">Teaching Scheme</td><td colspan="2">Examination Scheme</td></tr>
<tr><td colspan="2">Theory: 4 hrs./week</td><td colspan="2">Mid Term Exam I: 15 Marks</td></tr>
<tr><td colspan="2">Tutorial: Nil</td><td colspan="2">Mid Term Exam II: 15 Marks</td></tr>
<tr><td colspan="2">Practical: Nil</td><td colspan="2">Assignment & Quiz etc.: 20 Marks</td></tr>
<tr><td colspan="2">Credit Points: 4</td><td colspan="2">Semester End Exam: 75 Marks (Two third weightage for final reckoning i.e., 50 marks)</td></tr>
<tr><td colspan="4">Objective:</td></tr>
<tr><td>1.</td><td colspan="3">Impart a basic knowledge of measuring parameters to the students and familiarize them with different industrial instruments</td></tr>
<tr><td>2.</td><td colspan="3">Explain the working principle of different measuring instruments regarding temperature, pressure, flow and level measurement</td></tr>
<tr><td>3.</td><td colspan="3">Introduce the students to the basics of control system and application of control system to the real life processes, mathematical modeling of process using Laplace Transform and block diagram representation</td></tr>
<tr><td>4.</td><td colspan="3">Analyze the concept of stability of process control and introduce the concept of design of controllers</td></tr>
<tr><td colspan="4">Pre-Requisite</td></tr>
<tr><td>1.</td><td colspan="3">Knowledge of basic instrumentation and physics.</td></tr>
<tr><td>2.</td><td colspan="3">Knowledge of engineering mathematics, Laplace transform</td></tr>
<tr><td>Module</td><td>Content</td><td>Hours</td><td>Marks.</td></tr>
<tr><td>1</td><td>Introduction to Instrumentation
Introduction to measurement and different measuring instruments, static and dynamic characteristics of measuring devices: accuracy, precision, error, resolution, threshold;
Sensors and transducers, concept of calibration, industrial instrumentation</td><td>3</td><td></td></tr>
<tr><td>2</td><td>Temperature and Pressure measurement
Temperature measurement and its classification, different mechanical type measuring instruments, Thermo electric temperature measurement devices, Optical/Radiation type instruments.
Pressure measurement and its classification, mechanical type measuring instruments, Elastic type measuring instruments, Bellows and diaphragm, Electric type measuring instruments, Piezoelectric measurement</td><td>8</td><td></td></tr>
</table>

3	**Flow and Level measurement** Flow measurement and its classification, positive displacement flow meters, electric and electromagnetic flow measurement, ultrasound and digital sensor Level measurement: mechanical, thermal and electric sensors, Application of instrumentation in ceramic industry	5	
4	**Introduction to control system and process control** Introduction to control system and process control, open loop and close loop system, feed back end feed forward system, transient and steady state response, illustration with examples	4	
5	**Representation of system and process using Transfer function** Developing transfer function of a system with the application of Laplace transformation in solving practical problems, Representation of a system using block diagrams, analysis of block diagrams, mathematical modeling of simple physical systems, Transient response of 1st order and 2nd order systems	9	
6	**Control schemes and stability analysis of a system** Concept of stability, controller and final control elements of a system, P, PD and PID controller, Analysis of stability of a system, different industrial controller Illustration of control scheme and stability of some real life systems	7	

Course outcomes	
After completion of the course, a student would be able to:	
CO 1	**Illustrate** the importance of different parameters of measurement
CO 2	**Explain** the working principles of different measuring instruments for the measurement of physical parameters such as temperature, pressure, flow and level
CO 3	**Compare** the roles of several instruments in measuring different parameters in a process control system
CO 4	**Develop** transfer function of different physical systems with the aid of Laplace Transform
CO 5	**Determine** stability of a process control system
CO 6	**Analyze** the role of different controllers
Learning Resources:	
1.	D. Partanabis, "Principal of Industrial Instrumentation", Tata Mcgraw Hill
2.	Fribance, "Industrial Instrumentation Fundamentals", Mcgraw Hill
3.	Donald R. Coughanowr, "Process System Analysis and Control", Mcgraw Hill

4.	Considine & Considine, “Process Instrument and Control Handbook”, Mcgraw Hill
5.	Modern Control Engineering, K. Ogata, 5th Edition, Pearson Education India
6.	Control System Engineering, I. J. Nagrath & M. Gopal. 6th Edition, New Age International Publication.

Name of the course	**Cement, Concrete & Monolithic Lab.**
Course Code: PCL(CT) 620	**Semester: 6TH**
Duration: 6 months	**Maximum Marks: 100**
Teaching Scheme	**Examination Scheme**
Theory: Nil	Attendance: 10
Tutorial: Nil	Preparation of Lab Report: 20
Practical: 3 hrs./week	Experimental data/ Precision of work done: 30
Credit Points: 1.5	Presentation/ analysis of the result: 20
	Viva Voce: 20

Module	Content	Hours	Marks.
1	Tests like Consistency of cement, Initial Setting time, Final Setting Time, CCS as per standard specification	3	
2	Study of strength properties both as a function of composition and setting time of cement-sand mortars & concrete.	3	
3	Setting time of various grades of cements.	3	
4	Flow table test of mortar.		
5	Slump test of concrete.	3	
6	Vee- Bee consistometer test of concrete.	3	
7	Compaction factor test of concrete.	3	
8	NDT of cement-sand mortars/concrete blocks by Schmidt test hammer.	3	
9	Soundness of cement.	3	
10	Determination of flow properties of castables	3	
11	Fabrication of castable samples using proper size fractions and measure their strength at room temp. as well as different temps.	3	
12	Determination of slag corrosion resistance of the fabricated castables	3	

Course outcomes

After completion of the course, a student would be able to:	
CO 1	Gather knowledge on consistency of Cement, initial setting time, final setting time of cement
CO 2	Get an idea on the strength properties as a function of composition and setting time of mortars & concrete.
CO 3	Acquire knowledge on the soundness of cement, flow properties of mortar slump test, compaction factor of concrete.
CO 4	Get an idea of flow properties of castables their fabrication process and the strength at different temps.
CO 5	Get an exposure of the corrosion resistance of castable towards slag.
Learning Resources:	
1.	Lab Manuals

FOURTH YEAR FIRST SEMESTER

7th Semester B. Tech Ceramic Technology							
Sl. No.	Type of course	Course Code	Course Title	Hours per week			Credits
				Lecture	Tutorial	Practical	
Theory							
1.	Professional Core Course	PC(CT) 721	Computational Materials Science	3	0	0	3
2.	Professional Core Course	PC(CT) 722	Characterization of Materials	2	0	0	2
3.	Professional Elective Course	PE(CT) 704	Non-oxide Ceramics (A)/ Composites (B)	2	0	0	2
4.	Open Elective Course	OE(CT) 704	Artificial Intelligence & Robotics (A)/ Internet of Things (B)/ Machine Learning (C)	2	0	0	2
5.	Humanities & Social Sciences including Management Courses	HS(CT) 705	Fundamentals of Business Management	3	0	0	3
Sessional/Practical							
1.	Humanities & Social Sciences including Management Courses	HSL(CT) 706	Seminar	0	0	2	1
2.	Project	PROJECT (CT) 701	Project Work I	0	0	08	4
3.	Industrial Training	INDTRG(CT) 701	Training Proficiency	-	-	-	1
				Total credits			**18**

A student has to secure at least 50% marks in all papers mentioned above, failing which he/she would carry backlog(s).

Name of the course		**Computational Material Science**	
Course Code: PC(CT)721		**Semester: 7TH**	
Duration: 6 months		**Maximum Marks: 100**	
Teaching Scheme		**Examination Scheme**	
Theory: 3 hrs./week		Mid Term Exam I: 15 Marks	
Tutorial: Nil		Mid Term Exam II: 15 Marks	
Practical: Nil		Assignment & Quiz etc.: 20 Marks	
Credit Points: 3		Semester End Exam: 75 Marks (Two third weightage for final reckoning i.e., 50 marks)	
Objective:			
1.	To understand basic statistical measures		
2.	To apply Machine learning tools to solve various simple problems.		
3.	To design neural networks for simple problems		
4.	To implement various evolutionary algorithms		
Pre-Requisite			
1.	NIL		
Module	**Content**	**Hours**	**Marks.**
1	**Introduction to Statistical Measures 1:** Mean, Median, Mode, skewness and kurtosis. Box Plot, Simple correlation, Correlation ratio, correlation index. Rank correlation –Spearman's and Kendall's measures.	6	
2	**Introduction to Statistical Measures 2:** Null and alternative hypotheses, simple & composite hypotheses, critical region, type I and type II errors, level of significance, p-value.	4	
3	**Machine learning Tools**: Linear regression, Gradient Descent Algorithm for Linear Regression Model, Binary Classifier, Logistic Regression, Multiclass Classifier, k-Nearest Neighbors (KNN), Naive Bayes Classifiers, Decision Trees, Random Forests, Support Vector Machines, Principal Component Analysis (PCA), K-Means.	15	
4	**Neural network**: Artificial Neural Networks (ANNs), Perceptron, Multi-Layer Perceptron (MLP), Back propagation, Activation	5	

	Functions.		
5	**Evolutionary Algorithms**: Genetic Algorithms, Ant Colony Optimization(ACO). Particle Swarm Optimization (PSO).	6	

Course outcomes	
After completion of the course, a student would be able to:	
CO 1	apply Statistical measures to summarize data
CO 2	explain Hypothesis testing
CO 3	identify which Machine learning tool is needed to find solution to a given prediction or regression problem.
CO 4	design Neural networks to solve some simple problems.
CO 5	implement various evolutionary algorithms
Learning Resources:	
1.	Goon, A.M., Gupta, M.K. and Dasgupta, B. (2003): An Outline of Statistical Theory, Vol. I and Vol II 4th Edn. World Press, Kolkata
2.	S. Rajasekaran and G.A.V.Pai, “Neural Networks, Fuzzy Logic and Genetic Algorithms”, PHI
3.	David E. Goldberg, Genetic Algorithms in search, Optimization & Machine Learning, Pearson/PHI
4.	Christopher Bishop, Pattern Recognition and Machine Learning. 2e, Springer
5.	M. Nielsen, Neural Networks and Deep Learning, Determination Press, 2015
6.	Mood, A.M., Graybill, F.A. and Boes, D.C. (2007): Introduction to the Theory of Statistics, 3rd Edn. (Reprint).Tata McGraw-Hill Pub. Co. Ltd
7.	Tom Mitchell, Machine Learning, McGraw Hill Education
8.	Goodfellow, I., Bengio,Y., and Courville, A., Deep Learning, MIT Press, 2016
9.	Trevor Hastie, Robert Tibshirani, Jerome Friedman, The Elements of Statistical Learning: Data Mining, Inference, and Prediction, Springer

<table>
<tr><td colspan="2">Name of the course</td><td colspan="3">Characterization of Materials</td></tr>
<tr><td colspan="2">Course Code: PC(CT)722</td><td colspan="3">Semester: 7TH</td></tr>
<tr><td colspan="2">Duration: 6 months</td><td colspan="3">Maximum Marks: 100</td></tr>
<tr><td colspan="2">Teaching Scheme</td><td colspan="3">Examination Scheme</td></tr>
<tr><td colspan="2">Theory: 2 hrs./week</td><td colspan="3">Mid Term Exam I: 15 Marks</td></tr>
<tr><td colspan="2">Tutorial: Nil</td><td colspan="3">Mid Term Exam II: 15 Marks</td></tr>
<tr><td colspan="2">Practical: Nil</td><td colspan="3">Assignment & Quiz etc.: 20 Marks</td></tr>
<tr><td colspan="2">Credit Points: 2</td><td colspan="3">Semester End Exam: 75 Marks (Two third weightage for final reckoning i.e., 50 marks)</td></tr>
<tr><td colspan="5">Objective:</td></tr>
<tr><td>1.</td><td colspan="4">The objective of the course is to understand the different characterization techniques of ceramic material in relation with its application field.</td></tr>
<tr><td>2.</td><td colspan="4">The objective of the course is to provide a structural correlation with characterization techniques</td></tr>
<tr><td colspan="5">Pre-Requisite</td></tr>
<tr><td>1.</td><td colspan="4">knowledge of raw materials used in different ceramics industries</td></tr>
<tr><td>2.</td><td colspan="4">knowledge of whiteware, refractory, glass and advance ceramic materials for industrial and house hold application.</td></tr>
<tr><td>Module</td><td colspan="2">Content</td><td>Hours</td><td>Marks.</td></tr>
<tr><td>1</td><td colspan="2">Scope, Application & Basic background of different types of Engineering Materials:

Metals and Alloy, Ceramic (Oxides and Non oxides), Polymers, Composites, Natural and synthetic, Nuclear materials, Bio medical materials, Nano material.</td><td>5</td><td></td></tr>
<tr><td>2</td><td colspan="2">Physio-Chemical characterisation of materials:

Density, Porosity, Granularity, Differential thermal analysis (DTA), Thermogravimetric analysis (TGA), Differential scanning calorimetric (DSC), Chemical analysis, X-ray fluorescence (XRF), Particle size distribution (PSD)</td><td>8</td><td></td></tr>
<tr><td>3</td><td colspan="2">Microstructural characterization of materials:

X-ray diffraction (XRD), X-ray diffraction topography (XRT), Scanning electron microscopy(SEM), Transmission electron microscopy (TEM), Atomic force microscopy (AFM)</td><td>10</td><td></td></tr>
</table>

4	**Optical Characterizations of Materials:** Ultraviolet-visible spectroscopy (UV-vis), Fourier transform infrared spectroscopy (FTIR), Thermoluminescence (TL) and Photoluminescence (PL)	10	
5	**Mechanical Characterizations of Materials:** Time, temperature dependent stress-strain behavior of material, Dynamic mechanical analysis (DMA), Nano indentation, Toughness, Hardness, Brittleness, Fatigue strength, Wear, Fracture, ductility and malleability	6	
6	**Electric and Magnetic Characterizations of Materials:** Magnetic Hysteresis, B-H loop, M-H curve, Magnetic flux density, AC resistivity, Hall effect, Dielectric loss, Dielectric strength	6	
7	**Characterizations of some ceramic materials:** Clay, Bauxite, Group of silicate and aluminosilicate materials, Limestone, Magnesite, Silicon carbide, Boron carbide, Sialon etc.		

Course outcomes	
After completion of the course, a student would be able to:	
CO 1	apply the knowledge of ceramic materials in relation with different field of applications.
CO 2	apply the knowledge of physicochemical, mechanical, magnetic and electrical characterization of traditional and structural ceramic materials in relation with its applications
CO 3	apply the knowledge of reactivity of different ceramic materials in relation with its structural properties
CO 4	apply the knowledge of structural correlation with the properties and applications ceramic materials
Learning Resources:	
1.	Properties of Ceramic Raw materials: W. Ryan, Pergamon Press
2.	The Chemistry and Physics of Clays and other Ceramic Materials: R. W. Grimshaw, Ernest Benn Ltd
3.	Ceramic Raw Materials (2nd Revised Edition) – W. E. Worrall (1982). Pergamon Press, Oxford. 111p.
4.	Ceramic Raw Materials of India: A Directory – S.K Guha (Editor) (1982). Indian Institute of Ceramics, Kolkata. 202p.
5.	Hand Book of Nano Structure materials & Nano Technology edited by Hari singh Nalwa.
6.	Nano powder to Functional Materials edited by Radu Robert Piticescu, W. Lojkowski & J.R. Blizzard.

Name of the course		**Non-Oxide Ceramics**	
Course Code: PE(CT)704A		**Semester: 7TH**	
Duration: 6 months		**Maximum Marks: 100**	
Teaching Scheme		**Examination Scheme**	
Theory: 2 hrs./week		Mid Term Exam I: 15 Marks	
Tutorial: Nil		Mid Term Exam II: 15 Marks	
Practical: Nil		Assignment & Quiz etc.: 20 Marks	
Credit Points: 2		Semester End Exam: 75 Marks (Two third weightage for final reckoning i.e., 50 marks)	
Objective:			
1.	To familiarize with the non-oxide materials, their raw material sources, raw materials used for manufacturing the product, their structures, properties and also their uses in different advanced fields.		
Pre-Requisite			
1.	Engineering Materials Science: ES(CT)409		
2.	Advanced Ceramics: PC(CT)618		
Module	**Content**	**Hours**	**Marks.**
1	**Introduction:** The advanced ceramics of yesteryear, specially the non-oxide ceramics/materials, have become fully commercialized in several applications where long life, improved performance, unique design capability and cost advantages have been explicitly utilized. Exploiting the advantages of their unique properties combined with the availability of complex shapes, several industries like metallurgical, chemical, mechanical machinery, food processing, electronics, semiconductor processing, aerospace, defense etc. have been discovered the unique benefits of these ceramics. Non-Oxide Ceramics are compound important high-technology materials with applications as wear resistant engineering components and cutting tools because of their hardness and toughness.	**4**	
2	Carbides – Boron carbide, Silicon carbide, Titanium carbide, Zirconium carbide, Tungsten carbide, Hafnium carbide –raw materials used their methods of preparation, bonding / structure, properties and applications both in refractory and advanced application	5	
3	Graphite –Sources of raw materials, Effects of fabrication variables, Graphite processing technique, structure of graphite, properties-like	6	

	mechanical, erosion, oxidation, electrical resistivity, thermal shock resistance and its different types of applications.		
4	Borides – Fabrication, Structure, properties and applications	3	
5	Silicides –Raw materials used, Fabrication methods, bonding in silicides, Structure, properties and applications	6	
6	Sialon:-Why sialon ceramics developed? Different techniques for sialon preparation, structure of sialon, properties of sialon, and their different fields of applications,	6	

Course outcomes

After completion of the course, a student would be able to:

CO 1	Get an idea on the non-oxide ceramics, their advantages of using in different fields.
CO 2	Provide an exposure on processing and fabrication of Carbides, Graphites –their structures, properties and applications in different fields.
CO 3	Learn basic ideas on Borides, Silicides-their fabrication techniques, structure properties and applications in different fields.
CO 4	Provide exposure on the Sialon Ceramics, their classifications, different fabrication techniques of Sialon, structure, properties and applications in different fields.

Learning Resources:

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

Name of the course	COMPOSITES
Course Code: PE(CT)704B	**Semester: 7TH**
Duration: 6 months	**Maximum Marks: 100**
Teaching Scheme	**Examination Scheme**
Theory: 2 hrs./week	Mid Term Exam I: 15 Marks
Tutorial: Nil	Mid Term Exam II: 15 Marks
Practical: Nil	Assignment & Quiz etc.: 20 Marks
Credit Points: 2	Semester End Exam: 75 Marks (Two third weightage for final reckoning i.e., 50 marks)

Objective:	
1.	To understand Composite Materials and their requirement from ancient to present days of Advanced Technology.
2.	To learn properties and applications of different types of composite materials e.g., MMC, CMC, PMC etc.
3.	To know the processes of production of composite materials in industry.
4.	To learn the mechanical properties of matrix and fiber for design and fabrication of composites.

Pre-Requisite	
1.	Engg. Materials Science: ES(CT) 409
2.	Mathematics I:BS(CT)101

Module	Content	Hours	Marks.
1	Definition of composites – historical background – natural and man-made composites – exciting properties and important applications.	2	
2	Classification of composites: based on morphology of the reinforcing phase – particle and fiber reinforcement and laminated composites; based on and the chemical nature of the matrix- PMC, MMC and CMC; important properties and applications of each.	2	
3	Mechanical Behaviour: Comparison of stress-strain curve for monolithic and composite materials; Hook's Law and Poison's ratio – relationship between different coefficients; Generalized	4	

	Hook's law (3D) – stress and strain tensors, stiffness coefficients etc.; Changes in the number of coefficients under different symmetry conditions; rule of mixture as applied to composites- iso-stress and iso-strain conditions.		
4	Design of fiber reinforced composites: critical fiber length – shear lag model; concept of critical volume fraction of reinforcement under two different conditions i) matrix fails first and ii) fiber fails first.	2	
5	Manufacturing of fibers for reinforcement: glass fiber, boron fiber, carbon fiber, Kevlar fiber, basalt fiber etc – comparison of their structure and properties.	4	
6	Different types of matrix materials and their composites: properties and applications.	2	
7	Fabrication techniques of FRP: Open mould process – hand lay-up, spray lay-up, vacuum/ pressure bag molding, autoclave molding; Close mold processes – compression molding, injection molding, filament winding, pultrusion, centrifugal casting etc. Fabrication of MMCs: Diffusion bonding, squeeze casting, liquid infiltration, spray co-deposition, solution precipitation. Fabrication of CMCs: simple sintering, liquid impregnation, CVD/CVI, lamination.	6	
8	Failure of Composites: role of reinforcement-matrix interface, fiber pull-out etc.	2	

Course outcomes	
After completion of the course, a student would be able to:	
CO 1	relate composite materials with their basic characteristics.
CO 2	classify different types of composites based on morphology and combination of materials.
CO 3	correlate volume fraction of the reinforcing phase under two different conditions i.e matrix failing first and fiber failing first with mechanical property of composites.
CO 4	apply generalized Hook's law to find stress strain relationships of composite materials.
CO 5	correlate properties of different varieties of composites with fabrication technologies and applications
CO 6	fabricate reinforced composite with different types of fibers.
Learning Resources:	
1.	

2.	
3.	
4.	
5.	
6.	

Name of the course	**Artificial Intelligence & Robotics**		
Course Code: OE(CT)704A	**Semester: 7TH**		
Duration: 6 months	**Maximum Marks: 100**		
Teaching Scheme	**Examination Scheme**		
Theory: 2 hrs./week	Mid Term Exam I: 15 Marks		
Tutorial: Nil	Mid Term Exam II: 15 Marks		
Practical: Nil	Assignment & Quiz etc.: 20 Marks		
Credit Points: 2	Semester End Exam: 75 Marks (Two third weightage for final reckoning i.e., 50 marks)		
Objective:			
1.	To learn the basic principles, models, and algorithms of **AI** to recognize, model, and solve problems in the analysis and design of information systems.		
2.	To learn the structures and algorithms of a selection of techniques related to searching, reasoning, machine learning, and language processing.		
3.	To acquire knowledge on Robotics Engineering.		
Pre-Requisite			
1.	Mathematics I: BS(CT) 101		
2.	Mathematics II: BS(CT) 204		
3.	Engineering Mathematics: BS(CT)307		
4.	Programming for Problem Solving: ES(CT)101		
5.	Programming for Problem Solving Lab: ESL(CT)102		
Module	**Content**	**Hours**	**Marks.**
1	**Introduction of AI and Agents:** Overview of Artificial intelligence- Problems of AI, AI techniques, Agents & environment, nature of environment, structure of agents, goal based agents, utility based agents, learning agents.	2	
2	**Problem Solving:** Problems, Problem Space & search, Defining the problem as state space search, production system, problem characteristics, issues in the design of search programs.	2	

3	**Search techniques:** Problem solving agents, searching for solutions; uniform search strategies: breadth first search, depth first search, depth limited search, bidirectional search, comparing uniform search strategies. Greedy best-first search, A* search, memory bounded heuristic search: local search algorithms & optimization problems: Hill climbing search, simulated annealing search, genetic algorithms; constraint satisfaction problems, Games, optimal decisions & strategies in games, the minimax search procedure, alpha-beta pruning.	6	
4	**Knowledge Representation:** Knowledge representation issues, representation & mapping, approaches to knowledge representation, The First Order Predicate Logic, Semantic Nets, Frames and Scripts Formalisms, Resolution in Predicate Logic, Unification, Strategies for Resolution by Refutation, Procedural verses declarative knowledge, logic programming, forward verses backward reasoning, matching, control knowledge.	4	
5	**Understanding Natural Languages:** Introduction to NLP, Basics of Syntactic Processing, Basics of Semantic Analysis, Basics of Parsing techniques, context free and transformational grammars, transition nets, augmented transition nets, Shanks Conceptual Dependency, Scripts ,Basics of grammar free analyzers, Basics of sentence generation, and Basics of translation	2	
6	**Expert System:** Need and justification for expert systems, knowledge acquisition, Case studies: MYCIN,R1 **Learning:** Concept of learning, learning automation, genetic algorithm, learning by inductions, neural nets. **Programming Language:** Introduction to programming Language, LISP and PROLOG. **Handling Uncertainties:** Non-monotonic reasoning, Probabilistic reasoning, use of certainty factors, Fuzzy logic	6	
7	**Introduction to Robotics:** Fundamentals of Robotics, Robot Kinematics, Position Analysis, Dynamic Analysis and Forces, Robot Programming languages & systems: Introduction, the three levels of robot programming, requirements of a robot programming language, problems peculiar to robot programming languages.	4	

Course outcomes

After completion of the course, a student would be able to:

CO 1	Recommend use of AI in different applications.
CO 2	explain knowledge representation techniques, blind and heuristic search e.g., minimax, resolution, etc.
CO 3	apply the basic principles, models, and algorithms of AI to recognize, model, and solve problems in the analysis and design of information systems.
CO 4	write program with LISP and PROLOG.
CO 5	describe basics of Robotics Engineering and its application.
CO 6	explain principles of Natural language processing, Machine Learning, Robotics, Expert systems, and learning.
Learning Resources:	
1.	E. Rich and K. Knight, "Artificial intelligence", TMH, 2nd ed., 1992.
2.	Logic & Prolog Programming, Saroj Kaushik, New Age International
3.	N.J. Nilsson, "Principles of AI", Narosa Publ. House, 1990.
4.	John J. Craig, "Introduction to Robotics", Addison Wesley publication 24
5.	Tsuneo Yoshikawa, "Foundations of Robotics", PHI Publication

Name of the course		**Internet of Things**	
Course Code: OE(CT)704B		**Semester: 7TH**	
Duration: 6 months		**Maximum Marks: 100**	
Teaching Scheme		**Examination Scheme**	
Theory: 2 hrs./week		Mid Term Exam I: 15 Marks	
Tutorial: Nil		Mid Term Exam II: 15 Marks	
Practical: Nil		Assignment & Quiz etc.: 20 Marks	
Credit Points: 2		Semester End Exam: 75 Marks (Two third weightage for final reckoning i.e., 50 marks)	
Objective:			
1.	To understand the IoT architecture and challenges		
2.	To know the building blocks of Internet of Things and characteristics.		
3.	To become aware of the different type of sensors, actuators and smart objects and their integration using Arduino		
4.	To expose to real world cases of IoT implementation		
Pre-Requisite			
1.	NIL		
Module	**Content**	**Hours**	**Marks.**
1	**Introduction:** What is IoT, Impact of IoT, IoT Challenges, IoT Network Architecture and Design, Physical design of IoT, Logical design of IoT, A simplified IoT Architecture.	4	
2	**Major components of IoT:** IoT enabling Technologies, sources of IoT, M2M communication, M2M Architecture, Difference between M2M and IoT, an introduction to Data Analytics for IoT, .	4	
3	**Smart Objects: The "Things" in IoT:** Sensors, actuators, and smart Objects, sensor Networks, Connecting Smart objects, working Principles of sensors, selection of sensors for practical applications, introduction of Different Types of Sensors such as Capacitive, Resistive, Surface Acoustic Wave for Temperature, Pressure, Humidity, Toxic Gas etc.	6	

4	**IoT Physical Devices-Arduino Uno**: Introduction to Arduino, Different versions of Arduino, Features and applications of Arduino, Basic concept of integration of sensors and actuators with Arduino.	6	
5	**Recent trends in smart sensor for day to day life:** Real world applications for IoT: industrial IoT, connected Vehicles, smart Grid, agriculture, healthcare, smart cities and smart homes.	4	
Course outcomes			
After completion of the course, a student would be able to:			
CO 1	explain the impact and challenges posed by IoT leading to new architectural models.		
CO 2	Identify the major components of IoT.		
CO 3	assess the things in IoT.		
CO 4	Implement sensor and actuator integration with Arduino.		
CO 5	identify different sensor technologies for sensing real world entities.		
Learning Resources:			
1.	David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Robert Barton, Jerome Henry, "IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things".		
2.	Srinivasa K G, "Internet of Things", CENGAGE Leaning India, 2017 .		
3.	Yasuura, H., Kyung, C.-M., Liu, Y., Lin, Y.-L., Smart Sensors at the IoT Frontier, Springer International Publishing.		
4.	Jeeva Jose, Internet of Things, Khanna Publishing House		
5.	Vijay Madisetti and Arshdeep Bahga, "Internet of Things (A Hands-on-Approach)", 1st Edition, VPT, 2014. (ISBN: 978-8173719547)		
6.	Raj Kamal, "Internet of Things: Architecture and Design Principles", 1st Edition, McGraw Hill		

Name of the course	**Machine Learning**
Course Code: OE(CT)704C	**Semester: 7TH**
Duration: 6 months	**Maximum Marks: 100**
Teaching Scheme	**Examination Scheme**
Theory: 2 hrs./week	Mid Term Exam I: 15 Marks
Tutorial: Nil	Mid Term Exam II: 15 Marks
Practical: Nil	Assignment & Quiz etc.: 20 Marks
Credit Points: 2	Semester End Exam: 75 Marks (Two third weightage for final reckoning i.e., 50 marks)

Objective:	
1.	To understand the fundamentals of Machine Learning
2.	To introduce the idea of data pre-processing
3.	To implement and measure the performance of common machine learning models
4.	To expose students to real world machine learning applications
Pre-Requisite	
1.	NIL

Module	Content	Hours	Marks.
1	**Introduction:** Introduction to Machine Learning, Learning Models, Prepare the Data for Machine Learning Algorithms, Data Cleaning, Handling Text and Categorical Attributes, Handling Missing Values, Exploration of Data using Visualization.	**4**	
2	**Classification:** Training a Binary Classifier, Measuring Performance, Multiclass Classifier, Multi-label Classification, Multi-output Classification	4	
3	**Supervised Machine Learning Algorithms:** Decision Trees, Ensembles of Decision Trees: Random Forests, Kernelized Support Vector Machines, Model Evaluation and Improvement	5	
4	**Dimensionality Reduction:**	6	

	Dimensionality Reduction, Feature Extraction, Principal Component Analysis (PCA), Randomized PCA, Incremental PCA, Kernel PCA, Selecting a Kernel and Tuning Hyper-parameters.		
5	**Unsupervised Learning: Clustering:** K-Means, Image Segmentation using clustering, Finding Optimal Number of Clusters Using Elbow Curve Method, Normalizing the Features, Hierarchical Clustering, Compare the Clusters Created by K-Means and Hierarchical Clustering, Assessment Metrics for Clustering Algorithms.	5	

Course outcomes	
After completion of the course, a student would be able to:	
CO 1	Explain basic concepts and techniques of Machine Learning.
CO 2	Implement various classification algorithms
CO 3	Design Supervised learning models for classification problems
CO 4	Apply dimensionality reduction algorithms on data
CO 5	Identify the parameters for unsupervised learning models for clustering
Learning Resources:	
1.	Christopher Bishop. Pattern Recognition and Machine Learning. 2e
2.	Tom Mitchell, Machine Learning , McGraw Hill Education
3.	Devi V.S.; Murty, M.N. (2011) Pattern Recognition: An Introduction, Universities Press, Hyderabad.
4.	R. O. Duda, P. E. Hart and D. G. Stork, Pattern Classification, Wiley, 2000.

<table>
<tr><td colspan="2">Name of the course</td><td colspan="2">Fundamental of Business Management</td></tr>
<tr><td colspan="2">Course Code: HS(CT)705</td><td colspan="2">Semester: 7TH</td></tr>
<tr><td colspan="2">Duration: 6 months</td><td colspan="2">Maximum Marks: 100</td></tr>
<tr><td colspan="2">Teaching Scheme</td><td colspan="2">Examination Scheme</td></tr>
<tr><td colspan="2">Theory: 3 hrs./week</td><td colspan="2">Mid Term Exam I: 15 Marks</td></tr>
<tr><td colspan="2">Tutorial: Nil</td><td colspan="2">Mid Term Exam II: 15 Marks</td></tr>
<tr><td colspan="2">Practical: Nil</td><td colspan="2">Assignment & Quiz etc.: 20 Marks</td></tr>
<tr><td colspan="2">Credit Points: 3</td><td colspan="2">Semester End Exam: 75 Marks (Two third weightage for final reckoning i.e., 50 marks)</td></tr>
<tr><td colspan="4">Objective:</td></tr>
<tr><td>1.</td><td colspan="3">To learn the importance of Management and various elements of management.</td></tr>
<tr><td>2.</td><td colspan="3">To learn organisational behaviour and its importance.</td></tr>
<tr><td>3.</td><td colspan="3">To learn the process of planning.</td></tr>
<tr><td>4.</td><td colspan="3">To learn different motivational theories and process of communication.</td></tr>
<tr><td>5.</td><td colspan="3">To learn Materials, HR, Marketing and Financial management functions.</td></tr>
<tr><td colspan="4">Pre-Requisite</td></tr>
<tr><td>1.</td><td colspan="3">Economics & Statistics:HS(CT) 403</td></tr>
<tr><td>2.</td><td colspan="3">Total Quality Management: OE(CT) 603A</td></tr>
<tr><td>Module</td><td>Content</td><td>Hours</td><td>Marks.</td></tr>
<tr><td>1</td><td>Introduction: Why study management? Manager’s responsibilities, levels of management and their skills. Various functions of management, MBO, Managerial skills, . Different theories of management & business challenges.</td><td>5</td><td></td></tr>
<tr><td>2</td><td>Organisational behaviour-Introduction to Organizational Behaviour, Organization Design, Interpersonal Behaviour, Organizational Stress, Organization Culture, Organizational Conflict, Organization Change and Development

Organising – Definition & its purposes, characteristics & nature of organizing, importance of organizing, nature of organization, organizing processes, steps in organizing, delegation, span of management, type of organization</td><td>6</td><td></td></tr>
</table>

3	Planning- Definitions, why planning, different steps in planning, 6Ps in planning, classification of planning, types of plans, steps in goal setting, Strategic Planning – Definition, benefits & needs, types, strategic planning process, strategic planning tools & techniques	4	
4	Communication – Definition, objectives, process of communication, models of communication, principles of communication, methods of communication, types of communication, levels of communication, barriers of communication, how to make communication effective	4	
5	Motivation- Definition, Maslaw theory of Hierarchy of needs of motivation, Herzberg's two factor theory, McGregor's X-Y theory, Goal setting theory, Alderfer's ERG theory and MxClelland's Need theory	4	
6	Human resource management-Introduction to Human Resource Management, Human Resource Planning, Job Analysis and Design, Recruitment, Selection, Induction, Training, Performance Appraisal, Wages and Salary, Incentives, Employee Relations, succession planning, Marketing Management: Marketing Concepts, Marketing Environment, Marketing Mix, Marketing Planning and Strategies, Branding, Pricing Decisions, Distribution Strategy, Promotion, Market Segmentation, Consumer Behaviour, Services Marketing Materials Management - Introduction: Meaning and Scope, Objectives and Significance of Materials Management, ABC Analysis: Purchasing Management, Inventory Management, Stores Management	9	
7	Financial management - Scope and Functions of Finance Managers, Financial Planning, Time Value of Money, Cost of Capital, Capital Budgeting, Capital Structure, Sources of Finance, Working capital Management, Management of Cash, CVP	4	

Course outcomes	
After completion of the course, a student would be able to:	
CO 1	explain different management theories, its various components.
CO 2	classify the organization to achieve organizational goals.

CO 3	plan various activities in the domains of short term, long term, strategic planning in an organization.
CO 4	apply different communication techniques by addressing various barriers.
CO 5	motivate people by practicing different motivational theories.
CO 6	assess best sources of fund and its effective utilization
CO 7	explain different management theories, its various components.
Learning Resources:	
1.	Stephen P. Robins, Organisational Behavior, PHI Learning / Pearson Education, 11th edition, 2008
2.	Zipkin, Paul H., Foundations of Inventory Management. The McGraw-Hill Company, 2000.
3.	Industrial Management I by L. c. Jhamb and Savitri Jhamb

FOURTH YEAR SECOND SEMESTER

8th Semester B. Tech Ceramic Technology							
Sl. No.	Type of course	Course Code	Course Title	Hours per week			Credits
				Lecture	Tutorial	Practical	
Sessional/Practical							
1.	Professional Elective Course	PEL(CT) 805	Ceramic Plant & Equipment Design (A)/ Furnace & Kilns Design (B)	0	0	3	1.5
2.	Project	PROJECT(CT) 802	Project Work II	0	0	10	5
3.	Comprehensive Viva Voce	PCL(CT) 823	Comprehensive Viva Voce	-	-	-	1.5
				Total credits			**8**

A student has to secure at least 50% marks in all papers mentioned above, failing which he/she would carry backlog(s).

Name of the course	**CERAMIC PLANT & EQUIPMENT DESIGN**	
Course Code: PEL(CT) 801A	**Semester: 8TH**	
Duration: 6 months	**Maximum Marks: 100**	
Teaching Scheme	**Examination Scheme**	
Theory: Nil	Internal Examiner: 80 Marks	Attendance: 10
		Selection of raw materials/ Sites/ Equipment/ Equipment design: 30
		Material Balance and Energy Balance: 30
		Assessment of Report: 10
Tutorial: Nil	Assessment by External Examiner: 20	
Practical: 3 hrs./week		
Credit Points: 1.5		

Objectives:	
1.	To learn importance & requirement design a Plant and its
2.	To know the difference between Plant Design and Plant Equipment Design
3.	To acquire knowledge on the Basic Parameters to Design a Plant and Essential related information required for the Design
4.	To Learn the steps related to Design a Plant, specifically Ceramic Plant and the outcomes
5.	To Learn the steps related to Design an Equipment used in Ceramic Plant
6.	To know the way of Presenting the Design, related Factors in form of Report
7.	To Prepare and submit Design of Plants for different Ceramic Materials by Groups of Students
8.	To Gather Experience to learn Group activities and work experience in Group
Pre-requisites:	
1.	Basic knowledge of a Plant, Specially Ceramic Plant and Visualization of it
2.	Visit to any Ceramic Plant or Training Course in a Ceramic Plant will be of additional benefit

Module	Content	Hours	Marks.
1	Introduction to the Course including teaching –learning plan	1	
2	Explanation of a Plant and essential requirements to run a Plant & Maintenance of it in view of Plant Design such as Plant Location, Raw Materials and Source, Electricity, Water, Utility, Man Power, Infra Structure, Automation etc. and related Set-up like Electrical Control Room (ECR), Water System Area, Utility Pipe Line, Hydraulic Room, Raw Material Storage, Product Storage & Despatch, Mechanical Equipment, Upstream & Downstream facilities, Environment Pollution Controlling Devices or Systems, Plant Construction, Foundation etc.	4	
3	Learning details of various Terms related to a Plant, specifically a Ceramic Plant and as required in connection to the Design such as Road	3	

	Map, Design Basis, Product Mix, Plant Capacity, Selection of Process, Process Flow Chart, Mass Balance, Energy Balance, Single Line Diagram, Water Balance, Pipe Line Diagram, Logistics, Automation Diagram, Man Power Chart etc.		
4	Development of Plant Layout including Plant Equipment Layout, Plant General Layout for a typical Ceramic Plant	2	
5	Practical Process of Submission of Plant Design in form of Report or as a Part of a Report like Project Feasibility Report etc., Environment Clearance Report etc.	1	
6	Plant Equipment Design as an extension measure of the Subject Ceramic Plant Design. To Design any Important Mechanical Equipment of the Plant based on its Design Basis, Application, Principle, Mathematical Formula on Capacity etc.	3	
7	Giving Assignment to Students in groups. Assignment on Plant Design for any Ceramic Plant like Refractories, Cement, Glass, Whiteware, Tiles etc. Conventional Ceramics or any Advanced Ceramic Materials or any other Plant related to Ceramic Product Applications like Steel Plant etc. Assignment also to Design of any Mechanical Equipment to be used in that Plant.	1	
8	Submission of Assignment	1	

Course outcomes

After completion of the course, a student would be able to:

CO 1	Important items related to a Plant and its Design such as Road Map, Design Basis, Product Mix, Plant Capacity, Selection of Process, Process Flow Chart, Mass Balance, Energy Balance, Single Line Diagram, Water Balance, Pipe Line Diagram, Logistics, Automation Diagram, Man Power Chart etc.
CO 2	Basic Criteria to Set up & run a Plant such as Plant Location, Raw Materials and Source, Electricity, Water, Utility, Man Power, Infra Structure, Automation etc. and related Set-up like Electrical Control Room (ECR), Water System Area, Utility Pipe Line, Hydraulic Room, Raw Material Storage, Product Storage & Despatch, Mechanical Equipment, Upstream & Downstream facilities, Environment Pollution Controlling Devices or Systems, Plant Construction, Foundation etc.
CO 3	How to Design a Ceramic Plant and Plant Equipment and related required things
CO 4	Development of Plant Layouts including Plant General Layout, Plant Equipment Layout etc.
CO 5	Familiar with Project Feasibility Report, Environment Clearance Report etc.

Learning Resources:

1.	Layout and Description of different Ceramic Plants
2.	Project Feasibility Report on any Ceramic Plant

Name of the course	**FURNACE AND KILNS DESIGN**	
Course Code: PEL(CT) 801B	**Semester: 8TH**	
Duration: 6 months	**Maximum Marks: 100**	
Teaching Scheme	**Examination Scheme**	
Theory: Nil	Internal Examiner: 80 Marks	Attendance: 10
		Selection of raw materials/ Sites/ Equipment/ Equipment design: 30
		Material Balance and Energy Balance: 30
		Assessment of Report: 10
Tutorial: Nil	Assessment by External Examiner: 20	
Practical: 3 hrs./week		
Credit Points: 1.5		

Objectives:

1.	To understand the importance & requirement of the Subject
2.	To acquire knowledge on the Basic Parameters to Design a Furnace/Kiln and related essential information required for the Design
3.	To Learn the steps related to Design a Furnace/Kiln and the outcomes
4.	To know the way of Presenting the Design, related Factors in form of Report
5.	To Prepare and submit Design of Furnace/Kiln by Groups of Students
6.	To Gather Experience to learn Group activities and work experience in Group

Pre-requisites:

1.	Basic knowledge of a Furnace /Kiln, Types and differences between a Furnace & Kiln
2.	Knowledge on different types of Refractories used in construction o Furnace/Kiln, Fuels, Chimney etc.
3.	Visit to any Ceramic Plant or Training Course in a Ceramic Plant or Plant using Furnace e.g. Steel Plant will be of additional benefit

Module	Content	Hours	Marks.
1	Introduction to the Course including teaching –learning plan	1	
2	Discussion on Furnace & Kiln, their differences in use & construction and essential requirements to run & maintenance of it in view of Design such as Construction, Electricity, Water, Utility, Automation etc. and for large Plant, related Set-up like Electrical Control Room (ECR), Water System Area, Utility Pipe Line, Raw Material Storage, Product Storage & Despatch, Upstream & Downstream facilities, Environment Pollution Control Devices/Systems etc.	3	

3	Learning details of various Terms related to a Furnace/Kiln and as required in connection to the Design such as Design Basis, Product Mix, Capacity, Process Flow Chart, Mass Balance, Energy Balance etc.	3	
4	Discussion on Refractory requirement for a typical Furnace/Kiln, Refractory Lining Diagram	2	
5	Design a Furnace/Kiln based with Layout on its Design Basis, Application, Principle, related Mathematical Formulas, Capacity, Max.Temp. & Firing Schedule, Heat loss, Refractory Lining, Determination of Furnace Size & Volume, Refractory & Fuel consumption, Chimney height, Efficiency etc.	4	
6	Practical Process of Submission of Design in form of Report or as a Part of a Report like Project Feasibility Report etc., Environment Clearance Report etc.	1	
7	Giving Assignment to Students, in groups, to Design a Furnace/Kiln	1	
8	Submission of Assignment	1	

Course outcomes

After completion of the course, a student would be able to:

CO 1	Important factors related to a Furnace/Kiln and its Design
CO 2	Basic Criteria to Set up & run a Furnace/Kiln
CO 3	To Design a Furnace/Kiln by acquiring knowledge on related required items such as Design Basis, Principle, related Mathematical Formulas, Capacity, Max.Temp. & Firing Schedule, Heat loss, Refractory Lining, Determination of Furnace Size & Volume, Refractory & Fuel Consumption, Chimney height, Furnace/Kiln Efficiency etc.
CO 4	Development of Refractory requirement for a typical Furnace/Kiln, Refractory Lining Diagram
CO 5	Draw Furnace/Chimney Layout with Plan, Front & Side view
CO 6	Familiar with Project Feasibility Report, Environment Clearance Report etc.

Learning Resources:

1.	Layouts and Description of different Furnaces and Kilns
2.	Text Book on Fuels & Furnaces
3.	Steel Plant Furnaces
4.	Handbook of Refractories by Tata McGrow Hill
5.	Handbook of Chemical Engineering by Perrie

Course Structure for UG Engineering Degree in Ceramic Technology

1st Semester B. Tech Ceramic Technology							
Sl. No.	Type of course	Course Code	Course Title	Hours per week			Credits
				Lecture	Tutorial	Practical	
Theory							
1	Basic Science course	BS(CT) 101	Mathematics – I	3	1	0	4
2	Basic Science course	BS(CT) 102	Chemistry	3	0	0	3
3	Basic Science course	ES(CT) 101	Programming for Problem solving	3	0	0	3
Sessional/Practical							
1	Basic Science course	BSL(CT) 103	Chemistry Lab	0	0	3	1.5
2	Engineering Science Course	ESL(CT) 102	Programming for Problem solving Lab	0	0	4	2
3	Engineering Science Course	ESL(CT) 102	Engineering Graphics & Design	1	0	4	3
4		CLA(CT)-1	Comprehensive Laboratory Assessment	-	-	-	1
				Total credits			**17.5**

2nd Semester B. Tech Ceramic Technology							
Sl. No.	Type of course	Course Code	Course Title	Hours per week			Credits
				Lecture	Tutorial	Practical	
Theory							
1	Basic Science course	BS(CT) 204	Mathematics-II	3	0	0	3
2	Basic Science course	BS(CT) 205	Physics	3	1	0	4
3	Engineering Science Course	ES(CT) 204	Basic Electrical Engineering	3	1	0	4
4.	Humanities & Social Sciences including Management	HS(CT/IT/CS) 201	English	2	0	0	2
Sessional/Practical							
1	Basic Science course	BSL(CT) 206	Physics Lab	0	0	3	1.5
2	Engineering Science Course	ESL(CT) 205	Basic Electrical Engineering Lab	0	0	2	1
3	Engineering Science Course	ESL(CT) 206	Workshop /Manufacturing Practices	1	0	4	3
4	Humanities & Social Sciences including Management	HSL(CT/IT/CS) 202	Language Lab	0	0	2	1
5		CLA(CT) 2	Comprehensive Laboratory Assessment	-	-	-	1.0
				Total credits			**20.5**

3rd Semester B. Tech Ceramic Technology							
Sl. No.	Type of course	Course Code	Course Title	Hours per week			Credits
				Lecture	Tutorial	Practical	
Theory							
1.	Basic Science Course	BS(CT) 307	Engineering Mathematics	3	1	0	4
2.	Engineering Science Course	ES(CT) 307	Basic Mechanical Engineering	3	0	0	3
3.	Professional Core Course	PC(CT) 301	Ceramic Raw Materials	3	1	0	4
4.	Professional Core Course	PC(CT) 302	Unit Operation I	3	1	0	4
5.	Professional Core Course	PC(CT) 303	Energy Resources & Furnaces	4	0	0	4
6.	Engineering Science Course	ES(CT) 308	Chemical & Engineering Thermodynamics	3	1	0	4
Sessional/Practical							
1.	Professional Core Course	PCL(CT) 304	Powder Preparation & Chemical Analysis of Ceramic Raw Materials and Products Lab	0	0	3	1.5
2.	Professional Core Course	PCL(CT) 305	Fuels Testing Lab	0	0	3	1.5
3.	Basic Science Course	BSL(CT)308	Numerical Methods Lab	0	0	2	1
4.	Comprehensive Laboratory Assessment	CLA(CT) 3	All Labs	-	-	-	1
Mandatory Course							
1.	Mandatory course	MC(CT) 301	Environmental Sciences	2	0	0	0
				Total credits			**28**

4th Semester B. Tech Ceramic Technology							
Sl. No.	Type of course	Course Code	Course Title	Hours per week			Credits
				Lecture	Tutorial	Practical	
Theory							
1.	Basic Science Course	BS(CT) 409	Biology	2	0	0	2
2.	Professional Core Course	PC(CT) 406	Unit Operation II	3	0	0	3
3.	Engineering Science Course	ES(CT) 409	Engineering Materials Science	3	0	0	3
4.	Professional Core Course	PC(CT) 407	Processing of Ceramics	3	0	0	3
5.	Engineering Science Course	ES(CT) 410	Fundamentals of Metallurgy	3	0	0	3
6.	Professional Elective Course	PE(CT) 401	Process Calculations(A)/ Introduction to Industrial Ceramics (B)	2	0	0	2
7.	Humanities & Social Sciences including Management Courses	HS(CT) 403	Economics & Statistics	3	0	0	3
Sessional/Practical							
1.	Professional Core Course	PCL(CT)408	Physical Testing & Instrumental Methods of Analysis of Raw Materials & Products Lab	0	0	3	1.5
2.	Professional Core Course	PCL(CT)409	Unit Operation Lab	0	0	3	1.5
3.	Comprehensive Laboratory Assessment	CLA(CT) 4	All Labs	-	-	-	1
				Total credits			**23**

5th Semester B. Tech Ceramic Technology							
Sl. No.	Type of course	Course Code	Course Title	Hours per week			Credits
				Lecture	Tutorial	Practical	
Theory							
1.	Professional Core Course	PC(CT) 510	Refractories	3	0	0	3
2.	Professional Core Course	PC(CT) 511	Glass Science &Technology	3	0	0	3
3.	Professional Core Course	PC(CT) 512	Whitewares	3	0	0	3
4.	Professional Elective Course	PE(CT) 502	Bio Ceramics (A) / Nano Ceramics (B)	3	0	0	3
5.	Open Elective Course	OE(CT) 501	DBMS (A) / Object Oriented Programming (B) / Operation Research (C)	3	0	0	3
Sessional/Practical							
1.	Professional Core Course	PCL(CT) 513	Refractories Lab	0	0	3	1.5
2.	Professional Core Course	PCL (CT) 514	Glass Lab	0	0	3	1.5
3.	Professional Core Course	PCL(CT) 515	Whitewares Lab	0	0	3	1.5
4.	Open Elective Course	OEL(CT)502	DBMS Lab (A) / Object Oriented Programming Lab (B) / OR Lab (C)	0	0	2	1
1.	Comprehensive Laboratory Assessment	CLA(CT) 5	All Labs	-	-	-	1
				Total credits			**21.5**

6th Semester B. Tech Ceramic Technology							
Sl. No.	Type of course	Course Code	Course Title	Hours per week			Credits
				Lecture	Tutorial	Practical	
Theory							
1.	Professional Core Course	PC(CT) 616	Cement, Concrete & Monolithic Refractories	4	0	0	4
2.	Professional Core Course	PC(CT) 617	Physical Ceramics	3	0	0	3
3.	Professional Core Course	PC(CT) 618	Advanced Ceramics	3	0	0	3
4.	Professional Elective Course	PE(CT) 603	Refractories for Ferrous Industries (A) / Refractories for Non -ferrous & Other Industries (B)	3	0	0	3
5.	Open Elective Course	OE(CT) 603	Total Quality Management (A) / Environment Engg. & Management (B)	3	0	0	3
6.	Professional Core Course	PC(CT) 619	Instrumentation & Process Control	4	0	0	4
Sessional/Practical							
1.	Professional Core Course	PCL(CT) 620	Cement, Concrete & Monolithics Lab	0	0	3	1.5
2.	Comprehensive Laboratory Assessment	CLA(CT) 6	All Labs	-	-	-	1
3.	Humanities & Social Sciences including Management Courses	HSL(CT).604	Group Discussions	0	0	2	1
Mandatory Course							
4.	Mandatory Course	MC(CT) 602	Indian Constitution/Essence of Indian Traditional Knowledge / Law for Engineers	*3*	*0*	*0*	*0*
				Total credits			**23.5**

Students would undergo 8-12 weeks' internship after 6th Semester

7th Semester B. Tech Ceramic Technology							
Sl. No.	Type of course	Course Code	Course Title	Hours per week			Credits
				Lecture	Tutorial	Practical	
Theory							
1.	Professional Core Course	PC(CT) 721	Computational Materials Science	3	0	0	3
2.	Professional Core Course	PC(CT) 722	Characterization of Materials	2	0	0	2
3.	Professional Elective Course	PE(CT) 704	Non-oxide Ceramics (A)/ Composites (B)	2	0	0	2
4.	Open Elective Course	OE(CT) 704	Artificial Intelligence & Robotics (A)/ Internet of Things (B)/ Machine Learning (C)	2	0	0	2
5.	Humanities & Social Sciences including Management Courses	HS(CT) 705	Fundamentals of Business Management	3	0	0	3
Sessional/Practical							
1.	Humanities & Social Sciences including Management Courses	HSL(CT) 706	Seminar	0	0	2	1
2.	Project	PROJECT (CT) 701	Project Work I	0	0	08	4
3.	Industrial Training	INDTRG(CT) 701	Training Proficiency	-	-	-	1
				Total credits			**18**

8th Semester B. Tech Ceramic Technology							
Sl. No.	Type of course	Course Code	Course Title	Hours per week			Credits
				Lecture	Tutorial	Practical	
Sessional/Practical							
1.	Professional Elective Course	PEL(CT) 805	Ceramic Plant & Equipment Design (A)/ Furnace & Kilns Design (B)	0	0	3	1.5
2.	Project	PROJECT(CT) 802	Project Work II	0	0	10	5
3.	Comprehensive Viva Voce	PCL(CT) 823	Comprehensive Viva Voce	-	-	-	1.5
				Total credits			**8**