Syllabus of 3rd Year B. Tech.
Chemical Engineering
w.e.f. 2016-17

Third Year B. Tech. (Chemical Engineering) Revised Syllabus w.e.f. 2016-17							
Course Code	**Title of Course**	**Teaching Hours**	**Tutorial**	**Credits**	**Practical Hours**	**Credits**	**Total Credits**
Fifth Sem.							
HML-301	Industrial Management and Economics	03		03	-	-	03
CHC-301	Mass Transfer-I	04		04	03	1.5	5.5
CHC-302	Instrumentation & Instrumental Analysis	04		04	02	1	5
CHC-303	Chemical Reaction Engg.-I	04		04	03	1.5	5.5
HML-302	Managerial Behavior : Psychosocial Dimensions	03		03	-	-	03
ELECTIVE	Elective-I	04		04	-	-	04
Total		**22**	**-**	**22**	**08**	**4**	**26**
	Sixth Sem						
CHC-304	Mathematical Methods in Chemical Engg.	3		3	-	-	3
CHC-305	Chemical Reaction Engg.-II	04		04	03	1.5	5.5
CHC-306	Mass Transfer-II	04		04	03	1.5	5.5
CHC-307	Process Equipment Design & Drawing	03		03	02	1	4
ELECTI	Elective-II	04		04	-	-	4

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ELECTIVE	Elective-III	04		04	-	-	4
Total		**22**	**-**	**22**	**08**	**04**	**26**

SEMESTER- V

Department	**: Department of Chemical Engineering**
Course code	**: HML-301**
Course Title	**: Industrial Management and Economics (TH)**
Course Type	**: Theory**
Total Hrs	**: 03**
Course credit	**: 03**

Objective

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

1. Identification and selection of management & administration with aspect towards the Production planning and management Quality control and maintenance. Processes/operations according to job requirement in various departments.

2. Identification, selection and understanding of Financial Management capital structure Sources of Industrial finance including institutional feature inside the organisation as well as outside the organisation.

3. Understanding Cost Analysis Cost statement and sheet Cost control and various type of approach of the Industrial relation Quality management techniques Entrepreneurship Development Management information

4. Identification, understanding Micro and Macro economics Demand and Supply factors of market economy Functions of money w.r.t. organisation

Course Content:

Unit-I

Introduction meaning management & administration Functions of Management Planning and ,Organising staffing c monitoring and leading co-ordinating & communication tool Functional of management Production Material Finance personnel Marketing Management concept of productivity wages .Production planning and management Quality control and maintenance.

Unit-II

Types of management Different approaches of management Functional areas of management Forms of business organisation production management work study

productivity measurement material management Inventory analysis Financial Management capital structure Sources of Industrial finance including institutional feature.

Unit-III

Marketing management consumer satisfaction sales and advertising Marketing Research personnel management Industrial relation Quality management techniques Entrepreneurship Development Management information system Information technology In Management Cost Analysis Cost statement and sheet Cost control , Cost projection.

Unit-IV

Nature and significance of Economics Basic problem in Economics Introduction of Micro and Macro economics Demand and Supply factors of market economy Functions of money Banking types and Functions

Unit-V

Indian Economy Liberalisation privatisation and Globalisation Mixed Economy Public Sector Reforms National income determinants Economic planning nature and Entrepreneurship small scale Industries and SSI.

References:

1) Modern Economics by H.L.Ahuja.
2) Modern economics theory by K.K.Dewett.
3) Monitory economics by M.L.Seth.
4) Industrial Management by I.K. Chopde, A.M. Sheikh.
5). Business Organisation and Management by S.A. Sherlekar.
6) Marketing Management by Philip Kotler

Outcomes:

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

1. Identification and selection of management & production management work study productivity with aspect towards the material management &Inventory analysis Production planning Quality control and maintenance. Processes/operations according to job requirement in various departments in organisation.

2. Identification, selection and understanding the meaning and utility of Marketing management, consumer satisfaction, sales and advertising Marketing Research personnel management features of the organisation.

3. Understand the importance of Cost Analysis Cost statement and sheet Cost control and various type of approach of the Industrial relation Quality management techniques Entrepreneurship Development Management information system

4. Identification, understanding Micro and Macro economics Demand and Supply factors of market economy National income determinants Economic planning nature and Entrepreneurship Functions of money w.r.t. organisation

5. Identification, selection and understanding according to requirement in

Different organisation Financial Management, capital structure Sources of Industrial finance including institutional feature. Understanding of the working principle of Entrepreneurship Development and S.S.I.

Department	**: Department of Chemical Engineering**
Course code	**: CHC-301**
Course Title	**: Mass Transfer-I (TH)**
Course Type	**: Theory**
Total Hrs	**: 04**
Course credit	**: 04**

Objective:

At the end of the course student will understand the basic fundamental of mass transfer operations carried out in chemical industries, design of plate and packed column used for mass transfer operations, drying operation and fundamental of cooling tower.

Course Content:

Unit-I **(10hrs)**

Diffusion (Gas)

Introduction to Mass Transfer Operation:

Principles of diffusion, steady and unsteady state Operation, Fick's law, diffusion in binary mixture, equimolecular counter diffusion, diffusivities in liquid, vapor and gases, mass transfer through stationary gas, mass transfer velocities, gas phase mass transfer cases, thermal diffusion, Maxwell law, Diffusion in solids, individual and overall mass transfer coefficients concept.

Unit-II **(10hrs)**

Diffusion (Liquid)

Mass transfer across phase boundary, penetration theory, two film theory, surface renewal theories, film- penetration theory of mass transfer, mass transfer coefficients & correlation, counter current mass transfer and transfer units, Mass transfer and chemical reaction, simultaneous mass and heat transfer, diffusion in solids, types of solid diffusion.

Unit-III **(10hrs)**

Absorption

Mechanism of absorption, and application of mass transfer theories, choice of solvent for absorption, rate of absorption & material balance over absorption tower-counter current and concurrent flow, minimum gas-liquid ratio for absorber. Transfer coefficients in wetted wall

column, packed and spray towers. The absorption with & without chemical reaction, Brief Introduction to Desorption or stripping.

Unit-IV **(10hrs)**

Equipments for Gas-liquid Operation:

Mechanically agitated vessels of single phase liquid and gas-liquid contacts.

Packed towers: General construction & working, types of packing merits & demerits, operational difficulties, pressure drop & limiting G-L flow rates, heat liberation & temp. Variation in packed towers. Determination of height of columns, transfer units, capacity.

Plate towers: General characteristics, General construction & working, types of plate, merits and demerits, operational difficulties.

Unit-V **(10hrs)**

Humidification & Drying

Humidification: Principle, humidification terms and charts, adiabatic saturation temperature, wet bulb temperature humidification & dehumidification methods, design procedures and selection criteria along with mass transfer calculations. Types of cooling towers, cooling tower operational characteristics.

Drying: Principle, Rate of drying, constant rate and falling rate periods, equilibrium moisture contents, drying equipments, rotary dryers, drum dryers, vacuum dryers, Spray dryer, fluidized bed dryers, dryer calculations and dryer selection criteria.

References:

1. Treybal R.E. “Mass Transfer Operations” McGraw Hill Book Co., New York 1980
2. McCabe W.L. and Smith J.C. & Harriot, “Unit Operations of Chemical Engineering”, McGraw Hill Book Co., New York 1980
3. Principles of Unit Operations: Foust A.S.
4. Coulson J.M. and Richardson J.F., “Chemical Engineering Vol. I, II & III”, Pergamon Press, New York 1977
5. Unit Operation: Mc Cetta Vol. I
6. Badger W.L. and Banchero J.T., “Introduction to Chemical Engineering”, Tata McGraw Hill Book Co.
7. Chattopadyay P., “Unit Operations of Chemical Engineering”, Vol. 1 & 2, Khanna Publishers, New Delhi.

Course Outcomes:

1. Students will learn about the fundamentals of diffusional mass transfer in solids and fluids.
2. Student will understand the application of mass transfer theories in various unit operations.
3. Student will understand the mechanism and operation of absorption/stripping column.
4. Students will gain the knowledge about the equipments/columns used in various unit operation eg. Absorption, drying, humidification etc.
5. Student will understand Operation of Dryer and cooling tower.

Department	**: Department of Chemical Engineering**
Course code	**: CHC-301**
Course Title	**: Mass Transfer-I (PR)**
Course Type	**: Practical**
Total Hrs	**: 03**
Course credit	**: 1.5**

Objective:

To enhance the knowledge and clear the theoretical concepts in the subject by performing the hands on experiments in the laboratory for detail understanding of the topic.

Course Content:

List of Experiments:

1. Determination of vapour diffusivity
2. Study of Liquid –liquid diffusion through porous pot.
3. Solid -liquid diffusion.
4. Solid-air diffusion
5. Absorption with/ without chemical reaction.
6. Batch drying.
7. Tray dryer.
8. Fluidised bed tower.
9. Humidification study/ Cooling tower.
10. Wetted wall column.

(Minimum 8 experiments).

Outcomes:

Student will be able to solve basic piratical calculations of mass transfer operation.

Student will be able to design Absorption column, dryers, and cooling tower.

Department	**: Department of Chemical Engineering**
Course code	**: CHC-302**
Course Title	**: Instrumentation & Instrumental Analysis (TH)**
Course Type	**: Theory**
Total Hrs	**: 04**
Course credit	**: 04**

Course Objectives:

To impart the thorough knowledge about analysis, measurements of various parameters along with the advance controlled systems in chemical engineering and how to use them on the field in professional life. To make the student to be able to understand and solve the problems in measurement and controlled systems by using standard methods.

Course Content:

Unit-I **(10hrs)**

Measuring instruments:

Elements of measuring instruments

Static and dynamic characteristics of measuring instruments

Dynamic characteristics of 1^{st} order and 2^{nd} order tyope measuring instruments.

Unit-II **(10hrs)**

Temperature Measurements: -

Expansion thermometers

Thermocouples, Thermistors, R.T.D

Radiation based temperature-measuring instruments.

Unit-III **(10hrs)**

Manometers

Measuring elements for gauge pressure and vacuum

Indicating elements for pressure and vacuum gauges

Measurement of absolute pressure etc.

Unit-IV **(10hrs)**

Measurement of Head and Level

Direct and indirect methods: float type, bubbler systems, air purge method

Measurement of Chemical Composition:

Spectroscopic analysis: Absorption spectroscopy. Emission spectroscopy, mass spectroscopy, x-ray diffraction, colour, measurement by spectrometers.

Unit-V **(10hrs)**

Other special methods of analysis including:

Heat of combustion method , Chemical methods for analysis of hydrogen sulfide, carbon dioxide etc., Magnetic susceptibility method, Polarizing cell method, Dilatometer, Interferometer

Introduction to single loop control.

Feed back control system.: Concept of FBC , Block diagram development, Classical FBC controller.

Feed back control design: Preliminary considerations choice of sensors, Transmitters, and final control element,

Introduction to more advanced control system :-

Feed forward, cascade, Augmented feed forward control, ratio control, override controllers, spit range, Auctioneering control. Introduction to digital control system

References:

1. Industrial instrumentation : Eckman, Donald P.
2. Instrumentation devices & Systems: Rangan C. S., Sarma G.R.
3. Principle of Industrial instrumentation: Patranbis d.
4. Process control and instrumentation :vyas R.P.
5. Process Systems Analysis and control :Donald R. Couighanowr.
6. Process Dyanamics modeling and control by Harmon Ray.

Course Outcomes:

a) To get the students well acquainted with basic principles of operation, static and dynamic characteristics of various pressure and temperature measuring instruments.
b) To get the students well acquainted with basic principles of operation, static and dynamic characteristics of various level & chemical composition measuring instruments.
c) To enhance the knowledge of students about various spectroscopic and chromatographic techniques for analysis.
d) The get the students well acquainted with basic knowledge of various sensors, controllers and their application in the control systems, advance control systems.
e) To enhance the ability of students to identify and solve various engineering problems in control systems during operation.

Department	**: Department of Chemical Engineering**
Course code	**: CHC-302**
Course Title	**: Instrumentation & Instrumental Analysis (PR)**
Course Type	**: Practical**
Total Hrs	**: 02**
Course credit	**: 01**

Objective:

To enhance the knowledge and clear the theoretical concepts in the subject by performing the hands on experiments in the laboratory for detail understanding of the topic.

Course Content:

List of Experiments:

1. Study of bimetallic thermometers, Thermocouples, Thermistors, R.T.D, manometer,
2. To study the dynamic characteristics of 1^{st} order system.
3. To study the dynamic characteristics 2^{nd} order system.
4. To study of different pressure gauges.
5. To study control valve characteristics

Outcome:

Student will be able to explain working principle of bimetallic thermometer, Thermocouples, Thermistors, R.T.D and manometer

Student will be able to explain the basics of control valve characteristics.

Department	**: Department of Chemical Engineering**
Course code	**: CHC-303**
Course Title	**: Chemical Reaction Engineering-I (TH)**
Course Type	**: Theory**
Total Hrs	**: 04**
Course credit	**: 04**

Course Objectives:

To impart the thorough knowledge about examining the reaction rate data using various techniques to determine rate laws, and to use them to design chemical reactors.

Course Content:

Unit- I **(10hrs)**

Review of chemical reaction equilibrium, Temperature Dependent term of a rate equation: from Arrhenius classification of chemical reaction, homogeneous & heterogeneous systems, rates of reaction, order of reaction, and rate constant. Theories of reaction rate. Development of kinetics based reaction mechanism, determination of frequency factor & energy of activation.

Unit- II **(10hrs)**

Collection and interpretation of kinetic data using integral , differential half life etc., technique for constant & variable volume reactor , use of linear & nonlinear least square technique . Techniques for determination of kinetics of fast ractions.

Unit- III **(10hrs)**

Ideal reactions: Concept of ideality, Development of design expression for batch, tubular and stirred tank reactors. Combined reactor system, comparison between mixed and plug flow reactor advantages and limitation in application. Series and parallel combination of PFR & CSTR , Reactor set up for autocatalytic reactor .

Unit- IV **(10hrs)**

Thermal characteristics of rectors: Isothermal, adiabatic and non adiabatic conditions.

Principles of reactor stability and optimization: Multiple study state in CSTR.

Simplified objective functions. Kinetics & reactor design foe series, parallel, and complex reaction.

Unit- V **(10hrs)**

Residence time distribution: Residence time function and relation amongst their application to ideal reactors. The modeling of real systems. Non-ideality parameters, prediction of reactor performance. Concept of micro and macro mixing.

References:

1. Chemical Reaction Engineering : Leaven Spiel O
2. Chemical Reaction Engineering: : Fogler
3. Principles of Reaction Engineering : S.D. Dawande

Course Outcome:

a) To enhance the ability of students to understand the classification of reactions, effects of various parameters on rate of reactions with different reaction rate theories.

b) To get the students well acquainted with collection and analysis of rate data using integral, differential, half-life method of analysis of rate data. To understand the kinetics of fast reactions.

c) To enhance the knowledge of students about ideal reactors, autocatalytic reactor, various parameters affecting the reactor performance, combine reaction system and comparison of various reactors.

d) The get the students well acquainted with thermal characteristics of reactors, residence time distribution and modelling of real systems.

e) To enhance the ability of students to identify and solve various engineering problems during product optimization.

Department	**: Department of Chemical Engineering**
Course code	**: CHC-303**
Course Title	**: Chemical Reaction Engineering-I (PR)**
Course Type	**: Practical**
Total Hrs	**: 03**
Course credit	**: 1.5**

Objective:

To impart the thorough knowledge about examining the reaction rate data using various techniques to determine rate laws, and to use them to design chemical reactors.

Course Content:

Experiments based on chemical reaction engg. Such as Study of kinetics reaction, Residence time distribution, Study of various reactors (Batch reactor, PFR , CSTR ,)

Minimum eight experiments based on theory

Course Outcome:

To enhance the knowledge and clear the theoretical concepts in the subject by performing the hands on experiments in the laboratory for detail understanding of the topic.

Department	**: Department of Chemical Engineering**
Course code	**: HML-302**
Course Title	**: Managerial Behaviour and Psychosocial Dimension (TH)**
Course Type	**: Theory**
Total Hrs	**: 03**
Course credit	**: 03**

Course Objectives:

This subject aims at developing students with the required commitment and competencies for working towards the objectives within an organizational framework in order to improve both individual and organizational performance.

Course Content:

Unit- I

Psychosocial dimension of work in organisation Introduction and background

Unit- II

Approaches in Organisational analysis Organisational behaviour approach

Unit- III

Early practises in Management Theories of Organisation Organisational process and Function The structural variables context. Environment of work organisation Socio-cultural Environment Its impact on Organisation Social dimension of organisational and Behaviour Formal and Informal organisation Group Dynamics and terms

Unit- IV

Motivational Process and Theories Communication Technology and Interpersonnel process Leadership process and style. and T.Q.M.

Unit- V

Decision making behaviour, Decision making techniques creativity.

References:

1) Psychosocial Dimensions for management by T.V.Rao

2) Appraising and Developing Managerial Performance Management and Organisational Behaviour by Laurie J. Mullins

3) Managerial Behaviour and Effectiveness by E Ananda Raja, N R V Prabhu, P Kameshwara Rao

4) Managerial Behaviour by O.P. Khanna

Course Outcome:

1) It emphasis on understanding of the issues, problems and practice of managing, working and organising across cultures in organisations.

2) It develops the understanding of psychosocial dimensions in people of organization to sustain relationship.

3) It contributes in developing interpersonal behaviours.

4) The subjects helps students to learn organizational whesiveness, pursuing goal and understand behaviour.

Department	**: Department of Chemical Engineering**
Course code	**: Elective-I PTL-308**
Course Title	**: Specialty Pigments and Additives in Coatings (Th)**
Course Type	**: Theory**
Total Hrs/week	**: 04**
Course credit	**: 4**

Course Content:

Unit -I Metallic, Interference and Cholesteric Pigments **(10 hrs)**

Aluminium, copper, zinc dust, bronze, nickel stainless steel, lead powders and pastes,

Nacreous, luminescent (fluoresecent/phosphorescent) pigments-optical principles, substrate free pearlescent pigments, Special effect pigments based on mica (pigments formed by coating of substrates), pigments based on liquid crystal polymer

Unit -II Functional and Nano pigments **(10 hrs)**

Antifouling pigments-cuprous oxide, other copper compounds, mercuric oxide, barium metaborate, organotin pigments,

Manufacture and properties of nanopigments: alumina, silica, titanium dioxide, iron oxides, zinc oxides, silver, $CaCO_3$, etc. on Nano scale; Bimodally porous nanoparticles (e.g. titanium tetraisopropexide), variables affecting particle size aggregation and crystal structure. Their use as spacing extenders / functional pigments in paints, reinforcing agent in polymers, heat & wear resistant materials, etc.

Unit - III Surfactants **(10 hrs)**

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.

Unit - IV **(10 hrs)**

Mechanism, dosing and Trade information of coating additives: Antisettling agents, additives for rheology control, flow and levelling control agents, slip additives, adhesion promoters, antiskinning agents, light stabilizers (UV absorbers, antioxidants, HELS), moisture scavengers, hammer and wrinkle finish additives, conductivity control additives etc.

Unit - V **(10 hrs)**

Mechanism, dosing and Trade information of Additives for Water Borne Coating: - Auxiliary and coalescing solvents, neutralization agents, thickeners, flow and levelling control agents, antifoam, antifreeze-thaw, Preservatives (In- can/film)-fungicides, mildew agents, corrosion inhibitors etc.

Department	**: Department of Chemical Engineering**
Course code	**: Elective-I, PLL-308**
Course Title	**: Technology of Elastomers and Additives (TH)**
Course Type	**: Theory**
Total Hrs	**: 04**
Course credit	**: 04**

Course Objectives:

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

Course Content:

Unit-I **(10 hrs)**

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 **(10 hrs)**

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.

Section-B

Unit-III **(10 hrs)**

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 **(10 hrs)**

Manufacturing processes, properties and application of elastomers based on butadiene and its copolymers, acrylonitrile, butyl, ethylenepropylene, silicons, and polycholoprene Rubbers etc.

Unit-V **(10 hrs)**

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, proofed fabrica, moulded goods etc.

Reference books

1) Chemistry and Technology of Rubber: Morton
2) Polymer Chemistry of Synthetic Elastomers Vol: I &II: Kennedy
3) Chemistry of Rubber: Mounten

Course Outcomes:

1. The Students will be able to understand the various application of additives for improvement in mechanical, chemical, physical and environmental properties of the product.
2. This course abreast the students with collection of latex, processing of latex and its characterization for classification of natural rubber.
3. The synthetic rubber and their synthesis, processing and properties are also known to the students at the end of the course

Department	**: Department of Chemical Engineering**
Course code	**: Elective-I, OTL-307**
Course Title	**: Technological Advances in Perfumery and Cosmetics. (TH)**
Course Type	**: Theory**
Total Hrs	**: 04**
Course credit	**: 04**

Course Objectives:

This course will cover the raw material and characterizations of different cosmetics and perfumery materials along with production. The perfume blending for different applications will also be studied.

Course Content:

Unit - I

General Chemistry of essential oils. Raw materials for essential oils, general methods of their manufacture. Different types of essential oil bearing materials.

Unit -II

Physical and Chemical characteristic of essential oils-colour, specific gravity, refractive index, optical rotation, solubility, acid value and ester value. Analysis of essential oils for free alcohols, aldehyde and ketones. Grading and standardization of essential oils, common adulterants and their detection.

Unit- III

Production, properties and composition of important Indian Essential Oils viz Rose, jasmine, khus, sandalwood, keora, palmarosa, lemongrass, peppermint, lemon, clove oil, orange oil, eucalyptus oil, etc.

Unit- IV

The history of perfumery, Perfumery and its function, the mechanism of smelling, classification of perfume ingredients. Blending of perfumes. Important isolates, synthetic perfumery materials and fixatives e.g. menthol, camphor, thymol, citral, geraniol, terpin oil, vanillin, cumarin, musk, benzyl acetate, benzyl benzoate etc.

Unit -V:

Production techniques, functions of ingredients and desirable characteristics of cosmetic products like: Face creams, Face powders, Talcum powders, Hair oil & dyes, Shampoos, Tooth pastes & powders, Shaving creams, Lipsticks, Nail polishes, Depilatories, etc

Course Outcome:

1. Describe the general chemistry of essential oils including the different types of essential oil bearing materials and the method of their manufacture.
2. Understand the principles behind the physical and chemical analytical techniques associated with essential oils.
3. Understand the principles and current practices of production of essential oils.
4. Explain the concepts of perfumery, blending of perfumes and outline the use of synthetic perfumery materials.
5. Describe the production techniques and functions of ingredients in cosmetic products.
6. Use the knowledge acquired from the course for set-up of small and medium scale industries.

Department	**: Department of Chemical Engineering**
Course code	**: Elective-I, FTL-306**
Course Title	**: Advanced Technology in Food Packaging (Elective-I)**
Course Type	**: Theory**
Total Hrs	**: 04**
Course credit	**: 04**

Course Objectives:

1. To study basic packaging materials and their types and functions .
2. To study various packaging systems used for food products.
3. Estimation of shelf life of packaged products.
4. To acquire knowledge of recent trends in food packaging.
5. To acquire knowledge of sealing and lamination techniques.

Course Content:

Unit -I **(10 hrs)**

Principle of food packaging, types and functions of packaging materials, filling and sealing of metallic, glass and plastic containers.

Unit- II **(10 hrs)**

Flexible packaging laminated packaging and retortable pouches, concept and determination of ERH, calculation of shelf life and requirement for packaging. Testing of packaging materials.

Unit- III **(10 hrs)**

Active packaging system: - Packaging requirement for different moisture level food products, Aseptic packaging of fruits & veg. milk and milk products, high barrier plastic

Unit- IV **(10 hrs)**

Product- Package compatibility: - Packaging of microwavable food, MAP of fresh fruit and veg. vacuum and MAP of meat and meat products. Packaging of breakfast cereals, bakery and confectionary products

Unit -V **(10 hrs)**

Packaging requirement for soft drink, alcoholic beverages, distilled spirits fermented food, frozen food, future trends in food packaging.

Books Recommended:

1. Handbook of food packaging edited by F. A Paine and H.Y paine.
2. Modern processing and distribution system for food edited by F. A Paine.
3. Chemical engg. Thermodynamics by Daubert.
4. Chemistry of Food Packaging by Swalam C.M., American Chemical Society, Washington D. C. 1974.
5. Packaging by Neubaner R.G. Van Nostrand Co. New York.
6. Food Packaging Principles and Practice : Gordon L. Robertson

Course Outcomes:

Students learnt following regarding the food packaging:

1. Students learnt basics of food packaging materials, systems and packaging types and functions.
2. Students learnt Flexible packaging, Active packaging system, Aseptic packaging, MAP (fruits and vegetables, meat and poultry),vacuum packaging, smart packaging and sensors for various food products.
3. Students learnt estimation of Shelf life of packaged products
4. Students learnt Packaging of microwavable food, soft drink, alcoholic beverages, frozen food.
5. Students are able to learn sealing and lamination techniques.

SEMESTER- VI

Department	**: Department of Chemical Engineering**
Course code	**: CHC-304**
Course Title	**: Mathematical Methods in Chemical Engineering (TH)**
Course Type	**: Theory**
Total Hrs/ Week	**: 04**
Course credit	**: 04**

Objective

To make the students to apply mathematical techniques for solving set of various types of equations come across during learning of various chemical engineering courses.

Course Content:

Unit- I **(10hrs)**

Matrices properties & classification, eigen value, eigen vector, Hanilton – Caley theorem, Sylvester's formula, determination of A^{-1} (3X3) & (4X4) matrix & Root finding method – Transcendental equation:- 1) Bisection method, 2) Netwon Rapson method, 3) Mullers method, 4) Intention method (method of successive Approximation), 5) Regula falsi method.

Unit- II **(10hrs)**

Solution of simultaneous Linear equation using elimination methods

1) Gausses Jorden method, 2) Gausses elimination method

3) Gauss- Seidal method, 4) Matrix inversion method

5) Relaxation method 5) Augmented matrix method

Unit- III **(10hrs)**

Solution of ordinary differential equation

1) Taylor series method, 2) Piccards method, 3) Euler's method, 4) Euler's modified method, 5) Ranga Kutta method, 6) Ranga Kutta (Forth order) method.

[10 hrs]

Unit- IV **(10hrs)**

Numerical differentiation

1) Newton forward differential formula

2) Newton Backward differential Formula

3) 3) Differentiation at a non- tabular value near the beginning or near the end

4) Central differential formula

a. Bessels formula

b. Starlings formula

5) Dividend different formula & Numerical integration

a. Trapezodial Rule, b. Simpson's 1/3 rule

c. Simson's 3/5 rule d. Weddle's Rule

Numerical based on acted integrated & actual applying the rules

Unit- V **(10hrs)**

Optimisation

A) Mathematical Technique essential for optimization such as linear programming using

1. Graphical method, 2. Trial & Error Method

3. Simplex method,

a. Primary technique, b. Duel Technique

B) Application to equipment

1. Reactor system (Temp optimization in a catalytic reactor)
2. Kinetics of complex retion
3. Distillation (Optimisation of Reflux ratio for a binary distillation column)
4. Dryer Rotary (Optimisation of Dimensions)
5. Optimum of dimensions & outlet temp. of air preheater
6. Optimum design of a packed absorber

Outcomes

Ability to develop and convert chemical engineering problem in terms of mathematical equation and to solve those series of equations using various mathematical techniques.

To learn about optimization techniques for optimization of various parameters of unit operations and processes.

Department	**: Department of Chemical Engineering**
Course code	**: CHC-305**
Course Title	**: Chemical Reaction Engineering-II (TH)**
Course Type	**: Theory**
Total Hrs/ Week	**: 04**
Course credit	**: 04**

Course Objectives:

To impart the thorough knowledge about heterogeneous reacting systems and its design, fluid-fluid reactions, catalysis, solid-catalyzed reactions and design of heterogeneous catalytic reactor.

Course Content:

Unit- I **(10hrs)**

Heterogeneous reacting systems. Rate equations for heterogeneous reactions containing pattern for two phase system.

Fluid-particle reaction, selection of model, unreacted core model for particles of unchanging size, rate of reaction for shrinking spherical particles, determination of the rate controlling steps. Application to design ; particle single size, plug flow solids, uniform gas composition, mixed flow of particles of single unchanging size, mixed flow of size mixture of particle entrainment of solid fines. Instantaneous reaction.

Unit- II **(10hrs)**

Fluid- Fluid Reaction: Rate equation for instantaneous fast, intermediate and for slow reaction, slurry reaction kinetics, Rate equation for infinitely slow reaction, film conversion parameter, Aerobic fermentations, application to design – towers for fast, slow reactions. Mixer settlers, semi-batch contacting patterns, Reactive distillation and extractive reactions.

Unit- III **(10hrs)**

Catalysis:

Concept of catalyst selection, classification and characteristics of catalyst, preparation of a catalyst and its deactivation, poisoning of catalyst and regeneration. Adsorption and its classification, different types of isotherms determination of catalyst surface area By BET method.

Unit- IV **(10hrs)**

Solid-catalyzed reaction:

Rate equations, diffusion within porous catalyst, experimental methods for finding rates, product distribution in multiple reactions.

Application to design staged adiabatic, packed bed reactors and fluidized bed reactors. Fluid-solid catalytic fixed-bed reactors.

Unit- V **(10hrs)**

Design of Heterogeneous catalytic reactors:

Fixed bed reactors, isothermal and adiabatic fixed bed reactor, non-isothermal, non-adiabatic fixed bed reactors, fluidized bed reactors, slurry reactors. Trickle-bed reactors.

Mechanical features, details of mass transfer , heat transfer, fluid flow across reactors. Design problems.

References:

1) O Levenspiel – Chemical Reaction Engineering
2) Dawande S.D.: Chemical Reaction Engineering
3) Fogler : Elements of Chemical Reaction Engineering
4) Smith J.M.: Chemical Engineering Kinetics, M

Course Outcome:

a) To enhance the ability of students to understand the heterogeneous reacting systems and its design, contacting patterns and effects of parameters on rate of reactions.
b) To get the students well acquainted with detail study of fluid-fluid reactions and the reactors for conducting the reactions. to understand the kinetics of slow reactions.
c) To enhance the knowledge of students about catalysis, catalyst activation, deactivation, poisoning of catalyst, determination of surface area by using isotherms.
d) The get the students well acquainted with solid-catalyzed reactions, experimental methods for finding rates, product distribution and heterogeneous catalytic reactors.
e) To enhance the ability of students to identify and solve various engineering problems during product optimization.

Department	**: Department of Chemical Engineering**
Course code	**: CHC-305**
Course Title	**: Chemical Reaction Engineering-II (PR)**
Course Type	**: Practical**
Total Hrs/ Week	**: 03**
Course credit	**: 1.5**

Objectives:

To impart the thorough knowledge about heterogeneous reacting systems and its design, fluid-fluid reactions, catalysis, solid-catalyzed reactions and design of heterogeneous catalytic reactor.

Course Content:

Practical's based on chemical reaction engg. Such as Study of kinetics reaction, Residence time distribution , Study of various reactors (Packed Bed, Fluidised Bed) Study of adsorption isotherm, Study of catalytic reactor, etc. Minimum eight expt. Based on theory

Course Outcome:

To enhance the knowledge and clear the theoretical concepts in the subject by performing the hands on experiments in the laboratory for detail understanding of the topic.

Department	**: Department of Chemical Engineering**
Course code	**: CHC-306**
Course Title	**: Mass Transfer-II (TH)**
Course Type	**: Theory**
Total Hrs/ Week	**: 04**
Course credit	**: 04**

Objective:

To understand the fundamental of Distillation, Liquid-liquid extraction, Solid-liquid operation, Crystallization and Adsorption.

Course Content:

Unit- I **(10hrs)**

Distillation

Vapour liquid equilibria, ideal and non-ideal systems, minimum and maximum boiling azeotropes, relative volatility, X-Y, T-X-Y, H-X-Y diagram, partial vaporisation / condensation, differential distillation and equilibrium distillation, steam, azeotropic and extractive distillation, vacuum distillation, steam distillation.

Fractionation, binary distillation, plate and packed columns for distillation,

Unit- II **(10hrs)**

Various graphical methods for estimation of number of stages in binary distillation column, Importance of reflux ratio, minimum reflux ratio, optimum reflux ratio. Murphree plate efficiency and overall plate efficiency. Effect of feed condition of 'q' line. Concept of HETP, HTU, NTU in distillation

Unit- III **(10hrs)**

Liquid-Liquid Extraction: Principle, selection of solvent for extraction, estimation of mass transfer coefficients, triangular diagram representation, Equipment for liquid-liquid extraction. (Mixer settler, Rotating Disc Contractor, Packed column, spray column) design procedures and equipment selection criteria. Single stage, multistage operations etc.

Unit- IV **(10hrs)**

Solid–Liquid Extraction fundamentals, Solvent selection, equilibrium relationship, triangular diagram representation, single stage, multistage concurrent and counter current operation, equipments for solid – liquid extraction, their design procedure and selection criteria.

Unit- V **(10hrs)**

Crystallization:- Principle, Super saturation, methods of achieving super saturation, phenomenon of crystal formation, crystal structure, equipment for crystallization (agitated vessel, Oslo, vacuum Swenson walker crystalliser), material & heat balance over crystalliser & related problems.

Adsorption: Fundamentals, adsorbent, adsorption equilibria and isotherms.

References:

1. Treybal R.E. "Mass Transfer Operations" McGraw Hill Book Co., New York 1980
2. McCabe W.L. and Smith J.C. & Harriot, "Unit Operations of Chemical Engineering", McGraw Hill Book Co., New York 1980
3. Principles of Unit Operations; Foust A.S.
4. Coulson J.M. and Richardson J.F., "Chemical Engineering" Vol. I, II & III, Pergamon Press, New York 1977
5. Brown G.G., "Unit Operations", John Wiley & Sons, New York
6. Lyderson A.L. "Mass Transfer in Engineering Practice", John Wiley Co. (1983)
7. Badger W.L. and Banchero J.T., "Introduction to Chemical Engineering", Tata McGraw Hill Book Co.

Course Outcomes:

1. The students will develop understanding of implications of factors affecting column operation, and design, effect of reflux ratio, feed conditions, and operational difficulties and thus will demonstrate the calibre of product design according to the standards.

2. Students will understand basic of various phase equilibrium based separation processes such as distillation, liquid-liquid extraction, leaching and adsorption.

3. The students will develop ability to apply mass transfer principles to perform graphical calculations for binary distillation.

4. The students will understand and apply knowledge for calculation of single and liquid-liquid, solid liquid extraction,

Department	**: Department of Chemical Engineering**
Course code	**: CHC-306**
Course Title	**: Mass Transfer-II (PR)**
Course Type	**: Practical**
Total Hrs/ Week	**: 03**
Course credit	**: 1.5**

Objective:

To understand the fundamental of Distillation, Liquid-liquid extraction, Solid-liquid operation, Crystallization and Adsorption.

Course Content:

List of Experiments:

1. To verify Rayleigh's equation,
2. To study boiling point diagram/ vapour-liquid equilibria.
3. Binary Distillation,
4. Estimation of HETP.
5. To study distribution coefficient in liquid-liquid. Extraction.
6. To Construct bimodal curve for ternary system.
7. Study of Solid liquid extraction,
8. Liquid - Liquid extraction (Batch),
9. Liquid - Liquid extraction (column)
10. Laboratory Batch Crystallisation,

(minimum 8 experiments)

Outcome:

At the end of the course student will be able to :

1. To design binary plate and packed distillation column
2. To able to design liquid-liquid and solid-liquid extraction column.
3. To design crystallization and adsorption column.

Department	**: Department of Chemical Engineering**
Course code	**: CHC-307**
Course Title	**: Process Equipment Design & Drawing (TH)**
Course Type	**: Theory**
Total Hrs/ Week	**: 03**
Course credit	**: 03**

Objective-

To study the design procedure for designing chemical equipment and selection of proper material of construction by considering different mechanical and physical properties. To study the behavior of material under stresses. The student should be able to understand the designing of pressure vessels, storage vessels, high pressure vessels, supports, calendria evaporator,shell and tube heat exchanger ,sieve tray and bubble cap tray for distillation column, agitators, rotary dryers. The students should be able to do the proportioning of pressure vessels.

Course Content:

Unit- I **(10hrs)**

Mechanical properties of materials, Selection of materials, general design procedure for designing chemical equipment protective coating, corrosion causes and prevention. Theory of failure, factor of safety. The material behavior under stresses. Fabrication Methods. Unfired pressure vessel subjected to internal and external pressure. Design of shell, nozzle, different types of head.

Unit- II **(10hrs)**

Design for atmospheric storage vessel, types of storage vessel, and different types of roofs for storage vessels. Vessels for high pressure operation, constructional features, multi shell construction, determination of thickness of shell applying various theories of failures.

Unit- III **(10hrs)**

Agitators, design of agitator components, selection, types application, power required for agitation. Drying equipments, Design of rotary dryers in details

Unit- IV **(10hrs)**

Types of support for vertical and horizontal vessels, Design of skirt support in detail, process design for short tube calendria type of evaporator, Design for sieve tray and bubble cap tray for distillation column.

Unit- V **(10hrs)**

Design for heat exchanger, shell and tube heat exchanger construction and design in details. Heating and cooling arrangements for reaction vessel. The proportioning of pressure vessels. Selection of L/D ratio. Optimization.

References:

1 B.C. Bhattacharya, Introduction to Chemical Equipment Design (Mechanical Aspects), CBS Publisher and Distributors, New Delhi.

2 Coulson & Richardson Chemical Engineering (Vol. VI), Butterworth-Heinmann (Elsevier)

3 M.V.Joshi, V.V. Mahajani Process Equipment Design, Macmillan Publishers India Ltd.

4 S.D. Dawande, Process Equipment Design (Vol. I), Denett & Co., Nagpur._

Course Outcomes-

1.From the course the students will able to know the general design procedure for designing chemical equipment and selection of proper material of construction by considering different mechanical and physical properties. They will study the behavior of material under stresses.

2. The student will understand the method for designing of pressure vessels and its components subjected to internal and external pressure. Design for atmospheric storage vessel, vessels for high pressure operation. Design of support for pressure vessel, process design for short tube calendria type of evaporator, Design for sieve tray and bubble cap tray for distillation column.

3.Students understand various types of Agitators, design of agitator components, selection, types application, power required for agitation. Drying equipments, Design of rotary dryers .

4. Students should be able to know Design for heat exchanger, shell and tube heat exchanger construction and design in details. Heating and cooling arrangements for reaction vessel. The proportioning of pressure vessels. Selection of L/D ratio.

Department	**: Department of Chemical Engineering**
Course code	**: CHC-307**
Course Title	**: Process Equipment Design & Drawing (PR)**
Course Type	**: Practical**
Total Hrs/ Week	**: 02**
Course credit	**: 01**

Objective-

To study the design procedure for designing chemical equipment and selection of proper material of construction by considering different mechanical and physical properties. To study the behavior of material under stresses. The student should be able to understand the designing of pressure vessels, storage vessels, high pressure vessels, supports, calendria evaporator,shell and tube heat exchanger ,sieve tray and bubble cap tray for distillation column, agitators, rotary dryers. The students should be able to do the proportioning of pressure vessels.

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 etc. Types of agitators, supports. Design of bubble cap tray , sieve tray, different types of packing

Course Outcomes:

a) At the end of the course the student exhibits how to design and draw in a competitive manner various process equipment with proper scale and each components with detail dimensions.
b) Learn how to draw from the design problem solved in theory the exact Drawings of Pressure vessel, Reaction vessel, Shell and Tube Heat Exchanger, Short Tube Calendria Evaporator.
c) Understands the constructional features with the help of drawings of high Pressure vessels, Rotary Drier, Detail arrangement of Sieve tray and bubble cap trays.
d) Understand how to read drawings to know details about process equipment, which can be utilized for fabrication, maintenance, assembling and dismantling.

Department : Department of Chemical Engineering

Course code : Elective-II PTL-311

Course Title : Technology of Printing Inks

Course Type : Theory

Total Hrs/week : 04

Course credit : 4

Course Content:

Unit-I **(10 hrs)**

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

Unit- II **(10 hrs**

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 **(10 hrs)**

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, news paper inks, modern production trends and future of inks.

Unit-IV **(10 hrs)**

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

Unit-V **(10 hrs)**

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. Various ink trembles and remedial measures

General Textbook

1 . 'Organic coatings : Science and Technology'**,** Edited by Zeno W. Wicks, Jr., Frank N. Jones, S. Peter Pappas; Douglas A. Wicks,Third Edition, John Wiley & Sons, Inc., Hoboken, New Jersey. 2007.

2. Morgans, W.M., 'Outline of Paint Technology', 3rd Edition, CBS Publishers and Distributors, New Delhi, 1996

3 . " Surface Coatings" Volume 1 " Raw material and their usages" Oil and Colour Chemists' Association, TAFE Educational Books, NSW, Australia,1987.

4 . Paul Swaraj, "Surface Coatings – Science and Technology", Wiley Interscience Publishers, John Wiley and Sons, Inc.1986.

5. 'Paints, Coatings and Solvents', Dieter Stoye; Werner Freitag (ed.), 2nd. Edition, Wiley-VCH. Weinheim ; (1998).

Reference Books

1. 'Paint Technology Handbook', Rodger Talbert, CRC Press,Taylor and Francis Group, 2008.

2. Feist, W. C., Finishing Exterior Wood, Federation of Societies for Coatings Technology, Blue Bell, PA, 1996.

3. 'Surface Coatings', Vol. I & II, Oil and Colour Chemists' Association, Tafe Educational Books, NSW, Australia,1987.

4. 'Coating Technology Handbook', Edited by D. Satas and A. A. Tracton, Second Edition, Marcel Dekker, Inc., New York, 2001.

5. 'Automotive Paints and Coatings'Edited by Hans-Joachim Streitberger and Karl-Friedrich Dossel,, Second Edition, WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim 2008.

6. McBane, B. N., Automotive Coatings, Federation of Societies for Coatings Technology, Blue Bell, PA, 1987.

'Surface Coatings', Vol. I & II, Oil and Colour Chemists' Association, TAFE Educational Books, NSW, Australia,1987.

1. ‘Polymers for Electrical Insulations’, Edited by Horst Sulzbach, Ser. 314, DIE BIBLIOTHEK DER TECHNIK, Elantas GmbH, 2008.
2. ‘Powder coatings : chemistry and technology’, Misev, T. V., Third Edition, John Wiley & Sons, New York, 1991.
3. ‘Powder Coating Systems’, Wiliam D. Lehr, McGraw-Hill, New York 1991.
4. Kearne, J. D., Ed., Steel Structures Painting Manual, Vol. I, Good Painting Practices, 3rd ed., 1993; Vol. II, Systems and Specifications, 7th ed., Steel Structures Painting Council, Pittsburgh, PA, 1995. Hare, C. H., Protective Coatings, Steel Structures Painting Council, Pittsburgh, PA, 1995.
5. Martin, J. W.; et al., Methodologies for Predicting Service Lives of Coating Systems, Federation of Societies for Coatings Technology, Blue Bell, PA, 1996.
6. ‘Chemistry and Technology of formulating UV Cure Coatings, Inks, and Paints’, Edited by PKT Oldring, Vol.1-5, Sita Technology Limited, London UK 1991-94.
7. ‘Photoinitiated Polymerization’, Belfield, K. D.; Crivello, J. V., Eds., ACS Symp. Ser. 847, American Chemical Society, Washington, DC, 2003.
8. Koleske, J. V., ‘Radiation Curing of Coatings’, ASTM International, West Conshohocken, PA, 2002.
9. Scranton, A. B.; et al., Eds., Photopolymerization Fundamentals and Applications, ACS Symp. Ser. 673, American Chemical Society, Washington, DC, 1997.
10. ‘Radiation Curing of Polymers’, Edited by D. R. Randell, Ser. 89, The Royal Society of Chemistry, Cambridge 1991.
11. A Window to Paints & Coatings Technology by Dr. N.R. Kondekar, COLOUR PUBLICATIONS PVT. LTD., Mumbai2010
12. Essentials of Pigments - Application and Selection by Dr. Ashok B. Karnik, COLOUR PUBLICATIONS PVT. LTD., Mumbai

19 Glass, J. E., Ed., Technology for Waterborne Coatings, American Chemical Society, Washington,
DC, 1997.

20. Karsa, D. R.; Davies, W. D., Eds., Waterborne Coatings and Additives, Royal Society of Chemistry,Cambridge, 1995.

21. Pruskowski, S. J., Jr., Ed., Waterborne Coatings Technology, Federation of Societies for Coatings Technology, Blue Bell, PA, 2005.

22. G. Buxbaum (Ed.) Industrial Inorganic Pigments, Second, Completely Revised Edition1998 WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim.

23. H. M. Smith (Ed.) High Performance Pigments 2002 WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim.

24. J. Bieleman (Ed.) Additives for Coatings 2000 WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim.

25. Willy Herbst, Klaus Hunger, Industrial Organic Pigments- Production, Properties,Applications.

Third, Completely Revised Edition (With Contributions by Gerhard Wilker, Heinfred Ohleier,

and Rainer Winter) 2004 WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim

Department	**: Department of Chemical Engineering**
Course code	**: Elective-II, FTL-308**
Course Title	**: Treatment and Disposal of Food Industrial Waste (Elective–II)**
Course Type	**: Theory**
Total Hrs	**: 04**
Course credit	**: 04**

Course Pre-requisite:

To learn the basic knowledge of treatment and disposal of food industrial waste, requires pre-knowledge of Microbiology and molecular biology (FTC-302), instrumentation and process control (CHC-309) and physical chemistry (BSC-103).

Course Objectives:

1. To learn Primary, secondary and tertiary process for treatment of industrial effluent
2. To learn composition and health hazards of pollutants in effluent
3. To learn principle, design and working of various biological process for treatment of industrial effluent
4. To learn value addition to waste through effluent treatment
5. Estimation of kinetic coefficients for treatment.

Course Content:

Unit-I **(10 hrs)**

Physical, chemical and biological characteristics of food industry waste. Composition of food industry waste.

Unit-II **(10 hrs)**

Classification and application of waste water treatment methods. Treatment process flow sheets. Process design criteria.

Unit-III **(10 hrs)**

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

Unit -IV **(10 hrs)**

Activated sludge process. Suspended-Growth nitrification. Aerobic Aerated Lagoons.

Aerobic digestion. Aerobic stabilization ponds.

Unit-V **(10 hrs)**

Trickling filters, Roughing filters, Rotating biological contactors, Packed bed reactors, Byproduct recovery and value addition to the waste.

Books Recommended:

Waste Water Engineering: Treatment, Disposal and Reuse by Metcalf & Eddy (Second Edition)

Course Outcomes:

1. The students will learn and gain the basic knowledge of composition of industrial effluent and health hazards of pollutants in effluent
2. The students will learn various Primary, secondary and tertiary process for industrial effluent treatment
3. The students will learn principle, design and working of various biological process for treatment of industrial effluent
4. The students will learn various value addition to waste through effluent treatment
5. The students will be able to calculate kinetic coefficients for waste water treatment.

Department	**: Department of Chemical Engineering**
Course code	**: Elective- II, OTL-309**
Course Title	**: Modified and Tailor Made Oils. (TH)**
Course Type	**: Theory**
Total Hrs	**: 04**
Course credit	**: 04**

Course Objectives:

To apply the basic principles of chemistry and technology for the modification of oils and fats. This helps in producing w.r.t. effective and better tailormade products for edible and non-edible applications.

Course Content:

Unit – I

Chemistry of drying oils, natural and synthetic drying oil, modification of oils for surface coating industry, thermal and chemical modifications methods, properties of modified oils such as blown, stand oil, boiled oil, malenized, isomerised oil , etc. Process & plant employed for their commercial production. Chemistry & Technology of Alkyd resins: Classification on the basis of oil length, Selection of ingredients. Fatty acids & monoglyceride routes, fusion & Solvent process. Their merits & demerits.

Unit – II

Plants & process of manufacture of alkyd resin. Modification of alkyd resin. Oil modified synthetic resin: Chemistry, formulation & manufacture, oleoresinuous varnishes, epoxy esters, urethane oils, polyamides, polyester amides, etc.

Unit – III

Application of oils, modified oils, oil modified resins in surface coating industry. Brief review of paint formulation & application. Plants, Processes & applications of metallic soaps, lubricating oils and greases, cutting oil, Hydraulic oils, etc.

Unit – IV

Transesterification: Classification of transesterification: Acidolysis, Alcoholysis, Interesterification / Intraesterification. Mechanism of interesterification (directed and random). Different types of chemical and enzyme catalysts for transesterification. Plants for production of methyl ester, monoglyceride, interesterification products, etc.

Unit – V

Confectionery and Bakery Fats: Raw material for confectionery fats: Cocoa butter, processing of Cocoa butter, composition and properties of Cocoa butter, polymorphism and crystal behaviour of cocoa butter. Methods of obtaining cocoa butter substitutes, replacer, equivalents and extenders. Plastic shortening agents: different types of plastic shortening agents, selection of blends with reference to specific requirements and application in bakery products.

Course Outcome:

1. Understand the chemistry underlying the drying mechanism of oils.
2. Describe the plant and process for modifications of oil for surface coating industry.
3. Outline the paint formulation and applications of lubricating oils, metallic soaps etc.
4. Understand the classification and mechanism of major esterification reactions for synthesis of industrially important products like MG, ME etc.
5. Distinguish between the terminologies related to confectionary and bakery fat; describe the polymorphism and crystal behavior of cocoa butter and discuss the methods of cocoa butter substitute preparations.

Department	**: Department of Chemical Engineering**
Course code	**: Elective - II, PLL-311**
Course Title	**: Plastic Waste Management (TH)**
Course Type	**: Theory**
Total Hrs	**: 04**
Course credit	**: 04**

Course Objective:

a. To understand the concept of plastics recycling.
b. To understand about various sources of plastics waste.
c. To understand various identification and separation method for waste plastics.
d. To learn about different recycling methods for plastics recycling**.**

Course Content:

Unit- I

Introduction, Sources of plastics waste (Industrial waste, post consumer waste, scrap waste and nuisancewaste), Plastic identification and Separation techniques – (density - float sink and froth floatation methods,optical, spectroscopic, electrostatic, sorting by melting temperature, sorting by size reduction, sorting by selective dissolution and other methods), recycling codes.

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, Depolymerization of scrap rubber, tyre retreading, uses of recycled rubber – asphalt andother 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 books

1. John Scheirs., - "Polymer Recycling" John Wiley and Sons,1998

2. Nabil Mustafa – "Plastics Waste Management" Marcel Dekker Inc.,1998.

3. Steven Blow, Handbook of Rubber Technology, Galgotia Publicatins Pvt. Ltd., New Delhi, 1998.

4. Chandra R. and Adab A., Rubber and Plastic Waste, CBS Publishers & Distributors, New Delhi, 1994.

Reference books

1. Muna Bitter, Johannes Brandup, Georg Menges "Recycling and Recovery of plastics" 1996

2. Attilio.L.Bisio,Marino Xanthos, " How to manage plastics waste: Technology and market Opportunities"

Hanser Publishers, 1994

3. Francesco La Mantia., " Handbook of Plastics Recycling" Chem Tec Publishing,2002

Course Outcomes:

At the end of the course students will have knowledge of:

1. Sources of plastics waste, its identification and separation methods.
2. Approaches of plastic waste management
3. Mechanical and chemical recycling of polymers.
4. Recycling of plastics by surface refurbishing.

Department	**: Department of Chemical Engineering**
Course code	**: Elective-III, CHL-312**
Course Title	**: Energy Resources & Utilization (TH)**
Course Type	**: Theory**
Total Hrs/ Week	**: 04**
Course credit	**: 04**

Course Content:

Unit- I **(10hrs)**

Fuels - Classification, Properties, tests and analysis.

Solid Fuels - Coal, origin, classification, storage and handling, carbonization, gasification and briquetting - gasification of biomass.

Unit- II **(10hrs)**

Liquid fuels - Petroleum based fuels, synthetic fuels, alcohol and blended fuels, storage and handling.

Gaseous fuels - Water gas, carbureted water gas, producer gas, coal gas and natural gas.

Unit- III **(10hrs)**

Combustion - Air requirement for solid, liquid and gaseous fuels, Combustion equipment

Solar energy, Wind energy, Tidal energy

Unit- IV **(10hrs)**

Geothermal energy, Magneto hydrodynamics, Nuclear energy. Energy Management-Principles need, initiating and managing an energy management program.

Unit- V **(10hrs)**

Energy audit – elements, and concepts, types of energy audits, energy audit with respect to industries like sugar, paper etc.,

Energy Conservation-Thermodynamics of energy conservation, cogeneration, waste heat recovery technologies. Industrial insulation - material selection, economical thickness

References:

1. S.P.Sharma and ChanderMohan, “Fuels and Combustion”, Tata McGraw Hill, 2004.

2. J.K.Harker and J.R.Backhurst, “Fuel and energy”, Academic Press, 1981.

3. D.A.Raey, “Industrial Energy Conservation”, Pergomon Press, 1980.

4. J.D.Gilchrist, “Fuels, Furnaces and Refractories”, Pergamon Press, 1977.

Department	**: Department of Chemical Engineering**
Course code	**: Elective-III CHL-313**
Course Title	**: Advance Heat Transfer (TH)**
Course Type	**: Theory**
Total Hrs/ Week	**: 04**
Course credit	**: 04**

Course Content:

Unit-I **(10hrs)**

Steady State Heat Conduction with Heat Generation:

Introduction to Steady State Heat Conduction with Heat Generation, conduction in solid, hollow cylinder with uniform heat generation. Temperature distribution & heat flux in an infinite slab, hollow cylinder with uniform heat generation. Heat generation in nuclear fuel rod.

Unit-II **(10hrs)**

Thermal insulation, insulating materials, design factor, properties of insulating material, economic thickness of insulation, optimum thickness of lagging. Specific heat and thermal diffusivity of insulation. Critical thickness of insulation on minimum heat transfer rate. Determination of thermal conductivity of insulating material. Insulation of hot surface. Thermal insulation of cryogenic services.

Unit-III **(10hrs)**

Transient Heat Conduction:

Introduction to Transient Heat Conduction, classification of transient heat conduction processes, system with negligible internal resistance. Introduction to lumped heat capacity system, transient heat conduction in a plane walls-chart solution, long cylinder of radius r_o, and sphere of radius r_o, Transient heat flow in semi-infinite solid. Unsteady state heat transfer for food and biological materials.

Unit-IV **(10hrs)**

Multiple effect evaporator, Heat transfer area for multiple effect evaporator, criteria for selection of evaporator, factor related to mechanical design, economy of multiple effect evaporator, Optimum number of effect on cost basis, Empirical approach to steam

requirement, wate evaporation distribution approach, resistance time control ring, Multiple effect evaporatordesign, vapour compression technique.

Unit-V **(10hrs)**

Spiral coil and plate tupe heat exchanger, finned tube heat exchanger. Single and multi phase condenser. Designe of reboilers, veporisors, Kettle type and thermosiphon reboilers, forced circulation vaporizers. Heat transfer in agitated vessels both jacketed and with coil, transient heating or cooling, Heat transfer in packed and fluidized beds.

Referneces:

1. J. M. Colson and J. F. Richardson, "Chemical Engineering", 6th Ed. Vol-1. Elsevier Pub.
2. J. M. Colson and J. F. Richardson, "Chemical Engineering", 6th Ed. Vol-6. Elsevier Pub.
3. W. L. McCabe Smith and P. Harriot, "Unit Operation of Chemical Engineering", 6th ed. McGraw Hill,
4. S. D. Davande, "Principals of Heat and Mass Transfer"
5. Fundamentals of Heat and Mass Transfer, Sixth Edition, by F.P. Incropera and B. Lavine, Wiley, 2006.
6. Heat Transfer, A. F. Mills, 1998 (Prentice Hall). TJ260.M52 1998
7. A Heat Transfer Textbook, J. H. Lienhard, 2nd edition, 1987 (Prentice Hall, Englewood Cliffs). TJ260.L445
8. D. Q. Kern, "process Heat Transfer", McGraw Hill
9. Desmon and Karlekar, "Heat and Mass Transfer"
10. P. K. Nag, "Heat Transfer"
11. R. C. Sachdeva, "Fundamentals of Engineering-Heat and Mass Transfer"

Department	**: Department of Chemical Engineering**
Course code	**: Elective-III CHL-314**
Course Title	**: Plant Utility and Safety (TH)**
Course Type	**: Theory**
Total Hrs/ Week	**: 04**
Course credit	**: 04**

Course Content:

Unit -I **(10hrs)**

Various plant utilities, their role and importance in chemical process, Water Sources, Sources of water and their characteristics ;Treatment, storage and distribution of water; water for use in boilers, cooling purposes, drinking and process; Reuse and conservation of water; Water resource management.

Unit -II **(10hrs)**

Steam Generation and Utilization

Steam generation and its application in chemical process plants, distribution and utilization; Design of efficient steam heating systems; steam economy, Steam condensers and condensate utilization, Expansion joints ,flash tank design, steam traps their characteristics, selection and application, waste heat utilization.; Lagging, selection and thickness .Selection and sizing of boilers; waste heat boilers.

Unit- III **(10hrs)**

Compressors, blowers and Vacuum Pumps

Compressors, blowers and vacuum pumps and their performance characteristics; Methods of developing vacuum and their limitations, material handling under vacuum, Piping systems; Lubrication and oil removal in compressors and pumps, Air filters, Air and gas leakage. Inert gas systems, compressed air for process, Instrument air.

Insulation

Importance of insulation for meeting the process requirement, insulation materials and their effect on various material of equipment piping, fitting and valves etc. insulation for high intermediate, low and sub zero temperatures, including cryogenic insulation.

Unit- IV **(10hrs)**

Elements of Safety

Elements of safety, safety and site selection; Plant layout and unit plot planning; Definition of risk and hazard, Identification and assessment of the hazards, distinction between hazards and risk, Hazard operability (HAZOP) hazard analysis (HAZAN); Assessment of the risk, fault tree, event tree, scope of risk assessment; Control of hazards, controlling toxic chemicals and controlling flammable materials.

Prevention of losses

Prevention of losses, Pressure relief, Provision of fire fighting equipments, Technology selection and transfer, Choosing the right process.

Unit -V **(10hrs)**

Control of Process

Control of process, Prevention of hazardous deviation in process variables, e.g. pressure, temperature flow by provision of automatic control systems- interlocks, alarms, trips together with good operating practices and management.

Regulations

Regulations and legislation, Role of government role, risk management routines and tackling disaster.

References:

1. Lees, F. P., "Loss Prevention in Process Industries 3 volume set" Butterwort -Heinemann, Oxford (1996).

2. Nordell, Eskel, "Water Treatment for Industrial and Other Uses", Reinhold Publishing Corporation, New York.(1961).

3. Crowl, D.A. & Louvar, J.F.. "Chemical Process Safety: Fundamentals with Applications". New Jersey: Prentice-Hall. (1989).

4. Goodall, P. M., "The Efficient Use Of Steam" IPC Science and Technology (1980).

Department	**: Department of Chemical Engineering**
Course code	**: Elective-III CHC-315**
Course Title	**: Petroleum Refining Engineering (TH)**
Course Type	**: Theory**
Total Hrs/ Week	**: 04**
Course credit	**: 04**

Objective:

To study about crudes, different petroleum products, properties, testing method, use and applications and petroleum processes.

Course Content:

Unit- I **(10hrs)**

Crude oil & outline of its formation ,Hydrocarbon group wise composition of Petrolium & their structures , sulfur,nitrogen,oxygen & metal-organic compound in petroleum.

Unit- II **(10hrs)**

Characterization & properties of Crude oil, Preteatment of crude, removal of moisture, salt . Refinery flow diagram, equipment & tank layout.

Unit- III **(10hrs)**

Crude Distillation , Atmospheric Topping unit, Vacuum distillation ,TBP distillation of Petroleum fraction & construction of property midpercent ,Residue yield, distillate yield curve.

Unit- IV **(10hrs)**

Major petroleum product & their specifications like Liquified Petroleum Gas , Gasoline, Naptha, Kerosene, Aviation turbine fuel, High Speed Diesel , LDO, furnace fuels, lubricants,base oil,tar & biumen.

Unit- V **(10hrs)**

Catalytic Cracking and thermal processes, Fluidised bed Catalytic Cracking, Catalytic Reforming, cracking process.

References:

1) J.H Gary, & G.E .Handwerk, Petroleum Refining: Technology & Economic 3rd edition, Marcel Dekker Inc.1994

2) J. H. Speight, The chemistry & Techonogy of Petroleum Hydrocarbon, 3rd edition.
3) G.N. Sarkar, Advanced Petroleum Refining, Khanna Publisher,1998.

Outcomes:

a) Students able to know the composition of crudes, types of crudes and crude analysis.

b) Students will understand what are paraffins, napthalenes, aromatics,acetylenes and other hydrocarbons present in petroleum, their composition , properties and structures.

c) Students understand the methods like ASTM distillation, flash and fire point, aniline point, diesel index, pour point, cetane and octane.

Department	**: Department of Chemical Engineering**
Course code	**: Elective-III CHL-316**
Course Title	**: Biofuel (TH)**
Course Type	**: Theory**
Total Hrs/ Week	**: 04**
Course credit	**: 04**

Course Content:

Unit- I **(10hrs)**

Various biofuels, gasoline, biodiesel, bioethanol, market-supply & demand, foreign oil dependency

Unit- II **(10hrs)**

Biodiesel production from oil seeds, waste oils & algae, advantages and disadvantages of generating ethanol from corn, cellulose and sugar cane etc. value added processing of biofuel residues and co-products

Unit- III **(10hrs)**

Thermal gasification of biomass, gases from biomass, composition and properties of wood gas, water gas, producer gas, methane gas, syn gas

Unit -IV **(10hrs)**

Combustion process, nature of combustion process, types of combustion process, kinetics of liquid fuel combustion, kinetics of solid fuel combustion.

Unit -V **(10hrs)**

Biofuels and the environment, impact of biofuels in global change and food production, biomass, bagasse and product of wood carbonization.

References:

1) Anaerobic Biotechnology for bioenergy production; Principles and applications, Samir K. Khanal. Wiley-Blackwell Publishing (2008)
2) Fuel and combustion, Samir Sarkar, Second edition, Orient Longman.

Department	**: Department of Chemical Engineering**
Course code	**: Elective-III CHL-317**
Course Title	**: Industrial Pollution Control (TH)**
Course Type	**: Theory**
Total Hrs/ Week	**: 04**
Course credit	**: 04**

Course Objectives:

To provide detailed knowledge on the discharge of pollutants, either of natural or of anthropogenic origin, into the environment that can induce severe stresses on ecosystems and their inhabitants.

To train students to act as experts in the area of reducing and remediating the impact of wastewater and air pollution.

To introduce theoretical and practical principles of natural purification processes and technological processes to control discharges which drive purification and remediation technologies, with reference to the legislative framework concerned with safeguarding the environment and human health.

To impart knowledge to enable students to critically review modern technology and practices for the monitoring, prevention, treatment and disposal of wastewater and air pollutants.

Course Content:

Unit- I **(10hrs)**

Characterization and control of Air Pollution

Sources and pathological effects of COx, SOx, NOx, H_2S and volatile organic emissions; Methods of sampling and analysis of SOx, NOx, & COx, ; classification of particulate matter on the basis of particle size ; standards for clean air ; Sinks of Atmospheric gases; Factors affecting stability of Dispersion & temperature inversion; Mechanism and remedial measures of photochemical Smog, Green House Effect and Ozone layer depletion. Removal of gaseous pollutants by absorption by liquids and adsorption by solids, control of volatile organic emission.

Unit- II **(10hrs)**

Methods for control of particulate matter

Design, construction and operation of Gravity Settler, Cyclone separators, Electrostatic precipitators, Fabric Filters, Venturi scrubbers, Spray and Packed bed tower. Problems on Design, Comparative performance evaluation.

Unit- III **(10hrs)**

Wastewater characterization and Primary and secondary wastewater Treatment Techniques: Physical characterization of wastewater (Colour, odour, turbidity, MLSS, Dissolved solids etc.); Principle and significance of determination of BOD, COD, DO, TOC; Use of electrochemical analyzer and atomic absorption spectrometer in determination of elements; estimation of phosphorous and nitrogen. Standards for Drinking water.

Primary Treatment Techniques (Neutralization, equalization, segregation, flocculation, micros trainers etc.)

Unit- IV **(10hrs)**

Mechanism and kinetics of Biological oxidation of pollutants. Design, construction of operation of Activated sludge process, Anaerobic Lagoons, Trickling Filters, Rotating Disc Contactors, fluidized bed contactors; Remedial measures for problems in operation of Secondary Treatment Techniques.

Unit- IV **(10hrs)**

Tertiary/ Advanced Waste Water Treatment Techniques and Solid Waste Pollution :

Principle and utilization of Adsorption, Ion Exchange, Electrodialysis, reverse osmosis, ultra filtration in wastewater treatment. Overall layout of Municipal (Domestic) and Industrial Effluent Treatment Plant Techniques for handling , disposal and control of solid waste pollutants (Composting, dumping , incineration, physical and chemical recycling).

Unit- V **(10hrs)**

Overall pollution control in selected Food , Pharmaceutical & Chemical Industries :

Beverages, Distillery, Sugar, Canning, Dairy; Antibiotics (Penicillin, Cephalosporin; etc.), Sulpha Drugs, Petroleum Refinery and Petrochemical Industries.

References:

1. "Pollution Control in Process Industries" by S.P. Mahajan MC Graw Hill
2. " Wastewater Treatment" M. Narayanrao & A.K. Dutta, IBH Publicaiton Co Pvt. Ltd., Delhi.
3. "Wastewater Engineering" Mc Catta , Mc Gvaw Hill.
4. "Air Pollution Control", P. Pratap Mouli and N. Venkata, Diva Jyoti Prakashan, Jodhpur.

5. Physico- Chemical Process for water quality control, W.J. Weber, Wiley Interscience-1972.

Course Outcomes:

After successfully passing the course, graduate will be able to:

a) Build a scientific literacy which will permit a greater understanding industrial processes, products and environmental concerns and how everyday life depends on chemical phenomena
b) Identify sources, types and quantities of pollutants and determine their impact on the environment
c) Recognize and interpret quality parameters of water and air
d) Analyse pollutant transport issues in the environment
e) Identify and propose strategies and techniques for the management and control of pollution.