Syllabus of

B. Tech. (Paints Tech.)

(Overall Structure and Revised Syllabus w. e. f. 2018-19)

Faculty of Science and Technology

University Institute of Chemical Technology

KBC North Maharashtra University,

Jalgaon

Summary of Distribution of Credits under Academic Flexibility Scheme for

B. Tech (Paints Technology)

at

UICT, KBCNMU, Jalgaon

[University Campus under Academic Flexibility w.e.f. 2018-19]

Sr. No	Type of course	Sem I	Sem II	Sem III	Sem IV	Sem V	Sem VI	Sem VII	Sem VIII
01	Core	**15**	**15**	**18**	**23**	**16.5**	**10**	**-**	**15.5**
02	Skill based	**05**	**06**	**03**	**03**	**-**	**3**	**-**	**-**
03	Institute Elective	**-**	**-**	**-**	**-**	**3**	**6**	**-**	**3**
04	Project	**-**	**-**	**-**	**-**	**-**	**-**	**15**	**-**
05	Audit	**NC**	**NC**	**NC**	**-**	**NC**	**-**	**-**	**-**
06	Total Credits	**20**	**21**	**21**	**26**	**19.5**	**19**	**15**	**18.5**

Number of Audit Courses	**01**	**01**	**01**	**-**	**01**	**-**	**-**	**-**

Subject Type	Core	Skill based	Institute Elective	Project	Audit	Total
Credits	**113**	**20**	**12**	**15**	**NC**	**160**

Total Credits = 160

Program at a Glance

Name of the program (Degree)	: B. Tech (Paints Technology)		
Faculty	: Science & Technology		
Duration of the Program	: Four Years (Eight Semesters)		
Medium of Instruction and Examination	: English		
Exam Pattern	: 60: 40 (60 Marks University Exam& 40 Marks Continuous Internal Departmental Exam/Assessment)		
Passing Standards	: 40% in Each Exam separately for Theory courses and 50 % in Each Exam separately for Practical Courses.		
Evaluation Mode	: CGPA		
Total Credits of the Program	: 160	[Core Credits	:113]
		[Skill Based Credits	:20]
		[Inst. Elective Credits	:12]
		[Project Credits	:15]
		[Audit Credits	:NC]

Program Objectives (POb'S):

1. To impart basic engineering knowledge as well as capability of problem analysis.
2. To develop ability of investigation of complex problem and design/develop solutionfor their management.
3. To train the graduate for usage of modern tools in teaching - learning process
4. To develop ethics team spirit among the graduates.

Program Specific Objectives (PSOb'S):

PSO1: Inculcate the thought process for creative analysis and execution of fundamentals of basic sciences, coatings and foundation engineering courses..

PSO2: Develop competent graduates with working knowledge of paint, polymer and surface coating technology to pursue career in academics, industries and innovative start-up.

PSO3: Prepare the professional Paint Technologists with integrity and ethical values to become effective associate while addressing the social, moral, environmental and technically sustainable challenges.

Program Outcomes (PO)

Upon successful completion of the B.Tech. Program, the graduate student will be able to:

PO No.	PO	Cognitive level
PO1	Apply knowledge of mathematics, science, and engineering fundamentals to the solution of complex engineering problems.	3
PO2	Identify, formulate and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences.	1
PO3	Design solutions for complex engineering problems and design system components or processes that meet specified needs with appropriate consideration for public health and safety, cultural, societal and environmental considerations.	6
PO4	using research-based knowledge and research methods including design of experiments, analysis and interpretation of data and synthesis of information to provide valid conclusions.	5
PO5	Create, select and apply appropriate techniques, resources and modern engineering and IT tools including prediction and modeling to complex engineering activities with an under- standing of the limitations.	6
PO6	Apply reasoning informed by contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to professional engineering practice.	3
PO7	Understand the impact of professional engineering solutions in societal and environmental contexts and demonstrate knowledge of and need for sustainable development.	2

PO8	Apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice.	3
PO9	Function effectively as an individual, and as a member or leader in diverse teams and in multi-disciplinary settings.	6
PO10	Communicate effectively on complex engineering activities with the engineering com- munity and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations and give and receive clear instructions.	2
PO11	Demonstrate knowledge and understanding of Engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments	2
PO12	Recognize the need for and have the preparation and ability to engage in independent and life- long learning in the broadest context of technological change.	6

Program Specific Outcomes

PO No.	PO	Cognitive level
PSO1	Inculcate the thought process for creative analysis and execution of fundamentals of basic sciences, coatings and foundation engineering courses.	4
PSO2	Develop competent graduates with working knowledge of paint, polymer and surface coating technology to pursue career in academics, industries and innovative start-up.	6
PSO3	Prepare the professional Paint Technologists with integrity and ethical values to become effective associate while addressing the social, moral, environmental and technically sustainable challenges.	3

B. Tech. (Paint Technology) Revised Syllabus w.e.f. 2018-19							
Course Code	**Title of Course**	**Teaching Hrs**	**Tutorial**	**Credits**	**Practical Hrs**	**Credits**	**Total Credits**
First Semester							
BSL-101	Mathematics-I	03	01	04	-	-	04
BSL-105	Thermodynamics-I	03	01	04	-	-	04
ESL-102	Electrical and Electronics Engineering	03	01	04	-	-	04
ESC-103	Computer Lab (Programming for problem solving)	03	-	03	04	02	05
ESL-104	Material Science and Technology	03	-	03	-	-	03
NC-101	Induction Programme	-	-	-	-	-	NC
						Total	**20**
Second Semester							
Course Code	**Title of Course**	**Teaching Hrs**	**Tutorial**	**Credits**	**Practical Hrs**	**Credits**	**Total Credits**
BSL-104	Mathematics-II	03	01	04	-	-	04
BSC-102	Physics	03	01	04	03	1.5	5.5
BSC-103	Chemistry-I	03	01	04	03	1.5	5.5
HMC-101	Communication Skill	02	-	02	02	01	03
ESC-101	Engg Graphics	01	-	01	04	02	03
5555	Environmental Studies	-	-	-	-	NC	NC
						Total	**21**
Third Semester							
Course Code	**Title of Course**	**Teaching Hrs**	**Tutorial**	**Credits**	**Practical Hrs**	**Credits**	**Total Credits**
CHC-203	Heat Transfer	03	01	04	03	1.5	5.5
CHL-204	Fluid Mechanics	03	01	04	-	-	04
CHL-206	Material and Energy Balances Computations	03	01	04	-	-	04
HML-202	Industrial Management and Economics	03	-	03	-	-	03
PTC-201	Introduction to Coating Technology	03	-	03	03	1.5	4.5
NC-202	Indian Constitution	-	-	-	-	NC	NC
						Total	**21**

Fourth Semester							
Course Code	**Title of Course**	**Teaching Hrs**	**Tutorial**	**Credits**	**Practical Hrs**	**Credits**	**Total Credits**
ESL-205	Engg and Solid Mechanics	03	01	04	-	-	04
BSC-206	Chemistry II	03	01	04	03	1.5	5.5
CHL-201	Thermodynamics-II	03	01	04	-	-	04
CHC-207	Mechanical Operations	03	-	03	04	02	05
ESC-206	Engg Workshop	01	-	01	04	02	03
PTC-202	Technology of Pigments	03	-	03	03	1.5	4.5
Total							**26**
Fifth Semester							
Course Code	**Title of Course**	**Teaching Hrs**	**Tutorial**	**Credits**	**Practical Hrs**	**Credits**	**Total Credits**
CHL-314	Mass Transfer Operations	03	-	03	-	-	03
CHP-315	Mass & Momentum Transfer Operations				03	1.5	1.5
CHL-312	Process Design and Project Management	03	-	03	-	-	03
PTC-301	Architectural Coatings	03	-	03	03	1.5	4.5
PTC-302	Chemistry & Technology of Polymers	03	-	03	03	1.5	4.5
Elective I	Open Elective	03	-	03	-	-	03
NC-303	Essence of Indian Traditional Knowledge	-	-	-	-	NC	NC
						Total	**19.5**
Sixth Semester							
Course Code	**Title of Course**	**Teaching Hrs**	**Tutorial**	**Credits**	**Practical Hrs**	**Credits**	**Total Credits**
CHL-316	Chemical Reaction Engineering	03	01	04	-	-	04
HML-309	Psycho-social Dimensions of Industrial Management	03	-	03	-	-	03
PTL-303	Eco Friendly Coatings & Technologies	03	-	03	-	-	03
PTP-304	Formulation & Processing of Paints	-	-	-	06	03	03
Elective II	Open Elective	03	-	03	-	-	03
Elective III	Professional Core Elective	03	-	03	-	-	03
Total							**19**

Seventh Semester							
Course Code	**Title of Course**	**Teaching Hrs**	**Tutorial**	**Credits**	**Practical Hrs**	**Credits**	**Total Credits**
PTP-401	Industrial Training/ Project	-	-	-	24	12	12
PTP-402	Technical Seminar	-	-	-	06	03	03
						Total	**15**
Eighth Semester							
Course Code	**Title of Course**	**Teaching Hrs**	**Tutorial**	**Credits**	**Practical Hrs**	**Credits**	**Total Credits**
CHC-416	Process Dynamics and Control	03	-	03	03	1.5	4.5
CHC-417	Process Equipment Design and Drawing	01	-	01	02	01	02
PTL-403	Application Techniques & Paint Defects	03	-	03	-	-	03
PTL-404	Quality Assurance & Analysis of Surface Coatings	03	-	03	-	-	03
PTP-405	Application & Testing of Coatings	-	-	-	06	03	03
Elective IV	Professional Core Elective	03	-	03	-	-	03
						Total	**18.5**

Elective I (Open Elective) OTL-305 Technology of Perfumery and Cosmetics FTL-305 Advanced Technology in Food Packaging PTL-305 Specialty Pigments and Additives in Coatings PLL-304 Polymer Rheology CHL-320 Nanoscience and Nanotechnology	**Elective II (Open Elective)** OTL-306 Biochemistry & Biotechnology of Lipids FTL-306 Treatment and Disposal of Food Industrial Waste PTL-306 Technology of Printing Inks PLL-305 Plastics Waste Management CHL-321 Water Conservation and Management
Elective III (Professional Core Elective) PTL-307 Engineering of Pigmented Dispersion PTL-308 Synthesis and characterization of Polymers	**List of Electives (Elective IV)** PTL - 406 Special Purpose and Effect Coatings PTL- 407 Nanotechnology in Paint Industry

Total credits (20 + 21+ 21 + 26 + 19.5 + 19 +15 +18.5) **= 160**

Semester-I

Course Title: Mathematics- I

Course Code: BSL-101

Course Prerequisite:

The background expected includes a prior knowledge of mathematics from H.S.C. (Science) and familiarity with various principles and theorems.

Course Objectives:

The necessity for the foundation of Engineering and Technology being Mathematics, the main objective is to provide sufficient practice in the mathematical methods presented and develop mathematical skill and enhance thinking and decision-making power of student.

Unit –I: Linear Algebra

Elementary transformations on a matrix; Rank of a matrix; normal forms; Consistency and solutions of systems of linear equations; orthogonal matrix; Eigen values and eigen vectors; Cayley-Hamilton's theorem (without proof). (10)

Unit –II: Differential Calculus and Its Applications

Successive differentiation – standard results; Leibnitz's theorem; Expansions of functions: Maclaurin's theorem, Taylor's theorem; Application of Taylor's theorem. (10)

Unit –III: Partial Differentiation

Partial derivatives of first and higher orders; Homogeneous functions – Euler's Theorem; Total derivatives; Change of variables. (10)

Unit –IV: Applications of Partial differentiations

Jacobians - properties; Errors and approximations; Maxima and minima of functions of two variables; Lagrange's method of undetermined multipliers for single constraints. (10)

Unit –V: Complex Numbers

Definition and geometrical representation; De-Moivre‟s theorem (without proof); Roots of complex numbers by using De-Moivre‟s theorem; Circular functions of complex variable – definition; Hyperbolic functions; Relations between circular and hyperbolic functions; Real and imaginary parts of circular and hyperbolic functions; Logarithm of Complex numbers. (10)

Text/Reference Books:

1. Erwin Kreyszig, “Advanced Engineering Mathematics”, Wiley Eastern Ltd, 10th Edition.
2. B S Grewal, “Higher Engineering Mathematics”, Khanna Publication.
3. H K Das, “Advanced Engineering Mathematics”, S. Chand & Company.
4. N.P. Bali and M. Goyal, “A text book of Engineering Mathematics”, Laxmi Publications, 2008.
5. T. Veerarajan, “Engineering Mathematics”, Tata McGraw-Hill, New Delhi, 2010.

Upon successful completion of the course students will be able to

CO No.	Course Outcome	Cognitive level
1	**Apply** knowledge of mathematics in engineering and technology.	3
2	**Identify, formulate** and **solve** engineering problems.	4
3	**Design** Mathematical models for engineering problems and solve them.	5
4	**Use** partial derivative to find total derivative of implicit functions and to find Jacobians.	4
5	Find error and approximate values of problems **related** to engineering field.	4

Course Title: Thermodynamic-I

Course Code: BSL-105

Course Prerequisite:

The background expected includes a prior knowledge of physical chemistry, H.S.C. (Science) and familiarity with various basic laws, principles and theories.

Objectives:

Course objective are practical applicability of theoretical concepts of basic organic chemistry and thermodynamics to its practical applications.

UNIT-I: Introduction to Thermodynamics

Scope of thermodynamics, systems and process, homogeneous and heterogeneous system, closed and open systems, state functions, equilibrium, reversible process, irreversible process. (10)

UNIT-II : First law of thermodynamics and gas laws

work, energy, first law of thermodynamics, internal energy, Gas law: Boyl's law, Charls law, Avogadro's law, ideal gas equation, van der waals constant.

(10)

UNIT-III: Second law of thermodynamics

Heat engine, Carnot theorem. Heat effect: latent heat, sensible heat, standard heat of formation, reaction and combustion. Entropy, Enthalpy, Second law of thermodynamics. (10)

UNIT-IV: Some applications of the laws of Thermodynamics

Flow processes, continuity equation, energy balance, flow in pipes, flow through nozzles, ejectors, throttling process, compressors. (10)

UNIT-V: Refrigeration

Coefficient of performance, refrigerator capacity, Vapour- compression cycle, Absorption refrigeration, heat pump, Liquefaction processes. (10

Text/Reference Books:

1) J M Smith, H C Van Ness and M M Abbott, Introduction to Chemical Engineering Thermodynamics, 7th edition, McGraw- Hill International Edition, 2005.

2) M J Moran, H N Shapiro, D DBorttner and M B Bailey, Principal of Engineering Thermodynamics, 8th Edition, Willey.

3) K.V. Narayanan, A textbook of chemical engineering thermodynamics, PHI, Delhi,2001.

Course Outcomes:

Upon successful completion of the course students will be able to

CO No.	Course Outcome	Cognitive level
1	To The concepts of Electromagnetism, basic laws related to magnetic and dielectric properties of material.	2
2	The concepts of Optics such as interference, diffraction and polarization.	2
3	Some of the basic laws of quantum mechanics, Photoelectric effect	2
4	Basic concepts of Semiconductors, superconductors.	2
5	The X-rays, LASERS, Principles, production, properties and **applications** of X-rays and LASERS.	3

Course Title: Electrical & Electronics Engineering
Course Code: ESL-102

Course Prerequisite: The course provides basic knowledge of electrical engineering. Course explores the knowledge of electrical, magnetic circuit and AC circuit. Course also provides the basic working operation of different electrical machine along with their characteristics and applications. It also provides ideas of electrical installation and different switches. Higher standards of safety and precautions are important in any industry Chemical industries therefore electrical safety and safety measures also incorporated in the course. Energy calculation and optical use of electrical energy are important in view of entrepreneur, electric tariff also included in the syllabus.

Course Objectives:

1. Students will able to understand the basic concept of electric power, energy in the field of chemical engineering and technology.
2. Students will able to understand the characteristic of motor for suitability of different applications in chemical engineering and technology.
3. Students will able to control and use electrical appliances in chemical engineering and technology.
4. Students will able to calculate power and energy for efficient, economical process of plants.
5. Students will able to apply good electrical safety precaution even in temporary works.

Unit-I:

DC Circuits: Electrical circuit elements (R, L and C), voltage and current sources, open and short circuit in series and parallel circuit, effect of temperature on resistance.Kirchoff current and voltage laws, analysis of simple circuits with dc excitation. Loop analysis, Superposition and Thevenin Theorems.

Magnetic circuit: Concept of magnetic circuit, MMf, Flux and reluctance. Magnet circuit, composite magnetic circuit, Comparison of magnetic and electric circuit, B-H curve, hysteresis and eddy current loss. (10)

Unit-II:

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. Power in three phase circuit, Measurement of power in three phase circuit. (10)

Unit-III:

Transformers Magnetic materials, ideal and practical single-phase transformer, equivalent circuit, losses in transformers, regulation and efficiency. Auto-transformer and three-phase transformer connections. (10)

Unit-IV:

Electrical Machines:

DC Motor: Construction of DC motor, working operation, back emf, need of starter, classification of DC motors, torque, speed, characteristic of DC motor, speed control and applications.

AC Motor; Construction, working operation of three phase induction motor, Torque slip characteristic of induction motor, loss components and efficiency, Slip ring induction motor and applications. Classification and application of single phase motors.(10)

Unit-IV:

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,small and medium industrial electric tariff, power factor improvement and battery backup. Electrical safety precaution and measures in chemical industry. (10)

Text/Reference Books:

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.
6. B L Theraja, " Electrical Technology Vol-I and II", S Chand Publication
7. V N Mittal, "Basic Electrical Engineering"

Course Outcomes:

Upon successful completion of the course students will be able to

CO No.	Course Outcome	Cognitive level
1	**Use** the latest techniques, skills, and modern tools necessary for engineering practices.	3
2	**Design** a component, system or process to meet desired needs with	6

	in realistic constraints.	
3	**Determine** the values of constants such as Stefan's constant, Planck's constant specific charge etc	3

Course Title: Computer Lab (Programming for problem solving)

Course Code: ESC-103

Course Prerequisite: This course provides students with a comprehensive study of the C programming language. Introduction to program design and problem solving using the C programming language. Programming topics include control structures, functions, arrays, pointers, and file I/O.

Course Objectives: To impart knowledge so that the student will:

1. Learn the fundamentals, structure and syntax of C Language.
2. Write simple programs in C Language.

UNIT-I:

What is C?, The C Character set, Constant, Variables & Keywords, Types of C Constants, Rules for constructing Integer Constants, Rules for constructing Real Constants, Rules for constructing Character Constants, Types of C Variables, Rules for constructing Variable Names, C keywords, Comments in a C Program, Types of instructions, Type Declaration instruction, Arithmetic instruction, Integer and Float Conversion, Type Conversion in Assignments, Hierarchy of Operations, Associativity of Operations, Control instructions, Data Types Revisited: Integers, long & short, signed & unsigned, Chars, signed & unsigned, Float & Doubles, Console Input/Output: Types of I/O, Console I/O Function, Formatted Console I/O Functions, Unformatted Console I/O Functions, Decision Control Instruction: The if statement, Multiple Statements within if, The if- else statement, Nested if-else, Use of Logical Operators, The else if Clause, The !Operator.(08)

UNIT-II:

Loop Control Instruction: Loops, the while Loop, Tips & Traps, More Operators, The for Loop, Nesting of Loops, Multiple Initializations in the for Loop, The break Statement, The continue Statement, The do-while Loop, The Odd Loop, Case Control Instruction: Decisions using switch, The Tips & Traps, switch versus if-else Ladder, The goto Keyword. (08)

UNIT-III:

Functions: What is a Function? Why use Functions? Passing Values between Functions, Scope Rule of Functions, Order of Passing Arguments, Using Library Functions, Pointers: Call by Value and Call by Reference, An Introduction to Pointers, Pointer Notation, Back to Function Calls, Recursion Function. (08)

UNIT-IV:

Arrays: What are Arrays? A Simple Program using Array, More on Arrays, Array Initialization, Array Elements in Memory, Bounds Checking, Passing Array Elements to a Function, Pointers and Arrays, Passing an Entire Array to a Function, The Real Thing, Multidimensional Array: Two Dimensional Arrays, initializing a Two-Dimensional Array, Memory Map of a Two-Dimensional Array, Pointers and Two-Dimensional Arrays, Pointer to an Array, Passing 2-D Array to a Function, Array of Pointers. (08)

UNIT-V:

Strings: What are Strings? More about Strings, Pointers and Strings, Standard Library String Functions, Handling Multiple Strings: Two-Dimensional Array of Characters, Array of Pointers to strings, Limitations of Array of Pointers to Strings, Structures: Why use Structures? Declaring a Structure, Accessing Structure Elements, How Structure Elements are Stored? Array of Structure. (08)

Course Outcomes:

Upon successful completion of the course students will be able to

CO No.	Course Outcome	Cognitive level
1	**Understand** the fundamentals of C programming.	2
2	**Choose** the loops & decision-making statements to **solve** problem.	6
3	**Use** functions to **solve** the given problem.	6
4	**Implement** different Operations on arrays.	3
5	**Understand** strings and structures.	2
6	**Understand** the usage of pointers.	2

Computer Lab

Course description: This course provides students with a comprehensive study of the C programming language. Introduction to program design and problem solving using the C programming language. Programming topics include control structures, functions, arrays, pointers, and file I/O.

Course Objectives: To impart knowledge so that the student will:

1. Learn the fundamentals, structure and syntax of C Language.
2. Write simple programs in C Language.

Course Content:

1. Write a C program to find area of circle, triangle, rectangle, square using switch statement.
2. Write a C program to find the sum of a series (looping).
3. Write a C program to accept a string and reverse it without using library functions. Display the original and reversed string. (String handling).
4. Write a C program that uses functions to perform the following string operations using function and pointers:
    a. To insert a sub-string in to given main string from a given position.
    b. To delete n Characters from a given position in each string.
5. Write a C program to read 'N' elements into an array and compute the sum of all the elements stored in an array using pointer. (Arrays and pointers).
6. Write a C program to read a matrix of order (M *N) and (P * Q) and compute the addition and multiplication of two matrices. (Passing matrix to functions).
7. Write a C program to read 'N' students information and display the information with appropriate headings, where each student information consists of roll number, Name, total marks scored etc. (Structure handling).
8. Write a C program to find Factorial using Recursion.
9. Write a C program for Root Finding using Numerical Methods.
10. Write a C program to solve Linear Equations.

Text /Reference Books:

1. "Programming in ANSIC C" by E Balagurusamy, Tata McGraw Hill, 4/E, 2007
2. "Mastering C" by K. R. Venugopal and S. R. Prasad, Tata McGraw Hill, 2011
3. "The C Programming Language" by Brian W. Kernighan and Dennis M. Ritchie, PHI
4. "C How to Program" by Paul Deitel and Harvey Deitel, 8th Edition, Pearson
5. "Let Us C" by Yashavant Kanetkar, 14th Edition, BPB Publication.
6. "Test Your C Skills" By Yashavant Kanetkar, 5th Edition, BPB Publication.

Course Outcomes:

Upon successful completion of the course students will be able to

CO No.	Course Outcome	Cognitive level
1	**Understand** the fundamentals of C programming.	2
2	**Choose** the loops & decision-making statements to **solve** problem.	6
3	**Use** functions to **solve** the given problem	6
4	**Implement** different Operations on arrays.	3
5	**Understand** strings and structures.	2
6	**Understand** the usage of pointers.	2

Course Title: Material Science &Technology

Course Code: ESL-104

Course Prerequisite:

The goals of the course are to understand the basic principles of Material science and their applications in different areas. The background expected includes a prior knowledge of physics and Chemistry from H.SC. (Science) and familiarity with various laws, principles and theories.

Course Objectives:

The objective of this course will provide the students basic introduction to different concepts of Materials, different classes of materials relevant to Chemical Engineering. The intent of the course will be to relate the underlying molecular structure of the materials to their physical and chemical properties, and their processing and performance characteristics.

UNIT – I

Classification of solids (Amorphous, crystalline, polycrystalline), Space lattice, Bravais Lattices. Miller Indices, inter planar distances, Coordination number, Packing fractions. Imperfections in solids: point defects (stoichiometric defects and nonstoichiometric defects), line imperfections, surface imperfections, volume imperfection. (08)

UNIT – II

Introduction to materials, bonding between atoms: metallic bonding, ionic bonding, covalent bonding, vanderwaals bond, hydrogen bond. Mechanical properties of solids such as plastic deformation, Mechanism of plastic deformation-slip, twinning,modulus of elasticity, tensile strength,ducktility, toughness, elongation, plastic deformation, Schmid's law. Creep, requirement for creep resistance material, fracture, fatigue. (08)

UNIT – III

Classification of engineering materials (Metals, Polymers, Ceramics, Composites, Nanomaterials and Biomaterials). Polymers: classification of polymers, mechanism of polymerization, crystallization of polymers. Ceramics and glasses- properties of ceramics, Types of ceramics, electrical properties of ceramics, glasses, cermets. Nanomaterials-Introduction to nanomaterials, properties. Fabrication process-top down and bottom up approach.

Composite materials-dispersion reinforced composites, laminated composites, fiber reinforced composites, loading under isostrain and isostress condition. Biomaterials. (08)

UNIT – IV

Corrosion: Electrochemical principles, mechanisms, Formation and Growth of film, Growth Laws, polarization. Types of corrosion, prevention and control. Protective coatings, Application of inhibitors. Role of materials selection in design, structure-property–processing-performance relationships. (08)

UNIT – V

Material characterization techniques, X-Ray Diffraction, Braggs X-ray spectrometer, Debye Scherrer Camera. Principles of Raman Spectroscopy. Particle size analyzers. (08)

Text/Reference Books:

1. Material Science and Engineering Metallurgy: V. D. Kodgire.
2. Material Science: G.B.S. Narang.
3. Material Science: O P Khanna.
4. Engineering Metallurgy and Material Science: S.P. Nayak.
5. Material Science: Raghavan.
6. Material Science: Hazra Chaudhari.
7. Principles of Material Science and Engineering: William F. Smith
8. Material Science-Tata MC-Graw Hill Publication, V. Rajendran, R. A. Maricani.
9. Material Science and Engineering an Introduction, William D. Callister, David G. Rethwisch. WILEY Publications.
10. Instrumental Methods of Chemical Analysis, Gurdeep R. Chatwal, Sham K Anand.
11. Nanotechnology: Principles and Practices: S. K. Kulkarni.

Course Outcomes:

Upon successful completion of the course students will be able to

CO No.	Course Outcome	Cognitive level
1	**Acquaint** students with the basic concepts and properties of Materials and their use in Engineering applications.	2

2	**Develop** futuristic insight into Materials and introduction to some characterization technique	6

Course Title: Induction Programme

Course Code: NC-101

Course Objectives:

1. It aims at helping new students to adjust and feel comfortable in new environment
2. It will facilitate the students for self-exploration and helps to rectify critical lacunas if any.
3. It will develop ethical thinking in student to understand the importance of value-based education.

There will be a 3-week long induction program for the UG students entering the institution, right at the start. Normal classes start only after the induction program is over. The purpose of the *Student Induction Programme*is to help new students adjust and feel comfortable in the new environment, inculcate in them the ethos and culture of the institution, help them build bonds with other students and faculty members, and expose them to a sense of larger purpose and self-exploration.

Student Induction Program engages with the new students as soon as they come into the institution. At the start of the induction, the incumbents learn about the institutional policies, processes, practices, culture and values, and their mentor groups are formed. The time during the Induction Programme is also used to rectify some critical lacunas, for those students who have deficiency in it. Different activities, including those which are daily are to be planned. Here is a list of activities:

- Physical Activity
- Creative Arts and Culture
- Mentoring & Universal Human Values
- Familiarization with College, Dept./Branch
- Literary Activity
- Proficiency Modules
- Lectures & Workshops by Eminent People
- Visits in Local Area
- Extra-Curricular Activities in College
- Feedback and Report on the Program

References:

1. Student Induction Program: A Detailed Guide by AICTE dated 30 July 2018
   https://www.aicte-india.org/content/student-induction-program-detailed-guide
2. A Guide to Student Induction Programme by UGC dated 15 August 2018
   https://www.ugc.ac.in/pdfnews/0559509_A-Guide-to-Student-Induction-Programme.pdf

Course Outcomes:

Upon successful completion of the course students will be able to

CO No.	Course Outcome	Cognitive level
1	Familiar with the institutional and departmental policies, processes, and practices	1
2	Get sensitized to the engineering needs of the society.	1
3	Understand the importance of healthy lifestyle, yoga, meditation in their professional development	2

4	Understand the broader perspective of universal human values in technical education	2

Semester-II

Course Title: Mathematics- II

Course Code: BSL-104

Course Prerequisite:

Mathematics-I course of H.S.C. and BSL-101 (Mathematics-I) course of F. Y. B. Tech. (Semester- I).

Course Objectives:

To make aware students about the importance and symbiosis between Mathematics and Engineering. To develop the ability of mathematical modelling of systems using differential equations and ability to solve the differential equations.

Unit –I: Linear Differential Equations of n^{th} Order with Constant Coefficient

Solution of LDE of order n with constant coefficients, Method of variation of parameters (only second order), Cauchy's linear equation and Legendre's linear equation. (10)

Unit –II: Applications of Linear Differential Equations and Partial Differential equations

Applications of linear differential equations to Chemical Engineering, Applications of Partial Differential equations to one dimensional heat flow equation and two-dimensional heat flow equation. (10)

Unit –III: Laplace Transform

Definition and existence of Laplace transforms, Theorems and Properties of Laplace Transform (without proof), Laplace Transform of some special functions Inverse Laplace Transform, Convolution Theorem, Solution of linear differential equations using Laplace Transform. (10)

Unit –IV: Multiple Integrals and Their Applications

Double integrals and their evaluation; Change of order for integration; Double integrals in polar coordinates;Triple integrals; Application of multiple integrals to find area, volume, surface area (10)

Unit –V: Complex Variable

Analytic function, Harmonic function, Cauchy Riemann equations, Cauchy integral formula, Cauchy integral theorem, Residue theorem and Bilinear transformation. (10)

Text/ Reference Books:

1. Erwin Kreyszig, "Advanced Engineering Mathematics", Wiley Eastern Ltd, 10th Edition.

2. B S Grewal, “Higher Engineering Mathematics”, Khanna Publication.
3. H K Das, “Advanced Engineering Mathematics”, S. Chand & Company.
4. N.P. Bali and M. Goyal, “A textbook of Engineering Mathematics”, Laxmi Publications, 2008.
5. T. Veerarajan, “Engineering Mathematics”, Tata McGraw-Hill, New Delhi, 2010.
6. S. C. Gupta, “Fundamental of Statistics”, Publisher: Himalaya Publishing House Pvt. Ltd.; Seventh Edition (2016).

Course Outcomes:

Upon successful completion of the course students will be able to

CO No.	Course Outcome	Cognitive level
1	**Apply** knowledge of mathematics in engineering and technology.	3
2	**Identify, formulate** and **solve** engineering problems.	4
3	**Design** Mathematical models for engineering problems and solve them.	5
4	**Use** partial derivative to find total derivative of implicit functions and to find Jacobians.	4
5	Find error and approximate values of problems **related** to engineering field.	4

Course Title: Physics

Course Code: BSC-102

Course Prerequisite:

This course is aimed at introducing the fundamentals of basic sciences to undergraduate students. The background expected includes a prior knowledge of physics and mathematics from H.S.C. (science) and familiarity with various laws, principles and theories. The goals of the course are to understand the basic principles of science(physics) and their applications in different areas.

Course Objective:

The objective of this course is to provide learners with basic concepts and knowledge of sciences (various principles, theories, laws etc.) and to analyse it from experiments. The learner can apply the same in Chemical Engineering and Technology.

UNIT I:

Laws of electrostatics, electric current and the continuity equation, laws of magnetism, Ampere’s law, Faraday’s laws. Maxwell’s equations. polarization, permeability and dielectric constant, polar and nonpolar dielectrics, internal fields in a solid, Clausius-Mossotti equation,

Millikan's oil drop experiment.

Magnetic materials: Magnetization, permeability and susceptibility, diamagnetic, paramagnetic, ferromagnetic, antiferromagnetic ferromagnetic materials, Hysteresis, applications. (10)

UNIT II:

Interference: Conditions for interference of light, Interference in thin films, Newton's Rings experiment.

Diffraction: Fresnel & Fraunhofer diffraction, diffraction grating, Characteristics of diffraction grating and its applications.

Polarization: Introduction, polarisation by reflection, double refraction, scattering of light, circular and elliptical polarisation, optical activity, polaroids, applications of polaroids. (10)

UNIT III:

Introduction to quantum physics, blackbody radiation, Stefan's law. Explanation using the photon concept, photoelectric effect, Einstein's equation, photo-multiplier tubes, solar cell-working, merits and demerits. Production and detection of ultrasonic waves, properties and application of ultrasonic waves. (10)

UNIT IV:

Semiconductors: energy band diagram for conductor, semiconductor and insulator, Fermi level &Fermi function. Position of Fermi level in semiconductors in intrinsic and extrinsic semiconductors. Effect of temperature on the Fermi level.

Superconductivity: principle of superconductivity, properties of superconductors, Type-I and Type-II superconductors, applications of superconductors. (10)

UNIT V:

X-Rays: Production & properties of X-Rays, characteristics and continuous X-rays, Moseley's law, engineering applications of X-rays.

LASER: Principle and working, spontaneous and stimulated emission, population inversion, types of LASER-solid state, semiconductor and gas, application of LASERS. (10)

Text/Reference Books:

1. Concepts of Modern Physics, S. L. Gupta and S. Gupta.
2. Concept of Modern Physics, AurtherBiser, EditionThree.
3. Engineering Physics, R. K. Gaur & S.L. Gupta.
4. Applied Science - II by S. J. Walzade& S. N.Narkhede
5. Physics for Scientist and Engineers-5th Edition, Paul Tipler, Gene Mose

6. Text book of Engineering Physics, M. N. Avadhanulu, P. G. Kshirsagar, S. Chand Publication
7. M. R. Srinivasan, "Physics for Engineers", New Age International Publishers.
8. "Optics", S. Chand Publication, N. Subrahmanyam, M.N.Avadhanulu.
9. "Engineering Physics", Sanjay Jain, Universities Press (India) Pvt Ltd.
10. "Semiconductor physics devices", Donald A. Neamen, MC Graw Hill Publication.

Course Outcomes:

Upon successful completion of the course students will be able to

CO No.	Course Outcome	Cognitive level
1	To The concepts of Electromagnetism, basic laws related to magnetic and dielectric properties of material.	2
2	The concepts of Optics such as interference, diffraction and polarization.	2
3	Some of the basic laws of quantum mechanics, Photoelectric effect	2
4	Basic concepts of Semiconductors, superconductors.	2
5	The X-rays, LASERS, Principles, production, properties and **applications** of X-rays and LASERS.	3

Physics Lab

Course Prerequisite:

In this laboratory, course emphasis is on the understanding of basic principles, characteristic – properties of different instruments used in a field of optics, Heat and thermodynamics, Modern Physics and electronics. The learner here can use this knowledge and apply in various branches of engineering as required.

Course Objective:

The objective of the laboratory is to impart the fundamental knowledge of physics to the students and develop their ability to apply the specific procedures to analyze the experimental results.

In this lab, students will be familiar with the use of different equipments, basic principles, properties etc. which they can apply in various disciplines of engineering during their studies and in future.

Practical's List:

1. Determination of Stefan's constant.
2. Newton's Rings for the determination of radius of planoconvex lens.
3. Determination of specific rotation of given solution using polarimeter.
4. Determination of wavelength of Laser light by using diffraction grating.
5. To study I-V Solar cell characteristics.
6. To study I-V Characteristics of Photo-cell.
7. Surface Tension by capillary rise method.
8. e/m by Magnetron method.
9. Determination of Planck's constant using photocell.
10. Determination of divergence of He-Ne Laser beam.
11. Determination of conductivity of the sample by four probe method.
12. Thermal conductivity by Lee's method.

Text/Reference Books:

1. N Avadhanulu, A. A. Dani, P M Pokley, "Experiments in Engineering Physics", S.Chand Publication.
2. S P Singh, "Advanced Practical Physics", Pragati Prakashan.

Course Outcomes:

Upon successful completion of the course students will be able to

CO No.	Course Outcome	Cognitive level
1	**Use** the latest techniques, skills, and modern tools necessary for engineering practices.	3
2	**Design** a component, system or process to meet desired needs with in realistic constraints.	6
3	**Determine** the values of constants such as Stefan's constant, Planck's constant specific charge etc	3

Course Title: Chemistry-I

Course Code: BSC-103

Course Prerequisite:

The background expected includes a prior knowledge of chemistry, H.S.C. (Science) and familiarity with various laws, principles and theories.

Course Objectives:

This course provides basic knowledge of chemistry for undergraduate students of technology. It will develop their fundamentals to build own interface of applied chemistry concepts with industrial applicability in branch of chemical technology. This course will introduce to basic concepts of bonding, quantum chemistry, synthetic methodology, reagents in organic synthesis and influence of structure and its properties on bonding and chemical reactions.

UNIT-I: Quantum Theory

Introduction to quantum theory for chemical system: Postulates of quantum mechanics, Schrodinger equation, Application to hydrogen atom, Atomic orbitals (10)

UNIT-II: Chemical Bonding In Molecules

Coordination Chemistry, Magnetic properties and electronic spectra of complexes, bioinorganic-chemistry (haemoglobin, myoglobin, chlorophyll), organometallic chemistry.
(10)

UNIT-III: Reactivity of organic molecules

Factors influencing acidity, basicity, and nucleophilicity of molecules, kinetics Vs thermodynamic control reaction. (10)

UNIT-IV: Selective name reactions

Aldol condensation, Perkin reactions, Michael addition, Mannich reaction, Reagans: LiAlH4, NaBH4, DCC, SeO2, crown ether. Rearrangement: Pinacol rearrangement, Beckman rearrangement, Favorskii rearrangement, Wolff rearrangement. (10)

UNIT-V: Strategies for synthesis of organic compounds

Reaction intermediates. Introduction to green chemistry, principles and concepts of green chemistry. Waste production, problem and prevention. Alternative reaction media, solvent-less reaction, Industrial uses of aqueous solvents. (10)

Text/Reference Books:

1) Molecular Quantum Mechanics, Fifth Edition, Peter W. Atkins and Ronald S. Friedman

2) Principles of Quantum Mechanics, Authors: Shankar, R.

3) Organic Chemistry, I L Finar, Vol-I and Vol-II

4) Organic Chemistry, Morrison and Boyd,

5) Organic Chemistry, S H Pine

6) Organic Reaction Mechanism, P S Kalsi

8) Organic Chemistry; Jonathan Clayden, Nick Greeves, Stuart Warren, OUP Oxford.

9) Organic Reaction Mechanisms; V. K. Ahluwalia, Rakesh Kumar Parashar; Edition 4;

Publisher: Alpha Science International, 2011.

10)Concise Inorganic Chemistry, 5th Ed; J. D. Lee; John Wiley & Sons

11)Green Chemistry 3rd Edition; Mike Lancaster; Royal Society of Chemistry

Course outcome:

Upon successful completion of the course students will be able to

CO No.	Course Outcome	Cognitive level
1	**Appreciate** quantum theory of chemical system.	2
2	**Appreciate** co-ordination chemistry	2
3	**Write** simple organic mechanism	3
4	**Summaries** newer methods in organic synthesis	5
5	**Understand**environmental friendly chemistry	2

Chemistry –I Lab

Course Objectives:

Course objective are practical applicability of theoretical concepts of basic organic chemistry and thermodynamics to its practical applications.

About 08-10 experiments to illustrate the concept learn in chemistry -I

Suitable number of experiments from following categories.

1) Identification of organic compounds through group detection, physical constant (MP/BP)

2) Synthesis of Organic compound involving reactions such as oxidation, esterification, nitration, sulphonation etc.

3) Measurements of kinetics of simple reactions.

Course outcome:

Upon successful completion of the course students will be able to

CO No.	Course Outcome	Cognitive level
1	**Identify** the simple organic compound	1
2	**Identify** reaction rate parameter,	1
3	**Perform** and **optimize** the reaction conditions.	3

Course Title: Communication Skills
Course Code: HMC-101

Course Objectives:

To achieve the following objectives through this course:

a) To make the student industry ready in terms of his/her ability to communicate effectively

b) To augment the ability of the student to create, compose and render presentations with or without the help of media

c) To understand the importance of public speech and the role language plays in that.

d) To enhance the ability of written communication by giving a primer on English

UNIT I: **Communication Skills:** Introduction to major grammatical models. Phonological and syntactical structure of present-day English. Language of science and technology. Aspects of style. Vocabulary building, spelling patterns, some common errors, Reading and Comprehension Organizing principles of paragraphs in documents (05)

UNIT II: Communication Effectiveness: Importance of proper punctuation Formal and informal communication. The art of listening. Listening Comprehension, Strategies for effective communication, Social perception communication, written communication. Writing introduction and conclusion.Managerial report writing. Graphical representation of technical data, Technical presentations design and delivery. Resume Writing, Business etiquettes, social grace(05)

UNIT III: Personality Development: Concept of Soft Skills, Problem solving, decision making,

Positive Attitude and mindset, Communication at Workplace, Analytical Skills, Basic Writing Skills, Desire to learn and to be trained, coping with stress, Précis Writing Essay Writing, Multitask ability, Time Management, Model of success and failure in adjustment. (05)

UNIT IV: Interpersonal skills and rapport: Work Ethics, Personal Integrity & commitment, Flexibility, Teamwork and spirit, Group process, Group task performance, Adaptation development processes, Cultural influences on personality and social behavior. Managing Ability, Aggression and its management. (05)

UNIT V: Problem solving cooperation and competition, Motivational Skills:

Personality and social phenomenon. Negotiation Skills, Networking with industries and institutions. Approaches to the study of personality. Models of healthy & mature personality; Describing oneself and SWOT analysis, Emotional Intelligence (05)

Course Outcomes:

Upon successful completion of the course students will be able to

CO No.	Course Outcome	Cognitive level
1	**Understand** the importance of communicating effectively	2
2	**Communicate** effectively by removing barriers	3
3	**Address** an audience effectively and deliver speeches without inhibition	3
4	**Create** and **deliver** effective e-presentations	3
5	**Understand** the meaning and utility of Active Listening in communication	2
6	**Use** the vocabulary more effectively	3
7	**Expand** and **enrich** grammatical structure and vocabulary in English	3
8	**Comprehend** thoughts through body language and **use** it as a tool to understand non-verbal.	3

Communication Skills

Practical List:

1) Pronunciation & Spelling
2) Stress and Intonation
3) Errors in Spoken English
4) Business Letter (Layout)
5) Job application with Resume preparation
6) Newspaper Reading

Text/Reference Books:

1. English Pronouncing Dictionary, Cambridge University Press, India, 2012.

2. A Textbook of English Phonetics for Indian Students by T. Balasubramanian, Macmillan Publisher,

Course Outcomes:

Upon successful completion of the course students will be able to

CO No.	Course Outcome	Cognitive level
1	**Use** various drawing instruments to layout and draw a sheet.	3
2	**Explain** several types of lines used, Lettering, Numbering and Dimensioning and Scales.	2
3	**Draw** and **explain** Planes of projection, quadrants and first angle & third angle method of projection. To draw front view, Top View and side View of Simple objects.	3
4	**Illustrate** Principles of Isometric projection and Isometric view.	4
5	**Explain** energy management strategy and energy audit.	2
6	**Illustrate** with principle various conventional energy producing devices and energy absorbing devices.	4
7	**Illustrate** with principle various power transmission elements, drives, direction and flow control valves.	4

Course Title: Engineering Graphics

Course Code: ESC-102

Course Objective:

The student after studying this subject will be able to:-

1. Draw different engineering curves and know their applications.
2. Draw orthographic projections of different objects.
3. Visualize three dimensional objects and draw Isometric Projections.
4. Understand the basic concepts of projection of different entities.
5. Visualize and draw views of objects in various positions.
6. Develop lateral surfaces of different solids

Course Contents:

Unit - I: Introduction to Engineering Graphics

Principles of Engineering Graphics and their significance, usage of Drawing Instruments and Supporting Material, Letters and Numbers as per BIS: SP46-2003, Scale (Plane, diagonal & Vernier scale) .

Curves and Conic Section draw ellipse by directrix and arc of circle method. draw parabola by directrix and rectangle method. Draw hyperbola by rectangle and directrix method. Cycloid, Epicycloid, Hypocycloid and Involute. (04)

Unit – II: Orthographic Projections

Orthographic Projection: Types of lines, Methods of dimensioning, first angle method of projection and third angle method of projection. Principle of Orthographic Projections, Projections of Points, Projection of Line, Lines inclined to both the Planes.Projection of different simple shapes e.g. Circle, Triangle, Rectangle, Pentagon and Hexagon on principle plane (Inclined to one plane and to both planes). Conversion of pictorial view into sectional orthographic views. (04)

Unit – III: Projection of Solids

Introduction to solids, prism, cone, cylinder, pyramid, cube, tetrahedron. Projection of above solids with axis inclined to one plane and both planes. (04)

Unit – IV: Section of Solids

Introduction, section planes, true shapes of section, section plane parallel to VP, section plane parallel to HP, section plane perpendicular to HP and section plane inclined to VP, section plane inclined to HP. Section of prism, section of pyramid, section of cone, section of cylinder. (04)

Unit – V: Isometric Projection

Introduction to pictorial views, Isometric axes, lines and plane, true scale and Isometric scale. Isometric projection and Isometric View Conversion of given orthographic view into isometric projection. (04)

Text/Reference Books

1. Engineering Drawing: N.D. Bhatt, V. M. Panchal, by Charotar Publication
2. Engineering Drawing: M. L. Dobhade (Vol I + II), by Vision Publications
3. Engineering Drawing: P. S. Gill, by S. K. Kataria Publications
4. Engineering Drawing: Mali and Chaudhari
5. Engineering Drawing: Venugopal and Prabhu Raja V.

Course Outcomes:

Upon successful completion of the course students will be able to

CO No.	Course Outcome	Cognitive level
1	**Use** various drawing instruments to layout and draw a sheet.	3
2	**Explain** several types of lines used, Lettering, Numbering and Dimensioning and Scales.	2
3	**Draw** and **explain** Planes of projection, quadrants and first angle & third angle method of projection. To draw front view, Top View and side View of Simple objects.	3
4	**Illustrate** Principles of Isometric projection and Isometric view.	4
5	**Explain** energy management strategy and energy audit.	2
6	**Illustrate** with principle various conventional energy producing devices and energy absorbing devices.	4
7	**Illustrate** with principle various power transmission elements, drives, direction and flow control valves.	4

Engineering Graphics Lab

Practical: 04 Hrs/Week **Credits: 2.0**

Course Contents:

2. One drawing sheet on Lettering & Numbering
3. One drawing sheet on Engineering curves: Three different curves are to be draw using any one method
4. One drawing sheet on Projection of lines and Planes: Two problems on projection of lines and two problems on projection of planes

5. One drawing sheet on Projection of Solids: Two problems on two different solids
6. One drawing sheet on Section of Solids: Two problems on two different solids
7. One drawing sheet on Isometric Projections: Isometric views of two objects

Text/Reference Books

1. Engineering Drawing: N.D. Bhatt, V. M. Panchal, by Charotar Publication
2. Engineering Drawing: M. L. Dobhade (Vol I + II), by Vision Publications
3. Engineering Drawing: P. S. Gill, by S. K. Kataria Publications
4. Engineering Drawing: Mali and Chaudhari
5. Engineering Drawing: Venugopal and Prabhu Raja V.

Course Outcomes:

Upon successful completion of the course students will be able to

CO No.	Course Outcome	Cognitive level
1	**Use** various drawing instruments to layout and draw a sheet.	3
2	**Explain** several types of lines used, Lettering, Numbering and Dimensioning and Scales.	2
3	**Draw** and **explain** Planes of projection, quadrants and first angle & third angle method of projection. To draw front view, Top View and side View of Simple objects.	3
4	**Illustrate** Principles of Isometric projection and Isometric view.	4
5	**Explain** energy management strategy and energy audit.	2
6	**Illustrate** with principle various conventional energy producing devices and energy absorbing devices.	4
7	**Illustrate** with principle various power transmission elements, drives, direction and flow control valves.	4

Semester-III

Course Title: Heat Transfer

Course Code: CHC – 203

Course Objective: The objective of this course is to provide basic knowledge of various modes of heat transfer and detail design knowledge of various heat exchangers and evaporators.

Course Contents:

Unit - I

Concept of heat transfer and transport of heat. Fourier's law, significance of thermal conductivity of solid, liquid and gases, heat transfer through plane and composite wall, sphere and cylinder, problem related to this case. Thermal diffusivity, differential equation of heat conduction, lagging of pipes and other equipment, optimum lagging thickness, critical radius of insulation. Heat Transfer from extended surfaces (fins). (10)

Unit – II

Convection: Individual and overall heat transfer coefficients, natural and forced convection, laminar and turbulent flow, significance of dimensional numbers, dimensional analysis and heat transfer analogy, flimwise and dropwise condensation (horizontal & vertical Surfaces). (10)

Unit – III

Design aspects of condensers reboilers and evaporators, Concept of Boiling and their types, Nussult Equation. Evaporation: Single and Multiple effect evaporator. B.P.R. and hydrostatic head. Economy and capacity of evaporator. Problem based on single effect evaporator. (10)

Unit – IV

Radiation: Laws of radiation, radiation from solid surfaces, types of surfaces. Heat exchange by radiation between two finite black surfaces, between two infinite parallel surfaces, shape factor. Laws of shape factor, solid angle and radiation intensity, Green House effect. Electrical analogy of radiation shield. (10)

Unit – V

Heat Exchangers: classification, overall heat transfer coefficient, fouling factor, LMTD in single pass parallel, counter and cross flow arrangements. N.T.U.- effectiveness method for parallel and counter flow heat exchangers, general design aspect of heat exchangers. Problem based on LMTD and NTU effectiveness method. (10)

Text/ Reference Books

1. Holman,J..P.,S. Bhattacharya, Heat Transfer,10th edition, Tata McGraw-Hill,2011.
2. D.Q.Kern, Process heat transfer, Tata-McGraw Hill,1997.
3. R.Welty, C.E. Wicks, R.E.Wilson, G.Rorrer, Fundamentals of Momentum, Heat and Mass Tranfer, 4th edition, Wiley,2007.
4. W.J.Mccabe, J.Smith, P.Harriot, Unit Operations of Chemical Engineering, 6th edition, McGraw Hill, 2005.

Course Outcome:

Upon successful completion of the course students will have:

CO. No	CO	Cognitive level
1.	**Understands** the various modes of heat transfer.	2
2.	**Understands** the basics of fins.	2
3.	**Design** double pipe heat exchanger, shell and tube heat exchanger.	6
4.	**Design** single effect evaporator	6

Heat Transfer Lab

Course Code: CHC-203 (PR)

Practical: 03 Hours/ week **Total Credits: 1.5**

Course Contents:

1. To determine the heat transfer coefficient of air by using natural convection.
2. To determine the Stefan Boltzmann constant for radiation.
3. To determine the thermal conductivity of metal bar.
4. To determine the thermal conductivity of liquid (Lubricating oil).
5. To determine the heat transfer coefficient of double pipe finned tube heat exchanger.
6. To determine the log mean temperature difference in double pipe heat exchanger for parallel flow arrangement.
7. To determine the log mean temperature difference in double pipe heat exchanger for counter flow arrangement.
8. To Study the drop-wise and film-wise condensation.

Text/ Reference Books

1. Holman,J..P.,S. Bhattacharya, Heat Transfer,10th edition, Tata McGraw-Hill,2011.
2. D.Q.Kern, Process heat transfer, Tata-McGraw Hill,1997.
3. R.Welty, C.E. Wicks, R.E.Wilson, G.Rorrer, Fundamentals of Momentum, Heat and Mass Transfer, 4th edition, Wiley,2007.
4. W.J.Mccabe, J.Smith, P.Harriot, Unit Operations of Chemical Engineering, 6th edition, McGraw Hill, 2005.

Course Outcome:

Upon successful completion of the course, students will be able to

CO No.	Course Outcome	Cognitive level
1	Enhance the knowledge and clear the theoretical concepts of heat transfer by performing the hands-on experiments in the laboratory for detail understanding of the topic.	2

Course Title: Fluid Mechanics

Course Code: CHL-204

Course Objectives

The objective of this course is to make student well acquainted with different concepts in fluid mechanics like fluid statics, kinetics, dynamics, hydrostatic forces on submerged bodies, flow through pipes, instruments for flow & pressure measurement, types of flows, boundary layer theory, dimensional analysis & transportation of fluids by pumps, blowers and compressors etc& their applications particularly in chemical engineering.

Course Contents:

UNIT I

Concept of Fluid, Properties of Fluids, Viscosity, Newton's Law of Viscosity, Types of Fluids, Measurement of Pressure, Fluid Pressure at a Point, Pascal's Law, Hydrostatic Law, Absolute, Gauge, Atmospheric & Vacuum Pressures, Measurement of Pressure, Simple Manometers, Differential Manometers, Total Pressure & Centre of Pressure for a Vertical, Horizontal Surface Submerged in Liquid, Buoyancy, Centre of Buoyancy, Stability of Floating & Submerged Body.
Problems Based on All the Topics in a Unit. (10)

UNIT II

Kinematics of Flow: Types of Fluid Flows, Continuity Equation, Continuity Equation in Three Dimensions, Continuity Equation in Cylindrical Polar Coordinates, Velocity & Acceleration Concept, Stream Functions, Potential Flow & Its Important Cases.
Dynamics of Flow: Euler's Equation, Bernoulli's Equation, Applications of Bernoulli's Equation (Venturi Meter, Orifice Meter, Pitot Tube), Rotameter, Notches & Weirs.
Problems Based on All the Topics in a Unit. (10)

UNIT III

Flow Through Pipeline System: Loss of Energy in Pipes, Laws of Friction, Major Losses & Minor Losses, Loss of Head Due to Friction in Pipes (Darcy-Weisbach Formula), Chezy's Formula, Water Hammer in Pipes, Hydraulic & Total Energy Line.
Viscous Flow: Flow of Viscous Fluid through Circular Pipe (Hagen Poiseuille Formula), Between Two Parallel Plates, Methods of Determination of Coefficient of Viscosity**,** Kinetic Energy & Momentum Correction Factor.
Turbulent flow: Reynolds Experiment, Velocity Distribution in Turbulent Flow in Pipes, Hydrodynamically Smooth & Rough Boundaries, Velocity Distribution for Turbulent Flow in Smooth & Rough Pipes, Velocity Distribution for Turbulent Flow in Terms of Average Velocity, Variation of Friction Factor.
Problems Based on All the Topics in a Unit. (10)

UNIT IV

Dimensional Analysis: Fundamental Dimensions, Methods of Dimensional Analysis, Rayleigh's Method, Buckingham's π Theorem, Types of Similarities, Types of Forces Acting on Moving Fluid, Dimensionless Numbers, Classification of Models.

Boundary Layer Theory: Laminar & Turbulent Boundary Layer, Boundary Layer Thickness, Displacement Thickness, Momentum Thickness, Energy Thickness, Drag Force on a Flat Plate Due to Boundary Layer, Separation of Boundary Layer, Methods of Preventing Separation of Boundary Layer.

Problems Based on All the Topics in a Unit. (10)

UNIT V

Pumping of Liquids: Classification of Pumps, Principle, Construction, Working, Design, Discharge, Work Done & Power Requirement by Centrifugal Pump, Reciprocating Pump (Single & Double Acting), Pumps in Series, Pumps in Parallel, All Curves for Centrifugal Pump, Pump Efficiencies, Selection of Pumps, Priming, NPSH, Cavitation.

Pumping of Gases: Classification of Compressors, Principle, Construction, Working, Design, Discharge, Work Done & Power Requirement by Centrifugal & Reciprocating Compressor, Blowers, Vacuum Pump.

Problems Based on All the Topics in a Unit. (10)

Text/Reference Books

1. M. White, Fluid Mechanics, 8th Edition, Tata-McGraw Hill, 2016.
2. V. Gupta and S. K. Gupta, Fundamentals of Fluid Mechanics, 2nd Edition, New Age International 2011.
3. W. L. McCabe, J. C. Smith and P. Harriot, Unit Operations of Chemical Engineering, 7th Edition, McGraw-Hill International Edition 2005.
4. O. Wilkes, Fluid Mechanics for Chemical Engineers, Prentice Hall of India, 2005.
5. R. W. Fox, P. J. Pritchard and A. T. McDonald, Introduction to Fluid Mechanics, 7th Edition, Wiley-India 2010.
6. R. Welty, C. E. Wicks, R. E. Wilson, G. Rorrer, Fundamentals of Momentum, Heat and Mass Transfer, 4th Ed., Wiley (2007).
7. B. R. Munson, D. F. Young, T. H. Okiishi and W. W. Huebsch, 6th Edition, Wiley-India 2010.
8. R. B. Bird, W. E. Stewart and E. N. Lightfoot, Transport Phenomena, 2nd Edition, Wiley India 2002.

Course Outcome:

Upon successful completion of the course, students will be able to

CO No.	Course Outcome	Cognitive level
1	The students will have thorough knowledge of fluid properties, behaviour of fluid under different conditions, hydrostatics & pressure measurement.	2
2	The students will get well acquainted with basic principles in kinematics & dynamics of fluid flow with its application.	2
3	It will clear the basic concepts about various types of flows, complexities in flow through pipeline systems with detail study of laminar, turbulent	2

	flow.	
4	Students will get well acquainted with phenomena of boundary layer formation and separation. Students will be able to understand dimensional analysis and its application to **solve** the complex problems in heat & momentum transfer.	3
5	Student will have thorough knowledge of handling of fluids by various pumps, compressors, blowers and will be able to **design** the fluid handling system with calculation of power requirement in it. It will enhance the ability of students to identify and solve various engineering problems.	6

Course Title: Material and Energy Balance Computations

Course Code: CHL-206

Course Prerequisites: Physics, Chemistry-I, Mathematics-I, Thermodynamics-I

Course Objectives:

1. To teach students fundamental knowledge of chemical engineering and application of this knowledge in the solving of material and energy balances of chemical processes.
2. The course will cover concepts ranging from basics such as units and dimensions, stoichiometry to the simultaneous application of material and energy balances with and without occurrence of chemical reaction.

Course Contents:

UNIT- I

Units and Dimensions: Basic and derived units, different ways of expressing units of quantities and physical constants.

Calculations for mole, molecular weight, equivalent weight, etc., Composition of gaseous mixtures, liquid mixtures, solid mixtures, etc., Ideal gas law & other equations of state and their applications, Dalton law, Raoult's law, Hess's Law, Henry's law, Solutions and their properties. (10)

UNIT-II

Stoichiometry and unit operations:

Introduction to unit operation, development of block diagram and material balance for unit operations like blending, evaporation, crystallization, extraction and leaching, distillation, absorption & stripping, drying etc. (10)

UNIT-III

Material balance involving chemical reaction:

Introduction, definition and concept of terminologies like Excess Reactant, Conversion, Yield, Selectivity. Problems on material balance for chemical reactions for calculation of feed composition and product composition, Conversion, Yield, Selectivity etc. (10)

UNIT-IV

Humidity: Terminologies of Humidification like Humid Heat, Humid volume, % saturation, Molal Humidity, Molal saturation, absolute humidity etc.

Energy balance: Enthalpy calculation for systems (single component and multi components) without Chemical Reaction with Mean and Temperature dependent Heat Capacity, Enthalpy calculation for systems with Chemical Reactions. Heat of Reaction from Heat of Formation and Heat of Combustion Data, Effect of Temperature and Pressure on Heat of Reaction. (10)

UNIT-V

Introduction to Recycle, Bypass and purge operations: Applications of Recycle, Bypass and purge operations in unit operations and processes for calculation of recycle ratio, purge ratio, combined feed ratio.

Fuels: Types of fuels, Calorific value of fuels, Problems on combustion of coal, liquid fuels, gaseous fuels, etc., Proximate and ultimate analysis, Combustion calculations, Air requirement and flue gases. (10)

Text/ Reference Books:

Author, name of Book, latest edition year, publication

1. Bhatt., B.I. and Vora S.M. "Stoichiometry*"* 2nd edition, Tata McGraw Hill.
2. O.A. Hougen, K.M. Watson and R.A. Ragatz "Chemical Process Principles" Part-I, CBS Publishers &distributors, New Delhi.
3. K.A.Gavhane "Introduction to process calculations" Nirali Publications.
4. Shekhar Pandharipande and Samir Musharaf "Process Calculations" Pune Vidyarthi GrihaPrakashan, Pune.
5. Himmelblau, D.M. *"*Basic Principles and Calculations in Chemical Engineering*"*, 6th edition. Prentice Hall.

Course Outcome:

Upon successful completion of the course, students will be able to

S.No.	CO	Cognitive level
1.	The capability to convert units and dimensions and modify equations from system to another.	6
2.	The capability to apply the laws of physics and chemistry in solving process industry related applications	3
3.	The proficiency to integrate the data and formulate the mass and energy balance problems.	6
4.	The capability to use mathematical knowledge for solving mass and energy balance problems with and without chemical reactions.	3

Course Title: Industrial Management and Economics

Course Code: HML-202

Course Prerequisite: Basic Manufacturing Process, Principle of Economics

Course Objective

1. Identification and selection of management & administration with aspect towards the Production planning and management.
2. Understanding Micro and Macroeconomics Demand and Supply factors of market economy &institutional feature inside the organisation as well as outside the organisation.
3. Understanding GDP statement, Entrepreneurship Development

Course Content

Unit-I

Management: Introduction & meaning management & administration

Industrial management: Connotation of Industrial management

Organisation: Explication and Types of organisation

Manufacturing system: definition, class of manufacturing system

Plant layout: Classification of Plant layout (8)

Unit-II

Business organization: Forms of business organization

Productivity: Various techniques to increase Productivity

Sound wage program: Mechanics of sound wage program

Wages & Wage Administration: Introduction &meaning of Wages & Administration of remuneration

(8)

Unit-III

Marketing management: Introduction meaning and Concept of marketing management

Concept Sales management: Introduction meaning and Concept of Sales management significance of Sales management

Functions of Marketing management: prominence of marketing management

Functions of Sales management, role of Sales management (8)

Unit-IV

Economics: Introduction, meaning of Economics

Concept of GDP: Introduction meaning and Concept of GDP

Concept of ADP: influence of ADP

Introduction of Micro economics and Macro economics

Difference between Micro economics and Macroeconomics (8)

Unit-V

Entrepreneurship: Introduction, meaning and Concept of Entrepreneurship,

Types of Entrepreneurships: Order of Entrepreneurship

Entrepreneurship Development (8)

Text/ References Books:

1) John R. Hicks, "Value and Capital", 10th edition, Oxford, Clarendon Press, 2017
2) R. R. Barthwal, "Industrial Economics: An Introductory Text Book", 11th edition, New Age International, 2015
3) Martin Ricketts, "The Economics of Business Enterprise", 5th edition, ELGAR International, 2019
4) H. L. Ahuja, "Modern Economics" 9th edition, S. Chand Publishing, 2016
5) Alfred Marshal, "principle of Economics", 15th edition, Prometheus Books, 2016.

Course Outcome:

Upon successful completion of this course the student will be able to:

S.No.	CO	Cognitive Level
1.	Understanding of management and Productivity aspect towards the material management Production planning. Processes/operations according.	2
2.	Identification, selection and understanding the meaning and utility of Marketing management, consumer satisfaction, sales and advertising	2
3.	Understand the importance of Entrepreneurship Development.	2

Course Title: Introduction to Coating Technology
Course Code: PTC-201

Course Prerequisite: Chemistry-I and Material Science & Technology

Course Objective:

1**.** The Technocrat will have basic understandings of the commonly used terminologies, various ingredients and their role in coating formulations.
2. The Paint Technocrat will have general exposure to polymers technology
3. The Technocrat will have in-depth exposure to manufacturing, characterizations, and applications of modified oils and Alkyd resins

Course Content:

Unit-I

Overview of Indian and Global Paint Industry. Various terminologies and general classifications and Types of Coatings, Paints, Varnishes and Lacquers; Their components and functions; Binders, media/vehicles, pigmentations, PVC and CPVC, Paint making; Mechanism of film formation; Modern Surface Coatings; Properties of Surface Coatings and their films; Sealers, fillers, undercoats, topcoats. Convertible and non-convertible coatings, 1K and 2K systems (8 hrs)

Unit-II

Fundamentals of film-formers; resins and polymers; Thermosetting and thermoplastic, linear, branched; homo-polymers and co-polymers. Chain growth and step-growth polymerization, Chemical structure of monomers; Functionality; Degree of polymerization. Molecular weight and molecular weight distribution. Different types of molecular weights, number average, weight average, viscosity average, z average, Melting, Softening and freezing of polymers, Glass transition temperature, Mechanical properties of polymers. (8 hrs)

Unit-III

Pigment- Introduction to Pigments, extenders, dyes, lakes, and toners. Introduction to colour science, Inorganic and organic pigments with examples, Colour and chemical constituents, Chromophores, Adsorption and scattering of light; Influence of physical structure on colour, Colour index, General properties of pigments, Crystal structure, Particle size shape and distribution, Refractive index and hiding power, Oil absorption, Specific gravity, bulking value, tinting strength, Reducing strength. Fastness properties such as resistance to light, heat, water, chemicals, bleeding, etc. Corrosion resistance, Toxicity of pigments, Green pigments (8 hrs)

Unit-IV

Solvents; properties of solvents – solvent power, the rate of evaporation, boiling point & vapor pressure, distillation range, flash point, toxicity, thermodynamics of solubility; solubility parameters; solvent mixture (thinners) – true solvents, latent solvents, and diluents; safety, health & environmental aspects. Alcohols, ethers, esters, ether alcohols, ketones and hydrocarbons, Overview of paint and ink additives; Driers: active & auxiliary, primary and secondary, surface & through driers. Natural resins: Sources availability and properties of Congo, Copal, Kauri, etc. Rosin: sources, recovery, grades, composition, modification; limed rosin, rosin esters, maleic resins, Shellac: composition, properties, chemical modification, Natural Bitumens and Asphalts, petroleum bitumens; pitches, gums, glues, casein (8 hrs)

Unit-V

Oils for surface coatings: Drying, semi drying and non-drying oils; Properties and uses of oils; Chemical modifications of oils- heat bodied, polymerized oils, blown oils, isomerized oils; maleinized oils. Oleoresinous varnishes, Varnish making, spar varnish Alkyd Resin: Selection of raw materials like oils/ fatty acids, polyols, polyacids, etc. Oil length, chemical reactions involved in the Synthesis of alkyd resins, monoglyceride & fatty acid route, solvent & fusion process, Problems on Formulation Calculations of alkyd resins. Reactors and Plant for the manufacture of alkyd resins, Chemical & physical modifications of alkyd resins, High solids, and water reducible alkyds, Alkyd Emulsions (8 hrs)

Text/ Reference Books:

1. Organic Coating Technology, Volume I, by Henry Fleming Payne, John Wiley & Sons.1954
2. Surface Coatings, Volume I, by OCCA Australia (Prepd.), Chapman and Hall
3. Outlines of Paint Technology, III Ed. By W.M.Morgans,
4. Surface coatings: Science and Technology, by Swaraj Paul, John Wiley and Sons 1995
5. Organic Coatings: Science and Technology, by Z.W.Wicks, F.N.Jones and S.P.Pappas, Wiley-Interscience 2007
6. Basics of Paint Technology, Part I & II, by V.C. Malshe & Meenal Sikchi 2004
7. 'Resins for Surface Coatings', VOL. II 'Alkyds & Polyesters' by P. Deligny and N. Tuck, Edited by PKT Oldring, Second Edition, John Wiley and Sons, New York, SITA Technology Ltd, London, UK

Course Outcomes:

On completion of this course, the Technocrat will have

Co.No.	Course Outcomes	Cognitive Level
1.	**Awareness** of the present scenario of the national and global paint industry.	2
2.	**Understanding** of polymers, essential components of paints and their functions	2
3.	**Understanding** of manufacturing methods of modified oils, varnishes and alkyd resin	2
1.	**Understanding** of chemistry and technological aspects of natural resins, oleo resinous media.	2

Course Title: Introduction to Coating Lab
Course Code: PTC-201 (PR)

Course Prerequisite: Chemistry-I and Material Science & Technology

Course Objective:

1. The Technocrat will be exposed to laboratory practices related to the determination of physical and chemical characteristics of natural resins, oils, solvents, and plasticizers.
2. The Technocrat will be exposed to laboratory practices related to the synthesis and analysis of modified oils and alkyd resins.

Course Content:

Minimum of ten experiments with due coverage of the following:

Determination of various physical and chemical characteristics of drying, semi-drying and nondrying oils used in surface coatings such as color, refractive index, specific gravity, acid value, saponification value, iodine value, and hydroxyl value. Analysis of metal content and preparation of various driers

Spot Tests for Natural resins, Acid value of Rosin, preparation of limed rosin and ester gum

Preparation of varnishes by cold blending and cooking.

Technical Refining of Drying Oils, Preparation of modified oils used in surface coatings such as stand, boiled and double boiled oils, blown oils, D.C.O., Isomerized oils, Malenizedoils, etc.

Synthesis of coconut/ soya/ sunflower/ DCO alkyds (monoglyceride & fatty acid route, solvent & fusion process); determination of oil length of alkyd resins; preparation of alkyd emulsions

Text/ Reference Books:

1. Organic Coating Technology, Volume I, by Henry Fleming Payne, John Wiley & Sons.1954
2. Surface Coatings, Volume I, by OCCA Australia (Prepd.), Chapman and Hall

3. Outlines of Paint Technology, III Ed. By W.M.Morgans,
4. Surface coatings: Science and Technology, by Swaraj Paul, John Wiley and Sons 1995
5. Organic Coatings: Science and Technology, by Z.W.Wicks, F.N.Jones and S.P.Pappas, Wiley-Interscience 2007
6. Basics of Paint Technology, Part I & II, by V.C.Malshe & MeenalSikchi 2004
7. 'Resins for Surface Coatings', VOL. II 'Alkyds & Polyesters' by P. Deligny and N. Tuck, Edited by PKT Oldring, Second Edition, John Wiley and Sons, New York, SITA Technology Ltd, London, UK

Course Outcomes: Upon successful completion of this course the student will be able to:

Co.No.	Course Outcomes	Cognitive Level
1.	**Determination** of analytical parameters of oils	3
2.	**Evaluation** of solvency and plasticization.	5
3.	Empirical skills for the **synthesis** of varnishes, modified oils, and Alkyd resins	6
4.	**Analytical** skills for characterization and testing of natural resins, vegetable oils, and Alkyd resins.	6

Course Title: Indian Constitution

CourseCode: NC-202

Course Objectives:

To percolate & disseminate knowledge about constitution of India for imbibing & understanding importance of fundamental rights & duties so as to aware the students towards justice, equality & liberty.

Course Content:

- **Introduction to the Indian Constitution:** History and Making of the Constitution, Constituent Assembly, Salient features, The preamble
- **Fundamental Rights & Duties:** Meaning and types of fundamental rights; Fundamental duties, the Right to Equality, the Right to Freedom, the Right against Exploitation, the Right to Freedom of Religion, Cultural and Educational Rights and Right to Constitutional Remedies

- **Directive Principles and Human Right:** Meaning of Directive Principles; difference between of Fundamental Rights and Directive Principles of State Policy – Implementation of Directive Principles of State Policy
- **Union Government & Administration:** Structure of Indian union, Loksabha, Rajyasabha, Powers and Functions of the President, the Prime Minister, Council of Ministers; composition, powers and functions of the Parliament, organisation of judiciary; jurisdiction of the Supreme Court; independence of judiciary, Election Commission

- **State Government & Local Administration:** Powers and Functions of Governor, Chief Minister and Council of Minister; composition, powers and functions of State Legislature, Local administration and constitution: Panchayati, Municipalities.

Suggested Books/ Readings:

1. M. V. Pylee – An Introduction to Constitution of India, Vikas Publications, New Delhi-2005.
2. Subhash C. Kashyap – Our Constitution: An Introduction to India's Constitution & Constitutional Law, National Book Trust, New Delhi-2000.
3. Durga Das Basu – Introduction to the Constitution of India, PHI, New Delhi-2001.
4. Dr. S. N. Busi, Dr. B. R. Ambedkar framing of Indian Constitution, 1st Edition, 2015.
5. J. C. Johari – Indian Government & Politics, Sterling Publishers, Delhi-2004.
6. V. D. Mahajan – Constitutional Development & National Movement in India, S. Chand & Company, New Delhi.
7. Dr. S. N. Busi, Dr. B. R. Ambedkar framing of Indian Constitution, 1st Edition, 2015.
8. Granville Austin – Working of a Democratic Constitution: The Indian Experience, Oxford University Press, New Delhi-1999.
9. A. P. Avasthi – Indian Government & Politics, Naveen Agarwal, Agra-2004.
10. S. A. Palekar – Indian Constitution, Serials Publication, New Delhi-2003.

Course Outcome:

Upon successful completion of the course students will be able to

CO No.	Course Outcome	Cognitive level
1.	**Understand** various constitutional rights &fundamental duties.	2
2.	**Understand** the implementation of Directive &Principles of State Policy.	2
3.	Get **Knowledge** of powers and function of Central Government, Parliament, Supreme Court and Election commission.	2
4.	Get **Awareness** of powers & functions of Governor, State Government, Chief Minister and Council of Minister.	2

SEMESTER IV

Course Title: Engineering and Solid Mechanics
Course Code: ESL – 205

Course Pre-requisite: Physics, Mathematics and Engineering Graphics

Course Objective:

- Students would be introduced to fundamentals of Engineering Mechanics with emphasis on force systems, axioms, dynamics of rigid bodies.
- Second part of the course would be an introduction to Solid Mechanics, and students would be introduced to basic concepts of mechanics of deformable media: concept of stress tensor, strain tensor, strain rates, constitutive relations, and applications to one/two dimensional problems.

Course Contents:

Unit - I

Coplanar forces: Introduction, basic concepts, composition & resolution of forces. Resultant forces. Moment of forces, couples, equivalent force systems, free body diagrams, distributed forces. Equilibrium of coplanar force system, conditions of equilibrium. Types of supports. Support reactions for determination of beams. Problems on above topics.

Analysis of structure: Plane trusses, method of joints, cables subjected to part loads. (10)

Unit – II

Centroid &Centre of gravity of composite plane figures. Principal Moment of Inertia, Moment of Inertia of various geometry.

Friction: Laws of friction, Application of friction on horizontal & inclined planes, belt friction.

Introduction to point Kinematics: Curvilinear Motion: Moving point in various coordinate systems (Cartesian, cylindrical, path), Equation of motion.

Kinetics & Kinematics of Rigid body: Translation & Rotation motion, Linear and Angular velocity, momentum. (10)

Unit – III

Concept of stress & strain, classification, Hooke's law, Poisson's ratio, Modulus of elasticity, Modulus of rigidity, Bulk modulus, relation between elastic constants, Problems on stresses & strains for prismatic, linear varying & composites sections.

Introduction to thermal stresses & strains. Problems on simple & composite sections. (10)

Unit – IV

Concept & definition of shear force & bending moment in determinate beams due to concentrated loads, UDL, UVL, Shear force & Bending moment diagrams for cantilever & simply supported beams (with or without overhang). Theory of bending. Concept of shear stress distribution. (10)

Unit – V

Thin Cylinder: Hoop stress, longitudinal stress, riveted cylindrical vessels, wire bound thin pipes. Thin spherical shells, cylinder with hemispherical ends.

Torsion of a circular shaft: Theory of pure torsion, Assumptions. Simple problems on torsion & power transmission. Short & long columns & struts. Standard cases with axial load. (10)

Text/Reference Books

1. I. B. Prasad, "Applied Mechanics & Strength of Materials", Khanna Publishers.
2. Timoshenko, "Mechanics of Materials", CBS Publisher
3. Ramamruthan S., "Strength of Material", Dhanpat rai Publications

4. Bear & Johnson, “Mechanics of Materials”, 7th edition, McGraw-Hill Education, 2015
5. R. K. Rajput, “Strength of Materials”, S Chand Publications
6. R S Khurmi, “Strength of Materials”, S Chand Publications

Course Outcome:

Upon successful completion of the course students will be able to-

CO No.	Course Outcome	Cognitive level
1	**Solve** basic concept in structural members like column, beams, trusses, and concept in laws of frictions and various types of stresses and strains.	3
2	**Solve** shear forces and bending moment and plot diagrams.	3
3	**Analyze** various parameters on torsion in transmission system.	4

Course Title: Chemistry-II

Course Code: BSC-206

Course Prerequisite: Chemistry-I

Course Objectives:

1. To develop the arts and culture of organic chemical reactions and its significance in chemical and technology process industry.
2. To study how chemical reactions takes place differently in different environments i.e., reaction mechanism.
3. To study and apply the basic reactions mechanism to design synthesis of some classes of molecules.
4. To study industrially important chemical reactions, substrate and some reagents.
5. To study interconversion of functional group and their applications.
6. To study methods of determination of structure of molecules.

Course Contents:

UNIT- I

Aromatic molecules: Huckels rule of aromatic molecules, different classes of aromatic molecules, resonance.

Aromatic Electrophilic Substitution bimolecular reactions (ArSE2 reactions): Mechanism of ArSE2 reaction, Orientation of ArSE2 reaction in monosubstituted benzene, Mechanism and synthetic application of Nitration, Friedel-Craft’s alkylation and acylation reactions, Gatterman-Koch reaction, Vilsmeier-Haack’s reaction. (10)

UNIT-II

Aromatic amines: Methods of Preparation – benzyne mechanism, reduction of nitro aromatics, properties-basicity and application in synthesis.

Diazonium Salts: Preparation-diazotization reaction, chemical properties and reactions such as coupling, synthesis of azo dyes, replacements-Sandmeyer's reaction and deamination. Ullman's reaction and Benzidine rearrangement. (10)

UNIT-III

Reagents and Green solvents in organic synthesis:

Complex Metal hydride-DIBAL-H, Lithium dimethyl cuprate, applications in synthesis. Introduction to organoboron-diborane, organosilicon-silane. H2O2 and O3(Ozone) application in organic synthesis. Introduction to Green reactions, Green and hazardous solvents. (10)

UNIT-IV

Sulphonic acids: Methods of preparation, application of sulphonic acids in synthesis.

Heterocyclic compounds: Introduction, Methods of synthesis and ArSE2 reactions such as nitration, sulphonation, halogenations, acylation and mercuration of Furan, Pyrrole and Pyridine. (10)

UNIT-V

Spectroscopy: Basic principles and applications of IR, UV-VIS and ^{1}H NMR spectroscopy to structure determination of small molecules. (10)

Text/ Reference Books:

1. S. H. Pine, Organic Chemistry, Tata McGraw-Hill Education India, 5th Revised edition-1987
2. M. B. Smith, Jerry March, March's Advanced Organic Chemistry: Reactions, Mechanism and Structure, Wiley-Interscience, 6th Edition2007.
3. R. T. Morrison, R. N. Boyd, S. K. Bhattacharjee, Organic Chemistry, Pearson, 7th Edition 2011.
4. Jonathan Clayden, N. Greeves, S. Warren, P. Wothers, Organic Chemistry, Oxford University Press, 2000.
5. W. Carruthers, I. Coldham, Modern Methods of Organic Synthesis, Cambridge University Press, 4th Edition 2012.
6. P. S. Kalsi, Spectroscopy of Organic Compounds, New Age International Pvt Ltd Publishers, 6th Edition, 2006.
7. Elementary Organic Spectroscopy, Y. R. Sharma, S. Chand & Co. 4th Edition 2007.

Course Outcome:

Upon successful completion of the course students will have-

Co.No.	CO	Cognitive Level
1.	Clear basic **concepts** of different classes of organic molecules, their important reactions and functional group interconversions.	1
2.	They would know how organic reactions are takes place, how to **design** the desired product and factors to take care of it	6
3.	They will understand how to **apply** different concepts of reactions to workup/separation of product, to improve yields and to study structure of molecules.	3

4.	This course provides the knowledge of organic **concept** to undergraduate engineering students and is designed to strengthen the fundamentals so that they can build their own interface of applied organic chemistry concept with their industrial applications in the branch of chemical engineering and Technology.	1

Chemistry-II Lab Course

Code: BSC-206 (PR)

Course Prerequisite: Chemistry-I practical

Course Objectives:

1. To develop the arts and culture of organic chemical reactions and its significance in chemical and technology process industry.
2. To study how chemical reactions are takes place differently in different environments i.e., reaction mechanism.
3. To inculcate the laboratory skills.

Course content:

1. Qualitative analysis of organic binary mixture through type determination, separation. Elemental analysis, functional group determination and physical constant of any one component (at least Two mixtures)
2. Single step preparation involving greener approach, purification and characterization (m.p.) of product (at least Three)
   - i) Preparation of dibenzalpropanone using NaOH or LiOH as base
   - ii) Preparation of p-nitro aniline from p-nitroacetanilide
   - iii) Bromination of acetanilide by CAN, KBr in water
   - iv) Preparation of Osazone from Glucose
   - v) Preparation of Sudan-I from aniline
   - vi) Preparation of p-nitrobenzoic acid from p-nitrotoluene
   - vii) Oxidation of alcohol to ketone by sodium hypochlorite (NaOCl)
3. Determinations/Estimations (Any Two)
   - i) Determination of total hardness of water
   - ii) Determination of Molecular Weight of a monobasic/ dibasic acid by volumetric method.
   - iii) Estimation of amide by hydrolysis
   - iv) Study of kinetics of hydrolysis of methyl acetate
4. Laboratory Techniques (any Three)
   - i) Thin Layer Chromatography (TLC)
   - ii) Hydrogenation of organic compound-a demonstration
   - iii) Interpretation of IR and UV-VIS Spectra
   - iv) Interpretation of 1H NMR spectra

Text/ Reference Books

1. B. S. Furniss, A. J. Hannaford, P. W. G. Smith, A. R. Tatchell, Vogel's Textbook of Practical Organic Chemistry, Pearson, 5th Edition 2005.
2. R. K. Bansal, Laboratory Manual of Organic Chemistry, New Age International (P) Limited, 5th Revised Edition 2008.

Course Outcome:

Upon successful completion of the course students will have-

S.No.	CO	Cognitive Level.
1.	Clear basic **concepts** of different classes of organic molecules, their important reactions with developed laboratory skill andawareness.	1
2.	Basic concepts in preservation of environment by **adaptation** of Green Chemistry concepts.	6

Course Title: Thermodynamics II

Course Code: CHL – 201

Course Pre-requisite: Thermodynamics I

Course Objective: To introduce the concepts of fugacity, activity and their coefficients, Phase equilibria and Chemical reaction equilibria.

Course Contents:

Unit - I

Review of basic laws of thermodynamics, intensive and extensive properties, state and path function, calculation for work, enthalpy and entropy changes. Efficiency calculation to heat engine, heat pumps. Refrigeration cycle & Carnot cycle, 3(10)

Unit – II

Properties of pure substances: T-V, P-V, P-T diagram. Ideal gas law, compressibility factor, Van der waals equation, Viral equation, Redlich Kwong equation, Redlich Kwong Soave equation of state. P-V-T relation for isothermal, isobaric, isochoric, adiabatic & polytropic processes. (10)

Unit – III

The Maxwell relations, method of Jacobians, Gibbs &Helmotz relations, the Clapeyron equation. The general relations for du, dh, C_v, & C_p; Mayer relation. Isothermal compressibility, volume expansivity, coefficient of linear expansion, adiabatic compressibility & adiabatic bulk modulus. The Joule Thomson Coefficient. (10)

Unit – IV

Phase Equilibria: Chemical potential, Kay's rule, Phase rule for reacting system, Duhem's theorem, boiling point and equilibrium diagram, fugacity and activity coefficient, activity coefficient equations (Wohl's three-suffix equations; Margules equation; Van Laar equation; Wilson equation; Non-random two-liquid (NRTL) equation; Universal quasi-chemical (UNIQUAC) equation; Universal functional activity coefficient (UNIFAC)), Azeotropes, consistency tests for VLE data, modified Roult's law, liquid-liquid equilibria. (10)

Unit – V

Chemical Reaction Equilibria: Chemical equilibrium criteria, Equilibrium constant, chemical equilibria for simultaneous reactions, Feasibility of a reaction, Effect of temperature and pressure on equilibrium constant, Heterogeneous reaction equilibria. (10)

Text/ Reference Books

1. J.M.Smith, H.C.Van Ness and M.M.Abbott, "Introduction to Chemical Engineering Thermodynamics", 7th edition, McGraw-Hill International Edition, 2005.
2. K.V.Narayanan, "A textbook of Chemical Engineering Thermodynamics" PHI, New Delhi, 2010.
3. Y.V.C.Rao, "Chemical Engineering Thermodynamics" , University Press, Hyderabad,1997.

S.Sandler, " Chemical, Biochemical and Engineering Thermodynamics" , 4th edition, Wiley, India,2014.

Course Outcome:

Upon successful completion of the course students will be

CO	Course Outcome	Cognitive

No.		level
1	Familiar with Basics of thermodynamics.	1
2	Familiar with various thermodynamics relations.	1
3	Able to **solve** problems of phase equilibria	3
4	Able to **solve** problems of chemical equilibria	3

Course Title: Mechanical Operation

Course Code: CHC-207

Pre-requisites: Material and energy balance computations, Fluid Mechanics

Course Objectives

The objective of this course is to make student well acquainted with basic principles of various mechanical operations, construction and working of the equipment.

Course Contents:

UNIT- I

Properties & Handling of Particulate Solids: Particle size, shape; mixed particle size & size analysis, specific surface of mixture, average particle size; properties of particulate masses; storage of solids. Size Reduction: Size reduction equipment for coarse, intermediate & fine size reduction; energy & power requirement; open & closed loop circuit. (8)

UNIT - II

Screening: Equipment, ideal screen. Screen analysis methods & std. screen series; capacity & effectiveness of screen. Mixing of Solids & Pastes: Mixers for coasive solids, free flowing solids, paste & plastic masses, power requirement, mixing effectiveness by mixing index calculation, rate of mixing. Mixing & Agitation of Liquids: Agitation equipment & flow pattern; circulation velocities & power consumption in agitated vessel; blending & mixing. (8)

UNIT -III

Flow Past Immersed Bodies: Drag coefficient, Stokes law, Cozeny- Carman equation. Flow of Solids Through Fluids: maximum settling velocity, free & hindered settling conditions. Fluidization: Minimum fluidization velocity, types of fluidizations, application of fluidization in catalytic cracking, drying, etc.; fixed bed, spouted bed system. (8)

UNIT - IV

Classification & Sedimentation: Clarification & thickening, separation ratio; equipment for centrifugal & gravity classification; cyclone separator & design; hydrocyclones; principle of jigging, tabling, magnetic & electrostatic separation. Gravity sedimentation; laboratory batch & continuous sedimentation, centrifugal sedimentation. (8)

UNIT -V

Filtration: Filter aids, classification of filters, selection of filter media. Principle of batch filtration: constant pressure & constant rate filtration, factors affecting filtration. Continuous, centrifugal, vacuum, gravity filtration & related equipment. Washing of filter cake. (8)

Text/ Reference Books

1. Mc Cabe W. L. & Smith J. C. " Unit Operation for Chemical Engg." 5th Edition.

2. Coulson J. M. &Rechardson J. F. " Chemical Engg. - Vol. II"
3. Badger W. L. &Banchero J. T. " Introduction to Chemical Engg."
4. Narayan &Bhatacharya " Mechanical Operation in Chemical Engg."
5. P. Chattopadhaya " Unit Operation in Chemical Engg. Vol. I "
6. G. G. Brown " Unit Operations"

Course Outcome:

Upon successful completion of the course students will be

CO No.	Course Outcome	Cognitive level
1.	To build basic knowledge of various mechanical operations.	2
2.	To **review** the practical importance and relevance of unit operations used for crushing, grinding and size separation in chemical industry.	2
3.	To **define** the properties of solid and to select suitable size reduction equipment.	1
4.	To **understand** fluid particle system, solid liquid separation process.	2
5.	To **analyze** mixing processes and solid-solid separation method	4

Mechanical Operation Lab

Course Code: CHC – 207 (PR)

Course Contents:

1. Study of the properties of solid.
2. Calculation of critical speed of ball mill and grinding of given sample.
3. Calculation of power consumption for crushing operation in Hammer mill.
4. Study of relationship between drag coefficient and modified Reynolds number for spherical body falling through fluid for Stokes law region.
5. Study of Batch sedimentation process.
6. Calculation of efficiency of cyclone separator.
7. Study of sigma mixture.
8. Study of filtration process in basket centrifuge.

Text/ Reference Books

1. Mc Cabe W. L. & Smith J. C. " Unit Operation for Chemical Engg." 5th Edition.
2. Coulson J. M. &Rechardson J. F. " Chemical Engg. - Vol. II"
3. Badger W. L. &Banchero J. T. " Introduction to Chemical Engg."
4. Narayan &Bhatacharya " Mechanical Operation in Chemical Engg."
5. P. Chattopadhaya " Unit Operation in Chemical Engg. Vol. I "
6. G. G. Brown " Unit Operations"

Course Outcome:

Upon successful completion of the course students will be

CO	Course Outcome	Cognitive

No.		level
1	Ability to **calculate** the properties of solid	3
2	**Analysis** of the performance of size reduction equipment.	4
3	Ability to **analyze** separation process for solid liquid system.	4
4	Ability to **analyze** separation process for Gas solid system.	4

Course Title: Engineering Workshop

Course Code: ESC – 206

Course Objective:

In workshop practice, students will get familiar with use of different workshop practices like fitting, welding, tin smithy, black smithy, foundry and computer hardware workshop. Students will also get familiar with different tools, machines, equipment, and job holding devices, job drawing, job material, job manufacturing operations and processes in different workshops.

Course Contents:

Unit - I

Manufacturing Methods: Casting: Pattern Making, pattern materials, pattern allowances, Types of sand. Moulding hand tools, defect in casting.

Forming: Hot working and Cold working, forging, Drawing, Rolling, Extrusion

Machining: Lathe machine, Its major parts & operations (5)

Unit – II

Joining: Welding: (Arc welding, TIG, MIG & Gas welding, types of flames), Brazing, riveting & fastening

Advance manufacturing methods: Electrical discharge machine(EDM), laser beam welding(LBM)CNC machining: Introduction.

Fitting operation: Marking, measuring, filling, drilling, tapping, Power tool: Power hacksaw machine, Bench grinder Machine. (5)

Unit – III

Carpentry: Timber, Measuring & Marking tools, cutting tools, planning tools, boring tools, striking tools, holding tools. Use of plastics & composites as engineering materials.

Plastic Moulding: Injection moulding.

Metal casting: die casting, its advantages & dis advantages, (5)

Text/Reference Books

1. ’Elements of Workshop Technology Vol I & Vol II: Hajara Chaudhari S. K, Hajara Chaudhari A. K, Nirjhar Roy S. K, Media promoters & publishers pvt. Ltd., Mumbai
2. Manufacturing Engineering &Technology: Kalpakjin S. & Steven S. Schmid, 4th addition Pearson education India. Edition,2002

3. ’Manufacturing Technology: Gouri E. Hariharan & A. Suresh Babu, I Pearson education 2008
4. ’Processes & Material of manufacture’s: Roy A. Lindber, 4th edition, Prentice hall India 2008
5. Manufacturing Technologies I & II: Rao P. N. Tata McGraw-Hill house 2017

Course Outcome:

Upon successful completion of the course

CO No.	Course Outcome	Cognitive level
1	Students will gain knowledge of the different manufacturing processes which are commonly employed in industries, to fabricate components using different materials.	2

Course Title: Engineering Workshop Lab

Course Code: ESC – 206

Workshop Practice: (Any Five)

1. Machine Shop: Turning- Facing, plain turning, Step turning & Taper turning.
2. Fitting: Filling, Drilling & Tapping
3. Carpentry: (Halving, Mortise & Tenon, Bridle, Butt, Dowel, Dovetail) any one.
4. Electrical & Electronics: Common house wiring connection
5. Welding Shop: (Butt, Lap, Corner, T) Any one
6. Piping (Any Joint)
7. Plastic Moulding: Injection moulding

Examination could involve the actual fabrication of simple components, utilising one or more of the techniques covered above.

Course Outcomes:

Upon successful completion of the course

CO No.	Course Outcome	Cognitive level
1	Students will be able to **fabricate** components with their ownhands.	6
2	They will also get practical knowledge of dimensional accuracies &	2

	dimensional tolerances possible with different manufacturing processes.	
3	By assembling different component, they will be able to **produce** small devices of their interest.	6

Course Title: Technology of Pigments
Course Code: PTC-202(TH)

Course Prerequisites: Introduction to Coating Technology

Course Objectives:
The Technocrat will learn the chemistry and technology of manufacture, characterizations and applications of inorganic pigments, organic dyestuffs, and extenders.

Course Contents:
UNIT- I
General methods of processing and synthesis of inorganic pigments: Crushing and grinding, vaporization, coprecipitation, filtration, drying, flushing, calcinations/roasting, vapor phase oxidation, etc. Raw materials for organic pigments: A brief study of coal tar distillation and the role of distillation products in the manufacture of synthetic dyes: bases and precipitants used in the color striking, toners and lake formation. Intermediates: A brief study of the types of chemical reactions involved in the manufacture of various benzene, naphthalene and anthracene intermediates. Synthetic organic pigments: General methods for preparation and classification; Diazotization and coupling reactions and processes, General layouts for Colour House.
(8 hrs)
UNIT-II
Extenders or filler pigments: Sources, manufacture, properties, and uses of carbonates, sulphates and other extender pigments like Calcium carbonate, hydrated aluminium oxide, aluminum silicates/ china clays, Magnesium silicate/ talc, silica, Barytes /blanc fixe (barium sulfate), silica, mica etc. Anticorrosive pigments: Red lead, basic lead silicochromate, zinc and strontium chromates, zinc phosphate, white molybdate, calcium plumbate, etc. Green approaches (8 hrs)
UNIT-III
White prime pigments: methods of manufacturing, comparison of properties and composition of TiO2, ZnO, Zinc sulphide and lithopone, basic lead carbonate, basic lead sulphate, antimony oxide, zinc phosphate zirconium oxide. surface treatment of TiO2, crystal structure and hiding power of TiO2 Manufacture, properties and applications of Black Pigments: Channel blacks, Furnace blacks, Lampblacks, Acetylene black, Graphite, black iron oxide, Jetness of black pigments. (8 hrs)
UNIT-IV
Properties, composition and manufacturing of Yellow and Orange Pigments: Iron oxide yellows, FeO(OH), lead chromate (PbCrO4), combinations of lead chromate with PbO, co-crystals of lead chromate with lead molybdate (PbMoO4) and lead sulphate, titanium nickel yellow, bismuth yellow(BiVO4- Bi2MoO6), cadmium sulphoselenide; lithol fast yellow, Monoarylide (monoazo) yellow pigments, Diarylide yellows, Nickel azo yellow, benzidine yellow, isoindoline/ isoindoline yellow, flavanthrone yellow, benzimidazolone orange pigments, perinone and perylene orange/ yellow, 1,4diketopyrrolo-pyrrlo orange/ yellow etc. Properties, composition and manufacturing of Red Pigments: Natural and synthetic iron oxides, cadmium sulphide; Quinacridones, para red, Toluidine red, rubine red, monoazometallized pigments, lithol reds, perinone and perylene reds, BON acids coupled with diazo compounds, Naphthol reds, alizarine red, thioindigo red, etc.
(8 hrs)
UNIT-V
Properties, composition, and manufacturing of violet, Blue and Green Pigments: Manganese violet, cobalt violet phosphate, chrome green, ultramarine blue, Prussian blue, Cobalt blue, etc.

Phthalocyanines: Copper phthalocyanines, phthalocyanine green, metal free phthalocyanines, comparison with other pigments. Indathroneblue, Pigment Green B, Carbazole/ Dioxazineviolet, Azo tonners and lakes, Diazo and tetra azo compounds, Basic and acid dye pigments: PTA, PMA and PTMA pigments, Non-permanent type basic, acid dyes and pigments. Xanthane. (8 hrs)

Text/ Reference Books:

Braun, J. H., White Pigments, Federation of Societies for Coatings Technology, Blue Bell, PA, 1995.
Herbst, W.; Hunger, K., Industrial Organic Pigments, 3rd ed., Wiley-Interscience, New York, 2004.
Lewis, P. A., Ed., Pigment Handbook, 2nd ed., Vol. I, Wiley-Interscience, New York, 1988.
Lewis, P. A., Organic Pigments, FSCT, Blue Bell, PA, 1995.
Gunter Buxbaum, Industrial Inorganic Pigments, Wiley VCH; 1998
Hugh M. Smith, High Performance Pigments, Wiley-VCH Verlag GmbH 2013
E B Faulkner and R J Schwartz (Ed), High Performance Pigments Wiley-VCH, Weinheim 2009

Course Outcomes:

Upon successful completion of the course:

S.No.	CO	Cognitive Level
1.	An acquaintance of raw materials, general methods of processing and testing of inorganic pigments, organic dyestuffs and extenders.	2
2.	Understanding of chemical constitution and polymorphism in relation to color development and visualization.	2
3.	In-depth knowledge of methods of manufacture of important pigments.	2
4.	Awareness of recent developments, eco-friendly trends, good manufacturing practices and future challenges in relation to prime pigments.	2

Technology of Pigments Lab
Course Code: PTC-202 (PR)

Course Prerequisites: Introduction to Coating Technology

Course Objectives:

The Technocrat will be exposed to laboratory practices related to the synthesis and testing of major inorganic pigments, organic dyestuffs, and extenders.

Course content:

Minimum of ten experiments with due coverage of the following: 1. Identification of pigments, spot tests for organic pigments,

Evaluation of following pigmentary properties: Hiding power, Oil absorption, Refractive Index, Tinting Strength, Reducing power, Mass-tone, color permanence, resistance to bleeding in solvents, oils and resins, particle size, specific gravity and bulking value, resistance against acids, alkalis and different chemicals, Shade matching, etc.

Preparation of typical inorganic pigments, extenders and synthetic organic pigments and their analysis -Lead chromes, Zinc chromes, red and yellow iron oxide, Iron Blues, Para Red, lithol Red, Phthalocyanine blue, Toluidine Red, carbon black, $CaCO_3$, $BaSO_4$, etc. Synthesis of nanopigments.

Text/ Reference Books

Braun, J. H., White Pigments, Federation of Societies for Coatings Technology, Blue Bell, PA, 1995.
Herbst, W.; Hunger, K., Industrial Organic Pigments, 3rd ed., Wiley-Interscience, New York, 2004.

Lewis, P. A., Ed., Pigment Handbook, 2nd ed., Vol. I, Wiley-Interscience, New York, 1988.
Lewis, P. A., Organic Pigments, FSCT, Blue Bell, PA, 1995.
Gunter Buxbaum, Industrial Inorganic Pigments, Wiley VCH; 1998
Hugh M. Smith, High Performance Pigments, Wiley-VCH Verlag GmbH 2013
E B Faulkner and R J Schwartz (Ed), High Performance Pigments Wiley-VCH, Weinheim 2009

Course Outcomes:

Upon successful completion of the course:

Co.No.	Course Outcomes	Cognitive Level
1.	The techniques of purification of pigments and extenders.	3
2.	Empirical skills for the synthesis of inorganic pigments, organic dyestuffs, and extenders.	2
3.	Analytical skills for characterization and testing of inorganic pigments, organic dyestuffs, and extenders.	3

SEMESTER-V

Course Title: Mass Transfer Operations
Course Code: CHL-314

Course objectives:
Objective of this subject is to expose students to understand the basic mass transfer operation like diffusion, absorption, drying, humidification distillation, liquid-liquid extraction, adsorption, leaching and crystallization and its application to chemical engineering.

Pre-requisites:
Material and energy Balances Computations (CHL-206)

Course Content:

Unit-I
Constitutive laws of diffusion: Equimolecular counter diffusion and diffusion in stationary gas; Diffusivities in liquid, vapor and gases; Local and average overall mass transfer coefficients
Interphase mass transfer process: Mass transfer equilibrium, Mass transfer theories, Mass transfer and chemical reaction
Material balance: Steady state co-current and counter current processes, stage wise and differential contacts, Number of theoretical stages, Stage efficiency, Height of transfer units.

Unit-II
Distillation of binary mixtures: Vapor–liquid equilibria, Raoult's law, X-Y, T-X-Y & H-X-Y diagrams, Boiling point diagram and azeotropes
Types of distillation, Fractionating column and multistage column,MaCabe-Thiele method, Operating and feed lines, feed conditions, reflux ratio, minimum and optimum reflux ratio, Tray and column efficiency.

Unit-III
Absorption: Solubility, choice of solvent, concept of driving force and mass transfer coefficient, Material balance for transfer of one component -counter current and concurrent flow, minimum gas-liquid ratio for absorber. absorption with & without chemical reaction. Determination of height of columns, transfer units and HETP.
Packed towers: General construction & working, types of packing merits & demerits, operational difficulties, pressure drop & limiting G-L flow rates.
Plate towers: General construction & working, types of plate, merits and demerits, operational difficulties

Unit IV
Liquid-Liquid Extraction: fundamentals, solvent selection, triangular diagram representation, Single stage extraction- maximum and maximum solvent, Equipment for liquid-liquid extraction. (Mixer settler, Rotating Disc Contractor, Packed column, spray column) equipment selection criteria.
Solid–Liquid Extraction fundamentals, Solvent selection, equilibrium relationship, triangular diagram representation, single stage operation,

Unit-V
Crystallization: Theory of solubility and crystallization, phase diagram (temp/solubility relationship), methods of achieving Supersaturation, phenomenon of crystal formation, crystal structure. Material & heat balance over crystallizer & related problems.

Drying: Drying mechanism, Constant rate and falling rate periods, drying rate curves, estimation of drying time, moisture contents, drying equipments- rotary dryers, drum dryers, vacuum dryers, Spray dryer, fluidized bed dryers.

Text/ Reference Books

1. Dutta, Binay K. *Principles of mass transfer and seperation processes*. PHI Learning Pvt. Ltd., 2007.
2. Treybal, Robert E. "Mass transfer operations." *New York* 466 (1980).
3. Cussler, Edward Lansing, and Edward Lansing Cussler. *Diffusion: mass transfer in fluid systems*. Cambridge university press, 2009.
4. Foust, Alan S., Leonard A. Wenzel, Curtis W. Clump, Louis Maus, and L. Bryce Andersen. *Principles of unit operations*. John Wiley & Sons, 2008.
5. Geankoplis, Tansport. "Processes and unit Operations, 3rd Editions Prentice hall." *Englewood Cliffs, NJ* (1993).

Course Outcome:

Upon completion of the course students will be able to:

CO No.	Course Outcome	Cognitive level
1	**Recognize** laws of diffusion, **apply** them in mass transfer operation and **estimate** the number of stages in distillation.	1
2	**Interpret** the fundamentals of gas absorption and **evaluate** the height of packed column for absorption.	4
3	**Analyze** liquid–liquid extraction and **solve** problems on single stage extraction.	2
4	**Understand** the basics of crystallization and drying technology.	5

Course Title : Mass & Momentum Transfer Operations
Course Code: CHP-315

Course objectives:

To provide the hand-in-hand experience of lab-scale experiments on various types of equipment based on the theoretical understanding and its application learned in theory course.

Experiments:

1. Determination of diffusivity of Acetone in air; Acetic acid in water.
2. Determination of rate of drying of given sample.
3. Determination of Mass transfer coefficient in wetted wall column.
4. Determination of loading and flooding point in packed column.
5. Validation of Rayleigh equation (Differential distillation).
6. Determination of distribution coefficient of Single stage liquid -liquid extraction for Acetic acid- water-benzene system.
7. Determination of Reynolds Number & prediction of flow behavior.
8. Determination of coefficient of discharge of Venturimeter and Orifice Meter.

9. Determination of the coefficient of discharge for Triangular, Rectangular and Trapezoidal Notch.
10. Study of characteristics of pumps & compressors (Centrifugal & Reciprocating)

Reference Books

1. Departmental Practical Manual.

Course Outcome:

Upon completion of the course students will be able to:

S.No.	CO	Cognitive Level
1.	**Develop** the ability regarding analytical and data interpretation skills.	6
2.	**Understand** the scaling approach of understanding from Experimental to Industry applications.	2
3.	**Plan** an appropriate approach to experiment work and justify plans in the light of preliminary findings.	4
4.	**Demonstrate** safe working in the choice of method and apparatus.	2

Course Title: Process Design and Project Management
Course Code: CHL-312

Course objectives:

The objective of the course is to provide students with a firm grasp of the essential principles ofmanagement,projectidentificationprojectfeasibilityandprojectschedulingtechniquewith suitable examples. Students will able to understand HAZOP design and read the PID of the plant. Students will able to understand economics for chemicalprocesses.

Prerequisites:

Industrial Management and Economics (HML-202)

Course Content:

Unit -I

Project identification and its feasibility; project testing based on viability, risk & cost estimation; evaluation of project by different methods on the basis of visibility i) Net present valuemethod,ii)Methodofrateofreturnoninitialinvestment,iii)Payoutperiod,iv)Method ofdiscountcashflow,v)Capitalizedcostmethod,vi)Internalrateofreturnmethod,vi)Break evenchart;evaluationofprojectbydifferentmethodsonthebasisofriski)Profitabilityindex, ii) Demand fore casting, iii) Standard deviation approach; evaluation of project by different methods on the basis of cost i) Preparation of cost sheet and statements, ii) Preparation of profit loss statement.

Unit –II

New developments in management, CPM & PERT, principle and objective of CPM and PERT network diagram for calculation time duration.
Linear programming problem (Numerical based on each method) i) General simplex method ii) Primary& dual technique method iii) Direct simplex method iv) Graphicalmethod.

Unit –III

Cost analysis, fixed capital, working capital, preparation of store ledger account by pricing issue methods, LIFO, FIFO, simple average, weighted average.
Depreciation, significance of inadequacy and obsolescence, and depreciation methods.

Unit -IV
Layout and location, objective, principle; layout and location factors, equipment layout diagram (ELD); tank firm cum utility block diagram for different processes.

Unit -V
HAZOP: Introduction and guide word, application of HAZOP to processes with examples. PID: Basic symbols for various piping and instruments; development of PFD, P&ID, PDS for different processes.

Text/ Reference Books

1. S.D. Dawande*Process equipment Design*. Denett and Co FifthEdition
2. B.V. Pathak&M.S.Mahajan*IndustrialOrganization&Management,* NiraliPrakashan First Edition 1986
3. Peters, Max Stone, Klaus D. Timmerhaus, Ronald Emmett West, Klaus Timmerhaus, and Ronald West. *Plant design and economics for chemical engineers*. Vol. 4. New York: McGraw-Hill,1968.
4. Shreve, Randolph Norris, and Joseph A.BrinkJr.*ChemicalProcessIndustries*.No.4th Edition. McGraw-Hill Book Co.,1977.
5. Drydens*Outlines of Chemical Process Technology*, Third Edition,1997
6. D.B.Dhone*PlantUtilities*NiraliPrakashan, First Edition2008.

Course Outcomes:

Upon successful completion of the course, students will be able to-

CO No.	Course Outcome	Cognitive level
1	To **evaluate** feasibility of project.	5
2	To **apply** various methods of profitability evaluation.	3
3	To **identify** the new development in project management and optimization techniques.	2
4	To **apply** HAZOP analysis for safety of the process.	3

Course Code: PTC-301
Course Title: Architectural Coatings

Course Objectives:
1. The Paint Technocrat will have in depth exposure to Architectural Coatings.
2. The student will learn the constitution of Decorative paint and the basic role of paint ingredients.
3. The Technocrat will have in-depth exposure to manufacture, characterizations and applications of Trades Sales Paints.

Pre- requisites: Introduction to Coating Technology (PTC-201), Technology of Pigments (PTC-202)

Course Contents:

Unit-I: Formulation Mathematics & Steps

Cumulative specific gravity, drier additions, percentage volume solids; spreading rate and filmthickness; PVC & pigment binder ratio calculations, Oil absorption value, concept of CPVC & its determination, CPVC for latex paints, effect of CPVC on various properties of coatings. Formulation steps: Pre-requisites; Basic planning & initial decisions, perspectives of coating designs, fault diagnosis & formula adjustment; development of Paint formulations, multicoat systems.

Unit- II: Substrate- Coating Relations

Different types of substrates for decorative coating applications (glass, wood/plywood/ particle board/ chipboard/hardboard, metal, plastics, cement/Masonry etc.): Nature and morphology characteristics of surfaces, substrate – coating interactions, coating adhesion, specifications for preparation of surfaces requirement & salient characteristics of putty, sealer, stoppers/ fillers, primers, undercoats & topcoats.

Unit-III: Solvent Borne Architectural Coatings

Selection of binders, solvents, additives and pigmentation for formulation of solvent-based coatings for different surfaces in buildings: putty, sealer, stoppers/fillers, primers, undercoats & finishing coats/ enamels for metal, masonry, timber substrates; Physical drying paints, oxidative curing coatings, two component systems, stoving enamels.

Unit– IV: Latex Based Decorative Paints

Comparison of latex paints vs oil-based paints, manufacture of latexes: emulsion polymerization, mechanism of micelle formation, formulation and characteristics of different latexes, latex nanocomposites, stability of emulsions, formulation of latex paints for exterior and interior decorative paints for different surfaces in buildings: sealers, primers, stoppers/ fillers, undercoats; latex gloss enamels ; distempers, alkyd emulsions, flat wall paints; texture coatings, Calculations related to Paint Formulary.

Unit - V: Colour Matching

Colour perception, metamerism, spectral colour match, mathematics of colour matching, Munsell and Ostwald Colour Atlas, CIE chromaticity and Lab diagram; instrumentations for colour measurement, colour cards, procedure for shade matching at plant and paint shop, shade sensing and decision in relation to interior decoration; special effect paints, order of applications and preparation of surfaces, brushes, pads, and hand rollers as application devices; brief idea of spray painting, control of levelling and sagging, general idea of paint defects; weather resistance of exterior decorative coatings, DIY Market, coating calculations and costing for paint contractor.

Reference book:

Jones, Frank N., Mark E. Nichols, and Socrates Peter Pappas. Organic Coatings: Science and Technology. John Wiley & Sons, 2017.

Malshe, V. C. Basics of Paint Technology part I. Color Publications, 2010.

Swaraj, Paul. Surface Coatings: Science and Technology. J. Wiley & sons, 1985.

Lambourne, Ronald, and T. A. Strivens, eds. Paint and Surface Coatings: Theory and Practice. Elsevier, 1999.

Müller, Bodo, and Ulrich Poth. Coatings Formulation. Hanover: Vincentz Network, 2011.

Freitag, Werner, and Dieter Stoye, eds. Paints, Coatings and Solvents. John Wiley & Sons, 2008.

Course Outcome:

Upon successful completion of the course, students will be able to

Co.No.	Course Outcomes	Cognitive Level
1.	**Design** of coating formulation and understanding mathematics & steps.	6
2.	**Formulation** development of solvent borne/water borne architectural coatings in relation to their functions/end use.	6
3.	Selection, **comparison** and assessment of polymers, pigments, solvents and additives in Formulations of solvent borne/water borne architectural coatings.	5

4.	**Understanding** of DIY Market, coating calculations and costing for paint contractor in reference to end use.	2

Course Code: PTC-301
Course Title: Architectural Coatings (Pr)

Course Objectives:
The Technocrat will be exposed to laboratory practices related to:
1. The determination of physical and chemical characteristics of solvents, plasticizers and coating additives.
2. The general characteristics of trade sales paints / architectural coatings.
3. Processing and characterisation of varnishes and lacquers

Pre-requisites:
Introduction to Coating Technology (PTC-201) Technology of Pigments (PTC-202)

Course Contents:

Minimum of ten experiments with due coverage of following:
1. Analysis of solvents - solvent power, distillation range, evaporation rate (evaporation of mixed solvent, retarder solvent, evaporation of solvents from coating films, flash point, refractive index, moisture content/ hygroscopicity, acidity/ alkalinity etc.
2. Determination of surface tension and analysis of surface additives, dispersing agents and antifoams; Use of Ford Cup/ Gardner Tubes for estimation of viscosity; Analysis of rheological additives in paints.
3. Surface and Hard Dry for air drying paints. Estimation of covering power, wet opacity & dry hiding (chequer board/ contrast ratio/ spectral methods) and coating calculations related to practical painting
4. Processing and Characterization of Varnishes such as french polish, knotting, copal varnish, synthetic resin varnishes, preparation of lacquers etc. alkyd enamel, nitrocellulose-based fillers, stoving enamels for metal and wood substrates.

Text/ Reference Books:
1. Departmental Practical Manual.

Course Outcome:
Upon successful completion of the course, students will be able to-

Co.No.	Course Outcomes	Cognitive Level
1.	**Understanding** of general properties/characteristics of architectural coatings.	2
2.	**Evaluation** of solvents, plasticizers and other additives in paint formulations.	5
3.	The techniques of **analysis** of general coating characteristics	4
4.	Empirical skills for **formulations** of varnishes and lacquers.	6

Course Code: PTC-302
Course Title: Chemistry & Technology of Polymers

Course Objective:

1. The paint technocrat will have in depth exposure to high performance polymers.
2. The student will learn the structure and properties relationship of various organic and inorganic polymers.
3. The technocrat will have in-depth exposure to manufacture, characterisations and applications of high-performance polymers.

Pre -requisites:

Introduction to Coating Technology (PTC-201) Technology of Pigments (PTC-202)

Course Contents:

Unit-I

Polyurethane resin: Structures and characteristics of different Isocyanate, Isocyanate prepolymers, commercial polyisocyanate, polyols and catalysts for polyurethane coatings, polyurea, urethane oils and alkyds, polyols adducts, blocked isocyanates, moisture curing polyisocyanates, formulation of solvent borne and waterborne PU coatings, PU dispersions, curing mechanism for PU coatings, safety aspects of handling of isocyanates, applications in surface coating.

UNIT II

Epoxy resins and Polyamides: Use of epichlorohydrin, bisphenol A/F and novolac derivatives, glycidyl methacrylate, Chemistry of synthesis: Plants and processes for manufacture, chemistry and their selection one pack and two pack systems, epoxy ester, hardeners for epoxy coatings, applications in surface coating. Polyamides: Polyamides as hardener for epoxy resin, chemistry and technology of adducts, properties and applications in surface coating.

UNIT III

Acrylics and Polyester: Structure & properties of acrylic monomers, role of initiators, solvents, chain transfer agents, mechanism of polymerization (free radical/ anionic /cationic/ thermal / redox etc), thermoplastic and thermosetting acrylic, water reducible acrylics, application in coatings. Polyester resins: Selection of polyols & polybasic acids, polyesterification chemistry, manufacturing process and plant, properties, crosslinking, formulations and applications of hydroxyl/ carboxyl terminated saturated and unsaturated polyesters, High solids and water reducible polyesters.

Unit IV: Phenolic & Amino resins:

Chemistry of novolac and resols, plant and process for manufacture, properties and characterization of phenolic resins; modified phenolics, synthesis and application in coatings. Amino resins: Urea, benzoguanamine and melamine formaldehyde resins, chemistry of methylolation and etherification, plant and process for manufacture, self-condensation; MF– polyol reactions in coatings, properties and characterization of amino resins; coating formulations and properties of acrylic/ polyester /alkyd amino stoving coatings.

Unit-V: Cellulose Esters and Inorganic Polymers:

Cellulose Esters: Manufacturing of cellulose nitrate with detail plant and process setup, classification and characterization of cellulose nitrate, solvents and plasticizers for cellulose lacquers, modifying resins for cellulose nitrate, cellulose acetate and cellulose acetobutyrate, Formulation of lacquers for automotive and furniture coating, safety regulations. Inorganic Polymers: Formulation, properties and uses of silicone resins, water glass coatings, alkyl silicates, orthosilicates, reactive silanes, silicone and silicate modified resin for coatings, moisture cure silicone resin, thermosetting fluorinated resins, sol-gel coatings

Reference books:

1. Jones, Frank N., Mark E. Nichols, and Socrates Peter Pappas. Organic Coatings: Science and Technology. John Wiley & Sons, 2017.
2. Stoye, Dieter, Werner Freitag, and Günter Beuschel, eds. Resins for coatings: chemistry, properties, and applications. Hanser Verlag, 1996.
3. Swaraj, Paul. Surface Coatings: Science and Technology. J. Wiley & sons, 1985.

4. Lambourne, Ronald, and T. A. Strivens, eds. Paint and Surface Coatings: Theory and Practice. Elsevier, 1999.
5. Oldering, P. K. T., and G. Hayward. "Resins for surface coatings." Volume II, SITA Technology, London (1987).

Course Outcome:
Upon successful completion of the course, students will be able to-

C0.No.	Course Outcomes	Cognitive Level
1.	**Synthesis** techniques of different high-performance polymers.	6
2.	**Assessing** the structure-property relationship in high-performance polymers and polymerization/ curing methods.	4
3.	The applications of different high-performance polymers in general and their utilizations in surface coating industries.	3
4.	**Selection** of resin chemistry in paint formulation for specific application.	4

Course Code: PTC-302 (Pr)
Course Title: Chemistry & Technology of Polymers (Pr)

Course Objective:
The Technocrat will be exposed to laboratory practices related to the synthesis and analysis of acrylic, epoxy, urethane and polyamide resins.

Pre-requisites:
Introduction to Coating Technology (PTC-201) Technology of Pigments (PTC-202)

Course Contents:
Minimum of twelve experiments with due coverage of following:
1. Preparation of acrylic and vinyl resins by different methods: suspension, emulsion, bulk, solution, nonaqueous dispersion
2. Synthesis of epoxy resin, curing of epoxy resins, preparation of reactive and non-reactive polyamides, epoxy esters
3. Synthesis of urethane alkyds, blocked isocyanates, isocyanates adduct, polyurethane (single pack, two pack)
4. Analysis of synthetic resins: amine value, epoxide equivalent weight, isocyanate content, curing time and pot life, changes in properties with changes in resin-hardener combinations, viscosity and molecular weight determination etc

Source:
1. Departmental Practical Manual.

Course Outcome:
Upon successful completion of the course, students will be able to-

Co.No.	Course Outcomes	Cogniti ve Level
1.	**Synthesis** of acrylic, epoxy, urethane and polyamide resins.	6
2.	**Understanding** of various techniques of polymerizations	2
3.	**Evaluation** of curing and degree of polymerization.	5
4.	**Characterization** and testing of high- performance polymers	5

Elective-I (Open Elective) Course Code: PTL-305
Course Title: Specialty Pigments and Additives in Coatings

Course Objectives:

The Paint Technocrat will have in depth exposure to Specialty Pigments and Additives in Coatings.
1. The student will learn about the metallic and pearl effect and changes in pigmentary properties in reference to nano size.
2. The Technocrat will have exposure to Mechanism, dosing and Trade information of coating additives and surfactants.

Course Content:

Unit -I : Metallic, Interference and Cholesteric Pigments
Aluminum, copper, zinc dust, bronze, nickel stainless steel, lead powders and pastes; Nacreous, luminescent (fluorescent/phosphorescent) pigments, optical principles; substrate free pearlescent pigments, special effect pigments based on mica, metal oxides etc., pigments based on liquid crystal polymer.
Unit -II : Functional and Nano pigments:
Antifouling pigments-cuprous oxide, other copper compounds, mercuric oxide, barium metaborate, organotin pigments. Manufacture and properties of nano pigments: alumina, silica, titanium dioxide, iron oxides, zinc oxides, silver, CaCO3, etc., variables affecting particle size aggregation and crystal structure, use of nano pigments as spacing extenders / functional additive in coatings.
Unit -III: Surfactants and surface additives:
Anionic, cationic, non-ionic and amphoteric surfactants; polymeric surfactants, Gemini surfactants, HLB value, CMC, Kraft point; role of surfactants as- emulsifier, wetting agents, dispersing agents and surface additive; polyacrylate, silicone and fluoropolymers as flow and levelling agents.
Unit -IV: Specialty additives in solvent borne coatings:
Antisettling agents, additives for rheology control, adhesion promoters, antiskinning agents, light stabilizers (UV absorbers, antioxidants, HALS), moisture scavengers, slip additives, hammer and wrinkle finish additives, conductivity control additives etc.
Unit -V: Specialty additives for Water Borne Coating:
Auxiliary and coalescing solvents, neutralization agents, thickeners, antifoaming agents, antifreeze-thaw, preservatives (in- can/film), mildew agents, corrosion inhibitors etc.

Text/ Reference Books

1. Jones, Frank N., Mark E. Nichols, and Socrates Peter Pappas. Organic Coatings: Science and Technology. John Wiley & Sons, 2017.
2. Swaraj, Paul. Surface Coatings: Science and Technology. J. Wiley & sons, 1985.
3. Karsa, D. R.; Davies, W. D., Eds., Waterborne Coatings and Additives, Royal Society of Chemistry,Cambridge, 1995.
4. Buxbaum, Gunter, ed. Industrial inorganic pigments. John Wiley & Sons, 2008.
5. Berte, J. N. "High Performance Pigments, ed Smith HM." (2002): 27-40.
6. Bieleman, Johan, ed. Additives for coatings. John Wiley & Sons, 2008.
7. Herbst, Willy, and Klaus Hunger. Industrial organic pigments: production, properties, applications. John Wiley & Sons, 2006.
8. Calbo, Leonard J. Handbook of coatings additives. 1987.

Course Outcomes:

Upon successful completion of the course, students will be able to

Co.No.	Course Outcome	Cognitive level
1	Optical effects and evaluation of Metallic, Interference and Cholesteric Pigments in coatings.	5
2	Synthesis, properties and applications of Functional and Nanopigments.	5
3	Constructive, corrective and comparative role of various additives in solvent borne, waterborne and other coatings.	5

4	Dosing and trade information of Additives in Coatings.	2

Elective-I (Open Elective) Course Code: OTL-305
Course Title: Technology of Perfumery and Cosmetics

Course Objectives: This course provides a thorough knowledge about different essential oil, perfumery synthetics and cosmetic ingredients. Students shall acquire various extraction methodologies in recovery of essential oils, their physio-chemical properties and applications. Also, the course will cover raw material for different cosmetic preparations.

Course Content:

Unit -I

Essential oils: Chemistry, source materials, production methods

Production, properties and applications of essential oils (Rose, Jasmine, Khus, Sandalwood, Palmarosa, Lemongrass, Peppermint, Orange)

Unit –II

Physio-chemical properties of essential oils: Colour, specific gravity, refractive index, optical rotation, solubility, congealing point, evaporation residue, acid value and ester value.

Analysis of essential oils: Alcohol, Aldehyde, Ketones and Phenol content.

Unit- III

Grading and standardization of essential oils; common adulterants and their detection. Perfumery: History and its function, mechanism of smelling, classification & blending of perfume ingredients, perfumery isolates (Menthol, Geraniol and Musk)

Unit- IV

Synthetic perfumery materials and fixatives (Camphor, Thymol, Citral, Vanillin, Cumarin, Benzyl acetate, Benzyl benzoate)

Production, properties and applications: Hair oil & dyes, Shaving creams and Depilatories

Unit –V

Production, function and properties of cosmetic products: Face cream, Face powder, Talcum powder, Toothpaste/powder, Shampoo, Lipsticks and Nail polish

Text/ Reference Books

Valerie Ann Worwood "The Complete Book of Essential Oils and Aromatherapy"
Ernest Guenther "The Essential Oils" Volume-I
Sonia Malik "Essential Oil Research" Springer International Publishing
"Handbook of Perfumes with Formulations" Engineers India Research Institute.
Nigel Groom "The Perfume Handbook" Springer
Steffen Arctander "Perfume and Flavor Materials of Natural Origin"
S.K. Singh "Handbook on Cosmetics (Processes, Formulae with Testing Methods)"
H. W. Hibbott. "Handbook of Cosmetic Science" 1st Edition

Course Outcomes:

Upon successful completion of the course, students will be able to

CO.No.	Course Outcome	Cognitive level
1	**Understand** the fundamental of essential oils and **propose** methods of their production.	2
2	**Differentiate** the principles behind the physio-chemical analytical techniques in estimation of quality parameters of essential oils.	2
3	**Devise** the concepts of perfumery, blending of perfumes and **outline** the use of synthetic perfumery	6

	materials.	
4	**Propose** the production techniques and **illustrate** the functions of ingredients in cosmetics products.	6

Elective-I (Open Elective) Course Code: FTL-305

Course Title: Advanced Technology in Food Packaging

Course Objectives:

1. To study basic packaging materials, their properties, types of packaging, sealingand lamination process.
2. To study newer packaging technologies used for food products.
3. To estimate shelf life of packaged products.
4. To study packaging of soft drink and alcoholic beverages.

Prerequisites: ----Not Applicable----

Course Content:

Unit –I

Packaging as a method for conservation and protection of foods, different packaging material and their properties including barrier properties, strength properties, optical properties etc.Glass, Aluminium, tin, paper, plastic and composites. Sealing of metallic and plastic containers. Types of food packaging

Unit –II

Flexible packaging, laminated packaging and retortable pouches and biodegradablepackaging material. Concept and calculation of shelf life of laminate, wine in PET, glass bottle; shelflife based on browning, vitamin loss and microbial count in food container. Safety and testing of packaging containers.

Unit –III

Active packaging system: - Packaging requirement for different moisture level food products, Aseptic processing and packaging of fruits & vegetables, milk and milk products

Unit – IV

Product-Packagecompatibility:-MicrowavablePackaging,MAPoffreshfruitandvegetable, vacuum and MAP of meat and meat products. Packaging of breakfast cereals, bakery and confectionaryproducts

Unit –V

Packagingofsoftdrink,alcoholicbeverages,distilledspirits,frozenfood,futuretrendsinfood packaging: intelligent/ smart packaging.

Text/ Reference Books

1. HandbookoffoodpackagingbyF.APaineandH.Ypaine.,Publisher:BlackisandSonLtd London (1983)
2. Food Packaging Principles and Practice: Gordon L. Robertson
3. Modern processing and distribution system for food edited by F. APaine
4. Food and packaging interaction by Risch. S. H., Publisher: American chemical Society, Washington(1991)

5. PackagingmaterialsandcontainersbyPaineF.A.,Publisher:BlackisandsonsLtd,London (1983)
6. Mathlouthi, M. Food Packaging and Preservation. Gaithersburg: Aspen,1999
7. Paine F. A . Packaging media Publisher: Blackis and son Ltd; Bishop Briggs(1977)
8. Bureau, G., and J. L. Multon. Food Packaging Technology. New York, n.d. (1996)
9. Chemistry of Food Packaging by Swalam C.M., American Chemical Society, Washington D. C. 1974.
10. Packaging. Rockport, MA: Rockport Publishers,1995.

Course Outcome:

Upon successful completion of the course, students will be able to

CO No.	Course Outcome	Cognitive level
1	**Recognize** and **classify** food packaging materials and their use.	6
2.	**Differentiate** active packaging, aseptic packaging, MAP, vacuum packaging, smart packaging, microwave able packaging.	2
3.	**Estimate s**helf life of food packaged.	2
4.	**Device** packaging of, soft drink, alcoholic beverages, and frozen food.	6

Elective-I (Open Elective) Course Code: PLL-304
Course Title: Polymer Rheology

Course Objectives:

1. To understand the flow properties of polymers in terms of various models to study viscoelastic behavior of thepolymers.
2. To know the thermo viscoelastic behavior of polymers during processing andselection of design of processingdevice.
3. To understand the processing of various types of polymers, selection of device for processing on the basis of flowproperties.

Prerequisites: ----Not Applicable----

Course Content:

Unit -I

Rheological Principles: Rheological Parameters, relationship between rheological parameters, Rheological systems: purely elastic, viscous, Types of fluids: Newtonian and Non Newtonian fluids, Viscoelastics fluids, Rheological or Constitutive equations.

Unit -II

Viscoelastic Nature of Polymers: Elasticity moduli and their time dependence, static and dynamic experiments to understand the time dependence, tan, its significance and method of determination, models of viscoelasticity, mechanical models such as Maxwell, voight, combinations of Maxwell and Voight model stimulate viscoelastic behavior, salient features of molecular theories of viscoelasticity.

Unit -III

Glass Transition, Theories to determine the glass transition i.e. Dillatometric, Heat capacity, measurement, Thermomechanical, Measurement of modulus of elasticity, effect of Tg on molecular mass, kinetic chain flexbility and chemical constituent, Importance of Tg and Tm.

Unit -IV

Viscoelastic behavior of Polymer solution and melts stress-strain curves for Polymers, creep curves of Polymeric material, elastic deformation, irrecoverable followdeformation.
Rubber like deformation, Time-temp superposition (WLFEquation)

Unit -V

Methods to determine shear viscosity by capillary, parallel plate and cone and plate Rheometer, Measurement of normal stresses, Application of rheology to polymer processing.

Text/ Reference Books

1. P.N.Cogswell, Polymer Melt Rheology, A guide for Industrial Practice, George Godwin, Second Edition,1981.
2. RichardC.Progelh of and James L. Throne, Polymer Engineering Principles, Hanser Publishers, New York,1993.
3. John M. Dealy and Kurt F. Wissburn, Melt rheology and its role in plastics processing, Chapman, London,1995.R.S. Lenk, Polymer Rheology, Applied Science, London,1978.
4. J.D. Ferry, Viscoelastic Properties of Polymers, john Wiley & Sons, New York,1986.
5. Chang Dae Han. Rheology in Polymer Processing, Academic Press, New York,1976.
6. R.J. Crawford, Plastics Engineering, Butterworth - Heinemann, Oxford,1998
7. B.R. Gupta, Applied Rheology in Polymer Processing, Asian Books Pvt. Ltd. 1st Edition, 2005.

Course Outcomes:

Upon successful completion of the course, students will be able to

CO No.	Course Outcome	Cognitive level
1	Flow behavior of the polymers and various models used for **determination** of flow properties.	3
2	**Design** features of the processing device on the basis of processing parameter as temperature, pressure, shear rate.	6
3	Proper **selection** of processing equipment with respect to change in polymer, polymer flow properties.	4

Elective-I (Open Elective)Course Code: CHL-320
Course Title: Nanoscience and Nanotechnology

Course Objectives:

The objective of the course is to introduce students about emerging field of Nanoscience and Technology. Students will learn about properties of nanomaterials and their applications.

Prerequisites: ----Not Applicable----

UNIT-I
Quantum chemistry, Solid state Physics, Nanomaterial & Manufacturing, Renewable energy generation, Nanotechnology in drug delivery, Nanotechnology in cosmetics, Bio-nanotechnology, Nanotechnology & information technology, Nanotechnology in agriculture and food industry, Environmental nanotechnology, Nanotechnology Health risk.

UNIT-II
Synthesis methods of nanostructures: Top-Down and Bottom-up approach of synthesis, Chemical Routes for Synthesis of Nanomaterials: Chemical precipitation andco-precipitation; Sol-gel synthesis; Microemulsions or reverse micelles; Solvothermalsynthesis.

UNIT-III
Nanostructures and its applications: Carbon Nanotubes (CNT), Graphenes, Fullerenes, Nano Peapods, Quantum Dots and Semiconductor Nanoparticles Metal-based Nanostructures (Iron Oxide, Silver, Copper Nanoparticles) Nanowires Polymer-based Nanostructures including dendrimers, nanofillers like clay, $CaCO_3$, $CaSO_4$.

UINT-IV
Nanocatalysis: Nanomaterials as catalysts for a variety of homogeneous and heterogeneous catalysis applications. Impact of the intrinsic properties of nanomaterials on catalysis,Various methods like Chemical Reduction Method, Thermal, Photochemical and Sonochemical Reduction Method, Applications of Nanocatalysis in ChemicalIndustry.

UNIT-V
Characterization techniques in analysingNanomaterials: Scanning/transmission electron microscopy (SEM/ TEM), XRD, Atomic Force Microscopy, Particle size analyser (PSA) and their applications.

Text/ Reference Books

1. Nanochemistry: A Chemical Approach to Nanomaterials, Geoffrey A. Ozin, Andre C. Arsenault, Royal Society of Chemistry, Cambridge, UK, 2005.
2. Chemistry of Nanomaterials: Synthesis, Properties and Applications C. N. R. Rao, Achim Muller, A. K Cheetham, Wiely-VCH,2004.
3. Metal Nanoparticles: Synthesis Characterization & Applications, Daniel L. Fedlheim, Colby A. Foss, Marcel Dekker,2002.

4. Nanostructures and Nanomaterials - Synthesis, Properties and Applications - Cao, Guozhong, Ying Wang, World Scientific,2011.
5. Nanoparticles and Catalysis, Didier Astruc (Editor), Wiley-VCH Verlag GmbH & Co. KGaA,2008

Course Outcomes:

Upon successful completion of the course, students will be able to

Co. No.	Course Outcome	Cognitive level
1	**Choose** appropriate synthesis technique to synthesize nanostructures of desired size, shape and surface properties.	3
2	**Correlate** properties of nanostructures with their size, shape and surface characteristics.	4
3	**Select** appropriate analytical tools for characterization of nanomaterials.	4
4	**Appraise** on application of nanomaterials as catalyst.	5

Course Code: NC-303

Course Title: Essence of Indian Traditional Knowledge

Course Objectives:

1. The course aims at imparting basic principles of thought process, reasoning with emphasis on sustainability connecting society and nature.
2. TofacilitatethestudentswiththeconceptsofIndiantraditionalknowledgeandtomake them understand the importance of roots of knowledgesystem.
3. To focus on Indian Knowledge System, Indian perspective of modern scientific worldview and basic principles of Yoga and holistic health caresystem.

Prerequisites: ----Not Applicable----

Course Content:

Unit-I

Introduction to traditional knowledge: Traditional knowledge, nature and characteristics, scope and importance, kinds of traditional knowledge, physical and social contexts in which traditional knowledge develop, historical impact of social change on traditional knowledge systems. Indigenous Knowledge (IK), characteristics, traditional knowledge vis-à-vis indigenous knowledge, western knowledge. Indian personalities in traditional knowledge, linking science and the rural

Unit-II

Protection of traditional knowledge: Need for protecting traditional knowledge (TK), significance of TK protection, global mechanisms of protection and sharing, recognition and protection value of TK in global economy, role of government to harness TK.

Unit-III

Legal framework and TK: Scheduled Tribes and Other Traditional Forest Dwellers (RecognitionOfForestRights)Act(2006);PlantVarietiesProtectionandFarmer'sRightsAct (2001) (PPVFRAct); Biological Diversity Act (2002) and Rules (2004); Protection of Traditional Knowledge Bill (2016); Geographical Indicators Act(2003).

Unit-IV

Traditionalknowledgeandintellectualproperty:SystemsofTKprotection,Legalconcepts for the protection of TK, Certain non IPR mechanisms of traditional TK, Patents and TK, Strategies to increase protection of TK, Global legal fora for increasing protection of Indian Traditional Knowledge.

Unit-V

Traditional knowledge in different sectors: Traditional knowledge and engineering, Traditional medicine system, TK and biotechnology, TK in agriculture, Food and healthcare needs of Traditional societies, Importance of conservation and sustainable development of environment, Management of biodiversity, Food security of the country and protection of TK.

Text/ Reference Books

1. Sengupta, Nirmal, Nirmal Sengupta, and Ghosh. *Traditional Knowledge in Modern India*. Springer India, 2019.
2. Jha, Amit. *Traditional knowledge system in India*. Atlantic Publishers & Distributors, 2009.
3. Basanta Kumar Mohanta and Vipin Kumar Singh *Traditional Knowledge System and Technology in India*, Pratibha Prakashan2012.
4. Kapoor, Kapil, and Michel Danino. "Textbook of" Knowledge Traditions and Practices of India"." *Ancient Science of Life* 32, no. 1 (2012):59.

E-Resources:

1. https://www.youtube.com/watch?v=LZP1StpYEPM
2. http://nptel.ac.in/courses/121106003/

Course Outcomes:

Upon successful completion of the course, students will be able to

CO No.	Course Outcome	Cognitive level
1	Ability to **understand**, connect and explain basics of Indian Traditional knowledge modern scientific perspective	2
2	Know the need and importance of protecting traditional knowledge.	2
3	Know the various enactments related to the protection of traditional knowledge.	2
4	**Understand** the concepts of Intellectual property to protect the traditional knowledge.	2

SEMESTR-VI

Course Code: CHL-316

Course Title: Chemical Reaction Engineering

Course objectives:

1. This course will highlight basic concepts of kinetics and rate laws along with interpretation of rate data.
2. Thecoursewilldealwithproblemsinvolvingdesign&ratingofidealreactorsincluding heat effects, multiple reactions.
3. The course will also provide basic understanding of catalysts and their applications to industrial processes.

Pre-requisites:

Material and Energy Balance Calculations (CHL-206)
Chemistry-I (BSC-103)

Course Content:

Unit –I

Reactions and reaction rates - stoichiometry, extent of reactions, conversion, Selectivity Reaction rate fundamentals - elementary reaction sequences, steady state approximation and rate limiting step theory.

Unit –II

Analysis and correlation of experimental kinetic data - data collection & plotting, linearization of rate equations, differential and integral method of analysis**.**

Unit –III

Ideal reactors - generalized material balance, design equations, graphical interpretation. Sizing and analysis of ideal batch, mixed (CSTR), plug flow and recycle reactors – solving design equations for constant and variable density systems, reactors in series and parallel.

Unit –IV

Multiple reactions - conversion, selectivity, yield, series, parallel, independent and mixed series-parallel reactions.

Unit –V

Introduction to Catalysis, homogeneous and heterogeneous catalysis. Preparation and characterization of catalysts. Physical and chemical adsorption, Adsorption isotherms, Determination of BET surface area and pore volume of the Catalyst .

Text/Reference Books

1. H. Scott Fogler *Elements of Chemical Reaction Engineering* 2nd Edition, Prentice Hall 2001.
2. OctaveLevenspiel*ChemicalReactionEngineering*by,3rd Edition, John Wiley & Sons 2001

Course Outcome:

Upon completion of the course the students will be able to:

S.No.	CO	Cognitive Level
1.	**Design** chemical reactors involving heat effects optimally using minimum amount of data.	6
2.	Fix some problems related to operability and productivity.	2
3.	**Apply** methods of Catalysts' synthesis and catalyst characterization.	3
4.	**Understand** and **interpret** kinetics data.	2

Course Code: HML-309
Course Title: Psycho-Social Dimensions of Industrial Management

Course Objectives:

1. To prepare and develop the students for successful career that meets the global Industrial and Corporate requirements.
2. To guide the students about perception and attitude development to excel in organisation setting
3. To provide an environment for students to work on Multidisciplinary projects as part of different teams to develop their team building capabilities like leadership, motivation, teamwork etc.
4. To introduce professional ethics and codes of professional practices in Industry.

Pre-requisites:

Industrial Management and Economics (HML-202)

Course Content:

Unit –I

Concept and meaning of organization behaviour, Features & foundations of organization behaviour, Role of organization behaviour, Theories of organization behaviour, Behaviour Process, Innovation & creativity in organization

Unit –II

Perception: Meaning and definition, Factors influencing perception process, Perception Process, Perception and individual decision making, Nature of attitudes, Components of attitude, Formation of attitudes, Functions of attitudes, Work related attitudes: Job satisfaction & organizational commitment, Attitudes, values & organization behaviour

Unit –III

Motivation: Nature & Importance, Theories of Motivation, Content Theories and Process theories: Evaluation & criticism, Self motivation

Unit –IV

Leadership: Nature, Leadership and management, Importance, Leadership styles and their implications, Trait and behavioural approach of leadership, Decision making: Nature, types &conditions of decisions, Decision making process & styles

Unit –V

Nature and sources of ethics, Ethical dilemmas, Resolving dilemmas, Ethical decision making, Ways of managing ethics, Corporate social responsibility

Text/ Reference Books

1. Aswathappa, Kalupally, and G. Sudarsana Reddy. *Organisationalbehaviour*. Vol. 20. Himalaya Publishing House, 2009.
2. Martin, John. *Organizational behaviour and management*. Cengage learning EMEA, 2005.
3. Saiyadain, Mirza S. *Organisationalbehaviour*. Tata McGraw-Hill Education, 2003.
4. Mishra, MahaNarain. *Organisationalbehaviour*. Vikas Publishing House Pvt Ltd, 2001.
5. Robbins, Stephen P. *Organisationalbehaviour: global and Southern African perspectives*. Pearson South Africa, 2001.
6. Stoner, *Management-II*. Pearson Education India.

Course Outcome:

Upon completion of the course the students will be able to:

S.No.	CO	Cognitive Level
1.	**Develop** the process of individual behaviour and perpetual process along with conditioning of thinking process.	6
2.	**Identify** the concept and process of motivation and leadership.	2
3.	**Correlate** human behaviour, social skills, innovations, and creativity to improve workplace dynamics.	4
4.	**Develop** the knowledge of ethical considerations and administrative regulations by applying the theories and principles of Management in practice to improve performance of individual employee at a workplace.	6

Course Code: PTL-303
Course Title: Eco-friendly Coating Technologies

Course Objective:

1. the paint technocrat will have in depth exposure to diverse eco-friendly coating technologies.
2. The student will learn about the formulation and manufacture of electrodeposition, radiation cure and powder coatings.
3. The technocrat will have exposure to diverse applications and emerging trends of ecofriendly surface coatings.

Course Prerequisites:

Introduction to Coating Technology (PTC-201) Technology of Pigments (PTC-202) Architectural Coatings (PTC-301)

Course Content:

Unit I:

Waterborne coatings for Industrial /OEM applications Properties of water as solvent, classification and characteristics of waterborne coatings, solubility and dispersibility of paint resins in water, water soluble polymers- starch, gums, cellulose ethers (CMC, HEC), PVA, hydrosols; water-reducible binders (e.g. alkyds, polyesters, polyacrylates, epoxides, and epoxy esters), viscosity anomaly of water-reducible paints; PU dispersion, non-aqueous dispersions; hybrid systems, crosslinking /oven curing of water-borne coatings, film defects, industrial uses and environmental aspects

Unit -II:

Electrodeposition Coatings Anionic and Cationic: detail characterization and comparison, chemistry of electrodeposition, effect of different variables on electrodeposition throws and rupture voltage, plant set up, synthesis of resins and crosslinkers for electrodeposition, self-crosslinking systems, autophoretic coatings, typical paint formulations; electrodeposition automotive primer formulations and other applications; recent developments in electrodeposition coatings.

Unit - III:

Radiation Cure Coatings Fundamentals of photopolymerization-UV curing (free radial & cationic) & electron beam cure coating, free radical, and cationic photo initiators: structure and characterization mono and multi-functional monomers; free radical curing oligomers and polymers; epoxy resin for cationic cure; inhibitory effects and remedial measures; formulation principles, application of radiation curable coatings in various industries.

Unit – IV:

High solid coatings High solid coating, VOC regulations, necessities and possibilities, control of molecular weight & molecular weight distribution, functional group selections; high solid alkyd, polyester & acrylics; high solid primers and topcoats; control of sagging, sag control agents, acrylic microgels; formulation of solvent borne coatings for low VOC.

Unit -V:

Powder Coatings Introduction to powder coating; Binders for thermoplastic (PVC/PVDF/Nylons/Polyolefins) & thermosetting powder coating (Epoxy-DICY/ Phenolic Resins, Hybrid Polyester, PolyesterTGIC, PU Polyester, Acrylics), additives for powder coatings, formulations of powder coatings, UV curable powder coatings for wooden surfaces, manufacture of powder coating, applications of powder coatings.

Text / Reference Books:

1. Jones, Frank N., Mark E. Nichols, and Socrates Peter Pappas. Organic Coatings: Science and Technology. John Wiley & Sons, 2017.
2. Swaraj, Paul. Surface Coatings: Science and Technology. J. Wiley & sons, 1985.
3. Lambourne, Ronald, and T. A. Strivens, eds. Paint and Surface Coatings: Theory and Practice. Elsevier, 1999.
4. Müller, Bodo, and Ulrich Poth. Coatings Formulation. Hanover: Vincentz Network, 2011.
5. Misev, Tosko Aleksandar. Powder coatings: chemistry and technology. John Wiley & Sons Inc, 1991.
6. Lehr, William D. Powder coating systems. McGraw-Hill Companies, 1991.
7. Chemistry and Technology of formulating UV Cure Coatings, Inks, and Paints", Edited by PKT Oldring, Vol.1-5, Sita Technology Limited, London UK 1991-94.
8. Koleske, Joseph V. Radiation curing of coatings. No. 45. West Conshohocken, PA: ASTM international, 2002

Course Outcome:

Upon completion of the course, the students will be able to:

Co.No.	Course Outcomes	Cognitive Level
1.	**Assess** various environmental compliant practices in coating industry.	2

2.	**Propose** ecofriendly coating formulations for Industrial /OEM applications	6
3.	**Interpret** chemistry of binders to develop green coatings. Compare properties of various radiation cure monomers, prepolymers, and photo initiators to formulate coatings.	3

Course Code: PTP-304
Course Title: Formulation and Processing of Paints (Pr)

Course Objectives:
The Technocrat will be exposed to laboratory practices related to the formulations of decorative coatings and use of dispersion machineries in their processing.

Pre-requisite:
Introduction to Coating Technology (PTC-201) Technology of Pigments (PTC-202) Architectural Coatings (PTC-301)

Course Contents:
Minimum of twelve experiments with due coverage of following: Formulations, calculations of mill base compositions and processing of Architectural Coatings (covered under PTC-301) on different paint dispersion machineries: sealers, putties, distempers, emulsion paints, solvent borne primers/ undercoats/ topcoats.

Reference Books:
1. Departmental Practical Manual.

Course Outcome:
Upon completion of the course, the students will be able to:

Co. No.	Course Outcomes	Cognitive Level
1.	**Understanding** and calculation of mill base compositions of architectural coatings.	2
2.	**Formulation** and processing of sealers, putties, primers, undercoats and topcoats.	6
3.	**Constructive** and comparative use of ball mills, pug mill, triple roll mill, bead mill etc as paint processing and dispersion machineries	6
4.	**Proposing** cost effective dispersion of different paint formulations using various mills.	6

Elective-II (Open Elective)
Course Code: FTL-306
Course Title: Treatment and Disposal of Food Industrial Waste

Course Objectives:
1. To study composition, sources, permissible and health hazards of industrial waste water pollutants
2. To study various techniques of wastewater treatment by physical chemical and biological

methods

3. To study, design and operational problems of biological treatment and value addition to waste
4. Estimation of kinetic coefficients for treatment with design problem.

Prerequisites: ----Not Applicable----

Course Content:

Unit-I

Physical, chemical and biological characteristics of food industry waste. Composition of typical industry waste. BOD /COD and characterization of effluent. Typical BOD of some food industrial effluents and their discharge limit, types and point sources of industrial pollutants and adverse effect by their discharge.

Unit-II

Primary treatment, secondary and tertiary treatments by physical, chemical and biological methods. Process design criteria**.** Sanitary disposal of sludge**.**

Unit-III

Role of micro-organisms in food industry waste. Application of kinetics to biological treatment. Determination of kinetic coefficients with some design problems.

Unit -IV

Activated sludge process and modified activated sludge process. Nitrification and denitrification, Aerobic lagoons, aerated aerobic lagoons, aerated facultative lagoons, Design criteria for A.S.P and stabilization ponds

Unit-V:

Trickling filters, Rotating biological contactors, design criteria and problem on RBC and trickling filter design. By product recovery and value addition to the waste.

Text/ Reference Books

1. Rao, C. S. Environmental Pollution Control Engineering. New Delhi: New Age Internat., 2011
2. Arceivala Sol J., AsolekarShyamR. Wastewater Treatment for Pollution Control and Reuse Tata McGraw-Hill Education,2006
3. Green, John H., and AmihudKramer. Food Processing Waste Management. Westport, Conn: AVI Pub. Co,1979
4. Bartlett, Ronald Ernest.Wastewater Treatment:PublicHealthEngineeringDesInMetric., Applied Science Publishers Ltd,1971
5. Metcalf, L., H. P. Eddy, and Georg Tchobanoglous. Wastewater Engineering: Treatment, Disposal, and Reuse. New Delhi: McGraw-Hill,2010
6. Waldron Keith W.,Handbook of Waste Management and Co-Product Recovery in Food Processing, Elsevier,2007
7. Herzka, A., and R. G. Booth. Food Industry Wastes, Disposal and Recovery. London: Applied Science Publishers,1981
8. Bhattacharyya Bimal C., Banerjee Rintu, Environmental Biotechnology; Oxford University Press, 2007

Course Outcome:

Upon successful completion of the course, students will be able to

CO No.	Course Outcome	Cognitive level
1	**Explore** composition of industrial effluent and health hazards of pollutants in effluent.	6
2.	**Recognize** primary, secondary and tertiary treatment for industrial effluent treatment and design parameters.	6
3.	**Access** principle, design and working of fixed film biological reactor efficiency Students can **prepare** bakery and confectionary products	6
4.	**Manage** industrial effluent for recovery of biological as value addition to waste.	6

Elective-II (Open Elective)

Course Code:OTL-306

Course Title: Biochemistry & Biotechnology of Lipids

Course Objectives:

This course is designed to gain the insights about various bio-simulated reactions, pathways, and mechanisms in natural way. Also, the use of enzymes for synthetic modification and applications several fatty products will be studied. Environmental issues from bio- technological industries will also be discussed.

Prerequisites: ----Not Applicable----

Course content:

Unit-I

Biosynthesis of fatty acids and phospholipids; Mechanism of chain elongation and desaturation of acyl chains; Regulation of lipid metabolism; Biological role of fat in human nutrition; Atherosclerosis.

Unit-II

EFA, MUFA, PUFA –Sources and biological activities in human health; Biochemical aspects of vitamins in nutrition; Toxic constituents in oilseeds and oils: Sources, structures, toxicological effects and methods of detoxification.

Unit-III

Microbial production of fats and other lipids; Biotransformation of fats and lipids using whole microbial cells; General aspects of Microbial Lipases: Sources, isolation and purification and industrial applications

Unit-IV

Enzymatic Interesterification: Chemistry, reaction in (aqueous/organic) solvent systems,

immobilization of enzymes, factors affecting enzyme activity, enzyme kinetics, reactor design.

Unit-V

Structured lipids: Synthesis, analysis and applications
Genetically modified lipids: Physical, chemical and nutritional functionality modifications.
Environmental biotechnology concept: Principles in bioremediation and biological water & waste treatment.

Text/ Reference Books

1. Lehninger's Principles of Biochemistry by David L Nelson; A.L .Lehninger and Michael M. Cox, 5th edition, Worth Publishing.
2. Outline of Biochemistry by Eric.E. Conn and P.K. Stumpf, 5thedition, WileyIndia.
3. Lipids: Biochemistry, Biotechnology and Health, 6th Edition by Michael I. Gurr,John L. Harwood, Keith N. Frayn, Denis J. Murphy, Robert H. Michell, Wiley-Blackwell
4. Fatty Acids in Fish Oğuz Taşbozan and Mahmut Ali Gökçehttp://dx.doi.org/10.5772/68048
5. FoodLipidsChemistry,Nutrition,andBiotechnology,FourthEditionEditedCasimir C. Akoh Taylor & Francis Group

Course Outcome:

Upon successful completion of the course, students will be able to

CO No.	Course Outcome	Cognitive level
1	Acquire the fundamental knowledge of scholarly discourse in fatty acids and other lipid synthesis.	1
2.	Able to understand the biological roles of important fatty and non-fatty components.	2
3.	Identify and describe the toxicity effects and method of remediation.	2
4.	Apply the theories and concepts of microbial lipase in industrial applications.	3

Elective-II (Open Elective)
Course Code: PTL-306
Course Title: Technology of Printing Inks

Course Objective: The Paint Technocrat will have in depth exposure to

1. Formulation and manufacture of Printing Inks.
2. Various techniques of printing processes.
3. Different applications of printing inks

Prerequisites: ----Not Applicable----

Course Content:

Unit-I

Nature of Printing ink, Visual characteristics of inks, Major printing systems, classification and characteristics of printing inks, mechanism of ink drying, adhesive nature of printing inks, resistance properties of printing inks, physical chemistry of printing inks, rheological properties of inks principles of printing

Unit- II

Description and schematic diagram of printing processes, it‟s press configuration and applications e.g. Flexographic, lithographic, gravure, letterpress, planographic, screen, Inkjet printing, substrate selection principles of ink formulations, colour matching and process printing.

Unit-III

Manufacture of inks, manufacturing process, mixing equipments such as Highspeed impeller, butterfly mixer, Rotar and stator high speed mixer and milling equipments such as three roll mill, bead mill etc. handling, storage and manufacture of UV ink, news paper inks, modern production trends and future of inks.

Unit-IV

Inks for various substrates: paper, plastic, fabric, leather, glass and metal. Testing & Evaluation of finished ink and raw materials for ink manufacture. Inks for News paper (rotary and well offset), publication work, posters, labels, and packaging materials, heat set and quick set inks for multicolour printing.

Unit-V

Metaldecoratinginks,afterprintvarnishesandlacquers,magneticinks,ceramicinks,inksfor printed circuit boards, inkjet printing, laser printing, dot-matrix printing, and other miscellaneous inks. Identification of various ink troubles and remedial measures

Text/ Reference Books

1. Jones, Frank N., Mark E. Nichols, and Socrates Peter Pappas. *Organic Coatings: Science and Technology*. John Wiley & Sons, 2017.
2. Leach, Robert. *The printing ink manual*. Springer Science & Business Media,2012.
3. Thompson, Robert. *Printing materials: science and technology*. Pira International, 2004.
4. Flick, Ernest W. *Printing ink and overprint varnish formulations*. William Andrew, 1999.

Course Outcomes:

Upon successful completion of the course, the students will learn about

CO No.	Course Outcome	Cognitive level
1	Nature, characteristics and classification of printing inks.	4
2	Principles of ink **formulations** and manufacture of Inks for various substrates	6
3	Press configuration and **applications** of printing inks	3
4	**Comparison** and selection of various printing processes	4

Elective-II (Open Elective)

Course Code: PLL-305

Course Title: Plastics Waste Management

Course Objective:

1. To understand the concept of plastics recycling.
2. To understand about various sources of plastics waste.
3. To understand various identification and separation method for waste plastics.
4. To learn about different recycling methods for plastics recycling.

Prerequisites: ----Not Applicable----

Course Content:

Unit- I

Introduction, Sources of plastics waste (Industrial waste, post-consumer waste, scrap waste andnuisancewaste),PlasticidentificationandSeparationtechniques–(density-floatsinkand froth floatation methods, optical, spectroscopic, electrostatic, sorting by melting temperature, sortingbysizereduction,sortingbyselectivedissolutionandothermethods),recyclingcodes.

Unit- II

Plastics Waste Management - 4R‟s approach (reduce, reuse, recycle – mechanical and chemical, recover), recycling classification- - primary - secondary - tertiary - quaternary recycling with examples. Energy from waste – incinerators-pyrolysis, factors affecting incineration.

Unit- III

Recycling of polyolefins - PVC, PET, polystyrene, polyamides-nylon-6 and nylon-6,6, polyurethanes, mechanical process, applications of recycled materials.

Unit- IV

Recycling of rubber – comparison of thermoset and thermoplastic composites, reclaiming of rubber – fuel source – pyrolysis, Depolymerisation of scrap rubber, tyre retreading, uses of recycled rubber – asphalt and other uses.

Unit- V

Recycling of plastics by surface refurbishing - coating application, influence on plastics properties by coating, polishing of the plastics surface, commercial process. Plastics aging - environmental aging, thermal aging, weathering of plastics, mechanical degradation,chemical degradation and environmental stress cracking, wear and erosion, influence of plastic aging in recycling, energy from waste -incinerators

Text/ Reference Books

1. John Scheirs., - “Polymer Recycling Science, Technology and applications” John Wiley and Sons,1998
2. Nabil Mustafa – “Plastics Waste Management Disposal Recycling and Reuse” Marcel Dekker Inc., First Edition1993.
3. Steven Blow, Handbook of Rubber Technology, Galgotia Publications Pvt. Ltd., New Delhi,1998.
4. Chandra R. and Adab A., Rubber and Plastic Waste, CBS Publishers & Distributors, New Delhi,1994.
5. Muna Bitter, Johannes Brandup, Georg Menges “Recycling and Recovery of plastics” 1996

6. Attilio.L.Bisio, Marino Xanthos, “How to manage plastics waste: Technology and Market Opportunities” Hanser Publishers,1994
7. Francesco La Mantia., “Handbook of Plastics Recycling” Chem TecPublishing,2002

Course Outcomes:

Upon successful completion of the course, students will have knowledge of

CO No.	Course Outcome	Cognitive level
1	Sources of plastics waste, its identification and separation methods.	2
2	Approaches of plastic waste management	2
3	Mechanical and chemical recycling of polymers.	2
4	Recycling of plastics by surface refurbishing.	2

Elective-II (Open Elective)
Course Code: CHL-321
Course Title: Water Conservation and Management

Course objectives:
The Objective of this course is to:
1. Understand current water scenarios
2. Need for water conservation and management
3. Strategies for water conservation from source to sink in differentsector.

Prerequisites: ----Not Applicable----

Course Content:
Unit- I:
Introduction: water cycle, water storage, water quality. Water conservation, Current Demand of water for Domestic, Irrigation and Industries.
Current supply available, Shortage of water, water conservation process and ways to conserve water.

Unit -II:
Understanding water conservation and water quality parameter like TDS, pH, etc. Water management-water quality, controlling use and quality of water, water flow management, water quality control, testing water salinity, preserving water quality. Managing water quality in different sectors.

Unit- III:
Water conservation in agriculture-Reuse of wastewater for irrigation (Methods, Precautions), Irrigation system (Components) and Water user’s participation in irrigation system management. Current Supply, utilization and shortage of water

Unit- IV:
Water conservation in construction industry: Importance of saving water in the construction

industry in India, reduce and recycle water at construction sites, saving water during wall construction.

Unit- V:
Water Conservation in process industry: Water treatment, recycling, and reuse Water saving equipment, economics of water, minimising evaporation, water audits.

Text/Reference Books

1. IrrigationEngineering-R.K.SharmaandT.K.Sharma,S.Chand&CompanyLtd.,New Delhi.
2. Water Resources Systems: Modeling Techniques and Analysis Vedula, S.and Mujumdar, (2005); Tata McGraw Hill, NewDelhi.
3. Economics of Water Resources Planning, James, L.D., and Lee, R. R., Mc GrawHill.
4. Agriculture and water management, P.Verma, Amiga PressInc.
5. Industrial water treatment process technology, Parimal Pal, Elsevier Science.

Course Outcomes:

Upon successful completion of the course, students will be able to

CO No.	Course Outcome	Cognitive level
1	Students would able to **understand** the importance of water conservation and management in different sectors.	2
2	Students would able to **identify** the thrust area for water conservation and develop management strategies to achieve it.	2
3	Students would able to effectively **implement** the developed strategies.	2

Elective-III (Professional Core Elective)
Course Code: PTL-307
Course Title: Engineering of Pigmented Dispersion

Course Objective:
1. The paint technocrat will have in depth exposure to engineering of dispersion of pigments in polymeric binders using different machineries.
2. The student will learn about the mathematical modelling, comparative evaluation & selection of dispersion machineries.
3. The technocrat will have exposure to outline and layout of paint manufacturing plant.

Course Prerequisites: Introduction to Coating Technology (PTC-201) Technology of Pigments (PTC-202) Architectural Coatings (PTC-301)

Course Content:
Unit-I
Immersion & wetting of pigments, penetration and separation of agglomerates, statistical considerations of mechanical deagglomeration, Stabilization of colloidal pigment dispersion entropic & charged double layer mechanism of stabilization, variables affecting stabilization, stabilization of dispersion of high solid coatings, dispersion of nano pigments, adhesion & cohesion phenomenon associated with dispersion; initial

dispersion, mill base & letdown compositions; flow point curves, instrumental analysis of fineness of dispersion.

Unit-II

High speed mixers: underlying fluid mechanics, mill base rheology, tank & impeller dimensions, different impeller geometries & orientations, power input, preparation of latex dispersions on HSD. Heavy duty & miscellaneous mills: sigma kneaders, pug mixers, change can, planetary, cavitation mixers, edge runners, colloid mills, stone mills, bridge-banbury mixers etc.

Unit-III

Ball & pebble mills: Cascading principle, size, speed & design of ball mill; size, shape & composition of balls; mill base composition, power consumption, batch & continuous operation. Roll mills: single, double, triple & multiple roll mills, flow of mill base through rolls, material balance, mill base composition, roll design, power inputs, sophistication in temperature, pressure & safety controls, waste minimization

Unit-IV

Attritor: mechanism of attrition, batch & continuous operation, design aspects, comparison with ball mill. Microbead mill: vertical open, vertical closed & horizontal mills, mechanism of bead milling; effect of retention time/ flow rate, grinding media size, shape & composition, pigment size and size distribution, nature of premix processing, mill base composition, fineness and stability of microbead dispersion; design of discs & seals in different variants-dyno mill, centri mill, pearl mill etc., sophistication in temperature, pressure, discharge & safety controls, power consumption, cascading of mills; dispersion of nano pigments, ultrasound dispersion.

Unit- V

Comparative evaluation & selection of dispersion machineries, mathematical modeling, Thinning, tinting, straining & filling of finished products, design & operation of tinting machines. Factory layout: location of site, typical material & energy flow, plant layout. Fire, explosion & health hazards: general industrial hazards, prime causes of fire & explosion, safety considerations in arrangement of underground and above ground primary & secondary solvent storage tanks, design of piping, pumps & vessels from safety point of view, cleaning & disposal considerations, safety norms & regulations.

References:

1. Patton, Temple C. Paint Flow and Pigment Dispersion, pp. 479-479. 1964.
2. Jones, Frank N., Mark E. Nichols, and Socrates Peter Pappas. Organic Coatings: Science and Technology. John Wiley & Sons, 2017.
3. Malshe, V. C. Basics of Paint Technology part II. Color Publications, 2010.
4. Doroszkowski, A. "The physical chemistry of dispersion." In Paint and Surface Coatings: Theory and Practice. Woodhead Publishing Cambridge Cambridge, 1999.

Course Outcome:

Upon completion of the course, the students will able to:

Co.No.	Course Outcome	Cognitive Level
1.	**Formulate** stable pigment dispersion and understand various theories of stabilization.	6
2.	**Design** and compare high shear rate and shear stress paint processing machineries.	6
3.	**Compare** and select mills for paint processing based on mill base composition.	4
4.	**Plan** and **propose** safe handling and safety practices in paint industry.	6

Elective-III (Professional Core Elective)
Course Code: PTL-308
Course Title: Synthesis and characterization of Polymers

Course Objective:
The paint technocrat will have in depth exposure to
1. Synthesis techniques of polymers.
2. Physicochemical characterisation of polymers.
3. Qualitative and quantitative analysis of polymers.
4. Various sophisticated tools used in the analysis of polymers.

Course Prerequisites: Chemistry and Technology of Polymers (PTC-302)

Course Content:
Unit-I:
Mechanism, and applications of various techniques: Anionic polymerization, cationic polymerization, ring-opening polymerization, metathesis polymerization, group transfer polymerization, ATRP
Unit-II
Concept of average molecular weight, determination of number average, weight average, viscosity average and Z-average molecular weights, Molecular weight and molecular weight distribution determination by dilute solution viscometry, GPC/SEC with a RI/ Light scattering detector, vapor phase osmometry.
Unit- III
Polymer crystallinity, morphology analysis of polymers using XRD; thermal characteristics of crystalline/ amorphous polymer, differential thermal analysis (DTA), differential scanning calorimetry (DSC), thermogravimetric analysis (TGA), analysis polymer nanocomposite using atomic force microscopy (AFM), scanning electron microscopy (SEM), transmission electron microscopy (TEM)
Unit- IV
Identification of the type of functional groups present in a polymer using IR, attenuated total reflection (ATR), qualitative and quantitative analysis with respect to monomer composition and the average configuration of the polymer chain using NMR, assignment of the structure using pyrolysis-gas chromatography, mass spectrometry (time-of-flight matrix-assisted laser desorption/ ionization (TOF-MALDI) mass spectroscopy) analysis of polymers, Electrospray mass spectroscopy (ESMS) for biopolymers
Unit- V:
Curing and mechanism of film formation, functionality concept, resin-hardener curing, thermal curing, oxidative polymerization, radiation curing less commonly used cross linking agents: 2-hydroxyl alkyl amides, acetoacetate, acylamido glycolates, polyaziridine, polycarbodiimide etc., film formation by solvent evaporation from solutions of thermoplastic binders, film formation from solutions of thermosetting resins, film formation by coalescence of polymer particles, instrumental monitoring of curing

Text/Reference Books:
1. R. A. Pethrick and J. V. Dawkins, eds., Modern Techniques for Polymer Characterization, John Wiley & Sons, Inc., New York, 2003
2. D. Campbell, R. A. Pethrick, and J. R. White, Polymer Characterization: Physical Techniques, Stanley Thornes (Publishers) Ltd., Cheltenham, U.K., 2000
3. Barth, Howard G., and Jimmy W. Mays, eds. Modern methods of polymer characterization. Vol. 115. John Wiley & Sons, 1991.
4. Yang, Rui. Analytical methods for polymer characterization. CRC Press, 2018.

Course Outcome:
Upon completion of the course, the students will able to:

Co.No.	Course Outcome	Cognitive Level
1.	**Review** various types of polymerization techniques.	2
2.	**Demonstrate** various techniques for determination of molecular weight of polymers.	2
3.	**Analyse** structure, mechanical, thermal and electrical properties of polymers.	4
4.	**Propose** high end scientific tools in physicochemical characterisation of polymers and coatings.	6

SEMESTER-VII

Course Code: PTP-401
Course Title: Industrial Training/ Project

Course Objectives:
The objective is to create interest of graduates in the field of paint and coatings with subject knowledge they have acquired earlier. The graduates will get exposure of recent industrial practices and technological revolutions. They will also get exposure of technical report writing of their research work and its presentation.

Course Content:
Research Project at Department:
The entire semester will be devoted for the detail experimental work on a research problem from the field of Paint Technology selected by the student and specially approved by the faculty member/s designated as research guide/s. The student will present his/her findings in the form of neatly typed and bound thesis and will have to appear before panel of experts for defending his/her Thesis.
OR
Research Project/ Training at Industry:
The student will undertake research work/ Training at selected reputed Paint Industries for six months on a topic allotted by the concerned Industry Management and approved by the Department. His/her progress will be jointly reviewed by the Department and the concerned Industry Management. The student will present his/her findings in the form of neatly typed and bound thesis, which will carry approval and attendance certificate issued by the concerned Industry Management and will have to appear before panel of experts for defending his/her Thesis.

Course Outcome:
Upon completion of the course, the students will able to:

Co.No.	Course Outcome	Cognitive Level
1.	**Analysis** of paint, coatings, their production, application, and allied fields.	3
2.	**Understanding** of raw materials needs/inventory, coating selection, **formulation** and performance criteria, Plant Layout, efficient application method, paint defects, problem resolution and reducing rejection rates.	6
3.	Broad education necessary to **assess** the impact of technological solutions in a global, economics, environmental, and social context.	5
4.	**Demonstration** of individual and teamwork.	3
5.	**Identification** of better career opportunities and choices.	5

Course Code: PTP-402
Course Title:Technical Seminar

Course Objectives:
The students will develop necessary skills in understanding current technological trends in the field of paints, coatings, and related fields. Graduates will get an in-depth exposure of literature survey, preparing technical review report. It will also lead to improvement of technical presentation skills of the graduates.

Course content:
Students will be required to prepare a critical review of selected topics in Paint Technology and allied subjects and submit the same in the form of a standard typed report under the supervision of designated Guide. The student will also be required to make an oral presentation of the review before a panel of experts.

Course Outcome:
Upon completion of course the students will:

Co.No.	Course Outcomes	Cognitive Level
1.	**Understanding** of recent and emerging trends in the field of Surface Coating Technology	2
2.	Ability to identify, **formulateand** solve technical problems	6
3.	Development of skills necessary for **preparation** and **presentation** of Technical Reports.	6
4.	**Preparation** for advanced or independent study of a specific research topic.	6
5.	**Recognition** of the need for, and an ability to engage in life-long learning.	5

SEMESTER-VIII

Course Code: CHC-416
Course Title: Process Dynamics & Control

Course Objective:
To study the chemical process control and dynamics of automatic, advanced chemical processes and to study the response of various forcing functions for first, second order control system by studying the various types of control mechanisms for chemical process and to examine stability analysis and application .

Course Content:

Unit-I
Dynamic Behaviourof First Order Control System. Study of forcing functions Step, ramp,impulse, sinusoidal etc. Transfer functions of Continuous Stirred Tank Reactor, mercury in glass thermometer, mixing process, liquid level single tank system and problems with practical approach, response of first order control systems, step response, ramp or linear response, impulse response, sinusoidal response equations and problems. (08Hrs)

Unit-II
Interacting and Non-Interacting liquid level Control Systems. Step response for non-interacting, interacting control system, Transportation lag, the dynamic behaviour of second order control systems. Transfer function derivation for U tube Manometer and Damped vibrator system, Concept of underdamped, critically damped and overdamped systems, Step response equation for under damped second order system.Problems on under damped second order control system.(08Hrs)

Unit-III
Second order step response equations of critically and over damped control systems and derivations. Step response Characteristics of an Underdamped second order control systems for step function. Decay ratio,overshoot,rise time, response time and numerical. Mechanism of Control System and Block Diagram Representation Control aspects, negative verses positive feedback control systems, servo and regulator control problems. (08Hrs)

Unit-IV
Proportional, proportional plus derivative, proportional plus integral and Proportional plus Derivative plus Integral controller their input output relationship, transfer functions of different controllers, advantages and disadvantages and their applications. Stability Analysis of Control System. Stability for linear control system, Rouths stability criteria and problems based on stability of control system. (08Hrs)

Unit-V
Root locus analysis, procedure for plotting root locus diagram for negative feedback control systems. Various numerical and graphical problems based on Root locus analysis. Frequency response analysis of linear systems, procedure for plotting the Bodediagram, problems on Bode stability criteria, basics of open loop poles and zeroes at origins, first order poles and zeroes, corner frequency, concept of phase and gain margins, phase crossover and gain crossover frequencies. (08Hrs)

Reference Book:

1. Coughanowr, Donald R., Process Systems Analysis and Control, McGraw Hill.ThirdEdition,2009.

2. Stephanopoulos George, Chemical Process Control Prentice Hall Inc.First Edition.

3. Harriott Peter, Chemical Process Control, Tata McGraw Hill.T.M.H.Edition

4. Process Dynamic and Control,S.S.Bhagade and G,D,Nageswar First Edition 2011.

Course Outcomes:

Upon successful completion of the course, students will be able to

CO No.	Course Outcome	Cognitive level
1	From the course contents, the students will be able to know the complete dynamics of the chemical process and understand the different kinds of forcing function and responses.	3
2	The students understand the method for obtaining the transfer function, responseequation and physical behaviour of first, second and higher order control system.	2
3	Students understand various types of control actions like ON OFF, P, PI, PD, PID andapplications and usefulness in the different chemical process and Industries.	5
4	Students able to know stability of chemical process control system by solving the problems of graphical methods and analysis of rootlocus, frequency response analysis.	3

Course Code: CHC-416 (PR)

Course Title: Process Dynamics & control

Course Objective:

To carry outan experiment of Process Dynamics and Control, the students come to know how the equations developed from physical system, their response studies and actual application to chemical process Industries during automatic process control.

Course Content:

1. Study of dynamic behaviour and response of Mercury thermometer forstep change during heating.
2. Determination of time constant of mercury in glass thermometer, thermocouple, or bimetallic thermometer etc.
3. To study the dynamic behaviour of U tube manometer representing second order control system by giving impulse input.
4. Determination of damping coefficient and time constant of second order system.
5. ToStudythe pneumatic control valve and Valve characteristics.
6. To Study the two tank liquid level non-Interacting systems in series by giving step change and study the overall response.
7. To study the step response of single tank liquid level system.
8. Study of dynamic behaviour and step response of Mercury thermometer during cooling.
9. To study the impulse response of single tank liquid level system.
10. Study of Mixing process in single tank liquid level system and determine time constant.
11. Study of two tank liquid level Interacting systems in series by giving step change and study the overall response.

At least any seven experiment to be conducted.

Course Outcome:

Upon successful completion of the course, students will be able to:

CO No.	Course Outcome	Cognitive level
1	The students are capable to know about the basic theory of various physical systems and to know the actual responses for different inputs for first, second and Interacting non interacting control system.	3
2	Students able to determine mathematically and graphically time constant, transfer function and response equation by carried out an experiment.	2
3	Students come to know how the system behaves with different disturbances and how it can be optimized for stable control system	5
4	The order of the physical system like first, second and interacting non interacting control system is determined experimentally.	3

Course Code: CHC-417
Course Title: Process Equipment Design and Drawing

Course Prerequisite:

Engineering Graphics, engineering and solid mechanics, heat transfer, mass transfer operations, mechanical operations

Course Objectives:

1. To learn the design procedure for designing chemical equipment and selection of proper material of construction by considering different mechanical and physical properties.
2. To know the behaviour of material under stresses.
3. To understand the designing of pressure vessels, high pressure vessels, supports,
4. To do the process design calendria evaporator, shell and tube heat exchanger, sieve tray and bubble cap tray for distillation column, agitators.

Course Contents:

Unit –I

General design procedure for designing chemical equipment, protective coating, corrosion causes and prevention.. The material behaviour under stresses. (**5hrs**)

Unit –II

Unfired pressure vessel subjected to internal and external pressure. Design of shell, nozzle, different types of head.Vessels for high pressure operation, constructional features, multi shell construction, Types of support for vertical and horizontal vessels. (**5hrs**)

Unit-III

Agitators, selection, types application, power required for agitation, , Process design for short tube calendria Evaporator, shell and tube heat exchanger construction and design in detail. Design for sieve tray and bubble cap tray for distillation column, (**5hrs**)

Reference Books:

1.Sinnott, R. K. Coulson & Richardson's "Chemical Enginering: Volume 6/ChemicalEngineering Design", Elsevier Butterworth Heinemann,
2. Joshi, MansukhlaVrajlal, and V. V. Mahajani. Process Equipment Design. MacmillanIndia, .
3. Dawande, S. D. "Process design of equipments." Central Tecno Publication, Nagpur
4 Bhattacharya, B. C. "Introduction of Chemical Equipment Design." Mechanical Aspects.

Course Outcome:

Upon successful completion of the course, students will be able to:

CO No.	Course Outcome	Cognitive level
1	Exhibit how to design and draw in a competitive manner various process equipment with proper scale and each component with detail dimensions.	5
2	Learn how to design Pressure vessels, Reaction vessels, Shell and Tube Heat Exchanger, Short Tube Calendria Evaporator.	5
3	Understands the constructional features of high-Pressure vessels, Detail arrangement of Sieve tray and bubble cap trays. .	3
4	Be aware of how to read drawings to know details about process equipment, fabrication, maintenance, assembling and dismantling.	3

Course Code: CHC – 417 (Pr)
Course Title: Process Equipment Design & Drawing (Pr)

Course Objectives:

To learn the design procedure for designing chemical equipment and selection of propermaterial of construction by considering different mechanical and physical properties.
To know the behaviour of material under stresses.
To understand thedesigning of pressure vessels, high pressure vessels, supports,
To do the process design calendria evaporator, shell andtube heat exchanger, sieve tray and bubble cap tray for distillation column, agitators.

Course Prerequisite:

Engineering Graphics, engineering and solid mechanics, heat transfer, mass transfer operations, mechanical operations

Course Contents:

Students will be required to do process design and submit drawings of at least six equipments such as pressure vessels, heat exchangers, agitators, short tube calendria type evaporator.
Types of agitators, supports. Design of bubble cap tray, sieve tray, different types of packing

Course Outcome:

Upon successful completion of the course, students will be able to:

CO No.	Course Outcome	Cognitive level
1	Exhibit how to design and draw in a competitive manner various process equipment with proper scale and each component with detail dimensions.	
2	Learn how to design Pressure vessels, Reaction vessels, Shell and Tube Heat Exchanger, Short Tube Calendria Evaporator.	
3	Understands the constructional features of high-Pressure vessels, Detail arrangementof Sieve tray and bubble cap trays. .	
4	Learn how to read drawings to know details about process equipment, fabrication, maintenance, assembling and dismantling.	

Course Code: PTL-403
Course Title: Application Techniques & Paint Defects

Course Objectives:

To understand the importance of surface preparation in system recommendation over various substrates.

To acquire knowledge of various surface preparation standards.

To learn coat effective and easiest available methods for paint application and curing

Identification, analysis, and reduction of various paint defects during application

Pre-requisites:

Architectural Coatings PTC-301 Ecofriendly Coating Technologies PTL-303

Course Content:

Unit -I

Preparation Of Substrate Surfaces Nature and sources of contaminations/ Soils - mill-scale / rust, lubricants/grease/ washing oils, particulate soils/ welding pearls/ dirt/dust, old coatings, classification of rust Chemical paint removal methods for metals, alkaline, solvent type, and other paint removers, Mechanical Cleaning-Hand tool cleaning, Blasting, Blast Media, compressed air blasting, water jet blasting, standards for blast cleaned surfaces-testing, Chemical Surface preparation: Solvent wiping and degreasing, alkali/detergent cleaning, emulsifiable solvent cleaning, steam cleaning, flame cleaning, Ultrasonic Cleaning etc. (8hrs)

Unit -II

Pretreatment Techniques / Conversion Coatings for Substrates Surface cleaning and pretreatment of metals- Acid cleaning/pickling (H3PO4, HNO3, H2SO4, HF acid), Activation, passivation, chromatization, Chemical etching, Anodization, and other treatments. Zinc Phosphate-Electrochemical Mechanism, Eco-friendly tricationic phosphate conversion coatings based on Zn, Mn, and Ni, Plant Layout. Ferrous and nonferrous metals -Iron Phosphate, Coating Weight, Iron Phosphate Controls Temperature, Chemical Concentration, Acid Consumed, Role of accelerators, temperature, catalysts, and total acid to free acid ratio. Surface Treatment of Plastics, Flame Surface Treatment, Plasma Surface Treatment, Pretreatment of wood, and glass surfaces. Environmental Legislations on pretreatments. (8hrs) Department

Unit - III

Techniques for Applications of Solvent Thinnable / Waterborne paints Spray Techniques-Methods of Atomization, Compressed air-Manual and automatic, airless, AirAssisted Airless, Fluid Needles and Tips for air and airless spray, hot and two nozzle spray Electrostatic spray-automatic Air-Spray Guns and Rotary (disc and bell) Atomizers, supercritical fluid spray, Transfer Efficiency, Spray Booths Dipping, roller, and coil coating, curtain coating, flow coating, knife coating, vacuum impregnation. (8hrs)

Unit –IV

Application Setup for Powder and UV Cure coatings Design and operation of Carona &Tribo charging guns, Fluidized bed process, Flame Spray, Newer developments in application techniques, Recovery & recycling of powder waste. Design of UV Lamp, Application Plant Setup for UV and Electron Beam Cure, Dual Cure, Health and Safety Aspects.Paint shop ovens (8hrs)

Unit –V

Paint Defects Identification, assessment,causes & remedial measures. Crawling, cratering & related defects; Flooding, Floating, and Mottling, wrinkling, Silking, Solvent Popping, Bubbling and Pinholing, Overspray and Dry Spray, Blushing, foaming, blistering, checking and cracking, blooming, chalking, cissing, cobwebbing, crocodiling, embrittlement, gassing, lifting, opacity defects, orange peel, yellowing etc. Problems associated with drying (8hrs)

Reference Books:

1. Kearne, J. D., Ed., "Steel Structures Painting Manual, Vol. I, Good Painting Practices", Third Edition , Steel Structures Painting Council, 1993
2. Bernard R. Appleman, Janet Rex, Terry Sowers, "Steel Structures Painting Manual, Vol. II, Systems and Specifications", Seventh Edition, Steel Structures Painting Council, Pittsburgh, PA, 1995.
3. Hare, C. H., "Protective Coatings, Fundamental of Chemistry and Composition" Steel Structures Painting Council, Pittsburgh, PA, 1995.
4. Treseder, R. S. "NACE corrosion engineer's reference book." (1980).
5. Zeno W. Wicks, Jr., Frank N. Jones, S. Peter Pappas; Douglas A. Wicks,"Organic coatings : Science and Technology", Edited by Third Edition, John Wiley & Sons, Inc., Hoboken, New Jersey. 2007.

Course Outcome:

Upon successful completion of the course, students will be able to:

Co.No.	Course Outcomes	Cognitive Level
1.	**Preparation** of various surfaces for painting as per internationally recognized standards.	6
2.	**Understanding** of various methods of Pretreatment Techniques / Conversion Coatings for substrate surface	2
3.	In-depth Knowledge of specification and **selection** of spray guns, compressors, gun washers, pressure hoses, regulators, spray booths, and design of paint shop/ Ovens.	4
4.	**Identifying** the reasons for paint failure and coating defects, failure analysis, equipment technology, pretreatment methods and **troubleshooting,** and coatings service life **prediction.**	6

Course Code: PTL-404
Course Title: Quality Assurance & Analysis of Surface Coatings

Course Prerequisite:

Architectural Coatings PTC-301 Ecofriendly Coating Technologies PTL-303

Course Objective:

1. To provide knowledge to the students on various standard paint testing procedures.
2. To analyzethe influence of various paint formulating ingredients in the formulation.

3. To provide a knowledge to students in recommendation of various paint formulations according to service requirements

Course Content:

Unit –I

General Analysis of Paints and Awareness of Standard Specifications Objectives of paint testing for decorative & industrial finishes, IS, BS, ISO, ASTM, SSPC standards, classification of paint tests, methods of sampling; determination of wt per lit, % NVM, P/B ratio, PVC; preparation of metal/ glass/ wood/ cement panels, laboratory application techniques, measurement of wet & dry film thickness, determination of touch/surface/ tack free/ hard/ thorough dry & curing schedule; chemical separation of paints & printing inks into constituents. Analysis of separated binders/ pigments and extenders/ solvents/ additives (8hrs)

Unit -II

Specifications, Methods, Instruments for Evaluation of Appearance of Coatings I) Gloss: specular gloss, sheen, contrast ratio, DOI gloss, metallic luster, diffuse reflectance; II) Opacity: covering power, wet opacity & dry hiding; chequer board/ contrast ratio/ spectral methods; relation to practical painting. III) Colour matching & control in paint manufacture Experimental methods for measuring paint rheology for application and flow-out after application, Measurement of Flow & rheological Characteristics; leveling & sagging, Paint rheology during manufacture and storage (8hrs)

Unit -III

Mechanical Properties of Coatings Viscoelastic properties of polymers, Ultimate mechanical properties of polymers (Tensile strength and elongation at break, Loss Tangent; brittle-ductile transition, Dynamic mechanical analysis), definition, scope & determination of adhesion, mandrel and cupping flexibility and extensibility, impact test, indentation, pencil and scratch hardness, mar resistance, crock meter, wet-scrub abrasion, stone-chip Resistance, nano scratch test, field exposure & laboratory simulation tests. (8hrs)

Unit -IV

Durability Testing Mechanism of photo initiated oxidative& hydrolytic degradation; aging properties of coatings, effect of pigmentation, antioxidants, peroxide decomposers, UV absorbers, excited state quenchers, HALS, natural weathering, artificial weathering, construction and working of various artificial weatherometers, light fastness, Various characterization techniques to monitor changes in free radical concentration changes in coatings, Evaluation of bio-deterioration resistance; (8hrs)

Unit -V

Miscellaneous Testing Corrosion Resistance: mechanism of corrosion, water & humidity resistance, water vapour transmission, salt spray corrosion test, Miscellaneous testing: resistance to solvents, lubricating oils, fuels, chemicals, alkalis, acids, & salts, stain resistance, heat & fire resistance, efflorescence, cold- check, freeze-thaw stability, electrical resistance, freedom from lead, determination of VOC etc. The Use of X-ray Fluorescence for Coat Weight Determinations, Thermal Analysis (DSC-TGA-DTA) for Coatings Characterizations, Infrared Spectroscopy of Coatings, Cure Monitoring (8hrs)

Reference Books:

1. Koleske, J. V. “Paint and Coating Testing Manual”: Gardner-Sward Handbook Fifteenth Edition, ASTM International 2012
2. Tracton, Arthur A.,“Coatings Technology: Fundamentals, Testing, and Processing Techniques”,CRC Press, 2006.
3. Weldon, Dwight G. “Failure analysis of paints and coatings”, John Wiley & Sons, 2009.
4. Martin, J. W, “Methodologies for Predicting Service Lives of Coating Systems”, Federation of Societies for Coatings Technology, Blue Bell, PA, 1996.

Course Outcome:

Upon successful completion of the course, students will be able to:

Co. No.	Course outcomes	Cognitive Level
1.	**Understanding** of statistical process and quality testing.	2
2.	Benchmark **analysis** for all stages of coating Technology.	3
3.	Advances in characterization and instrumental analysis in coating **evaluation**	6
4.	Awareness of recent developments, eco-friendly trends, good manufacturing practices and future challenge in relation to quality assurance**, testing** and **analysis** of surface coatings	3
5.	**Identifying** their academic and career interests for career mapping.	5

Course Code: PTP-405
Course Title: Application& Testing of Coatings

Course Objective:
1. To provide knowledge to the students on various practical aspects of surface preparation, pretreatments, and application of paints on various substrates.
2. To understand various application techniques, application defects, their probable causes, and remedies
3. To provide the students a brief information about various available products in the market from standard paint manufacturing companies.
4. Performance evaluation of standard commercial products according to standard procedures

Course Prerequisite:
Application Techniques & Paint Defects PTL-403 Quality Assurance & Analysis of Surface Coatings PTL-404

Course Content:
Minimum of twelve experiments with due coverage of following: Preparation of MS, Tin, Al, glass, plastics and wooden surfaces, Phosphating of ferrous and nonferrous surfaces, Spray application, Electrostatic spray application of powder coatings, UV cure set up, analysis of flow, Coating calculations, Identification and analysis of various paint defects covered under PTL-- 403 Characterization & application of coatings covered under Paper PTL-404. Sampling, application, and Evaluation of standard commercially available coating products from market

Reference Books: Departmental Practical Manual

Course Outcome:
Upon successful completion of the course, students will be able to:

Co. No.	Course Outcomes	Cognitive Level
1.	**Preparation** and pretreatment of surfaces.	5
2.	**Understanding** of paint system inspections, requirement of standards and coating calculations in refer to covering and cost per square foot	2
3.	**Selection** of various techniques for application of	6

	solvent/ waterborne paint, UV cure and powder coatings	
4.	**Identification** and **analysis** of various paint defects.	5
5.	Sampling, application, and **evaluation** of standard coating products from commercial market.	6

Course Code: Professional Core Elective III PTL-406
Course Title: Special Purpose and Effect Coatings

Course Objective:
1. To provide knowledge to the students on various paint systems for specialized applications
2. To know about performance requirement, raw material selection and formulating techniques in various paints for specialized applications.
3. To learn about standard coating practices in various industries in paint application and recommendation of paint types and systems in industry applied and site applied coatings according to service environment.

Course Prerequisite:
Architectural Coatings PTC-301 Ecofriendly Coating Technologies PTL-303

Course Content:
Unit –I
OEM and Refinish Coatings Automotive coatings- Methods of car body construction, formulations of surfacer, antichip coatings, solid Color Monocots, Basecoat-clear coat for topcoats, High solid top coats, waterborne/ powder surfacers and topcoats, Wet-On-Wet-On-Wet Application (3 Coat 1 Bake) of Primer-Surfacer–Base Coat–Clear Coat, Painting of plastic body components, Repair and Refinish automotive paints, Coatings for Domestic Appliances, Coatings for Packaging (Can/ Container coatings) (8hrs)
Unit-II
Insulation, Furniture and Coil Coatings Fundamentals of Electrical Insulation, Binders used in electrical insulation, Formulation of Insulating varnishes, Wire enamels, Impregnating Compounds, Casting & Potting Compounds etc., Application & Testing methods, Coil Coatings. (8hrs)
Unit - III
Marine Paints and Heavy-Duty Paints Coatings for ships topcoats for boot topping, topside, and Superstructure, Tanks Ballast Coatings for Ship Bottom, Antifouling Agents/biocides, Self-polishing paints, Mechanism of antifouling based on prevention of adhesion of fouling organisms. Formulation and performance. Coatings for dockyard (dock and harbor installations), Paint systems for off-shore structures, underwater coatings Heavy-Duty Coatings, maintenance paints, Painting specifications-new/old work, at site/works. (8hrs)
Unit -IV
Special Effect Paints Aluminium/Bronze paints, general and special floor paints, Road marking paints, Multicolor Coatings, flamboyant finishes, polychromatic finish, wrinkle/ hammer finish, fungistatic paints, Elastomeric Coatings, Anti carbonation coatings, Anti-condensation paints, flame retardant and heat resisting paints, (8hrs)
Unit -V
Special Purpose Coatings Paints Used for Commercial Transport Vehicles-Railroad Rolling Stock, Freight Containers, Road Transport Vehicles, Aircraft Coatings, Paintings Conservation Varnish, Peelable Medical Coatings, Conductive Coatings, Leather Coatings, Coated Fabrics for Protective Clothing and Apparel Use, Computers and modelling in paint and resin formulating (8hrs)

Reference Books:

1. Zeno W. Wicks, Jr., Frank N. Jones, S. Peter Pappas; Douglas A. Wicks,"Organic coatings : Science and Technology", Edited by Third Edition, John Wiley & Sons, Inc., Hoboken, New Jersey. 2007.
2. Hans-Joachim Streitberger, Karl-Friedrich Dossel, "Automotive Paints and Coatings" Second Edition, John Wiley & Sons 2008.
3. McBane, B. N., "Automotive Coatings", Federation of Societies for Coatings Technology, Blue Bell, PA, 1987.
4. Horst Sulzbach, "Polymers for Electrical Insulations", Elantas GmbH, 2008.
5. Hare, C. H., "Protective Coatings, Fundamental of Chemistry and Composition" Steel Structures Painting Council, Pittsburgh, PA, 1995.
6. Hellio, Claire, and Diego Yebra, "Advances in Marine Antifouling Coatings and Technologies", Elsevier, 2009.

Course Outcome:

Upon successful completion of the course, students will be able to:

Co.No.	Course Outcomes	Cognitive Level
1.	**Formulation** of industrial, heavy duty, OEM and refinish coatings.	6
2.	To **propose** cost-effective formulations of Special effect coatings such as Multicolor Coatings, Flamboyant finishes, polychromatic finish, wrinkle/ Hammer finish, fungistatic paints, Elastomeric Coatings etc.	6
3.	**Selection** of raw materials for Special purpose coatings such as Conservation Varnish, Peelable Medical Coatings, Conductive Coatings, Leather Coatings etc.	5
4.	**Understanding** of recent developments, Eco-friendly trends, good manufacturing practices and future challenges to **design** coatings for various applications.	6

Course Code: Professional Core Elective III PTL-407
Course Title: Nanotechnology in Paint Industry

Course Objective:

1. To provide in depth knowledge of nanotechnology and its applications in developing various high performance and special formulations.
2. To understand various nanotechnology advantages in paint and coating formulation development.
3. To learn about synthesis methodology and incorporation of various nanoparticles in performance enhancement of various surface coatings.

Course Prerequisite:

Architectural Coatings PTC-301 Ecofriendly Coating Technologies PTL-303

Course Content:

Unit -I

Introduction to Nanotechnology Different approaches in Nanotechnology- The top-down approach, The bottom-up approach, Classification of Nanomaterials, unique properties at nanoscale- chemical, optical, magnetic, physical, thermal, mechanical-detail discussion with examples; Nanopigments-properties, changes in characteristics of nanocomposite coating through nanosized additions, exfoliation of the inorganic material, Polymer-melt intercalation, Coating nanoparticles with layers of polymers andmachines for dispersion (8hrs)

Unit -II

Synthesis of Nanomaterials Synthesis using oriented monolayers, direct/Reverse Micelles, O/W or W/O microemulsions, Solvothermal synthesis, Hydrothermal synthesis, Sonochemical routes, Photochemical synthesis, Electrochemical synthesis, Nanocrystals of semiconductors and other materials by arrested precipitation, Sol-gel method and Hybrid Coatings, Role of Dendrimers in size reductions (8hrs)

Unit -III

Retrofitting in Existing Paint Products through use of Nanotechnology Enhancement of hiding power, nano-spacing extenders such as CaCO3 and silica for improvement of TiO2 spacing, Bacteria Proof Material, Paint against UV Degradation (Nanoparticles as UV absorber for Wood Coatings), Scratch and Abrasion Resistant automotive clear top coats, Fire Retardant Coatings, Hybrid Coatings with Improved corrosion resistance, Coatings with Improved Barrier properties (e.g. oxygen and water permeability, for packaging and metal protection) (8hrs)

Unit-IV

Smart and Functional Coatings Self-Cleaning / Hygienic Coatings- Self-cleaning paint employing photocatalytic activity of TiO2 and antimicrobial activity of nanosilver, The natural lotus leaf self-cleaning effect, Paint for Purifying the gas detrimental to the environment. Functional Coatings through Special-Effect Pigments, Smart Windows, Self-Healing/ Repair Coatings- Microencapsulation, Bleeding Composites, Colloidal aggregation Sensor Coatings- Thermochromic Paints, Pressure sensing / Barochromic Paints, Corrosion sensing Paints, Antireflective Coatings, Hydrophilic Surface Coatings as Anti-Fogging Coatings, Anti-Graffiti Coatings(8hrs)

Unit -V

Analysis of Nanocomposite Coatings and Safety Aspects Construction, Working Principle, Operation of following Instruments-Scanning Electron Microscope, Transmission Electron Microscope, Atomic Force Microscopy, XRD, Particle size by light scattering method, Zeta potential; analysis of nano systems using these instruments. Risk of nanotechnology - Negative consequences for health and the environmental measures (8hrs)

Reference Books:

1. Makhlouf, Abdel Salam Hamdy, “Handbook of Smart Coatings for Materials Protection” Elsevier, 2014.
2. Ghosh, Swapan Kumar, “Functional Coatings: by Polymer Microencapsulation” John Wiley & Sons, 2006.
3. Baghdachi, Jamil, Heidi Perez, and Amit Shah. "Design and Development of Self-healing Polymers and Coatings." Smart Coatings III. American Chemical Society, 2010.
4. Saji, Viswanathan S., and R. M. Cook, “Corrosion Protection and Control using Nanomaterials” Elsevier, 2012.

Course Outcome:

Upon successful completion of the course, students will be able to:

Co. No.	Course Outcomes	Cognitive Level
1.	**Synthesis** methodologies of various nanoparticles.	6
2.	Performance enhancement and **formulation** development using various nanoparticles.	6
3.	Awareness of recent developments and future challenges in relation to specialized **formulation** using nanoparticles	6
4.	**Assessment** of impact of nanoparticles on health and environment and safety measures to prevent them.	5