Syllabus of

B. Tech. (Plastics 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 (Plastics 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 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 solution for 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, unit operations, Plastics technology.
PSO2: Develop the graduates with competitive skills to pursue career in academics, Plastics and allied industries as well innovative start-up.
PSO3: Prepare the professional Plastics Technologists with integrity and ethical values to become effective associate while addressing the social, moral, environmental and technically sustainable challenges.

Program Outcomes (PO) for B.Tech.
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, unit operations, Plastics technology. .	4
PSO2	Develop the graduates with competitive skills to pursue career in academics, Plastics and allied industries as well innovative start-up.	6
PSO3	Prepare the professional Plastics Technologists with integrity and ethical values to become effective associate while addressing the social, moral, environmental and technically sustainable challenges.	3

B. Tech. (Plastics 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
PLC-201	Introduction to Polymer 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
PLC-202	Chemistry and Technology of Polymers	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
PLC-301	Plastic Materials and Applications-I	03	-	03	03	1.5	4.5
PLC-302	Processing of Plastics-I	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
PLC-303	Plastic Materials and Applications-II	03	-	03	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**

PLP-401	Industrial Training/ Project	-	-	-	24	12	12
PLP-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
PLL-403	Processing of Plastics – II	03	-	03	-	-	03
PLL-404	Testing of Plastics	03	-	03	-	-	03
PLP-405	Processing & Testing of Plastics	-	-	-	06	03	03
Elective IV	Professional Core Elective	03	-	03	-	-	03
						Total	**18.5**

Elective I (Open Elective) PLL-304 Polymer Rheology OTL-305 Technology of Perfumery and Cosmetics FTL-305 Advanced Technology in Food Packaging PTL-305 Specialty Pigments and Additives in Coatings CHL-320 Nanoscience and Nanotechnology	**Elective II (Open Elective)** PLL-305 Plastics Waste Management OTL-306 Biochemistry & Biotechnology of Lipids FTL-306 Treatment and Disposal of Food Industrial Waste PTL-306 Technology of Printing Inks CHL-321 Water Conservation and Management
Elective III (Professional Core Elective) PLL-306 Mould and Die Design PLL-307 Technology of Elastomers and Additives	**Elective – IV: Professional Core Elective** PLL – 406: Polymer Blends and Composites PLL – 407: Plastics for Packaging

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

Program at a Glance

Name of the program (Degree)	: B. Tech (Plastic 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]

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 textbook 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 be able to understand the basic concept of electric power, energy in the field of chemical engineering and technology.
2. Students will be able to understand the characteristic of motor for suitability of different applications in chemical engineering and technology.
3. Students will be able to control and use electrical appliances in chemical engineering and technology.
4. Students will be able to calculate power and energy for efficient, economical process of plants.
5. Students will be 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	6

	within 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 YashavantKanetkar, 14th Edition, BPB Publication.
6. "Test Your C Skills" By YashavantKanetkar, 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	2

	Materials and their use in Engineering applications.	
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	2

	their professional development	
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 Work place, 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 dropwise 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 Entrepreneurship: 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 Polymer Technology
Course Code: PLC-201

Course Prerequisites: Chemistry-I, Thermodynamics-I

Course Objectives:

To gain knowledge of polymer basics.
To make the student acquire knowledge of structure and properties of polymers.
To acquaint the student with the techniques of polymerization.

Course Contents:

UNIT- I

Basic concepts and Definitions: such as monomer, Initiator, functionality, oligomers, polymer, repeating units, degree of polymerization. Classification of polymers: thermoplastic/ thermoset, addition/ condensation, natural /synthetic, crystalline/amorphous, step growth /chain growth, commodity…specialty, homochain/ heterochain, confirmation: homo & copolymers (detailed graft, block alternate, random etc. & nomenclature), configuration cis/trans; tacticity, branched/ crosslinked, Classification of polymers based on end use etc. (8)

UNIT-II

Addition and Condensation polymerization with mechanisms, Different techniques of polymerizations such as bulk, solution, suspension and emulsion polymerization with merits, demerits and applications.

UNIT-III

Concept of average molecular weight, polydispersity and molecular weight distribution on polymers, significance of polymer molecular weight. Molecular weight determination: basic concepts of end group analysis, Gel permeation chromatography, solution viscosity method. (8)

UNIT-IV

States of aggregation and states of phases in polymers, Concept of Tg, Tc & Tm. Relation between Tm and Tg, and their significance, Factors affecting the Tg, Factors affecting crystallization and crystalline melting. Relation of structure to mechanical properties of polymers: Stress-strain properties, yield strength and modulus, impact strength. (8)

UNIT-V

Relation of structure to chemical properties, polymer solubility, concept of solubility parameter, polymer dissolution, Thermodynamics of polymer dissolution, Effect of molecular weight on solubility, solubility of amorphous and crystalline polymers.
Effect of thermal, photochemical & high energy radiation on polymers. (8)

Text/ Reference Books:

Bahadur and Sastry, “Principles of Polymer Science” Narosa Publishing House, 2002.
Gowarikar, “Polymer Science” , Johan wiley and Sons 1986.
Premamoy Ghosh, “Polymer Science and Technology of Plastics and Rubbers”, Tata McGraw- Hill Publishing Company, New Delhi, 1990.
Charles E. Carraher, “Introduction to Polymer Chemistry”, Second Edition, Taylor and Francis Group
Andrew Peacock and Allison Calhoun, “Polymer Chemistry”, Hanser Gardner publications.
George Odian, “Principles of Polymerization”, Wiley-Interscience, Fourth edition, 2004
J. A. Brydson, “Plastics Materials, Seventh Edition,2005
F.W. Billmeyer, “Textbook of Polymer Science”, Wiley International Publishers, 1984

Course Outcome:

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

CO. No.	Course Outcomes	Cognitive Level
1.	Able to **understand** the fundamentals of polymers.	2
2.	Able to **understand** the structure and properties of polymers.	2
3.	Able to **understand** the physical properties of polymers.	2
4.	Acquainted with the techniques of polymerization.	2

Introduction to Polymer Technology lab
Course Code: PLC-201 (PR)

Course Prerequisites: Chemistry-I

Course Objectives:

To make the students acquire a practical skill in

1. Identification of polymers.
2. Physical and chemical analysis of polymers
3. To improve skills of handling chemicals and equipment's.

Course content:

1. Identification of polymer containing C &H
2. Identification of polymer containing C, H &O
3. Identification of polymer containing C, H, N &O
4. Determination of monomer purity, NVM.
5. To find specific gravity, Distillation range, evaporation rate, flash point of solvent.
5. To determine Acid value, amine value, iodine value etc.
6. To determine the filler content, bulk density.

(Minimum 8 Experiments)

Text/ Reference Books

1. D.Braun, Identification of Plastics, Hanser Gardner Publications, Fourth Edition
2. D.G. Hundiwale, U.R. Kapadi,V.D.Athawale,V.V. Gite , "Experiments in Polymer Science", Published by New Age International (P) Limited (2008)
3. Kuruvilla Joseph, Gem Mathew. "Advanced Practical Polymer Chemistry" Polymer Publication, Kottayam second edition, 2004
4. British standard methods of Analysis of Oils and Fats, B.S.684:1958 General Council Publication, June 1958

Course Outcome:

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

CO. No.	Course outcomes	Cognitive Level
1.	Ability to identify the polymers.	3
2.	Ability to carry out physical and chemical analysis of different polymers.	4

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-

Sr. No.	CO	Cognitive Level.
1.	Clear basic **concepts** of different classes of organic molecules, their important reactions with developed laboratory skill and awareness.	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, Throttling Process. (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 No.	Course Outcome	Cognitive 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 fluidization, 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 No.	Course Outcome	Cognitive 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 & disadvantages, (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 & dimensional tolerances possible with different manufacturing processes.	2
3	By assembling different component, they will be able to **produce** small devices of their interest.	6

Course: Chemistry and Technology of Polymers
Course Code: PLC-202

Course Prerequisites: Chemistry-I, Thermodynamics - I, Introduction to Polymer Technology

Course Objectives:

To gain knowledge of mechanism and kinetics of homo polymerization and copolymerization.
To make the student understand the various factors influencing polymerization.

Course Contents:

UNIT- I

Mechanism of Step-Growth polymerization, Functionality principle, Kinetics of Step polymerization, Carother's equation, molecular weight control in linear polymerization, molecular weight distribution, Network step polymerization, critical conversion. (8)

UNIT-II

Free-Radical chain growth polymerization, effect of monomer substituents on polymerizability, types of initiators in radical chain polymerization, free radical polymerization mechanism, termination and transfer reactions, inhibition and retardation, ceiling temperature, kinetics of free radical chain polymerization, Molecular weight distribution. (8)

UNIT-III

Ionic chain polymerization, types of initiators in cationic and anionic chain polymerizations, anionic and cationic polymerization mechanism, Kinetics of cationic and anionic polymerization. comparison of radical cationic and anionic polymerizations. Heterogeneous Ziegler-Natta polymerization, Mettalocene polymerization. Advanced Polymerization Techniques - Atom Transfer Radical Polymerization (ATRP), Group Transfer Polymerization (GTP), Reversible Addition Fragmentation Termination (RAFT). (8)

UNIT-IV

Copolymerization**:** Copolymer Composition, monomer reactivity ratio and copolymerization behaviour. Ionic copolymerization, Copolycondensation. (8)

UNIT-V

Chemical reactions of polymers: Hydrolysis, Acidolysis, Aminolysis, Hydrogenation, etc. Degradation of polymer, Types of degradation, Thermal Degradation, Mechanical Degardation, Degradation by high energy radiation, photodegradation, oxidative degradation. (8)

Text/ Reference Books:

Bahadur and Sastry, “Principles of Polymer Science” Narosa Publishing House, 2002.
Gowarikar, , “Polymer Science” , Johan wiley and Sons 1986.
Premamoy Ghosh, “Polymer Science and Technology of Plastics and Rubbers”, Tata McGraw- Hill Publishing Company, New Delhi, 1990.
Charles E. Carraher, “Introduction to Polymer Chemistry”, Second Edition, Taylor and Francis Group
Andrew Peacock and Allison Calhoun, “Polymer Chemistry”, Hanser Gardner publications.
George Odian, “Principles of Polymerization”, Wiley-Interscience, Fourth edition, 2004
J. A. Brydson, “Plastics Materials, Seventh Edition,2005
F.W. Billmeyer, “Textbook of Polymer Science”, Wiley International Publishers, 1984

Course Outcome:

Upon successful completion of the course students will be

CO. No.	Course Outcomes	Cognitive Level
1.	The different types of polymerization mechanisms.	2
2.	Kinetics of different types of polymerizations	2
3.	The effect of reaction features on the polymer formed.	2
4.	The copolymerization kinetics and the factors affecting copolymer formed.	2

Course : Chemistry and Technology of Polymers lab
Course Code: PLP-202(PR)

Course Prerequisites: Chemistry, Introduction to Polymer Technology

Course Objectives:

To make the students acquire a practical skill in
Different techniques of Polymerization
Polymerization of different monomers.
Characterization methodologies for synthesized polymers.

Course content:

To synthesis polymer using different techniques of polymerization such as Bulk, solution, and Suspension & emulsion.
Preparation of copolymers by Addition and Condensation polymerisation

Free Radical Polymerization of Styrene/MMA/Acrylic Acid/Ethyl Acrylate/ Methyl Acrylate

Ionic Polymerization of MMA/Styrene/Acrylonitrile/Methyl Ethaacrylate

Preparation of Epoxy resin

Preparation of Alkyd resin

Preparation of Phenol-formaldehyde resins / UF / MF.

(Minimum 8 Experiments)

Text/ Reference Books

D.G. Hundiwale, U.R. Kapadi,V.D.Athawale,V.V. Gite , “Experiments in Polymer Science”, Published by New Age International (P) Limited (2008)
Kuruvilla Joseph, Gem Mathew. “Advanced Practical Polymer Chemistry” Polymer Publication, Kottayam second edition, 2004
British standard methods of Analysis of Oils and Fats, B.S.684:1958, General Council Publication, June 1958

Course Outcome:

Upon successful completion of the course students will be

CO. No.	Course Outcomes	Cognitive Level
1.	To carry out polymerization of different monomers	3
2.	To characterize different polymer synthesis in laboratory.	4
3.	Handle chemical and laboratory equipment's with required safety.	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 Fifth Edition
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.Brink Jr.*Chemical Process Industries*.No.4th Edition. McGraw-Hill Book Co.,1977.
5. Drydens *Outlines of Chemical Process Technology*, Third Edition,1997
6. D.B.Dhone *Plant Utilities* Nirali Prakashan, 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: Plastic Materials and Applications-I
Course Code:PLC-301

Course Objectives:
To understand preparation/manufacturing techniques of different materials.
To understand structure-property relation of different polymers.
To understand the applications of different polymers.
Pre-requisites:
Chemistry – I (BSC-103), Introduction to Polymer Technology (PLC – 201), Chemistry and Technology of Polymers (PLC – 202)
Course Contents:
Unit-I

Polyolefins: Brief Idea of Preparation/Manufacturing methods, structure-properties relationship, processing and applications of PE (LDPE, HDPE, LLDPE etc.) and PP and its Copolymers of PE, PP
Styrenics: Manufacturing methods, structure-properties relationship, processing and applications of PS, SAN, ABS, HIPS, and expandable PS, important copolymers of styrene maleic anhydride and styrene acrylics copolymers, toughing mechanism of impact modified plastics.

Unit-II

Acrylics: Manufacturing methods, structure-properties relationship, processing and applications of PAN, PMMMA, Polyacrylamide and their copolymers.
Manufacturing methods, structure-properties relationship, processing and applications of PVAlcohol, Polyvinyl acetate and poly vinyl acetal.

Unit-III

Engineering Polymers: Manufacturing methods, structure-properties relationship, processing and applications of PC, PET, PBT, PTT.

Unit-IV

Polyamides: Manufacturing methods, structure-properties relationship, processing and applications of Nylon 6, Nylon 6, 6, Nylon 11, aromatic Polyamide such as Kevlar etc.

Unit-V

PVC: Manufacturing methods, structure-properties relationship, processing and applications of PVC and its copolymers
Brief Idea of materials like PES, PAES, PEEK, PEAK, Liquid crystalline polymers, Light Emitting Polymers, Conducting Polymers, Biodegradable polymers.

Reference books:

Plastics Materials, Seventh Edition, Heinemann/Elsevier Pblication, 2005: J. A. Brydson
Encyclopedia of PVC vol I, II, III: L.I. Nass and Charles A. Heiberger Eds, Marcel Dekker, New York, 1988.
Manufacture of plastics: W.S.Mayo, Reinhold Publishing Corporation, Chapman and Hall Ltd., London, 1964.
Plastic Materials Handbook: A.S.Athylye, Multi Tech Publisher Mumbai, third edition, 1995
Handbook of Plastics Materials and Technology: Irvin. Rubin, John Wiley and sons Inc. New York 1990.
Polymer Science: V.R.Gowarikar, N. V. Viswanathan and J. Sreedhar, John Wiley & Sons, 1986:

Course Outcomes:

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

CO No.	Course Outcome	Cognitive level
1	**Discuss** Preparation /manufacturing techniques of different polymers.	2
2	**Illustrate** structure-property relation of polymers.	2
3	**Compare** different materials for their structural features.	2
4	**Select** an appropriate polymer for the required applications.	2

Course: Plastic Materials and Applications-I (Pr)
Course code: PLC-301

Course Objectives:
To provide experimental knowledge to the students on synthesis of various homopolymers and copolymers by different polymerization techniques.
To understand the analysis techniques for characterization of different polymers.

Pre-requisites:
Chemistry – I (BSC-103)
Introduction to Polymer Technology (PLC – 201) Chemistry and Technology of Polymers (PLC – 202)

Course Contents:
Synthesis of polystyrene and its copolymers.
Synthesis of acrylic polymers by bulk, solution, suspension and emulsion polymerization and study the effect of various process variable like time, temperature, initiator concentration, etc,
Synthesis of thermoplastics polyester resin.

Synthesis of polystyrene by ATRP.
Analysis of molecular weight of different thermoplastic materials by solution viscosity method.
Determination of acid value, hydroxyl value, solid content, etc. At least eight experiments.

Text/ Reference Books:
D.Braun, Identification of Plastics, Hanser Gardner Publications, FourthEdition
D.G. Hundiwale, U.R. Kapadi,V.D.Athawale,V.V. Gite, "Experiments in Polymer Science", Published by New Age International (P) Limited(2008)
Kuruvilla Joseph, Gem Mathew. "Advanced Practical Polymer Chemistry" Polymer Publication, Kottayam second edition,2004
British standard methods of Analysis of Oils and Fats, B.S.684:1958 General Council Publication, June1958

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

CO No.	Course Outcome	Cognitive level
1	**Demonstrate** the laboratory synthesis of various polymers and copolymers.	2
2	**Design and conduct** experiment by altering various process variables.	2
3	**Analyse** the materials for their physicochemical properties.	4
4	**Exhibit** the teamwork and problem solving skills.	6

Course: Processing of Plastics-I
Course Code: PLC-302

Course Objective:
To provide knowledge about various compounding techniques used in processing.
To understand the principle and working of different processing techniques.
To understand various processing parameters and material aspects responsible for product quality.
To learn advances in processing techniques used for plastic moulding

Pre-requisites:
Introduction to Polymer Technology (PLC – 201) Chemistry and Technology of Polymers (PLC – 202)

Course Contents:
UNIT-I
Compounding: Basic Concept of Compounding and Processing, Principle and practice of compounding of polymers, brief idea of type and nature of additives, mixing of polymers, master batches, roll mills, internal batch mixer, motion less mixers, kneaders, sigma blade mixers, high speed mixers, Extruders, blenders etc.
UNIT II
Compression Moulding: Moulding process equipments and auxiliary equipment, type of compression moulding, mouldingmaterials and properties of materials relevant to moulding process, moulding cycle, interrelation between flow properties of polymers, effect of process parameters and moulding design on product quality, process defect and other remedies, limitations of compression moulding. Comparision with other processes etc.
UNIT III
Transfer Moulding: Basic Principle and transfer moulding cycle, types of transfer moulding-intergral and auxiallymould process control, compression of transfer moulding and compression moulding, choice of material for transfer moulding effect of process parameters and moulding design on product quality, process defects and other remedies, limitations of transfer moulding.
Unit-IV
Injection Moulding: Fundamentals of injection moulding, Moulding cycle, Specification of injection moulding machine. Injection unit, Clamping unit, two plate and three plates type injection mould , venting, runner and gates, Various Components of injection mould, effect of material properties and process variables on product quality, runnerless and hot injection moulding, Types of clamping systems, orientation in injection moulding and its effects, Trouble shooting of injection moulding
Unit-V

Advanced Injection Moulding: Principle, Need of Reaction injection moulding, material selection for RIM, Process defects and remedies. Gas assist injection moulding. Injection moulding of thermosets and elastomers. Process defects and remedies.

Reference books:

Fundamentals of Polymer Processing, Stanley Middleman, Mc Graw-Hill, 1977.
Injection moulding theory and practice, Irvin Rubin II, John Wiley and Sons. Inc., New York, 1972.
Plastics engineering Handbook of SPI: Joel Fredos, Wiley & Sons, Incorporated, John 1976.
Plastics moulding engineering: Deorle D. A. Chemical Pub. Co.
Principles of polymer processing: Z.Tadmorz&C. G. Gogos C. G. Wiley Inter Science, New York,. 1979.

Course Outcomes:

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

CO No.	Course Outcome	Cognitive level
1	**Employ** the thorough knowledge of different polymer processing techniques.	3
2	**Interpret** the effect of various processing parameters.	3
3	**Illustrate** the factors responsible for product defects and **appraise** on suitable remedies.	3
4	**Select** the proper processing method for desired application.	2

Course: Processing of Plastics-I (Pr)
Course Code: PLC-302 (Pr)

Course Objective:

To provide experimental knowledge to the students on various compounding and processing techniques used for plastics moulding.
To understand various processing parameters and material aspects responsible for product quality.
To learn about processing defect, their probable causes and remedies

Pre-requisites:

Introduction to Polymer Technology (PLC – 201) Chemistry and Technology of Polymers (PLC – 202)

Course Contents:

List of Experiments:
Compounding of polymers using two roll mill.
Mastication of elastomers with different ingredients on two roll mill
Study the operation and processing parameters of Compression Moulding machine.
Study the operation and processing parameters of Transfer moulding technique.
Study the operation and processing parameters of Injection moulding machine by preparing different items.
Scrap grinding
Sheet casting of polymer solutions.

Source: Instrument manuals, Lab manuals

Course Outcomes:

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

CO No.	Course Outcome	Cognitive level
1	**Operate** different plastic processing equipments with required safety and precautions.	3
2	**Setup** the processing parameters for different materials	6
3	**Identify** processing defect and **illustrate** the factors responsible for them.	4
4	**Appraise** on suitable remedies to overcome the defects.	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, $CaCO_3$, 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	5

	Nanopigments.	
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	2

	quality parameters of essential oils.	
3	**Devise** the concepts of perfumery, blending of perfumes and **outline** the use of synthetic perfumery materials.	6
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, Aluminum, 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 biodegradable packaging 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-Package compatibility:- Microwavable Packaging MAP of fresh fruit and vegetable, vacuum and MAP of meat and meat products. Packaging of breakfast cereals, bakery and confectionary products

Unit –V

Packaging of soft drink, alcoholic beverages, distilled spirits, frozen food, future trends in food 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 the polymers.
2. To know the thermo viscoelastic behavior of polymers during processing and selection of design of processing device.
3. To understand the processing of various types of polymers, selection of device for processing on the basis of flow properties.

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, Viscoelastic 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 models to simulate 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.
4. R.S. Lenk, Polymer Rheology, Applied Science, London,1978.
5. J.D. Ferry, Viscoelastic Properties of Polymers, john Wiley & Sons, New York,1986.
6. Chang Dae Han. Rheology in Polymer Processing, Academic Press, New York,1976.
7. R.J. Crawford, Plastics Engineering, Butterworth - Heinemann, Oxford,1998
8. 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 analysing Nanomaterials: 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

Traditional knowledge and intellectual property: Systems of TK protection, Legal concepts 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: PLC – 303: Plastic Materials and Applications - II

Course Objectives:
To understand preparation/manufacturing techniques of different materials.
To understand structure-property relation of different polymers.
To understand the applications of different polymers.

Pre-requisite:
Chemistry – I (BSC-103)
Introduction to Polymer Technology (PLC – 201) Chemistry and Technology of Polymers (PLC – 202)

Course Contents:

Unit-I

Unsaturated Polyester: Raw Materials, polybasic acids, polyfunctional glycols, curing of resin through unsaturation of the resin/polymer backbone. Curing systems, catalysts and accelarators. Water reducible polyesters, and high solids polyesters. Molding compositions, DMC, SMC compositions.

Unit-II

Phenolics Resins: Basic components of the resin, different kinds of aldehyde, phenols and their derivatives, Novolac and Resol formation, effect of phenol and aldehyde on the nature and property of the resin, details of resinification and effect of pH on the reaction mechanism and the reaction products along with the curing of phenolics resin and it's properties and applications.

Amino Resins: Basic Raw materials used like urea, melamine, aniline, formaldehyde. Synthesis of UF, MF resins and their properties and applications.

Unit-III

Epoxy: Basic raw materials like epichlorohydrin and di-hydroxy phenols, synthesis of epoxy resins Ratios of

reaction components and their effect on the properties of reaction product, Plant and process of manufacturing resin, curing systems for epoxy (amines, anhydrides, acids etc.) One pack and two pack systems. Manufacturing of Epoxy esters, its properties and applications.

Unit-IV

Polyurethane: Structure and properties of different isocynates, diisocynates, diols. Reaction of isocynates with various other functional groups. Synthesis of PU Foams, One shot and two shot processes. Safety aspects of handling of Isocynates, Curing of PU, Applications of PU.

Unit-V

Cellulose and its derivatives:

Manufacturing and plant process of Cellulose esters like Cellulose nitrate, cellulose acetate, cellulose acetate butyrate and cellulose ethers like Ethyl cellulose, Methyl Cellulose, CMC along with their properties and applications.

Silicon Containing Polymers: Properties and Applications

Reference Books:

Encyclopedia of Polymer Science and Technology, Johan Wiley and Sons 1984.
Plastics Materials, Seventh Edition, Heinemann/Elsevier Publication, 2005: J. A. Brydson
Polymer and Resins, Their Chemistry and Chemical Engineering, Brage Golding, D.Van Nostrand Company Inc.1959.
Handbook of Coating Additives, volume 2 Leonard J.Calbo, King Industries, Inc.1992
Surface Coating, OCCA Publication.
Organic Coating Technology by H. F. Payne.
Organic Coating: Science and Technology by Z. Wicks.

Course Outcome:

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

S.No.	CO	Cognitive Level
1.	**Discuss** Preparation /manufacturing techniques of different polymers.	2
2.	**Illustrate** structure-property relation of polymers.	4
3.	**Compare** different materials for their structural features.	5
4	**Select** an appropriate polymer for the required applications.	4

Course: PLC – 303: Plastic Materials and Applications – II (Pr)

Course Objectives:

To provide experimental knowledge to the students on synthesis of various thermosetting polymers
To get understand the analysis techniques for characterization of different polymers.

Course Contents:

Synthesis and analysis of following Polymers (Thermosets):
Synthesis of amino resins (UF and MF)
Synthesis of phenolic resins
Synthesis of epoxy resins.
Synthesis of polyesters resins/ Alkyd resins.
Determination of Epoxy equivalent weight and Epoxy value.
Determination of viscosity of polymers using Brookfield viscometer.
Analysis of resins for amine value, acid value, hydroxyl value, Saponification value, Iodine value.

Text/ Reference Books:

D.Braun, Identification of Plastics, Hanser Gardner Publications, FourthEdition

D.G. Hundiwale, U.R. Kapadi,V.D.Athawale,V.V. Gite, "Experiments in Polymer Science", Published by New Age International (P) Limited(2008)
Kuruvilla Joseph, Gem Mathew. "Advanced Practical Polymer Chemistry" Polymer Publication, Kottayam second edition,2004
British standard methods of Analysis of Oils and Fats, B.S.684:1958 General Council Publication, June1958

Course Outcome:

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

Co. No.	Course Outcomes	Cognitive Level
1.	**Demonstrate** the laboratory synthesis of various polymers and copolymers.	3
2.	**Design and conduct** experiment by altering various process variables.	6
1.	**Analyse** the materials for their physicochemical properties.	4
2.	**Exhibit** the team work and problem solving skills.	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 industrialwastewater pollutants
2. To study various techniques of wastewater treatment by physical chemical and biological methods
3. Tostudy,designandoperationalproblemsofbiologicaltreatmentandvalueadditionto waste
4. Estimation of kinetic coefficients for treatment with designproblem.

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: Public Health Engineering DesInMetric., 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.,Handbookof 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 usingwhole 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'sPrinciplesofBiochemistrybyDavidLNelson;A.L.LehningerandMichael 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. Food Lipids Chemistry, Nutrition, and Biotechnology, Fourth Edition Edited Casimir 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 Printingink, Visualcharacteristicsofinks,Majorprintingsystems,classificationand characteristics of printing inks, mechanism of ink drying, adhesive nature of printing inks, resistancepropertiesofprintinginks,physicalchemistryofprintinginks,rheologicalproperties of inks principles ofprinting

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 High-speed 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, newspaper 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 Newspaper (rotary and well offset), publication work, posters, labels, and packaging materials, heat set and quick set inks for multicolour printing.

Unit-V
Metal decorating inks, after print varnishes and lacquers, magnetic inks, ceramic inks, inks for 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 and nuisance waste), 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, Depolymerizations 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: PLL – 306

Course Title: Mould and Die Design

Course Objective:-
To understand workshop equipments machine in terms of design and development of moulds and dies with materials used.
To get knowledge for designing the dies for the processing various plastics products.
To understand the design and development of moulds of various aspects of polymer processing.
To acquaint with role of computer in machine design and product design.

Pre-requisite: Processing of Plastics – I (PLC – 302)
Course Contents:
Unit-I
Design and Fabrication of Moulds: Mould function, requirement, mechanical properties, tolerance-basic mould types, Mould construction nomenclature, Stress relieving, Heat treatment-mould steel requirements, Selection of steel for mould, Surface treatments, Alloy steels-Non Ferrous materials for moulds.
Design and Fabrication of Moulds: Machine Tools and Hand Tools used in mould making with special reference to grinding, milling, lathe, drilling, die sinking machine, casting, hobbing and polishing operations, eletro discharge machinery, electrolytic deposition process, different types of materials used for mould fabrication, methods of heat treatment and advantages, equilibrium diagram, non-ferrous alloy, chromium plating.
Unit-II
Compression moulds: Mould fabrication: steels for moulding tools and their treatment include processes used for mould fabrication, finishing processes.
Compression moulds: Positive, semi-positive and flash mould with horizontal and vertical flash, arrangement of loading shoes, simple two plate and three-plate moulds, split moulds.
Unit-III
Injection moulds and Transfer moulds: Two plate and three plates types, injection, venting, runner and gates, calculation of number of cavities, hot runner mould. Computer softwares used in designing of moulds&mould flow analysis.
Transfer moulds: Principles of integral pot, auxiliary ram and separated pot mould, calculation of number of cavities.
Unit-IV
Dies: Extrusion of simple shapes tubing, cable covering and sheeting dies heating systems for plates and moulds, measurement and control of temperature of moulds and dies, simple blow mould. Types of Blown film dies and their construction types of sheet dies and their construction, dies for specific profile and their construction, function of mandrel, die body, heating systems for dies.
Unit-V
Mould Design and Part Design: Study of computer aided design, computer aided manufacturing and computer aided Engineering steps for part and mould design, Factors affecting path design, Wall thickness, Fillets, Radii, Ribs, Undercuts, Bosses, Taper and draft angle, Tolerance External and internal thread, parting line, reason for failure of plastics part, Study of Hot runner system, limitation of Hot runner systems

Reference Books:
Plastics mold engineering handbook (4th edition), J. Harry DuBois and Wayne I. Pribble, Eds., Van Nostrand Reinhold, New York, 1987.
Plastic moulds and Dies Laszlo Sors. Van Nostrand Reinhold Co; First Edition edition 1981.
Injection mould Design by R.G.W. Pye, George Goodwin Pub. 3rd Revised edition ,1983.
Compression and transfer moulding of plastics by J. Butler interscience New York, Iliffe; First edition 1959
Extrusion dies design by M. V. Joshi, Hanser Publication, and Fourth Edition.
Plastic engineering data book by Glanvill.
Mould making Handbook- Stoekhert/Menning, Hanser Pub. Second Edition.
Material Science and Metallurgy by V. D. Kodgire, Everest Pub. House
Robert A. Malloy, “Plastic Part Design for Injection Moulding”, Hanser Publishers, Munich Vienna, New York, 1994.
Paul A. Tres, “Designing Plastic Parts for Assembly”, 2nd Revised Edition, Hanser Publishers, Munich Vienna New York, 1994.

Course Outcome:

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

CO No.	Course Outcome	Cognitive level
1	**Recognise** the type of metal/alloy suitable for mould manufacturing.	1
2	**Discuss** the types of mould required for plastics moulding.	2
3	**Explain** the design considerations of moulds and Die.	4
4.	**Inspect** the suitability of mould design with respect to flow behavior of plastics materials.	4

Elective-III (Professional Core Elective)
Course Code: PLL – 307
Course Title: Technology of Elastomers and Additives

Course Objectives:
To provide knowledge on various additives used in polymer for various applications.
To understand about the natural rubber with its history from latex collection to processing of various types of natural rubber.
To dessiminate knowledge of various types of synthetic rubber in terms of synthesis, processing, properties and applications.
To understand the physical properties of elastomers in terms of vulcanization and testing parameters.

Prerequuisite:
Chemistry and Technology of Polymers (PLC-202)

Course Contents:
UNIT-I
Additives in plastics, types of stabilizing additives (antioxidants, light emitting stabilizers, metal deactivators, heat stabilizers, flame retardance etc.), selection and properties of stabilizing additives, function and level of addition examples, types of processing aids (lubricants, high polymer impact mixture processing aids, slip, antislip, antiblock, mould release agent), their function and level of addition.
UNIT-II
Types of fillers and reinforcement, choice of fillers and properties theory of plasticizers, types of plasticizers, reinforcement of plasticizers, function of blowing agent and examples, pigments and dies.
UNIT-III
Sources and history of natural and synthetic rubber, natural rubber vs. synthetic rubber, significance of structure of natural rubber. Production of different grades of natural rubber from latex and its classification, mastication, compounding and processing of natural rubber synthetic rubbers, compounding ingredients and method of compounding.
UNIT-IV
Manufacturing processes, properties and application of elastomers based on butadiene and its copolymers, acrylonitrile, butyl, ethylene propylene, silicon's, and polychloroprene Rubbers etc.
UNIT-V
Mechanism of reinforcement of rubbers, chemistry and technology of vulcanization, processing of rubbers, physical testing of rubbers. Industrial fabrication of rubber articles such as transmission belts, hoses, tyres, tubes, etc.

Reference books:
Chemistry and Technology of Rubber: Morton,1999
Polymer Chemistry of Synthetic Elastomers, Vol: I &II. Joseph Paul Kennedy, Erik G. M. Törnqvist Snippet view – 1968
Plastics Additives, Geoffrey Pritchard, Rapra Technology ltd.UK 2005
Chemistry of Rubber: Mounten
Brydson, J.A., Rubber Chemistry, Allied science Publishers, London, 1978.
Franta, Elastomers and Rubber Compounding materials, Elsevier, 1989.
Klingender R.C, Handbook of speciality elastomers, CRC Press, 2008.

Course Outcomes:

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

CO No.	Course Outcome	Cognitive level
1	**Explain** the types of additives used in polymer formulations.	4
2	**Illustrate** the effect of different types of fillers on properties of polymers	4
3	**Categorize and discuss** different types of rubbers / elastomers and their manufacturing.	2
4.	**Describe** the application of elastomers.	4

SEMESTER-VII

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

Course Objectives:

The objective is to create interest of graduates in research with subject knowledge they have acquired earlier. The graduates will also get exposure for recent industrial practices and technological revolutions. The graduates will get exposure for 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 Plastics 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 Institute / Industries for six months on a topic allotted by the concerned institute / Industry Management and approved by the Department. His/her progress will be jointly reviewed by the Department and the concerned Institute / 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 Outcomes:

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

CO No.	Course Outcome	Cognitive level
1	Understanding industrial practices for manufacturing and processing of plastics	2
2	Identification of raw materials needs/inventory, material selection, performance criteria, applicable processing method, product defects, their practical causes and remedies.	4
3	Broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context.	2
4.	Identify betterCareer opportunities and Choices.	
5.	Building up teamwork abilities.	5

Course Code: PLP - 402
Course Title: Technical Seminar

Course Objectives:
The students will develop necessary skills in understanding current technological trends in the field of polymer and plastics technology. 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:
Student will be required to prepare a critical review of selected topics in Plastic 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 panel of experts.

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

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

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 Behaviour of 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 for step 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. To Study the 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 experiments 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.	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 arrangementof Sieve tray and bubble cap trays. .	3
4	Learn how to read drawings to know details about process equipment, fabrication, maintenance, assembling and dismantling.	3

Course Code: PLL - 403
Course Title: Processing of Plastics - II

Course Objectives:
To enable the students:
To understand the principle and working of different processing techniques.
To understand various processing parameters and material aspects responsible for product quality.
To learn advances in processing techniques used for plastic moulding.

Pre-requisites:
PLC-301: Plastic Materials and Application – I PLC-302: Processing of Plastics –I
PLC-303: Plastic Materials and Application – II

Course Content:

Unit- I

Extrusion: Principle, Basic Features of Extruders screw, design of mixing sections, screw zones, Selection of screw for specific polymers, study of different ratios like L/D, Compression Ratio, Blow-up ratio, Axial Ratio, Bridging during Fluxing, Melt pool development, different machine parameters homogenising and devolatizing, working of twin screw extruder, Faults, causes and remedies. (8hrs)

Unit-II

Calendering: Principle, Typical calendaring process, Different arrangements of calendaring rolls, cooling unit and embosser, material of construction of rolls in calendaring, Types of calendars, deflection in calendaring rolls, machine and material related defects, causes and remedies. (8hrs)

Unit-III

Blow Molding: Principle of Blow Molding, two basic blow molding processes, material properties required for the process, Cycle, Parison Programming, parison variation, Blow pin inserts, Material of construction, Techniques of continuous extrusion blow molding of thermoplastics and others, Trouble shooting in blow molding. (8hrs)

Unit IV

Rotomolding: Principle, basic difference between blow and rotomolding, Batch type, three and four arm carousel-type machine, other machines, Heating of mould, Different materials used for fabrication of moulds, Polymeric materials which are rotational moulded, Composite rotational molding, study of different part design, advantages and disadvantages of process, products defects, causes and remedies. (8hrs)

Unit-V

Thermoforming: Principle, basic concept, Types of thermoforming, detail study of each process, material properties required for the thermoforming, important applicability of different thermoforming processes for producing polymer parts, Trimming, advantages and disadvantages of the process, Trouble shooting guide for thermoforming, and comparison with the other mouldings. (8hrs)

References:

Chris Raweendan, Polymer extrusion, 5th Edition, Hanser Publication, 2014.
Briston, Plastics Films, Goodwin George Publication, 1974.
S.H. Pinner, W.G. Simpsons, Plastic Surface and Finish, 1st Edition, Pinner and Simpson Butter Worth Publication, 1971.
Joel Frados, Plastic Engg. Handbook, 4th Edition, Van Nostrand Reinhold Publication, 1976.
A. Kobayashi, Machining of Plastic, McGraw-Hill Publication, 1967.

Course Outcomes:

Upon completion of course the students will be able to:

CO No.	Course Outcome	Cognitive level
1	Employ the methodical knowledge of different polymer processing techniques like extrusion, calendaring, blow moulding, thermoforming, rotational moulding	3
2	Interpret the effect of various processing parameters	3
3	Illustrate the factors responsible for product defects and appraise on suitable remedies.	4
4	Select the proper processing method for desired application.	5

Course Code: PLL - 404
Course Title: Testing of Plastics

Course Objectives:

To develop the knowledge of National & International standards for testing methods.
To create the knowledge about the different testing techniques and its basic concepts for evaluating the Mechanical, Thermal, Electrical, Chemical, and permanence properties properties of plastic materials.
To enable the students to identify and compare the properties of different plastics materials.
To enable the students to learn about the property of the plastic material for several applications.

Pre-requisites:
PLC-301: Plastic Materials and Application – I PLC-302: Processing of Plastics –I
PLC-303: Plastic Materials and Application – II

Course Content:
Unit I
Need of testing plastic materials, Standards and specifications for testing of plastics such as ASTM, DIN, BS, ISI, , types of testing (destructive and non-destructive), Preconditioning and test atmosphere, parameters affecting test results.
Significance of Mechanical properties of the surface, test method for Hardness, abrasion resistance, coeff. of friction. (8hrs)
Unit II
Significance of mechanical test, test methods, standard specimen preparation for mechanical testing such as tensile strength and flexural, modulus, Impact strength.
Study of significance of electrical test, test methods, standard specimen preparation for electrical testing such as breakdown voltage, volume and surface resistivity. (8hrs)
Unit III
Significance of thermal test, test methods, standard specimen preparation for heat deflection temperature, vicat softening point, TMA, TGA, DSC.
Study of significance of flammability tests, test methods, standard specimen preparation for flammability test such as rate of burning, limiting oxygen index test. (8hrs)
Unit IV
Study of significance of environmental test, test methods, standard specimen preparation for environmental test such as chemical and solvent resistance test, weatherability test, environmental stress cracking resistance test.
Study of significance of rheological test, test methods, standard specimen preparation for rheological test such as Melt flow index. Polymer solution viscosity test. (8hrs)
Unit V
Product Testing: specific test for product like films, sheets and pipes. (8hrs)

References:
Brown; Roger P (Ed.), Hand Book of Polymer Testing, Marcel Dekker, Inc, New York (1999).
Brown; Paul F (Ed), Hand Book of Plastics Test Methods, Longman Scientific and Technical, Harlow (1988).
Shah, Vishnu, Hand Book of Plastics Testing Technology, John Wiley and Sons, SPE Monograph (1984).
Testing and Evaluation of Plastics: A.B. Mathur, I.S. Bhardwaj, Allied Publishers Pvt. Ltd. (2003)

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

CO No.	Course Outcome	Cognitive level
1	explain the test methods for measuring the Mechanical, Thermal, Electrical, Chemical, and permanence properties of plastic materials.	2
2	evaluate various properties of plastic materials for some specified applications	5
3	decide test conditions for evaluation the properties of plastic materials.	5
4	predict the effect of various environmental factors performance properties of plastics.	5

Course Code: PLP- 405
Course Title: Processing & Testing of Plastics

Course Objective:
To provide experimental knowledge of various processing techniques used for plastics moulding.
To provide experimental knowledge of different testing equipments used for testing of plastics raw materials

and finished products as per standards test methods**.**

Pre-requisites:
PLC-301: Plastic Materials and Application – I PLC-302: Processing of Plastics –I
PLC-303: Plastic Materials and Application – II

Course Content:
Study of process principle, sequence of operations, process parameters, for Extrusion moulding, Blow moulding, Thermoforming, Calendaring and Rotomoulding.
To determine properties of material using following test methods:
Tensile Testing,
Izod and Charpy impact tester,
Hardness tester
Abrasion resistance
Specific gravity
Melt Flow Index
DSC & TGA
Flammability / LOI/ Smoke Density
Vicat softening point and Heat distortion temperature
Coefficienr of friction

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

CO No.	Course Outcome	Cognitive level
1	explain the operating of various plastics processing machines.	3
2	Identify and appraise on processing defect and illustrate the factors responsible for them.	5
3	estimate the properties required for different applications.	5
4.	decide test conditions for evaluation the properties of plastic materials.	5

Elective-IV (Professional Core Elective)
Course Code: PLL - 406
Course Title: Polymer Blends and Composites

Course Objectives:
Enable the students:
1. To understand the concept of blending of polymers and to have knowledge of different types of blend.
2. To understand the concept of polymer composites.
3. To have knowledge about different reinforcements for polymer matrix, their advantages and limitations.
4. To have knowledge about processing of polymer composites.

Pre-requisites:
PLC-301: Plastic Materials and Application – I PLC-302: Processing of Plastics –I
PLC-303: Plastic Materials and Application – II

Course Content:
Unit-I
Blends: Polymer Blends, Need for Polymer blends, Thermodynamics of polymer solutions, Binary systems, thermodynamics of polymer blends, Criteria for miscibility, Compatible and incompatible polymer blends, advantages of blends over conventional polymers different methods of blending.-Polymer Alloys. (8hrs)
Unit-II

Compatibilization and Phase Morphology**:** Role of compatibilizers in blend technology, techniques of compatibilization, phase structure development in polymer blends, study of factors affecting the morphology of polymer blends, structure determination of polymer blends, Characterization of Polymer Blends, Studies of physical properties of polymer blends, toughness of polymer blends, examples of commercial successful blends. (8hrs)

Unit III

Composite Materials: Polymer composite materials, classification and theory of composite materials; Polymer matrices - thermoplastics and thermosetting plastics; Fiber reinforcement of elastomers, short and long fiber composites, other additives

Basic idea about morphological and thermal properties of blend and composites. (8hrs)

Unit-IV

Fillers And Reinforcements: Principles of reinforcement, Reinforcing and Non-reinforcing fillers, Size and Shape of Fillers, effect of fibrous reinforcement on composite strength, types of reinforcement (such as glass, carbon, aramid), surface treatment and various forms of fibers, thermosetting and thermoplastic for the composite and their selection for a particular application, trouble shooting and repair of composites. (8hrs)

Unit-V

Manufacturing Process: Hand lay up, spray up, resin transfer molding, vacuum bag and pressure bag molding; centrifugal-casting, pultrusion, filament winding; compression, transfer and injection molding; Sandwich construction and Foam reservoir moulding. (8hrs)

References:

D.R.Paul and C.B.Bucknall, Polymer Blends, Vol. I and II, 2000
R.M. Jones, "Mechanics of composite materials", McGraw-Hill, KogakushaLtd.Tokyo, 1975.
L.R. Calcote, "Analysis of laminated structures", Van Nostrand Reinhold Co., 1989.
Dominick V.Rosato,"Designing with reinforced composites", Hanser publishers, 1997.
Autar Kaw," Mechanics of composite materials", CRC Press, 1997.
R.G.Weatherhead,"FRP Technology",Applied science publishers Ltd,1980.
Peter Morgan,"Carbon fiber and their composites", Taylor and Francis, 2005.
Stuart M.Lee,"CompsoitesTechnology",Vol 1 & 2, Technomic Pub.,1989.

Course Outcomes:

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

CO No.	Course Outcome	Cognitive level
1	appraise on applications and advantages of the blends and composites over the virgin polymers as well as blending processes.	5
2	explain the processes of blending and classify blends and composites	4
3	able to design a new blends / composite for an appropriate application	6

Elective-IV (Professional Core Elective)
Course Code: PLL - 407
Course Title: Plastics for Packaging

Course Objectives:

To enable the students

1. To understand the purpose of packaging and the requirements of plastics/polymers for packaging application.
2. To have knowledge about current packaging trends.
3. To have knowledge about characterization and evaluation of packaging materials.

Pre-requisites:

PLC-301: Plastic Materials and Application – I PLC-302: Processing of Plastics –I
PLC-303: Plastic Materials and Application – II

Course Content:

Unit-I

Introduction: History, Definition of Packaging, Function of Pakaging, Its advantages. Introduction to packaging laws and regulations. Packaging hazards and its control. (8hrs)

Unit-II

Packaging Materials: Criteria for selection of plastics packaging materials, origin, types, properties and limitations of plastics packaging materials., different packaging material and their properties including barrier properties, strength properties, optical properties etc. (8hrs)

Unit –III

Flexible Packaging: Package design, factors influencing design / product package relationship. Flexible packaging and forms of flexible packaging laminated packaging and retortable pouches and biodegradable packaging material. (8hrs)

Unit-IV

Fabrication & Decorative Techniques: Cutting, sealing, welding, adhesive bonding, metallising, embossing, labelling, painting, lacquring, foil in lay moulding, hot stamping, In mould decoration. (8hrs)

Unit-V

Printing: Surface Treatment, Printing Processes, and Printing inks, Packaging quality control, Criteria, physical, Chemical, Mechanical test procedure for packaging materials and packaged products. (8hrs)

Reference Books:

Packaging. Rockport, MA: Rockport Publishers, 1995.
Food Packaging Technology Hand Book, ByNIIR, 2nd edition, 2012.
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Course Outcomes:

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

CO No.	Course Outcome	Cognitive level
1	Acquainted with plastics packaging materials and their physio-chemical requirements.	5
2	able explore of new concepts of designs in plastic packaging.	6
3	able to evaluate of different plastic packaging materials for required application.	6