KONGU ENGINEERING COLLEGE

(Autonomous Institution Affiliated to Anna University, Chennai)

PERUNDURAI ERODE – 638 060

TAMILNADU INDIA

Estd : 1984

REGULATIONS, CURRICULUM & SYLLABI - 2020

(CHOICE BASED CREDIT SYSTEM AND OUTCOME BASED EDUCATION)

(For the students admitted during 2020 - 2021 and onwards)

BACHELOR OF TECHNOLOGY DEGREE
IN
CHEMICAL ENGINEERING

DEPARTMENT OF CHEMICAL ENGINEERING

KONGU
Assuring the Best

B.Tech.– CHEMICALENGINEERING CURRICULUM – R2020

SEMESTER – I									
Course Code	Course Title	Hours / Week			Credit	Maximum Marks			Category
		L	T	P		CA	ESE	Total	
Theory/Theory with Practical									
20EGT11	English Language Skills	3	0	0	3	50	50	100	HS
20MAC11	Matrices and Differential Equations	3	1*	2*	4	50	50	100	BS
20PHT11	Applied Physics	3	0	0	3	50	50	100	BS
20CYT11	Applied Chemistry	3	0	0	3	50	50	100	BS
20CHT11	Chemical Process Industries	3	0	0	3	50	50	100	PC
20MEC11	Engineering Drawing	2	0	2	3	50	50	100	ES
Practical / Employability Enhancement									
20MEL11	Engineering Practices Laboratory	0	0	2	1	50	50	100	ES
20PHL11	Physical Sciences Laboratory - I	0	0	2	1	50	50	100	BS
	Induction Training Program #	---	---	---	0	100	0	100	MC
20VEC11	Yoga and Values for Holistic Development	1	0	1	1	100	0	100	HS
Total Credits to be earned					**22**				

SEMESTER – III

Induction Training Program (including, Indian Constitution and Essence of Indian Knowledge Tradition, etc.) to be conducted at the beginning of the semester for 2 weeks.

SEMESTER – II									
Course Code	Course Title	Hours / Week			Credit	Maximum Marks			Category
		L	T	P		CA	ESE	Total	
Theory/Theory with Practical									
20EGT21	Advanced Communication Skills	3	0	0	3	50	50	100	HS
20MAC21	Multivariable Calculus and Complex Analysis	3	1*	2*	4	50	50	100	BS
20PHT25	Physics for Chemical Engineering	3	0	0	3	50	50	100	BS
20CYT24	Industrial Chemistry	3	0	0	3	50	50	100	BS
20CHT21/ 20CSC31	Chemical Process Industries/ Programming in C	3	1/0	0/2	4	50	50	100	PC/ES
20CHT22	Electrical Drives and Industrial Electronics	3	0	0	3	50	50	100	ES
Practical / Employability Enhancement									
20CHL21	Electrical Drives and Industrial Electronics Laboratory	0	0	2	1	50	50	100	ES
20PHL29	Physical Sciences Laboratory - II	0	0	2	1	50	50	100	BS
Total Credits to be earned					**22**				

Course Code	Course Title	Hours / Week			Credit	Maximum Marks			Category
		L	T	P		CA	ESE	Total	
Theory/Theory with Practical									
20MAT31	Probability and Partial Differential Equations	3	1	0	4	50	50	100	BS
20CSC31/ 20CSC41	Programming in C/Python Programming	3	0	2	4	50	50	100	ES
20CHT31	Chemical Engineering Thermodynamics	3	1	0	4	50	50	100	ES
20CHT32	Applied Organic Chemistry	3	0	0	3	50	50	100	PC
20CHT33	Fluid Mechanics	3	0	0	3	50	50	100	PC
20CHT34	Chemical Process Calculations	3	1	0	4	50	50	100	PC
Practical / Employability Enhancement									
20CHL31	Applied Organic Chemistry Laboratory	0	0	2	1	50	50	100	PC
20CHL32	Fluid Mechanics Laboratory	0	0	2	1	50	50	100	PC
20MNT31	Environmental Science	2	0	0	0	100	0	100	MC
Total Credits to be earned					**24**				

SEMESTER – IV

Course Code	Course Title	Hours / Week			Credit	Maximum Marks			Category
		L	T	P		CA	ESE	Total	
Theory/Theory with Practical									
20MAT41	Statistics and Numerical Methods	3	1	0	4	50	50	100	BS
20CSC41/ 20CHT21	Python Programming/Chemical Process Utilities	3	0/1	2/0	4	50	50	100	ES/PC
20CHT42	Mechanical Operations	3	0	0	3	50	50	100	PC
20CHT43	Process Heat Transfer	3	0	0	3	50	50	100	PC
	Open Elective I*	3	1	0	4	50	50	100	OE
Practical / Employability Enhancement									
20CHL41	Mechanical Operations Laboratory	0	0	2	1	50	50	100	PC
20CHL42	Process Heat Transfer Laboratory	0	0	2	1	50	50	100	PC
20EGL31	English for Workplace Communication Laboratory	0	0	2	1	50	50	100	HS
20GET41	Universal Human Values	2	0	0	2	100	0	100	HS
Total Credits to be earned					**23**				

*Software willing students can opt Data structures using Python and others can opt any other Open Elective

SEMESTER – V

Course Code	Course Title	Hours / Week			Credit	Maximum Marks			Category
		L	T	P		CA	ESE	Total	
Theory/Theory with Practical									
20CHT51	Mass Transfer I	3	1	0	4	50	50	100	PC
20CHT52	Chemical Reaction Engineering I	3	0	0	3	50	50	100	PC
20CHT53	Chemical Equipment Design and Drawing	3	1	0	4	50	50	100	PC
	Professional Elective I	3	0	0	3	50	50	100	PE
	Open Elective II*	3	1	0	4	50	50	100	OE
Practical / Employability Enhancement									
20CHL51	Chemical Reaction Engineering Laboratory	0	0	2	1	50	50	100	PC
20CHL52	Process Computation Laboratory	0	0	2	1	50	50	100	PC
20GEL51/ 20GEI51	Professional Skills Training -I / Industrial Training-I $	--	--	--	2	100	0	100	EC
Total Credits to be earned					**22**				

$ Professional Skills Training / Industrial Training for a total period of about 80 hr during the period of 4thsem end summer holidays and 5th sem

*Software willing students can opt Data structures using Python, Java Programming/Web Engineering and others can opt any other Open Elective

SEMESTER – VI

Course Code	Course Title	Hours / Week			Credit	Maximum Marks			Category
		L	T	P		CA	ESE	Total	
Theory/Theory with Practical									
20CHT61	Mass Transfer –II	3	0	0	3	50	50	100	PC
20CHT62	Process Modeling and Simulation	3	0	0	3	50	50	100	PC
20CHT63	Process Instrumentation Dynamics and Control	3	0	0	3	50	50	100	PC
	Open Elective- III*	3	0	0	3	50	50	100	PE
Practical / Employability Enhancement									
20CHL61	Mass Transfer Laboratory	0	0	2	1	50	50	100	PC
20CHL62	Process Modeling and Simulation Laboratory	0	0	2	1	50	50	100	PC
20CHL63	Process Instrumentation Dynamics and Control Laboratory	0	0	2	1	50	50	100	PC
20GEL61/ 20GEI61	Professional Skills Training –II / Industrial Training –II@	---	---	---	2	100	0	100	EC
20CHP61	Project Work –I	0	0	4	2	100	0	100	EC

20GEP61	Comprehensive Test/Viva	---	---	---	2	100	0	100	EC
Total Credits to be earned					**21**				

#Project Work 1 Phase I (6thsem) shall be continued further as Project Work 1 Phase II (7thsem). @ Professional Skills Training / Industrial Training for a total period of about 80 hr during 6thsem end summer holidays and 7thsem.

SEMESTER – VII									
Course Code	**Course Title**	**Hours / Week**			**Credit**	**Maximum Marks**			**Category**
		L	**T**	**P**		**CA**	**ESE**	**Total**	
Theory/Theory with Practical									
20GET71	Process Engineering and Economics	3	0	0	3	50	50	100	HS
20CHT72	Transport Phenomena	3	1	0	4	50	50	100	PC
	Professional Elective- II				3				
	Professional Elective- III	3	0	0	3	50	50	100	PE
	Professional Elective- IV	3	0	0	3	50	50	100	PE
	Professional Elective- V	3	0	0	3	50	50	100	PE
Practical / Employability Enhancement									
20CHP71	Project Work- II Phase -I	0	0	6	3	50	0	50	EC
Total Credits to be earned					**22**				

$ Project Work 1 Phase II (7thsem) shall be continuation of Project Work 1 Phase I (6thsem).

* Software willing students can opt Data structures using Python, Java Programming/Web Engineering and others can opt any other Open Elective

Engineering Economics & Management, Open Elective III and Professional Elective III shall be completed in the first half of the semester.

Professional Elective IV and Professional Elective V shall be handled in the second half of the semester.

One or both of these two courses can also be completed in 5th semester (fast track). Intern students can study these two courses through NPTEL/MOOC portals also.

SEMESTER – VIII									
Course Code	**Course Title**	**Hours / Week**			**Credit**	**Maximum Marks**			**Category**
		L	**T**	**P**		**CA**	**ESE**	**Total**	
Theory/Theory with Practical									
	Open Elective- IV	3	0	0	3	50	50	100	OE
	Professional Elective -VI	3	0	0	3	50	50	100	PE
Practical / Employability Enhancement									
20CHP81	Project work-II Phase -II	---	---	14	7	50	50	100	EC
Total Credits to be earned					**13**				

Internship / Project work for a total period of about 240 hrs.

One or both of the courses of Open Elective IV and Professional Elective VI can also be completed in 6th semester (fast track). Intern students can study these two courses through NPTEL/MOOC portals also.

PROFESSIONAL ELECTIVE (PE)

S. No.	Course Code	Course Name	L	T	P	C
		Elective – I				
1.	20CHE01	Chemical Process Plant Safety	3	0	0	3
2.	20CHE02	Organic Synthesis	3	0	0	3
3.	20CHE03	Instrumental Methods of Analysis	3	0	0	3
4.	20CHE04	Chemical Analysis	3	0	0	3
5.	20CHE05	Bio Chemical Engineering	3	0	0	3
		Elective 2				
6.	20CHE06	Pulp and Paper Technology	3	0	0	3
7.	20CHE07	Chemical Reaction Engineering -II	3	0	0	3
8.	20CHE08	Surface Coating Technology	3	0	0	3
9.	20CHE09	Energy Technology	3	0	0	3
10.	20CHE010	Modern Separation Processes				
		Elective 3				
11.	20CHE11	Air Pollution Control	3	0	0	3
12.	20CHE12	Transport Phenomena	3	0	0	3
13.	20CHE13	Process Instrumentation	3	0	0	3
14.	20CHE14	Fertilizer Technology	3	0	0	3
15.	20CHE15	Corrosion Technology	3	0	0	3
		Elective 4				
16.	20CHE16	Natural Gas Engineering	3	0	0	3
17.	20CHE17	Nano materials and composite materials for Chemical Engineers	3	0	0	3
18.	20CHE18	Fundamentals of Computational Fluid Dynamics	3	0	0	3

19.	20CHE19	Pharmaceutical Process Technology	3	0	0	3
20.	20CHE20	Process optimization	3	0	0	3
		Elective 5				
21.	20CHE21	Nuclear Engineering for Chemical Engineers	3	0	0	3
22.	20CHE22	Numerical techniques in Chemical Engineering	3	0	0	3
23.	20CHE23	Petroleum Refinery Engineering	3	0	0	3
24.	20CHE24	Industrial Waste Water Treatment	3	0	0	3
25.	20CHE25	Piping Engineering	3	0	0	3
		Elective 6				
26.	20CHE26	Battery and Fuel Cell Technology	3	0	0	3
27.	20CHE27	Fluid Movers	3	0	0	3
28.	20CHE28	Advanced Process Control	3	0	0	3
29.	20CHE29	Ores and Mineral Processing	3	0	0	3
30.	20CHE30	Polymer Technology	3	0	0	3
Total Credits to be earned						**18**

LIST OF PROFESSIONAL ELECTIVES

Course code	Course Title	Hours/Week			Credit	Sem	Domain/ Stream
		L	T	P			
Elective I-5 SEM							
20CHE01	Chemical Process Plant Safety	3	0	0	3	V	PSS&RE
20CHE02	Organic Synthesis	3	0	0	3	V	PSS&RE
20CHE03	Instrumental Methods of Analysis	3	0	0	3	V	PSS&RE
20CHE04	Bio Chemical Engineering	3	0	0	3	V	E&EM
Elective II- 7SEM							
20CHE05	Pulp and Paper Technology	3	0	0	3	VII	T.O
20CHE06	Chemical Reaction Engineering II	3	0	0	3	VII	PSS&RE
20CHE07	Surface Coating Technology	3	0	0	3	VII	E&EM
20CHE08	Energy Technology	3	0	0	3	VII	E&EM
20CHE09	Modern Separation Processes	3	0	0	3	VII	S.T
Elective III-7 SEM							
20CHE10	Air Pollution Control	3	0	0	3	VII	T.O

20CHE11	Process Instrumentation	3	0	0	3	VII	S.T
20CHE12	Fertilizer Technology	3	0	0	3	VII	TM&TD
20CHE13	Corrosion Technology	3	0	0	3	VII	DMPC&E
20GEE01	Fundamentals of research	3	0	0	3	VII	GE
Elective IV-7 SEM							
20CHE14	Natural Gas Engineering	3	0	0	3	VII	E&EM
20CHE15	Nano materials and composite materials for Chemical Engineers	3	0	0	3	VII	T.O
20CHE16	Fundamentals of Computational Fluid Dynamics	3	0	0	3	VII	T.O
20CHE17	Pharmaceutical Process Technology	3	0	0	3	VII	TM&TD
20CHE18	Process optimization	3	0	0	3	VII	T.O
20CHE19	Total Quality Management	3	0	0	3	VII	GE
Elective V-7 SEM							
20CHE19	Nuclear Engineering for Chemical Engineers	3	0	0	3	VII	DMPC&E
20CHE20	Numerical techniques in Chemical Engineering	3	0	0	3	VII	E&EM
20CHE21	Petroleum Refinery Engineering	3	0	0	3	VII	TM&TD
20CHE22	Industrial Waste Water Treatment	3	0	0	3	VII	S.T
20CHE23	Piping Engineering	3	0	0	3	VII	DMPC&E
Elective VI-8 SEM							
20CHE24	Battery and Fuel Cell Technology	3	0	0	3	VIII	PSS&RE
20CHE25	Fluid Movers	3	0	0	3	VIII	T.O
20CHE26	Advanced Process Control	3	0	0	3	VIII	S.T
20CHE27	Ores and Mineral Processing	3	0	0	3	VIII	S.T
20CHE28	Polymer Technology	3	0	0	3	VIII	PSS&RE
		18					

***** Domain/Stream Abbreviations: T.O-Transport Operations, S.T-Separation Techniques, DMPC&E- Design, Modeling, Process Control and Economics, PSS&RE -Process Synthesis, Safety and Reaction Engineering , TM&TD-Thermal, Materials and Thermodynamics, E&EM -Energy and Environment

OPEN ELECTIVE COURSES OFFERED TO OTHER DEPARTMENTS (OE)							
S. No.	**Course Code**	**Course Name**	**L**	**T**	**P**	**C**	**Sem**
1.	20CHO01	Drugs and Pharmaceuticals Technology	3	1	0	4	IV
2.	20CHO02	Process Automation	3	1	0	4	IV
3.	20CHO03	Renewable Bioenergy Resources	3	1	0	4	V
4.	20CHO04	Intelligent Controllers	3	1	0	4	V
5.	20CHO05	Food as Medicine	3	0	0	3	VII
6.	20CHO06	Organic Farming	3	0	0	3	VII
7.	20CHO07	Cosmetics and Personal health Care Products	3	0	0	3	VIII
8.	20CHO08	Brewing and Alcohol Technology	3	0	0	3	VIII

20CHT31 CHEMICAL ENGINEERING THERMODYNAMICS

Programme & Branch	B.TECH. – Chemical Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	3	ES	3	1	0	4

Preamble	This course introduces the laws and concepts of thermodynamics which can be applied for analyzing and evaluating the performance of various systems and processes in the field of chemical engineering	
Unit - I	**Laws of Thermodynamics**	**9+3**
Basic concepts: categorization of systems, properties and processes - internal energy – enthalpy. Zeroth law. First Law: applications to non-flow and flow processes. Second Law: heat engines - Carnot cycle and theorem- Entropy calculations. Third Law of thermodynamics.		
Unit - II	**Properties of Real Gases and Thermodynamics Formulations**	**9+3**
PVT behaviour of fluids: compressibility factor - two-and three-parameter theorems of corresponding states. Equation of states: Virial - van der Waals – Redlich & Kwong – Peng &Robinson equations. Basic energy relations. Maxwell relations.		
Unit - III	**Properties of Solutions**	**9+3**
Partial molar properties. Chemical potential. Fugacity and activity coefficients. Gibbs-Duhem equation. Enthalpy, entropy and Gibbs free energy changes in mixing of ideal solution.		
Unit - IV	**Phase Equilibria**	**9+3**
Phase equilibrium and stability. Criteria for equilibrium between phases in single and multi- component non-reacting systems. Vapour-liquid equilibrium of binary ideal and non-ideal solutions. Azeotropes. Raoult's law and Henry's law. P-x-y and T-x-y diagrams using Antoine equations.		
Unit - V	**Chemical Reaction Equilibria**	**9+3**
Criteria for chemical equilibrium. Standard free energy change and reaction equilibrium constant. Effect of temperature and pressure on reaction equilibrium constant. Homogeneous chemical reactions. Thermodynamic analysis and prediction of equilibrium compositions.		

Lecture:45, Tutorial:15, Total:60

TEXT BOOK:

1.	Joseph Mauk Smith, Hendrick C. Van Ness, Michael M. Abbott, Mark Thomas Swihart, Introduction to Chemical Engineering Thermodynamics, 8th Edition, McGraw Education, New Delhi, 2017

REFERENCES:

1.	Noel De Nevers, Physical and chemical Equilibrium for Chemical engineers, 2nd Edition, John Wiley & Sons, Inc., New Jersey, 2012.
2.	Milo D. Koretsky, Engineering and Chemical Thermodynamics, 2nd Edition, Wiley, 2012.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	Apply the laws of thermodynamics to practical systems and processes	Applying (K3)
CO2	Determine the volumetric properties of pure fluids	Applying (K3)
CO3	Evaluate the molar and partial molar properties of solutions	Analyzing (K4)
CO4	Apply phase equilibrium concepts to systems at VLE	Applying (K3)
CO5	Analyze the homogeneous chemical reactions and evaluate the equilibrium	Analyzing (K4)

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	2								1	2	2
CO2	3	3	2	3								1	2	2
CO3	3	3	2	3								1	2	2
CO4	3	3	2	3								1	2	2
CO5	3	3	2	2								1	2	2

1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy

ASSESSMENT PATTERN - THEORY

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT1	10	30	60				100
CAT2	10	30	40	20			100
CAT3	10	30	40	20			100
ESE	10	30	40	20			100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20CHT32 APPLIED ORGANIC CHEMISTRY

Programme & Branch	B.TECH. – Chemical Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	3	PC	3	0	0	3

Preamble	To gain knowledge in writing organic reactions and understand the reaction mechanism for various applications.	
Unit – I	**Basic Principles:**	**9**
Classification of organic compounds - Aliphatic, Aromatic compounds - saturated and unsaturated compounds - Functional groups – aldehyde, ketone, amine, amide, acids, Shapes and Structural representation of organic compounds, Isomerism, Steric-hindrance, Inductive effect and Resonance structures. Separation and Purification of organic compounds.		
Unit – II	**Organic Reactions:**	**9**
Mechanism of Electrophilic reaction and applications – Friedel craft reaction, Riemer Tiemann Reaction, Beckmann rearrangements; Mechanism of Nucleophilic reactions and applications -Aldol condensation, Perkins reaction, Benzion condensation; Mechanism of Free radical reactions and applications - Halogenations of Alkanes, Addition of HBr on Alkenes in presence of peroxide, Thermal halogenations reaction.		
Unit – III	**Carbohydrates and Protein:**	**9**
Classification of carbohydrates, Mono saccharides – Glucose and Fructose, Disaccharides – Sucrose and maltose - Polysaccharides – Starch and Cellulose – Structural aspects. Industrial uses of starch and cellulose. **Protein** Classification and Properties - Amino Acids – classification and properties.		
Unit – IV	**Synthesis of Dyes and Drugs:**	**9**
Classification, Synthesis and applications of Dyes – Congo red. Triphenylmethane dyes –Malachite green, Para Rosaniline, Alizarin, Eosin; Synthesis and applications of drugs – Sulphanilamide, Sulphapyridine, Chloroquine, penicillin, erythromycin.		
Unit – V	**Oils, Fats, Soaps and Detergents:**	**9**
Oil and Fat – Occurrence and Extraction, Physical and chemical characteristics, Analysis of oil/fat and Uses, hydrogenation of oil. Soap and Detergent – raw material, manufacture of detergent, biodegradability, purification of fatty acids, manufacture of glycerin and synthetic detergent.		

Total:45

TEXT BOOK:

1. Tiwari K.S, Vishnoi N.K, “A text book of organic chemistry”, 4th edition, Vikas Publication, India, 2014.

REFERENCES:

1. Graham Solomons T.W., Craig B. Fryhle, Scott A. Snyder, "Organic Chemistry", 11th edition, John Wiley & Sons Inc, New York, 2013.
2. Jonathan Clayden, Nick Greeves, Stuart Warren, "Organic Chemistry", 2nd edition, Oxford University Press Inc, United State of America, 2012.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	Infer about the organic compounds and separate the compounds using simple techniques	Remembering (K1)
CO2	Interpret the mechanism of the organic reactions	Understanding (K2)
CO3	classify the carbohydrates, amino acids with characteristics	Understanding (K2)
CO4	demonstrate the synthesis of dyes and drugs	understanding (K2)
CO5	Summarize the extraction and uses of oils and carry out the synthesis of soaps and detergents	Understanding (K2)

Mapping of COs with POs and PSOs

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	2											1	2	1
CO2	3	2										1	3	1
CO3	3	2										1	3	1
CO4	2	1										1	3	1
CO5	2	1										1	2	1

1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy

ASSESSMENT PATTERN - THEORY

Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	40	60					100
CAT2	40	60					100
CAT3	40	60					100
ESE	40	60					100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20CHT33 FLUID MECHANICS

Programme & Branch	B.TECH. – Chemical Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	3	PC	3	0	0	3

Preamble	This course provides a brief knowledge about the fundamentals of momentum transfer, metering and transportation of fluids	
Unit - I	**Fluid Properties and Fluid Statics:**	**9**
Nature of fluids: Liquids and Gases - Properties of fluids - Fluid statics: Basic equations, Pressure-depth relationships- Pressure measurement: Manometer and its types - Units and Dimensions: Dimensional analysis and its methods- Principles of Similarity.		
Unit - II	**Flow of Incompressible fluids in Pipes:**	**9**
Types of fluid flow – Boundary layer - Basic equation of fluid flow: Mass balance equation- Bernoulli's equation and its applications- Fluid friction in steady, one dimensional flow: Reynolds's experiment- Laminar flow- Turbulent flow – Moody's chart – Enlargement and Contractions - Fitting losses- Flow of compressible fluids.		
Unit - III	**Flow Past Immersed Bodies:**	**9**
Flow around submerged objects: Drag and drag coefficients- Flow through porous media: Determination of pressure drop using Ergun equation. Fluidization: Types- Determination of minimum fluidization velocity and pressure drop – Motion of particles through fluids.		
Unit - IV	**Fluid Flow Measurements:**	**9**
Classification and selection of flow meters- Pitot tube, Venturi, Orifice and Rotameters - Determination of discharge coefficient - Principle and applications of Anemometers, Turbine, Coriolis, Vortex flow and Magnetic flow meters - Introduction to notches and weirs.		
Unit - V	**Transportation of Fluids:**	**9**
Classification and selection of pumps and compressors: Positive displacement pumps and compressors- Centrifugal pumps and compressors- Rotary pumps and compressors- Elementary principles of gear, air lift, diaphragm and submersible pumps - Introduction to pipe, fittings and valves.		

Total:45

TEXT BOOK:

1.	Noel de Nevers, "Fluid Mechanics for Chemical Engineers", 3rd Edition, McGraw-Hill Chemical Engineering Series, 2004.

REFERENCES:

1.	McCabe W.L, Smith J.C. and Harriot P, "Unit Operations of Chemical Engineering", 7th Edition, McGraw Hill Education, United States of America, 2017
2.	Frank M White, "Fluid Mechanics", 8th Edition, McGraw Hill International Edition, United State of America, 2015.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	determine pressure drop and power based on properties of fluids	Applying (K3)
CO2	apply the principles of flow behavior for incompressible fluids	Applying (K3)
CO3	analyze the hydrodynamic behavior of packed and fluidized bed	Analyzing (K4)
CO4	analyze the choice of flow meters for the given fluid flow application	Analyzing (K4)
CO5	inspect the selection of pumps, compressors and valves in process industries	Analyzing (K4)

Mapping of COs with POs and PSOs

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	2	1									1	3	2
CO2	3	2	1									1	3	2
CO3	3	3	2									1	3	2
CO4	3	3	3									1	3	2
CO5	3	3	3									1	3	2

1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy

ASSESSMENT PATTERN - THEORY

Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	20	30	40	10			100
CAT2	10	30	30	30			100
CAT3	10	20	35	35			100
ESE	10	20	40	30			100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20CHT34 CHEMICAL PROCESS CALCULATIONS

Programme & Branch	B.TECH. – Chemical Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	3	PC	3	1	0	4

Preamble	This course provides basic knowledge of materials and energy balance calculation in chemical industries.	
Unit - I	**Basics of Process Calculation:**	**9+3**
Compositions of mixtures and solutions – molality, molarity, normality, mole fraction, mass fraction; Application of Dalton's law and Amagat's law for gas mixture calculation; Calculations of pressure, volume and temperature using ideal gas law.		
Unit - II	**Material Balance for Unit Operation:**	**9+3**
Material balance calculations - distillation, evaporation, crystallization, drying, extraction and mixing; Humidification and Dehumidification **-** Calculation of absolute, molal, relative, percentage, and saturation humidity; use of Psychrometric chart.		
Unit - III	**Material Balance for Unit Process:**	**9+3**
Stoichiometric principles - limiting and excess reactants, conversion, yield and selectivity; material balance with bypass, recycle and purging.		
Unit - IV	**Energy Balance:**	**9+3**
Heat requirement calculations for solids, liquids, and gases using molal and mean molal heat capacity; Enthalpy change - reaction, formation, combustion, solution, mixing; Effect of pressure and temperature on heat of reaction; Adiabatic flame temperature..		
Unit - V	**Fuels and Combustion:**	**9+3**
Classification and analysis of fuels; Calculation of calorific value and composition of fuels; theoretical and excess air for combustion of solid, liquid and gaseous fuels; Composition of flue gases by Orsat analyzer.		

Lecture:45, Tutorial:15, Total:60

TEXT BOOK:

1.	Narayanan K.V., Lakshmikutty B, "Stoichiometry and Process Calculations", 2nd Edition, Prentice Hall of India, New Delhi, 2016.

REFERENCES:

1.	Himmelblau D.M, "Basic Principles and Calculations in Chemical Engineering", 8th Edition, Prentice Hall of India, New Delhi, 2013.
2.	Venkataramani V., Anantharaman N. and Sheriffa Begam K.M, "Process Calculations", 2nd Edition, Prentice Hall of India, New Delhi, 2011.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	compute the composition of mixture and solution; apply ideal gas law and vander waals equation of state for gas mixture	Applying (K3)
CO2	calculate the mass/ molar flow rate and composition of streams for diverse unit operation and compute material balance for the given system using spread sheet	Applying (K3)
CO3	apply stoichiometric principles to various unit process, bypass, purge and recycle operation	Applying (K3)
CO4	analyze the enthalpy change and adiabatic flame temperature for given system	Analyzing (K4)
CO5	examine the calorific value of fuel, composition of fuel and flue gas and percentage excess air	Analyzing (K4)

Mapping of COs with POs and PSOs

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	2	1											3	2
CO2	3	2	1									1	3	2
CO3	3	2	1									2	3	2
CO4	2	1	1									2	3	2
CO5	2	1	1									2	3	2

1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy

ASSESSMENT PATTERN - THEORY

Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	10	10	80				100
CAT2	10	10	80				100
CAT3	10	10	20	60			100
ESE	10	10	40	40			100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20CHL31 APPLIED ORGANIC CHEMISTRY LABORATORY

Programme & Branch	B.TECH. – Chemical Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	3	PC	0	0	2	1

List of Exercises / Experiments :

1.	Determination of carbohydrates from unknown organic compounds
2.	Determination of acids from unknown organic compounds-ester
3.	Determination of esters from unknown organic compounds-thiourea
4.	Determination of amine from unknown organic compounds-nitro compound
5.	Determination of amide from unknown organic compounds
6.	Determine the yield of m-dinitro benzene from nitro benzene
7.	Determine the yield of benzoic acid from ethyl benzoate
8.	Determine the yield of benzoic acid from benzaldehyde
9.	Estimation of phenol/aniline using Winkler's method
10.	Determination of qualitative separation of acid from hydrocarbon mixture
11.	Estimation of acid value and iodine value of the given oil sample
12.	Determination of the alkali content and fatty acid content in the given sample soap

Total:30

REFERENCES/MANUAL/SOFTWARE:

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	determine the functional group of Carbohydrate, Ester, Amide, Amine and Acid	Applying (K3), Precision (S3)
CO2	synthesis of the organic compounds and calculate its yield	Applying (K3), Precision (S3)
CO3	estimation of phenol and/or aniline by Winklers methods/ separation efficiency of binary mixtures	Applying (K3), Manipulation (S2)

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3												3	1
CO2	3	2											3	1
CO3	2	1											3	1

1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy

20CHL32 FLUID MECHANICS LABORATORY

Programme & Branch	B.TECH. – Chemical Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	3	PC	0	0	2	1

List of Exercises / Experiments :

1.	Estimate the discharge coefficient of variable head flow meters
2.	Investigate of flow characteristics of Rotameter
3.	Estimate the discharge coefficient of V- notch and open drum
4.	Measure the air velocity using Pitot tube
5.	Determine the loss coefficient of valves and pipe fittings
6.	Verify the Moody diagram for flow through straight pipe and Helical coils
7.	Study the effect of Reynolds number on friction factor for flow through concentric pipes
8.	Verify of Bernoulli's Theorem by Bernoulli's apparatus
9.	Determine the pressure drop for flow through Packed bed
10.	Determine the minimum fluidization velocity for flow through fluidized bed
11.	Estimate the characteristics of centrifugal and reciprocating pump
12.	Estimate the characteristics of vacuum and gear pump

Total:30

REFERENCES/MANUAL/SOFTWARE: Laboratory Manual

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	Estimate coefficient of discharge for flow through open and closed channels, show the relationship between Reynolds number and friction factor for flow through closed conduits	Applying (K3), Precision (S3)
CO2	Estimate pressure drop and minimum fluidization velocity through packed bed and fluidized bed	Applying (K3), Manipulation (S2)
CO3	Perform characteristic studies of centrifugal and reciprocating pump	Applying (K3), Manipulation (S2)

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	1									3	3	2
CO2	3	2	1									3	3	2
CO3	3	2	1									3	3	2

1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy

20CHT42 MECHANICAL OPERATIONS

Programme & Branch	B.TECH. – Chemical Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	4	PC	3	0	0	3

Preamble	This course enables the students to understand the handling and operation of solids	
Unit - I	**Properties and Handling of Particulate Solids:**	**9**
Particle characterization, agglomeration and segregation; Methods of handling, transportation and storage of bulk solids		
Unit - II	**Size Reduction:**	**9**
Laws and mechanism of size reduction; types of crushing equipment; industrial screens and screen effectiveness.		
Unit - III	**Separation of Particulate Solids:**	**9**
Gravity separation: classifier, clarifier, settler; sedimentation and centrifugal separation; flotation, magnetic separators and electrostatic precipitator.		
Unit - IV	**Filtration:**	**9**
Filtration theory, classification of filtration process, Selection of filters; Industrial filtration equipment.		
Unit - V	**Agitation and Mixing:**	**9**
Significance of agitation and mixing, equipment for agitation, types of impellers, power requirement for mixing of Newtonian liquids; Mixers for powders and pastes, mixing index.		

Total:45

TEXT BOOK:

1. Swain A.K, Patra H. and Roy G.K, "Mechanical Operations", 1st Edition, Tata McGraw Hill Education Pvt. Ltd, New Delhi, 2017.

REFERENCES:

1. Coulson J.M. and Richardson J.F, "Chemical Engineering", 5th Edition, Butterworth-Heinemann Ltd, United States of America, 2002.
2. Badger Walter L. and Banchero Julius T, "Introduction to Chemical Engineering", 1st Edition, Tata McGraw Hill Publishing Company Ltd, New Delhi, 2008.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	determine the characteristics of solids, size analysis and demonstrate the transportation and storage of solids	Applying (K3)
CO2	categorize the size reduction equipment and estimate the power consumption and effectiveness of the screen	Applying (K3)
CO3	examine the separation equipment for solid-solid, solid-liquid and solid-gas system and design of thickener	Applying (K3)
CO4	categorize various filters and determine the rate of filtration	Applying (K3)
CO5	analyze the working of various types of impellers, mixers and determine the power consumption for mixing and agitation	Applying (K3)

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2											3	1
CO2	3	2	1										3	1
CO3	2	2	1										2	2
CO4	2	2	1										3	2
CO5	2	2	1										3	2

1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy

ASSESSMENT PATTERN - THEORY

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT1	20	40	40				100
CAT2	20	40	40				100
CAT3	10	50	40				100
ESE	10	45	45				100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20CHT43 PROCESS HEAT TRANSFER

Programme & Branch	B.TECH. – Chemical Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	4	PC	3	0	0	3

Preamble	This course will help the students to apply the modes of heat transfer and its application in design of heat transfer equipment.	
Unit - I	**Conduction:**	**9**
Nature and Modes of heat transfer. Concept of heat conduction -Fourier's law, thermal conductivity of materials, one dimensional steady state heat conduction equation for composite flat plate, hollow cylinder, and hollow sphere, heat conduction through a series of resistances. Relationship between Individual and overall heat transfer coefficients; critical thickness of insulation; fundamental concepts in extended surfaces heat transfer; Transient heat conduction.		
Unit - II	**Convection:**	**9**
Natural and forced convection –Application of dimensional analysis for convection and dimensionless numbers, Reynolds and Colburn analogy –jH factor, Equations for forced convection under laminar and turbulent flow conditions in pipes, Equations for natural convection in vertical plates and vertical and horizontal cylinders		
Unit - III	**Heat Transfer with Phase Change:**	**9**
Boiling heat transfer-General aspects, boiling regimes, factors affecting boiling, boiling correlations, condensation heat transfer—film and dropwise condensation, Evaporator-Types and method of feed -steam economy and surface area calculations for single effect evaporator.		
Unit - IV	**Heat Exchangers:**	**9**
Types of heat exchangers; LMTD; use of correction factor charts; Fouling factors; surface area calculations for double pipe and shell and tube heat exchangers; effectiveness and number of transfer units –Wilson's plot.		
Unit - V	**Radiation**	**9**
Concept and nature of thermal radiations -Concept of Black and grey bodies; Stefan Boltzmann, Kirchhoff's, Planck's and Wien laws; Radiation between surfaces –configuration factor; radiation shield.		

Total:45

TEXT BOOK:

1.	Rajput R.K, "Heat and Mass Transfer", 5th Edition, S.Chand, New Delhi, 2007

REFERENCES:

1.	Holman. J.P. and Souvik Battacharyya, "Heat Transfer", 10th edition, McGraw-Hill Education, Europe, 2011
2.	Binay K. Dutta, "Heat Transfer: Principles and Applications", 7th edition, PHI Learning Pvt. Ltd., 2000
3.	Kern D.Q Process Heat Transfer, 2nd Edition, Tata McGraw Hill Europe, 1997
4.	Necati 0zisik.M, Helcio R. B. Orlande, "Inverse Heat Transfer", 1st edition Taylor and Francis, New York, 2000

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	calculate heat transfer rate for different geometries under steady state and transient heat conduction	Applying (K3)
CO2	apply the different flow conditions by convective heat transfer.	Applying (K3)
CO3	Inspect the fundamentals of boiling and condensation and determine the economy of evaporator	Applying (K3)
CO4	design and analyze the performance of heat exchangers.	Applying (K3)
CO5	apply the laws of radiation heat transfer for different configurations.	Applying (K3)

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2									2	3	2
CO2	3	3	2									2	3	2
CO3	3	3	3		1							2	3	3
CO4	3	3	3		1							2	3	3
CO5	3	3	2									2	3	2

1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy

ASSESSMENT PATTERN - THEORY

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT1	20	30	50				100
CAT2	10	30	60				100
CAT3	10	30	60				100
ESE	10	30	60				100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20CHL41 MECHANICAL OPERATIONS LABORATORY

Programme & Branch	B.TECH. – Chemical Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	4	PC	0	0	2	1

List of Exercises / Experiments :

1.	Determine the crushing law constants and the power consumption using Jaw crusher and Roll crusher
2.	Examine the critical speed and the power consumption using ball mill
3.	Calculate the average particle size using size analysis and finding the effectiveness of Screen
4.	Estimate the particle size distribution and the average particle size using Beaker decantation.
5.	Examine the specific surface area of the given powder using Air permeability.
6.	Determine of the specific cake resistance and filter medium resistance using plate and frame filter press /leaf filter.
7.	Calculate the performance analysis of a screw conveyor.
8.	Estimate the separation efficiency of cyclone separator
9.	Conduct the batch sedimentation test to design a thickener
10.	Determine the power consumption for mixing in a liquid agitator

Total:30

REFERENCES/MANUAL/SOFTWARE:

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	determine crushing characteristics, power requirements and constants of crushing laws using Jaw and Roll Crusher	Applying (K3), Manipulation(S2)
CO2	calculate the critical speed and assess work index by using Ball mill and performance analysis of a screw conveyor	Applying (K3),Manipulation (S2)
CO3	estimate average particle size and specific surface area by conducting Sieve Analysis, Beaker Decantation and Air Permeability experiments	Applying (K3),Manipulation (S2)

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2											3	3
CO2	2	1											3	3
CO3	2	1											3	3

1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy

20CHL42 PROCESS HEAT TRANSFER LABORATORY

Programme & Branch	B.TECH. – Chemical Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	4	PC	0	0	2	1

List of Exercises / Experiments :

1.	Calculate the thermal conductivity of a material.
2.	Estimate transient heat conduction- constant flux and constant temperature
3.	Evaluate the overall heat transfer coefficient and heat transfer rate in a Column.
4.	Calculate the heat transfer coefficient and fin efficiency in an extended surface
5.	Investigate the heat transfer coefficient under natural convective heat transfer.
6.	Estimate the heat transfer coefficient under forced convective heat transfer
7.	Evaluate the Stefan Boltzmann constant
8.	Determine the combined convective and radiative heat transfer coefficient
9.	Investigate the boiling mechanism in heat transfer equipment
10.	Estimate the steam economy and efficiency of a single effect evaporator.
11.	Evaluate the heat transfer coefficient in horizontal and vertical condensers.
12.	Calculate the heat transfer coefficient in a jacketed vessel.
13.	Estimate and compare the heat transfer coefficient in a double pipe heat exchanger for co-current and counter current flow pattern.
14.	Determine the overall heat transfer coefficient in a shell and tube heat exchanger for parallel flow pattern.

Total:30

REFERENCES/MANUAL/SOFTWARE: Laboratory Manual

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	apply the heat transfer concepts to solve steady state and unsteady state heat transfer	Applying (K3), Manipulation (S2)
CO2	appraise boiling and condensation mechanism to evaluate steam economy in evaporator and heat transfer coefficient in condenser	Applying (K3), Manipulation (S2)
CO3	evaluate the heat transfer coefficient for jacketed vessel, double pipe and shell and tube heat exchanger	Applying (K3), Manipulation (S2)

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3											3	3
CO2	3	3											3	3
CO3	3	3											3	3

1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy

20CHT51 MASS TRANSFER- I

Programme & Branch	B.Tech. & Chemical Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	Chemical Process Calculations	5	PC	3	1	0	4

Preamble	The subject focuses on the diffusion, mass transfer co-efficient, theories of mass transfer, the process aspects and equipment used in the operations like Absorption, Adsorption, Ion Exchange and Humidification.	
Unit – I	**Diffusive Mass Transfer:**	**9+3**
Molecular diffusion in gases and liquids, measurement and calculation of diffusivities, steady state diffusion in multi component mixtures. Diffusion in solids, molecular and Knudsen diffusion in porous solids.		
Unit - II	**Turbulent Transfer of Mass and Interface Mass Transfer:**	**9+3**
Mass transfer in turbulent flow, eddy diffusion, mass transfer coefficients, estimation of mass transfer coefficient in wetted wall column, correlations for the calculation of mass transfer coefficients. Theory of interface mass transfer, Individual and overall mass transfer coefficients, steady state co-current and counter current mass transfer processes, stages and stage efficiencies, cross flow and counter current cascades of stages, Kremser equations for the calculation of number of theoretical stages. Equipments for gas-liquid contact operations.		
Unit - III	**Absorption:**	**9+3**
Gas Absorption - Tray tower absorber, absorption factor, calculation number of theoretical stages, Murphree efficiency - point efficiency, tray efficiency and overall tray efficiency, calculation of actual number of trays.Packed tower absorber - HETP, HTU and NTU calculations Non-isothermal absorber, absorption with chemical reaction.		
Unit - IV	**Adsorption and Ion Exchange:**	**9+3**
Adsorption – Types of adsorption, nature of adsorbents, adsorption equilibria, effect of pressure and temperature on adsorption isotherms, Freundlich equation. Adsorption operation – stage wise operations, steady state moving bed absorbers, unsteady state fixed bed adsorbers, break through curves, rate of adsorption in fixed beds, design of fixed bed adsorbers. Ion Exchange – Selectivity, univalent, divalent-univalent, ion diffusion – particle and film control, Equipment – Fixed bed, Fluidized bed, Higgins moving packed bed, Industrial applications.		
Unit - V	**Humidification:**	**9+3**
Humidification - Humidity chart, adiabatic saturation curves, wet bulb temperature and measurement of humidity, Lewis relation, equipments for humidification operations, water cooling towers and spray chambers. Theory and calculation of humidification processes - gas liquid interaction, conditions in the top and bottom of cooling towers, design of cooling towers and dehumidifiers.		

Lecture:45, Tutorial:15, Total:60

TEXT BOOKS:

1.	Treybal R. E., "Mass-Transfer Operations", 3rd Edition, McGraw Hill Education, India, 1981.
2.	Binay K Dutta, Principles of Mass Transfer and Separation Process, PHI learning private limited, 2007.

REFERENCES:

1.	Anantharaman N., Meera Sheriffa Begum K.M., "Mass Transfer Theory and Practice", Prentice Hall of India Pvt. Ltd, New Delhi, 2017.

2.	Geankoplis C.J., “Transport Processes and Separation Process Principles”, 4th Edition, Prentice-Hall of India, New Delhi, 2005.
3.	Coulson J.M. and Richardson J.F., "Chemical Engineering", 5th Edition, Butterworth Heinemann, United State of America, 2002.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	measure and determine diffusion coefficients of gas, liquid systems	Applying (K3)
CO2	determine mass transfer coefficients and appreciate stage concept	Applying (K3)
CO3	perform process design calculations related to absorption and stripping operations	Applying (K3)
CO4	perform process design calculations related to adsorption operation and describe ion exchange concepts	Applying (K3)
CO5	perform process design calculations related to humidification operation	Applying (K3)

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	2										3	1
CO2	2	2	2										3	2
CO3	3	2	2										3	2
CO4	3	2	2										3	2
CO5	3	2	2										3	2

1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom’s Taxonomy

ASSESSMENT PATTERN - THEORY

Test / Bloom’s Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT1	30	50	20				100
CAT2	10	30	60				100
CAT3	10	30	60				100
ESE	20	20	60				100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20CHT52 CHEMICAL REACTION ENGINEERING- I

Programme & Branch	B.TECH. – Chemical Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	20CHT32 Applied Chemistry & 20CHT34 Chemical Process Calculations	5	PC	3	0	0	3

Preamble	This course enables the student to learn about basic concepts of kinetics and design of various ideal reactors.	
Unit - I	**Elements of Reaction Kinetics:**	**9**
Classification of chemical reactions, rate equation, Reaction Mechanism–elementary and non-elementary reaction. Integral and differential methods for analyzing kinetic data-constant volume and variable volume batch reactor, half life period, irreversible and reversible reaction.		
Unit - II	**Ideal Reactor:**	**9**
Temperature dependency on rate equation, Performance equations and kinetics studies for Batch, Semi-batch and steady state flow reactors.		
Unit - III	**Design for Single Reactions:**	**9**
Size comparison of Single reactors: Batch reactor with plug flow reactor, Mixed flow reactor with plug flow reactor. Multiple reactor system: CSTR in series, equal and different size of CSTRs in series, Different types of reactors in series, Plug flow reactors in series and parallel		
Unit - IV	**Design for Multiple Reactions:**	**9**
Parallel reactions: Product distribution and reactor size Series reactions: Irreversible reactions. Yield: Fractional yield and Selectivity. Recycle reactor, Autocatalytic reactions.		
Unit - V	**Reaction Equilibrium:**	**9**
Equilibrium in chemically reactive systems, evaluation of reaction equilibrium constant, effect of temperature on equilibrium conversion. Optimum temperature progression, reactor sizing.		

Total:45

TEXT BOOK:

1.	Levenspiel O, "Chemical Reaction Engineering", 4th Edition, Wiley India Pvt Ltd, New Delhi, 2009.

REFERENCE BOOKS:

1.	Fogler H.S., "Elements of Chemical Reaction Engineering", 4th Edition, Prentice Hall of India, New Delhi, 2008.
2.	Mark E. Davis , Robert J. Davis, "Fundamentals of Chemical Reaction Engineering", 1st Edition, Tata McGraw Hill Publishing Company Ltd, New York, 2014.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	apply the principles of reaction kinetics and formulate rate equations	Applying (K3)
CO2	analyze ideal reactor concepts to develop the performance equation to workout conversion and space time	Analyzing (K4)
CO3	analyze the experimental kinetic data to select a suitable reactor combination for a particular application	Analyzing (K4)
CO4	determine selectivity and yield for series, parallel and mixed reactions	Applying (K3)
CO5	calculate reaction equilibrium constant, equilibrium conversion and optimum size of reactor	Applying (K3)

Mapping of COs with POs and PSOs

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	1											2	1
CO2	3	3	1										3	3
CO3	3	3	1										3	3
CO4	3	3	1										3	3
CO5	3	2											3	2

1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy

ASSESSMENT PATTERN - THEORY

Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	30	30	40				100
CAT2	20	20	30	30			100
CAT3	20	30	50				100
ESE	20	20	30	30			100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20CHT53 CHEMICAL EQUIPMENT DESIGN AND DRAWING

Programme & Branch	B.TECH. – Chemical Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	20CHT34 - Chemical Process Calculations & 20CHT43 – Process Heat Transfer	5	PC	3	1	0	4

Preamble	To acquire knowledge on process and mechanical design of various process equipment used in process industries with suitable codes and standards like ASME, ASTM and BIS.	
Unit - I	**Vessels:**	**9+3**
Introduction to design – Codes and Standards. Design of Pressure vessel – under internal pressure, external pressure and combined loading. Design of storage vessel.		
Unit - II	**Heat Transfer Equipment:**	**9+3**
Design of Shell and tube and double pipe heat exchangers		
Unit - III	**Heat Transfer Equipment with Phase change:**	**9+3**
Design of condensers. Design of vertical thermosyphon reboiler. Design of single effect evaporator.		
Unit - IV	**Mass Transfer Equipment:**	**9+3**
Design of distillation column for binary systems – estimation of height and diameter. Design of plate and packed absorption column.		
Unit - V	**Reactors:**	**9+3**
Mechanical and process design of conventional mixed flow reactor, packed/tubular reactor and fluid reactor		

Lecture:45, Tutorial:15, Total:60

TEXT BOOKS:

1.	Towler C. Gavin and Sinnott Ray, "Chemical Engineering Design: Principles, Practice and Economics of Plant and Process Design", 6th Edition, Butterworth-Heinemann , Burlington, USA, 2019	
2.	BI, Thakore SB, "Introduction to Process Engineering and Design", 2nd Edition, Tata McGraw Hill Publishing Company Ltd, New Delhi, 2015.	V

REFERENCE BOOKS:

1.	Bh Luyben, William Lat, “Chemical Reactor Design and Control”, Edition, John Wiley & Sons, New Jersey, 2007.
2.	Perry’s , “Chemical Engineers Handbook”, 9th Edition, Tata McGraw Hill Publishing Company Ltd, United State of America, 2018.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	analyze the different stresses and estimate the plate thickness required for pressure, storage vessel under different pressure conditions	Analyzing (K4)
CO2	estimate the suitable design parameters of shell and tube and double pipe heat exchangers for the given process conditions	Analyzing (K4)
CO3	calculate the required design dimensions of a condenser, reboiler and single effect evaporator for the given duty	Analyzing (K4)
CO4	compute the height and diameter of the distillation and absorption columns for the given systems	Analyzing (K4)
CO5	perform the mechanical and process design of reactors for the given operating conditions	Analyzing (K4)

Mapping of Cos with Pos and PSOs

Cos/Pos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	1	1					1			2	3	3
CO2	3	3	1	1					1			2	3	3
CO3	3	3	1	1					1			2	2	3
CO4	3	3	1	1					1			2	2	3
CO5	3	3	1	1					1			2	3	3

1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy

ASSESSMENT PATTERN – THEORY

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT1		5	30	65			100
CAT2		5	30	65			100
CAT3		5	30	65			100
ESE		5	30	65			100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20CHL51 CHEMICAL REACTION ENGINEERING LABORATORY

Programme & Branch	B.TECH. – Chemical Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	5	PC	0	0	2	1

List of Exercises / Experiments :

1.	Investigate the kinetics of equimolar and non-equimolar reactions in a batch reactor
2.	Determine the effect of flow rate of reactants on conversion in a plug flow reactor
3.	Determine the effect of flow rate of reactants on conversion in a mixed flow reactor
4.	Compare of plug flow and mixed flow reactors
5.	Investigate the effect of flow rate of reactants on conversion in a combined reactor
6.	Study the effect of temperature on reaction rate and conversion in a batch reactor
7.	Estimate the effect of temperature on reaction rate and conversion in a plug flow reactor/ mixed flow reactors
8.	Calculate the residence time distribution in a plug flow and mixed flow reactors
9.	Evaluate the non-ideal reactors using dispersion and tank in series models
10.	Estimate the residence time distribution studies in fixed bed/ fluidized bed reactors
11.	Determine the surface area using BET isotherm
12.	Compare the catalytic and non catalytic systems in batch reactor

Total:30

REFERENCES/MANUAL/SOFTWARE: Laboratory Manual

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	apply the fundamentals of reaction engineering for batch and continuous systems and analyze the reactor performance	Applying(K3)/ Manipulating(S2)
CO2	perform experiments to develop models for non ideal reactors	Applying(K3)/ Manipulating(S2)
CO3	apply the principles of catalytic reactions and determine the surface area of a catalyst	Applying(K3)/ Manipulating(S2)

Mapping of COs with POs and PSOs

COs/Pos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2											3	1
CO2	3	2											3	1
CO3	3	2											3	1

1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy

20CHL52 PROCESS COMPUTATION LABORATORY

Programme & Branch	B.TECH. – Chemical Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	5	PC	0	0	2	1

List of Exercises / Experiments :

1.	Perform basic Thermodynamic calculations using spreadsheet
2.	Linearization and Error Analysis of graphical data using spreadsheet
3.	Solving Material and Energy Balance for Non-Reactive systems using spread sheet
4.	Development of a Process Flow Diagram using AutoCAD
5.	Development of Piping and Instrumentation Diagram using AutoCAD and MS Visio
6.	3D drawing of a pressure vessel/ tubular reactor/ flash column using AutoCAD and MS Visio
7.	Basic Commands and Operations in MATLAB: a) Matrix computations b) Solving algebraic, ODE and PDE problems c) 2D and 3D Plots using MATLAB
8.	(a) Determine the average heat transfer coefficient for forced and natural convection using MATLAB (b) Determine the friction factor for laminar and turbulent flows using MATLAB
9.	Design of Shell and Tube heat exchanger using MATLAB / C Programming
10.	Calculation of Transfer Function of I, II and higher order processes using MATLAB
11.	Design of Double pipe heat exchanger using PYTHON Programming
12.	Design of Single / Multiple effect evaporator using PYTHON Programming
13.	Design of Plug Flow / Mixed Flow Reactor for a given reaction using PYTHON Programming

Total:30

REFERENCES/MANUAL/SOFTWARE: Laboratory Manual

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	Perform Chemical Process Calculations using Spreadsheet	Analyzing(K4)/ Manipulating(S2)
CO2	Develop Process Flow and Process Instrumentation Diagrams in AUTOCAD	Applying(K3)/ Manipulating(S2)
CO3	Design Chemical Engineering Equipment/Processes using MATLAB / C Programming / PYTHON Programming	Applying(K3)/ Manipulating(S2)

Mapping of Cos with Pos and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2		2								2	3
CO2	3	2	3		3								2	3
CO3	3	2	3		3								2	3

1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy

20CHT61 MASS TRANSFER- II

Programme & Branch	B.Tech. & Chemical Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	Mass Transfer I	6	PC	3	0	0	3

Preamble	This subject focuses on the process aspects and equipment used in the operations like Distillation, Extraction and Leaching, Drying and Crystallization.	
Unit - I	**Distillation:**	**9**
Vapour liquid equilibria - Raoult's law, relative volatility, vapour liquid equilibrium diagrams for ideal and non-ideal systems, enthalpy concentration diagrams. Principle of distillation - flash distillation, differential or simple distillation, steam distillation, multistage continuous rectification, calculation of number of ideal stages by Ponchan - Savarit method, Total reflux, minimum reflux ratio, optimum reflux ratio.		
Unit - II	**Stage Calculations:**	**9**
Number of ideal stages by McCabe - Thiele method, effect of operating conditions on the number of ideal stages, Murphree stage and overall efficiency, calculation of actual number of stages, batch distillation with reflux, packed bed distillation, NTU and HTU calculations.		
Unit - III	**Extraction and Leaching:**	**9**
Liquid - liquid extraction, ternary liquid- liquid equilibrium, solvent characteristics, equipments for liquid-liquid extraction, stage wise contact - cross current and counter current extraction, continuous contact extraction, packed bed extraction with reflux. Leaching - Leaching by percolation through stationary solid beds, moving bed leaching, counter current multiple contact (shank's system), equipments for leaching operation, multi stage continuous cross current and counter current leaching, stage calculations, stage efficiency.		
Unit - IV	**Drying:**	**9**
Equilibrium in ternary systems- equilibrium stage wise contact calculations for batch and continuous extractors- calculation of number of stages- differential contact extraction equipment- spray, packed and mechanically agitated contactors, pulsed extractors, centrifugal extractors. Solid -Liquid equilibria- - calculations in single stage, multi stage cross flow and counter current leaching -Equipment and industrial applications.		
Unit - V	**Crystallization:**	**9**
Crystallization - principles of crystallization, types of crystals, nucleation theories, crystal growth and law, particle size distribution of crystals, yields, heat and material balances in crystallization, equipments for crystallization.		

Total: 45

TEXT BOOK:

1. Treybal R.E., "Mass Transfer Operations", 3rd Edition, McGraw Hill Book Co., New York, 1981.
2. Binay K Dutta, Principles of Mass Transfer and Separation Process, PHI learning private limited, 2007.

REFERENCE BOOKS:

1. Anantharaman N., Meera Sheriffa Begum K.M., "Mass Transfer Theory and Practice", Prentice Hall of India Pvt. Ltd, New Delhi, 2017.
2. Geankoplis C.J., "Transport Processes and Separation Process Principles", 4th Edition, Prentice-Hall of India, New Delhi, 2005.
3. Coulson J.M., Richardson J.F., "Chemical Engineering", 5th Edition, Vol. II, P. Butterworth Heinemann, New Delhi, 2002.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	understand the concept of vapour-liquid equilibrium and its application in the distillation	Applying(K3)
CO2	analyze distillation operations through stage concept	Applying(K3)
CO3	analyze extraction and leaching operations through ternary diagrams	Analyzing(K4)
CO4	able to suggest drying time requirements for various devices and design industrial driers	Applying(K3)
CO5	Estimate crystal yields for batch and continuous equipments	Applying(K3)

Mapping of COs with POs and PSOs

COs/Pos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2										2	2
CO2	3	3	2										2	2
CO3	2	3	2										2	2
CO4	3	3	2										2	2
CO5	3	3	1										2	2

1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy

ASSESSMENT PATTERN - THEORY

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT1	10	30	60				100
CAT2	10	20	50	20			100
CAT3	10	30	60				100
ESE	10	20	60	10			100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20CHT62 PROCESS MODELING AND SIMULATION

Programme & Branch	B.TECH. – Chemical Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	20CHT34 - Chemical Process Calculations, 20CHT33- Fluid Mechanics, 20CHT43 – Process Heat Transfer, 20CHT31 – Engineering Thermodynamics, 20CHT52 – Chemical Reaction Engineering, 20CHL41- Mass Transfer I & 20CHL51 Mass Transfer II	6	PC	3	0	0	3

Preamble	To make the students knowledgeable in different aspects of modeling chemical process systems & familiarize with the numerical simulation of models in fluid flow operations, separation processes and reactors. They will also acquire knowledge on the fundamental concepts of recent techniques in process simulation.	
Unit – I	Fundamentals of process modeling:	**9**
Mathematical modeling, use of modeling, fundamental laws used in modeling, Model building, , Constitutive equations, initial conditions and boundary conditions, black box modeling, gray box modeling, Introduction to simulation.		
Unit – II	Modeling of Reactors:	**9**
Batch reactor, CSTR, CSTBR (bio reactor), fed batch bio reactor, tubular reactor		
Unit - III	Modeling of Separation Processes**:**	**9**
Batch distillation column, batch reactive distillation column, gas absorber column, liquid-liquid extractor		
Unit - IV	Numerical methods and simulation**:**	**9**
Over-view on Newton-Raphson method for solving of a set of nonlinear algebraic equations and Runge-Kutta method for IVP ODES. Simulation of model equations developed for CSTBR, fed-batch bio reactor, absorber, tubular reactor.		
Unit – V	Process simulation:	**9**
Basics of modular approach and equation solving approach. Over view of simulation of processes by using the package Aspen plus.		

Total:45

TEXT BOOK:

1. Babu B.V, "Process Plant Simulation", 1st edition, Oxford University Press, New Delhi, 2004.
2. Finlayson, B.A, “Introduction to Chemical Engineering Computing”, 1st Edition, Wiley India, New Delhi , 2006.

REFERENCE BOOKS:

1. Luyben W.L, "Process Modeling, Simulation and Control for Chemical Engineers", 2nd edition, Tata McGraw Hill Publishing Company Ltd, New York, 1990.

2.	Amiya K. Jana, "Chemical Process Modeling and Computer Simulation", 3rd edition, Prentice Hall of India Pvt. Ltd, New Delhi, 2017.
3.	Gaikwad R.W and Dhivendra, "Process Modeling and Simulation", 2nd Edition, Denett & Co, 2006.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	Describe the fundamental principles, types and applications of modeling and simulation	Understanding (K2)
CO2	Develop mathematical models for various reactors used in process industries	Applying (K3)
CO3	Develop mathematical models for industrial separation processes – Distillation, Absorption and Extraction units	Applying (K3)
CO4	Apply appropriate numerical techniques for modeling and simulating reactors and absorbers	Applying (K3)
CO5	Explain process simulation and Illustrate the simulation of Unit Operations & Processes using software package	Applying (K3)

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2		2						1	2	3	2
CO2	3	3	2		2						1	2	3	2
CO3	3	3	2		2						1	2	3	2
CO4	3	3	2		2						1	2	3	2
CO5	3	3	2		3						1	2	3	2

1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy

ASSESSMENT PATTERN – THEORY

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT1	20	80					100
CAT2	10	30	60				100
CAT3	10	30	60				100
ESE	10	30	60				100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20CHT63 PROCESS INSTRUMENTATION DYNAMICS AND CONTROL

Programme & Branch	B.TECH. – Chemical Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	6	PC	3	0	0	3

Preamble	This course will enable the students to compute the response of various control system strategies for different process dynamics	
Unit – I	**Principles of Measurement**	**9**
Introduction to measurement and its hardware element - Transducer function and types – Static and Dynamic characteristics of measuring device – Types and principle of temperature transmitter – Types and principle of pressure transmitter - Types and principle of level transmitter - Types and principle of flow transmitter		
Unit – II	**Transient response of system**	**9**
Introduction to process control – Review of Laplace transforms principles – Transfer function for chemical system- Standard input functions – Transient response and characteristic of first and second order system – Linearization of nonlinear system		
Unit – III	**Development of Feedback control system**	**9**
Feedback control system concept, hardware element and development of block diagrams – Controller types and transfer function – Principles of pneumatic and electronic controller – Pneumatic control valve working mechanism and transfer function – Transportation lag		
Unit – IV	**Analysis of closed loop system**	**9**
Servo and regulator mechanism problems – reduction of feedback control loop – dynamic response of closed loop system – offset calculations; Stability analysis: Routh test and root locus diagrams		
Unit – V	**Frequency Response Analysis and Advance Control System**	**9**
Introduction to frequency response – frequency response characteristic – Bode diagram – Bode stability criterion – Phase and gain margin – Tuning of controller setting : Ziegler-Nichols and Cohen-Coon method; Advanced control systems : principle and applications of cascade, ratio and feed forward control		

Total:45

TEXT BOOK:

1. Donald R. Coughanowr, Steven E. LeBlanc, “Process Systems Analysis and Control”, 3rd edition, Tata McGraw Hill Publishing Company Ltd, New Delhi, 2013.
2. Alan S Morris, “Measurement and Instrumentation: Theory and Application”, 3rd edition, Butterworth-Heinemann, New Delhi, 2001.

REFERENCES:

1. Stephanopoulos S.G, “Chemical Process Control: An Introduction to Theory and Practice”, edition, Prentice Hall of India Pvt. Ltd, New Delhi, 2012.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	Describe various transmitters used in process industries	Understanding (K2)
CO2	Classify the forcing function and examine the response of system	Applying (K3)
CO3	Explain the principles of controllers and control elements for different applications	Understanding (K2)
CO4	Analyze the closed loop control systems to determine the transient response, offset and their stability	Analyzing (K4)
CO5	Analyze control system using frequency response and describe the advanced control strategies	Analyzing (K4)

Mapping of Cos with Pos and PSOs

Cos/Pos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	1										3	1
CO2	3	3	1										3	1
CO3	3	3	2										3	1
CO4	3	3	2										3	1
CO5	3	3	1										3	1

1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy

ASSESSMENT PATTERN – THEORY

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT1	10	50	40				100
CAT2	10	30	60				100
CAT3		20	40	40			100
ESE	10	20	30	40			100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20CHL61 MASS TRANSFER LABORATORY

Programme & Branch	B.TECH. – Chemical Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	6	PC	0	0	2	1

Total:30

List of Exercises / Experiments:

1.	Determine the diffusivity of a fluid – fluid and fluid - solid system
2.	Estimate the mass transfer co-efficient using Wetted wall column
3.	Estimate the mass transfer coefficient of a air-water system in a cooling tower.
4.	Conduct the batch drying study and estimate the mass transfer coefficient and psychometric ratio
5.	Conduct the drying experiment using Vacuum dryer
6.	Determine the activity coefficients & Van Laar constant for the given system by performing VLE experiments
7.	Verify Raleigh's equation for the given system using simple distillation setup
8.	Estimate the height equivalent to a theoretical plate (HETP) and find out percentage recovery of the overhead and bottom products of given system under total reflux conditions
9.	Determine the vaporization efficiency (Ev) and thermal efficiency (Et) of the given system using steam distillation apparatus
10	Conduct simple Leaching studies using given system
11.	Conduct the liquid - liquid extraction studies and plot binodal curve for the given ternary system
12.	Verify adsorption isotherms by Batch Adsorption
13.	Determine the exchange rate and saturation point by deionising water using Ion-Exchange experiment

REFERENCES/MANUAL/SOFTWARE: Laboratory Manual

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	determine diffusivity and mass transfer co-efficient of a given system using mass transfer operations	Applying (K3), Manipulating(S2)
CO2	evaluate the performance and design parameters for various distillation operations	Applying (K3),Manipulating (S2)
CO3	estimate the separation efficiency of various mass transfer equipment	Applying (K3),Manipulating (S2)

Mapping of COs with Pos and PSOs

Cos/Pos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2											3	2
CO2	3	2											3	2
CO3	3	2											3	2

1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy

20CHL62 PROCESS MODELING AND SIMULATION LABORATORY

Programme & Branch	B.TECH. – Chemical Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	6	PC	0	0	2	1

List of Exercises / Experiments :

1.	Analyse of physical properties and thermodynamic equilibrium diagram construction
2.	Estimate the physical property for a non- data bank component
3.	Simulate the heat exchanger using Aspen Plus by short cut and detailed method
4.	Simulate the mixer and flash separator
5.	Simulate the steady state plug flow reactor
6.	Simulate the distillation column
7.	Simulate and analyze the extraction column
8.	Perform the sensitivity analysis and influence of flow rate of single component on absorption and its optimization
9.	Generate a simple process flow diagram and perform simulation study
10.	Design of shell and tube heat exchanger using HTRI

Total:30

REFERENCES/MANUAL/SOFTWARE: Laboratory Manual

1. Aspen Plus
2. HTRI

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	construct T-x-y / P-x-y diagrams and estimate the physical properties of chemicals using aspen plus software	Applying (K3),Manipulating (S2)
CO2	simulate heat and mass transfer equipment using various simulation software	Analyzing (K4),Manipulating(S2)
CO3	perform simulation of reactors; simulate a simple process flow diagram	Analyzing (K4),Manipulating(S2)

Mapping of Cos with Pos and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2			3							1	3	1
CO2	3	2			3							1	3	1
CO3	3	2			3							1	3	1

1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy

20CHL63 PROCESS INSTRUMENTATION DYNAMICS AND CONTROL LABORATORY

Programme & Branch	B.TECH. – Chemical Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	6	PC	0	0	2	1

List of Exercises / Experiments :

1.	Estimate the time constant for first order system
2.	Study the response and evaluate the time constant for two tank non-interacting level systems
3.	Evaluate the time constant for two tank interacting level systems
4.	Verify the flow coefficient and performance characteristics of pneumatic control valves
5.	Examine the response of servo problem for various controller (P/PI/PID) in pressure control loop.
6.	Study the response of regulator problem for a choice of controller(P/PI/PID) in temperature control loop.
7.	Analyze the response of different controller setting for PI & PID controller in level control loop
8.	Perform comparison of ON-OFF and different gain value for P controller in flow control loop
9.	Estimate the optimum controller settings using shell and tube heat exchanger.
10.	Analyze the response of ratio control system
11.	Study the response of cascade control system
12.	Perform experiment using feed forward control system

Total:30

REFERENCES/MANUAL/SOFTWARE: Laboratory Manual

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	estimate time constant and transient response of various dynamic systems	Applying (K3),Manipulation (S2)
CO2	analyze the response of controllers for different applications	Applying (K3),Manipulation (S2)
CO3	estimate optimum controller setting and study the advance control system responses	Applying (K3),Manipulation (S2)

Mapping of Cos with Pos and PSOs

Cos/Pos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2											3	1
CO2	3	2											3	1
CO3	3	2											3	1

1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy

20CHP61 PROJECT WORK-I

Programme & Branch	B.TECH. – Chemical Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	6	EC	0	0	4	2

Total:60

COURSE OUTCOMES: On completion of the course, the students will be able to		BT Mapped (Highest Level)
CO1	identify and define the problems that need to be solved	Applying (K3)
CO2	select appropriate literature and frame the objectives	Applying (K3)
CO3	develop/ design value added products equipment using research tools and methods	Creating(K6)
CO4	analyze the experimental data and device the valid conclusion	Analyzing(K4)
CO5	elaborate the project in the form of oral presentation, report and technical paper publication	Creating(K6)

Mapping of Cos with Pos and PSOs

Cos/Pos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	3	2	2	3	2	3	3	3	3	3	3
CO2	3	2	2	2	3	2	2	2	3	3	3	3	2	2
CO3	3	3	3	3	3	3	3	2	3	3	3	3	3	3
CO4	3	3	2	3	3	2	2	2	3	3	3	3	2	2
CO5	3	2	2	2	2	2	2	2	3	3	3	3	2	2

1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy

20CHT71 PROCESS ENGINEERING AND ECONOMICS

Programme & Branch	B.TECH. – Chemical Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	7	HS	3	0	0	3

Preamble	This course enables students to learn the process design development, plant location and layout, cost accounting and estimation, capital investments, taxes and depreciation	
Unit – I	**Process Design Development:**	**9**
Design Project Procedure- Types of designs-Feasibility survey-Process development- construction and operation- Design information from the literature- flow diagrams- The preliminary design- Economics- Scale up in design- safety factors- Specifications- Materials of construction.		
Unit – II	**Plant Location and Layout:**	**9**
Selection of the Plant Site – factors- Plant layout- Preparation of the layout- Plant operation and control- Instrumentation- Maintenance- Utilities- Structural design- storage- materials handling- patent considerations.		
Unit – III	**Cost accounting and Estimation:**	**9**
Outline of accounting procedure- basic relationships in accounting- balance sheet- income statements- cost accounting methods. Cost estimation- cash flow for industrial operations- tree diagram- cumulative cash position- factors affecting investment and production costs-sources of equipment- Price Fluctuations- Company Policies- Operating Time and Rate of Production- Governmental Policies.		
Unit – IV	**Taxes and Depreciation:**	**9**
Types of taxes- Property taxes- excise taxes- income taxes- Depreciation- meaning of value- Purpose of Depreciation as a Cost- types of depreciation- service life- salvage value- present value- Methods for determining depreciation- Straight-Line Method- Declining- Balance method- Sinking-Fund Method. Break even analysis.		
Unit – V	**Capital Investments:**	**9**
Fixed-Capital Investment- Working Capital- estimation of capital investment- Types of capital cost estimates- Cost Indexes- cost factors in capital investment- estimating equipment costs by scaling – Methods for estimating capital investment- estimation of total product cost. Selection of alternatives and equipment replacement.		

Total:45

TEXT BOOK:

1. Peter and Timmerhaus, “Plant Design and economics for Chemical Engineers”, 5th Edition Reprint, Mc Graw Hill Book Co, New York, 2017.

REFERENCES:

1. Harry Silla, “ Chemical Process Engineering: Design and Economics”, 1st Edition, CRC press, USA, 2003
2. Sivasubramanian V, “Process Economics and Industrial Management” 1st Edition, New Delhi, Galcotia Publishers, 2008.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	describe the procedure for process design development in process industries.	Applying (K3)
CO2	explain the factors affecting plant location and layout	Understanding (K2)
CO3	estimate the cost for industrial operations	Applying (K3)
CO4	calculate the capital cost investment for process industries	Applying (K3)
CO5	determine taxes and depreciation for industrial operations	Applying (K3)

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	1	2								3			
CO2		1	2				1				3		2	
CO3	1	2	1								3		2	
CO4	1	2	1								3		1	
CO5	2	2									3		2	

1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy

ASSESSMENT PATTERN - THEORY

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT1	20	60	20				100
CAT2	20	50	30				100
CAT3	15	60	25				100
ESE	15	65	20				100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20CHT72 TRANSPORT PHENOMENA

Programme & Branch	B.TECH. – Chemical Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	20CHT34 Chemical Process Calculations, 20CHT33 Fluid Mechanics, 20CHT52 Chemical Reaction Engineering, 20CHT41 Mass Transfer I, 20CHT43 Process Heat Transfer	7	PC	3	1	0	4

Preamble	To enable students to relate the concepts of heat, mass and momentum transfer.	
Unit - I	**Fundamentals of Transport Phenomena:**	**9**
Importance of Transport Phenomena; Analogous nature of transfer processes; Conservation laws; Newtonian and Non-Newtonian fluids- Rheological models; Transport properties of gases and liquids- theories, pressure and temperature effects		
Unit - II	**Shell Momentum Balances and Velocity Distribution in Laminar Flow:**	**9**
Shell balance and boundary conditions; Momentum flux and velocity distribution in falling film, circular tube, annulus and two adjacent immiscible fluids; creeping flow around a Sphere. Equations of Continuity and Motion.		
Unit - III	**Shell Energy Balances and equations of change:**	**9**
Heat Conduction with Electrical, Nuclear and Viscous Heat Sources; Heat Conduction - Composite Walls and Cooling Fin; Use of equations of change to solve tangential flow in an annulus with viscous Heat Generation and Transpiration cooling.		
Unit - IV	**Shell Mass Balance and Concentration Distributions in Solids and Laminar Flow:**	**9**
Diffusion - Stagnant Gas Film, Heterogeneous and Homogeneous Chemical Reactions, Falling Liquid Film (Gas Absorption); Diffusion and Chemical Reaction inside a Porous Catalyst.		
Unit - V	**Analogies of Transport Process:**	**9**
Development and applications of analogies between momentum, heat and mass transfer- Reynolds, Prandtl, Von Karman and Chilton-Colburn analogies.		

Total:45

TEXT BOOK:

1. Bird R.B., Stewart W.E. and Lightfoot E.N, "Transport Phenomena", 2nd Edition, John Wiley & Sons, USA, 2007.

REFERENCES:

1. Brodkey Robert S. and Hershey Harry C., "Transport Phenomena - A united approach", 1st Edition, Brodkey Publications, United State of America, 2003.
2. Welty J.R., Wicks C. E. and Wilson R. E., "Fundamentals of Momentum, Heat and Mass Transfer", 5th Edition,

	John Wiley & Sons Inc, United State of America, 2007.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	comprehend the analogous nature of Transport processes; Gain insight about different rheological models and transport properties of fluids	Applying (K3)
CO2	apply the shell momentum balance approach to determine momentum flux and velocity distribution; understand equations of continuity and motion	Applying (K3)
CO3	use equations of change to solve heat transfer problems; Develop shell balance approach for conduction and convection	Applying (K3)
CO4	develop solutions for homogeneous and heterogeneous chemical reactions by applying shell mass balance	Applying (K3)
CO5	interpret the analogy between the transport processes	Applying (K3)

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	1									3	1
CO2	3	3	2	1									3	1
CO3	3	3	2	1									3	1
CO4	3	3	2	1									3	1
CO5	3	2	2	1									3	1

1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy

ASSESSMENT PATTERN - THEORY

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT1	20	50	30				100
CAT2	20	30	50				100
CAT3	20	40	40				100

ESE	20	30	50				100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20CHP71 - PROJECT WORK -II PHASE- I

Programme & Branch	**B.Tech. & Chemical Engineering**	**Sem.**	**Category**	**L**	**T**	**P**	**Credit**
Prerequisites	Nil	**7**	**EC**	**0**	**0**	**6**	**3**

Total:90

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	identify and define the problems that need to be solved	Applying (K3)
CO2	select appropriate literature and frame the objectives	Applying (K3)
CO3	develop/ design value added products equipment using research tools and methods	Creating(K6)
CO4	analyze the experimental data and device the valid conclusion	Analyzing(K4)
CO5	elaborate the project in the form of oral presentation, report and technical paper publication	Creating(K6)

Mapping of COs with POs and PSOs

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	3	2	3	2	2	3	2	3	3	3	3	3	3
CO2	3	2	2	2	3	2	2	2	3	3	3	3	2	2
CO3	3	3	3	3	3	3	3	2	3	3	3	3	3	3
CO4	3	3	2	3	3	2	2	2	3	3	3	3	2	2
CO5	3	2	2	2	2	2	2	2	3	3	3	3	2	2

1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy

20CHP81 – PROJECT WORK- II Phase -II

Programme & Branch	B.Tech. & Chemical Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	8	EC	0	0	14	7

Total:210

COURSE OUTCOMES: On completion of the course, the students will be able to		BT Mapped (Highest Level)
CO1	identify and define the problems that need to be solved	Applying (K3)
CO2	select appropriate literature and frame the objectives	Applying (K3)
CO3	develop/ design value added products equipment using research tools and methods	Creating(K6)
CO4	analyze the experimental data and device the valid conclusion	Analyzing(K4)
CO5	elaborate the project in the form of oral presentation, report and technical paper publication	Creating(K6)

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	3	2	2	3	2	3	3	3	3	3	3
CO2	3	2	2	2	3	2	2	2	3	3	3	3	2	2
CO3	3	3	3	3	3	3	3	2	3	3	3	3	3	3
CO4	3	3	2	3	3	2	2	2	3	3	3	3	2	2
CO5	3	2	2	2	2	2	2	2	3	3	3	3	2	2

1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy

20CHE01 CHEMICAL PROCESS PLANT SAFETY

Programme & Branch	B.TECH. – Chemical Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	20CYT11 Applied Chemistry, 20CYT24 Industrial Chemistry and 20CHT11 Chemical Process Industries	5	PC	3	0	0	3

Preamble	The course outlines the workplace safety and associated terms applicable to the Process Industries	
Unit - I	**Industrial Safety and Standards:**	**9**
Industrial Safety programs - Training and Education; Personal protective Equipments; Safety codes & Standards: NFPA, API, IS and OSHA standards, Colour codes for pipe lines; Materials Safety Data sheets.		
Unit - II	**Hazards and Occupational Health:**	**9**
Occupational health hazards and their control - Types of Hazards & Exposure Controls; Safety in storage and handling of hazards; Designs to prevent fire and explosion hazards; Relief valves; Occupational diseases –Types, Causes, effects and Control measures.		
Unit - III	**Process Safety and Safety Studies:**	**9**
Safety in processes and plant operations, Process Safety Information (Key Terminologies & Definitions), Plant Layout spacing (Safety Distance), Inherently Safer plant Design Principles, Chemical Reactivity (Runaway reactions)-Handling of unstable products, Safety Critical Elements, Classification of Electrical Equipment's in Hazardous area, Fire and Gas Detection Systems, Fire Protection Systems, Emergency Planning and Response. Hazard Identification Safety Reviews – HAZID, HAZOP & SIL. Hazard Evaluation Safety Studies – Risk Assessment (QRA, FERA), Toxic Release & Dispersion Models, Layer of Protection Analysis, Fault tree, Event tree Methods for Risk analysis, ALARP, Risk Management Approach.		
Unit - IV	**Industrial Accidents and Case Studies:**	**9**
Accidents - Causes, Effects, Costs, and Prevention; Accident Investigation; Accident proneness; Major Accident Case Histories and Loss statistics - The Flixborough UK - Cyclohexane Disaster, Seveso Accident, The Chernobyl Nuclear Disaster, Bhopal Gas Tragedy; Field visits.		
Unit - V	**Legal Aspects of Industrial Safety:**	**9**
Safety Laws - Factories act, ESI act and Workmen's compensation act; Promotion of safety - Role of Government, Management, Safety organizations, and Trade unions; Rules and requirements governing Chemical industries in India.		

Total:45

TEXT BOOK:

1.	Daniel A. Crowl, Joseph F. Louvar, "Chemical Process Safety: Fundamentals with Applications", 3rd Edition, Prentice Hall, India, 2011.

REFERENCES:

1.	Roy E. Sanders, "Chemical Process Safety: Learning from case histories", 4th Edition, Butterworth Heinemann, United State of America, 2015.
2.	Raju K.S.N, "Chemical Process Industry Safety", 1st Edition, McGraw Hill International Edition, New Delhi, 2017.

COURSE OUTCOMES: On completion of the course, the students will be able to		BT Mapped (Highest Level)
CO1	recall the industrial safety programs and the safety standards	Understanding (K2)
CO2	recognize the industrial hazards and associated safety procedures to ensure occupational health	Applying (K3)
CO3	describe the process safety in plant operations and analyze the safety failures through safety studies	Analyzing (K4)
CO4	examine major industrial accidents, their consequences and describe the preventive methods	Applying (K3)
CO5	summarize the safety law and regulations and recognize the roles played by different bodies in promoting safety	Understanding (K2)

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	1				3	3					2	1	1
CO2	2	1				3	3					2	1	1
CO3	2	2	1	1		3	3					2	1	1
CO4	2	2				3	3					2	1	1
CO5	1					3	3					2	1	1

1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy

ASSESSMENT PATTERN - THEORY

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT1	30	70					100
CAT2	20	40	30	10			100
CAT3	20	40	40				100
ESE	20	40	30	10			100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20CHE02 ORGANIC SYNTHESIS

Programme & Branch	B.TECH. – Chemical Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	NIL	**5**	**PE**	**3**	**0**	**0**	**3**

Preamble	This course highlights the synthesis of industrially important organic compounds	
Unit - I	**Nitration and Amination:**	**9**
Principle of Nitration, N-Nitro compounds and Nitration esters- Typical industrial equipment and processes- Nitration of Benzene, Naphthalene, and Propane; Principle of Amination, methods – reduction and its methods, Manufacture of Aniline and Nitro-Aniline by different methods.		
Unit II	**Halogenation and Sulfonation Processes**	**9**
Halogenation reactions, Chlorination mechanism, Manufacture of Vinyl Chloride, Allyl chloride, Chloral and DDT. Sulfonation and sulfation agents, Industrial process- sulfonation of benzene, potassium anthraqunioline sulfonate and production of ethanol; Desulfonation reactions		
Unit III	**Ammonolysis and Oxidation**	**9**
Principles of Ammonolysis. Aminating agents and survey of amination reactions, Manufacture of Aniline, p-Pheneyldiamine and Methylamines; Principles of Oxidation, Oxidizing agents, Types of Oxidative reaction, Synthesis of Acetic acid, Formaldehyde and Styrene.		
Unit – IV	**Hydrogenation and Hydroformylation**	**9**
Production and Properties of Hydrogen, Catalytic hydrogenation and Hydrogenolysis-Hydrogenation of Cottenseed oil and Heavy oil and Synthesis of Methanol; Methanation and Fisher-Tropsch reactions- Oxo, Synol and Isosynthesis processes.		
Unit – V	**Esterification, Hydrolysis and Alkylation:**	**9**
Esterification of organic and inorganic acids, applications in chemical industries- Manufacture of ethyl acetate and vinyl acetate monomer; Hydrolyzing agents, processes and equipment-manufacture of Glycerol, Furfural and Ethanol. Types and Factors affecting alkylation, Industrial alkylation process-Alkyl aryl detergent		

Total:45

TEXT BOOK:

1.	Groggins, P.H., "Unit Processes in organic synthesis", 5th Edition, McGraw Hill Book Co, New York, 2007.

REFERENCES:

1.	Austin, G.T, "Shreve's chemical process industries", 5th Edition, McGraw Hill International Edition, New York, 2005.
2.	Tiwari, K.S., Vishnoi, N.K., "A Textbook of Organic Chemistry", 4th Edition, Vikas Publications, India, 2014.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	describe the nitration and amination in various unit processes	Understanding (K2)
CO2	explain the halogenation and sulfonation processes	Understanding (K2)
CO3	sketch process flow diagrams for ammonolysis and oxidation processes	Understanding (K2)
CO4	employ various methods for production of hydrogen and hydrocarbon	Understanding (K2)
CO5	demonstrate the unit processes involved in hydrolysis, esterification reaction and alkylation reaction	Understanding (K2)

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2											2	1
CO2	3	1											3	1
CO3	3	2											3	1
CO4	3	2											3	1
CO5	3	1											3	1

1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy

ASSESSMENT PATTERN - THEORY

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT1	40	60					100
CAT2	40	60					100
CAT3	40	60					100
ESE	40	60					100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20CHE03 INSTRUMENTAL METHODS OF ANALYSIS

Programme & Branch	B.TECH. – Chemical Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	5	PE	3	0	0	3

Preamble	This course helps the student to understand the basic principle, instrumentation and applications of various chemical analysis techniques	
Unit – I	**Introduction to Instrumental Methods and UV-Visible and IR Spectroscopy:**	**9**
Classification of instrumental methods based on physical properties of molecules – The electromagnetic spectrum – Interaction of photons with matter – Absorbance and transmittance – Beer and Lambert's laws. Ultra violet and Visible spectrometry: Theory – Types of Transitions – Red and blue shifts – Instrumentation – Single beam and double beam spectrophotometers and applications. Infrared spectrometry: Requirements for IR absorption – Modes of vibrations – Instrumentation- Applications – Finger print region.		
Unit – II	**Flame emission Photometer, Thermal Methods and** Morphology Analysis	**9**
Flame emission photometer, Polarimetry and Refractometry – Principle, instrumentation and applications – Thermogravimetry: Principle, instrumentation and applications, factors affecting shapes of thermograms. Differential Thermal Analysis: Principle, instrumentation and applications. Differences between DSC and DTA. Application of DSC (Inorganic & Polymer samples). Morphology Analysis **–** Scanning Electron Microscopy – Transmission Electron Microscopy – Principle and Applications.		
Unit – III	**Atomic Absorption Spectrophotometer, NMR and Mass spectroscopy:**	**9**
Advantages of ASS over FES – Principle, Instrumentation – Interference and applications. Nuclear Magnetic Resonance: Introduction to NMR – Energy levels of nucleus – Equivalent and non-equivalent protons – Chemical shift – Shielding – TMS – Factors affecting chemical shift and instrumentation (proton NMR) – Applications. Theory – components of mass spectrometer – General rules for Interpretation of mass spectra – Applications of mass spectra.		
Unit – IV	**Conductance, EMF measurement and Electrophoresis**	**9**
Definitions, conductance measurements, applications, Types, advantages and disadvantages of Conductometric titrations. Potential measurements, pH determination, Potentiometric Titrations. Basic principles of electrophoresis, theory and application of paper, starch gel, agarose, PAGE, SDS-PAGE electrophoresis.		
Unit – V	**Chromatographic Methods :**	**9**
Introduction – Classification of chromatographic methods: Column chromatography, Thin Layer chromatography, Paper chromatography, Gas chromatography and High Performance Liquid Chromatography (HPLC) – Principle, important components and their functions mode of separation, Instrumentation and applications		

Total:45

TEXT BOOK:

1. Gurdeep R. Chatwal Shan K Anand, "Instrumental methods of Chemical Analysis", 5th edition, Himalaya Publishing House, New Delhi, 2018

REFERENCES:

1. Willard H.H., Merritt L.L., Dean J.A., and Settle F.A., "Instrumental Methods of Analysis", 7th edition, C B S Publishers & Distributors, Delhi, 2004.
2. Daniel C. Harris, "Qualitative chemical analysis", 9th edition, W. H. Freeman and Company, New York, 2015.
3. Banwell. G. C, "Fundamentals of Molecular Spectroscopy", 5th edition, Tata McGraw Hill Publishing Company Ltd, New Delhi, 2013.

COURSE OUTCOMES: On completion of the course, the students will be able to		BT Mapped (Highest Level)
CO1	describe UV-Visible, IR instrument for chemical analysis	Applying (K3)
CO2	infer the principle of thermal and Morphology techniques for chemical Analysis.	Understanding (K2)
CO3	explain the principle, instrumentation and applications of ASS, NMR and Mass spectroscopy	Understanding (K2)
CO4	demonstrate the usage of conductance and potential measurements for chemical components and separation by electrophoresis.	Understanding (K2)
CO5	identify suitable chromatographic methods to separate and quantify the chemical components.	Understanding (K2)

Mapping of COs with Pos and PSOs

Cos/Pos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3		3	2							1	2	1
CO2	3	3		2	2							1	2	1
CO3	3	3		3	2							1	2	1
CO4	3	3		2	2							1	2	1
CO5	3	3		3	2							1	2	1

1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy

ASSESSMENT PATTERN – THEORY

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT1	30	60	10				100
CAT2	40	60					100
CAT3	40	60					100
ESE	30	60	10				100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

18CHE04 - CHEMICAL ANALYSIS

Programme & Branch	B.Tech. & Chemical Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	5	PE	3	0	0	3

Preamble	This course helps the student to understand the basic principle, instrumentation and applications of various analysis techniques	
Unit - I	**Analytical Process:**	**9**
Measurement, general steps of analysis, statistics (only theoretical) and error calculation. Quality assurance and calibration methods. Principles of acid-base equilibria and titration. Sample preparation.		
Unit – II	**Chromatographic Methods:**	**9**
Classification of chromatographic methods; Column, Thin layer, Paper, Gas, High Performance Liquid Chromatography. HPLC - principle, mode of separation and technique. Gas chromatography - principle, mode of separation and technique. Estimation of organic compounds by GC and HPLC.		
Unit – III	**Spectrophotometry:**	**9**
Electromagnetic Radiation-Various ranges, Dual properties, Various energy levels, Interaction of photons with matter, absorbance and transmittance. Classification of instrumental methods based on physical properties.		
Unit – IV	**Thermal Methods:**	**9**
Thermogravimetry: Principle, instrumentation and applications, factors affecting shapes of thermograms. Differential Thermal Analysis: Principle, instrumentation and applications. Differences between DSC and DTA. Application of DSC (Inorganic & Polymer samples).		
Unit - V	**Molecular Spectroscopy:**	**9**
Principle, Instrumentation and applications of spectroscopy and Ramans spectroscopy. Various electronic transitions in organic and inorganic compounds effected by UV, visible and IR radiations, Woodward-Fischer rules for the calculation of absorption maxima (dienes and carbonyl compounds). Nuclear Magnetic Resonance: principle and instrumentation. Relaxation, Chemical shift and its causes.		

Total:45

TEXT BOOKS:

1. Daniel C. Harris, "Qualitative Chemical Analysis", 9th Edition, W.H. Freeman and Company, New York, 2015 for Units I, II.
2. Banwell G.C., "Fundamentals of Molecular Spectroscopy", 5th Edition, Tata McGraw Hill Publishing Company Ltd., New Delhi, 2013 for Units III, IV, V.

REFERENCE BOOK:

1. Skoog D.A. and West D.M., "Fundamentals of Analytical Chemistry", 7th Edition, Saunders College Publishing, New York, 1996.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	explain the quantitative and qualitative methods of sampling and analytical procedures	Understanding (K2)
CO2	classify chromatographic techniques and elaborate the principle of GC and HPLC	Understanding (K2)
CO3	illustrate the characteristics of EM radiation and classify the instrumental methods based on physical properties	Understanding (K2)
CO4	describe the principle, instrumentation and applications of various thermal analysis methods	Understanding (K2)
CO5	outline the principle, instrumentation and applications of spectroscopy and nuclear magnetic resonance	Understanding (K2)

Mapping of COs with POs and PSOs

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	1	3										2	1
CO2	3	1	3										2	1
CO3	3	1	3										2	1
CO4	3	1	3										2	1
CO5	3	1	3										2	1

1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy

ASSESSMENT PATTERN - THEORY

Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	40	60					100
CAT2	40	60					100
CAT3	30	70					100
ESE	40	60					100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20CHE05 BIO CHEMICAL ENGINEERING

Programme & Branch	B.TECH. – Chemical Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	NIL	5	PE	3	0	0	3

Preamble	To gain knowledge in Microbes, Enzymes and Bioreactors for various Industrial applications.	
Unit - I	**Microbes and Microbial Kinetics:**	**9**
Classification of Microbes, Typical growth characteristics of microbial cells- Factors affecting growth, Monod model, Microbial Taxonomy.		
Unit - II	**Enzyme Kinetics:**	**9**
Classification of Enzymes- Mechanism of enzymatic reactions, Michaelis-Menten Kinetics. Enzyme Inhibition. Industrial Applications of Enzymes, Immobilization of Enzymes.		
Unit - III	**Sterilization and Fermentation:**	**9**
Batch and Continuous Sterilization, Sterilization of Air, Effect of Sterilization on Quality of Nutrients Requirements of fermentation process, Aerobic and Anaerobic fermentation Processes, Solid state and Submerged fermentation.		
Unit - IV	**Transport in Microbial Systems:**	**9**
Theories of Diffusional Mass Transfer, Mass Transfer by Convection, Measurement of mass transfer coefficient K_La, Oxygen Transfer Methodology, Factors affecting Oxygen Transfer Rate.		
Unit - V	**Bioreactors and Downstream Processes:**	**9**
Classification based on feeding Mechanism-batch, continuous, fed batch reactors, Fluidized bed reactor, Immobilized cell reactor, Air-Lift reactor. Suspended solids removal, Filtration, Sedimentation, Centrifugation, Cell disruption, Extraction, Membrane Separation, Chromatography, Crystallization and Drying.		

Total:45

TEXT BOOK:

1. Bailey, J. E. and Ollis, D. F, "Biochemical Engineering Fundamentals", 2nd Edition, Tata McGraw-Hill, New Delhi, 2010.

REFERENCE BOOKS:

1. Rao,D.G., "Introduction to Biochemical Engineering", 2nd Edition, Tata McGraw Hill Publishing Company Ltd, New Delhi, 2009.
2. T Palmer and P L Bonner, "Enzymes Biochemistry, Biotechnology, Clinical Chemistry", 2nd Edition, Woodhead Publishing, Europe, 2007.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	classify microbes and describe microbial growth kinetics	Understanding (K2)
CO2	explain Michaelis Menten Kinetics and various immobilization techniques	Applying (K3)
CO3	describe the sterilization and fermentation process	Understanding (K2)
CO4	apply theories of mass transfer to microbial systems	Applying (K3)
CO5	classify bioreactors and explain the downstream processing techniques	Understanding (K2)

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	1											2	2
CO2	3	1											2	2
CO3	3	1											2	2
CO4	3	2											2	2
CO5	3	1											2	2

1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy

ASSESSMENT PATTERN - THEORY

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT1	30	60	10				100
CAT2	20	60	20				100
CAT3	20	60	20				100
ESE	20	60	20				100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20CHE06 PULP AND PAPER TECHNOLOGY

Programme & Branch	B.TECH. – Chemical Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	NIL	7	PE	3	0	0	3

Preamble	This course will able to help the students to understand the production of paper in industries	
Unit - I	**Wood Preparation and Pulping:**	**9**
Basics of pulp and paper technology- Wood as raw material- Pulpwood harvesting, debarking, chipping, screening and storage- Mechanical pulping, Chemical pulping and Semi chemical pulping- Chemical recovery.		
Unit - II	**Processing and Bleaching of Pulp:**	**9**
Processing of pulp- Cooking, Defibering, Deknotting ,Washing, Screening and Thickening- Bleaching- Oxygen bleaching, Chlorine-dioxide bleaching, Hydrosulfite bleaching, Peroxide bleaching, Ozone bleaching - Stock preparation.		
Unit - III	**Paper Manufacture Operations:**	**9**
Secondary Fiber Processing- Paper making process- Wet end operations- Fourdrinier paper machine- Forming and Pressing- Dry end operations- Drying, Calendering, Reeling, winding and Roll finishing -Surface treatments- Sizing, Coating and super calendering.		
Unit - IV	**Specific grades and Testing of Pulp and Paper:**	**9**
Manufacturing techniques of Specific paper and Board grades – Properties and testing of pulp - Properties and testing of paper - Paper end uses- Sheet finishing, Converting and Printing - Process control- Quality assurance.		
Unit - V	**Sources and control of Pollution:**	**9**
Sources of Pollutants from pulp and paper industry – Characteristics of pollutants-Solid, liquid & gaseous wastes-Water pollution control- Color removal-Air pollution control- Solids handling and Land disposal.		

Total:45

TEXT BOOK:

1. Smook G.A., "Handbook for Pulp & Paper Technologists", 3rd Edition, Angus Wilde Publications, Incorporation, USA, 2003.

REFERENCES:

1. Kenneth W. Brittt, "Handbook of Pulp and Paper Technology", 2nd Edition, John Wiley & Sons Inc, United State of America, 1971.
2. Kent J.A., "Riggel's Hand Book of Industrial Chemistry", 1st Edition, Van Nostrant Reinhold, United State of America, 1974.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	discuss the various methods for wood preparation and pulping	Understanding (K2)
CO2	explain the processing and bleaching of pulp	Understanding (K2)
CO3	deduce the finishing and surface treatment of various grades of paper	Understanding (K2)
CO4	demonstrate various methods for testing of pulp and paper	Understanding (K2)
CO5	demonstrate control measures relevant to solid , liquid and gaseous pollution from pulp and paper industry	Understanding (K2)

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2											2	1
CO2	2	1											3	1
CO3	3	3											3	1
CO4	3	2											3	1
CO5	2	1					2						3	1

1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy

ASSESSMENT PATTERN - THEORY

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT1	30	70					100
CAT2	20	80					100
CAT3	30	70					100
ESE	30	70					100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20CHE07 CHEMICAL REACTION ENGINEERING -II

Programme & Branch	B.TECH. – Chemical Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	20CHT52 - Chemical Reaction Engineering I	7	PE	3	0	0	3

Preamble	This course offers an insight into the non ideal flow, adsorption and catalytic reaction, diffusion and reaction in porous catalysts, catalytic reactors and fluid-solid non catalytic reactions	
Unit - I	**Non Ideal Flow:**	**9**
Residence time distribution studies; models for non-ideal flow- segregation, maximum mixedness, dispersion and tanks-in-series; conversion in non-ideal reactors.		
Unit – II	**Adsorption and Catalytic Reaction:**	**9**
Catalysis, Types, Nature of catalysis, catalyst preparation and characterization, catalyst deactivation; surface area and pore-volume distribution , Adsorption isotherm and rates of adsorption, desorption and surface reaction; analysis of rate equation and rate controlling steps.		
Unit – III	**Diffusion and Reaction in Porous Catalysts:**	**9**
Diffusion within catalyst particle, effective thermal conductivity, mass and heat transfer within catalyst pellets; effectiveness factor		
Unit – IV	**Catalytic Reactors:**	**9**
Types and operation of Fixed bed, Fluidized bed, Slurry, Trickle bed and Airlift Reactors. Industrial application of multiphase reactors		
Unit – V	**Fluid-Solid non-Catalytic Reactions:**	**9**
Models for explaining the kinetics; shrinking core model; controlling resistances and rate controlling steps; time for complete conversion for single and mixed sizes particle.		

Total:45

TEXT BOOK:

1. Smith, J. M., "Chemical Engineering Kinetics", 3rd Edition, Tata McGraw Hill Publishing Company Ltd, New York, 1981.

REFERENCES:

1. Fogler H.S, "Elements of Chemical Reaction Engineering", 5th Edition, Prentice Hall of India Pvt. Ltd, India, 2015.
2. Martin Schmal, "Chemical Reaction Engineering: Essentials, Exercises and Examples", 1st Edition, CRC Press, United State of America, 2014.
3. Viswanathan B, Sivashankar S and Ramasamy A V, Catalysis- Principles and Applications, Narosa Publications, 2002

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	apply the concepts of residence time distribution for the design of non ideal reactors	Applying (K3)
CO2	discuss the types of catalysts, their preparation techniques and analyze the mechanism of adsorption	Analyzing (K4)
CO3	deduce the mechanism of catalysis for porous catalysts and determine the effectiveness factor	Analyzing (K4)
CO4	discuss the multiphase reactors used in industries	Applying (K3)
CO5	explain the principles of non-catalytic fluid-solid reactions and understand their mechanisms	Applying (K3)

Mapping of COs with POs and PSOs

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	3	2										3	1
CO2	3	3	2										3	1
CO3	3	3	2										3	1
CO4	3	3	1										3	1
CO5	3	3	1										3	1

1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy

ASSESSMENT PATTERN - THEORY

Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	20	30	50				100
CAT2	10	20	50	20			100
CAT3	20	30	50				100
ESE	10	30	50	10			100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20CHE08 SURFACE COATING TECHNOLOGY

Programme & Branch	B.TECH. – Chemical Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	NIL	7	PE	3	0	0	3

Preamble	To gain knowledge on surface engineering, chemical conversion, surface coating, electro-deposition coating methods and design guidelines for surface coating	
Unit - I	**Surface Engineering**:	**9**
Introduction to surface engineering, scope of surface engineering, surface engineering to combat corrosion and wear, Surface preparation– selective surface hardening, laser melting, shot peening, shot blasting, sand blasting, vapor phase degreasing and hydro-blasting.		
Unit - II	**Chemical Conversion Coating:**	**9**
Phosphate and chromate chemical conversion coating – types and applications. Aluminium, chromic, sulfuric and hard coat anodizing. Oxidation treatments, Diffusion heat treatment coatings and pack-cementation diffusion coatings.		
Unit - III	**Surface coating methods**:	**9**
Organic coating - paints, Ceramic coating and Linings – Glass lining, porcelain enamels, concrete and cementations coating and lining, high performance ceramic coating and lining, Hot dipping – Batch and continuous process, coating microstructure, galvanized aluminium and terne coatings.		
Unit - IV	**Electro-deposition coating methods**	**9**
Electrochemical deposition – aqueous solution electroplating, continuous electro deposition, fused-salt electroplating, precious metal plating, electroless plating, and composite coatings. Weld-overlay coatings, Thermal spray coatings, Chemical and physical vapor deposition coatings.		
Unit - V	**Design guidelines for surface coating:**	**9**
Pre-processing and Post processing Heat Treatment, Coating Thickness, Case Depth, and Component Distortion Considerations, Surface Roughness and Finishing, Design guidelines for surface preparation, organic and inorganic coating and other important considerations.		

Total:45

TEXT BOOKS:

1.	J.R. Davis and Associates, “Surface Engineering for corrosion and wear resistance”, ASM internationals and IOM communications, 2001.

REFERENCE BOOKS:

1.	Rudolf Strauss, “Surface Mount Technology”, Butterworth-Heinemann Publisher, 1994
2.	Brian Griffiths, “Manufacturing Surface Technology: Surface Integrity and Functional Performance (Manufacturing Processes Modular S.) (Manufacturing Processes Modular)”, 2001.

COURSE OUTCOMES: On completion of the course, the students will be able to		BT Mapped (Highest Level)
CO1	explain the basics of surface engineering and surface preparation methods.	Understanding (K2)
CO2	describe the principles and applications of different chemical conversion coating methods.	Understanding (K2)
CO3	illustrate the principles and applications of different surface coating methods.	Understanding (K2)
CO4	explain the principles and applications of various surface laying methods.	Understanding (K2)
CO5	demonstrate the design guidelines and surface preparation methodologies for various surfaces.	Understanding (K2)

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	1	1				1						2	2
CO2	3	2	1				1						2	2
CO3	3	2	1				1						2	2
CO4	3	2	1				1						2	2
CO5	3	2	3				1						2	2

1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy

ASSESSMENT PATTERN - THEORY

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT1	50	50					100
CAT2	50	50					100
CAT3	30	70					100
ESE	30	70					100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20CHE09 ENERGY TECHNOLOGY

Programme & Branch	B.TECH. – Chemical Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	NIL	**7**	**PE**	**3**	**0**	**0**	**3**

Preamble	The course outlines the world energy scenario, available energy resources and production technologies	
Unit - I	**Overview of Energy Scenario**	**9**
Introduction to Global and domestic energy supply and consumption and Energy statistics, Sector wise energy consumption, Energy Crisis, Energy alternatives, Units of energy and conversion factors, Classification of Energy Sources.		
Unit - II	**Non – Renewable Sources**	**9**
Fossil Fuels: Coal - Classification and Conversion technologies, Petroleum - Products and Properties, Shale oil and gas, Natural gas - CNG and LNG. Nuclear energy sources - Fission and fusion processes, Types of nuclear reactors, Nuclear Power plants.		
Unit - III	**Renewable Energy Sources-I**	**9**
Biomass Energy - Resources and conversion processes, Fundamentals of power generation systems and applications - Hydro power plants, Wind mills and Solar energy systems.		
Unit – IV	**Renewable Energy Sources-II**	**9**
Fundamentals of Power generation systems and applications – Geothermal and ocean energy, fuel cells, Hydrogen Technologies-storage, transportation and applications.		
Unit – V	**Energy Conservation and Management**	**9**
Energy forecasting and planning, Energy conservation – Act, Waste heat recovery and heat pipes, Energy Audits, Cogeneration practices in industries, Energy Storage – Batteries and Fuel Cells, and Energy efficiency in emerging economies.		

Total:45

TEXT BOOK:

1.	Rao S. and Dr. B.B. Parulekar, “Energy Technology”, 4th Edition, Khanna Publishers, 2005.
2.	Twidell John and Weir Tony, — “Renewable Energy Sources”, 2nd Edition, Taylor and Francis, New York, 2006-V unit

REFERENCE BOOKS:

1.	Beggs Clive, “Energy: Management Supply and Conservation”, Butterworth-Heinemann, Oxford, 2002.
2.	Fay James A. and Golomb Dan S., “Energy and the Environment”, Oxford University Press Inc., New York, 2002

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	Summarize the global energy scenario and available sources for energy production	Understanding (K2)
CO2	Explain the energy production and associated technologies from fossil fuels and nuclear sources	Understanding (K2)
CO3	Illustrate the energy production from renewable energy sources like biomass, hydro, wind and solar systems	Understanding (K2)
CO4	Explain the contributions of renewable resources like geothermal, ocean energy, fuel cells and hydrogen technologies in energy production	Understanding (K2)
CO5	Describe the energy conservation measures and efficient energy management practices.	Understanding (K2)

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2					3					1	2	2
CO2	2						3					1	2	
CO3	2						3					1	2	
CO4	2						3					1	2	
CO5	2	2				1	3					1	2	2

1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy

ASSESSMENT PATTERN - THEORY

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT1	40	60					100
CAT2	40	60					100
CAT3	40	60					100
ESE	40	60					100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20CHE10 MODERN SEPARATION PROCESSES

Programme & Branch	B.TECH. – Chemical Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	NIL	**7**	**PE**	**3**	**0**	**0**	**3**

Preamble	This course highlights the modern separation techniques adopted in process industries.	
Unit - I	**Fundamentals and Filtration:**	**9**
Basic Concepts – Characteristics and Mechanism of Separation, Feasibility of Separation Processes. Theory and Selection of Equipment for Filtration Process		
Unit - II	**Membrane Process:**	**9**
Theory of Membranes Process, Types and Choice of Membranes, Types and Relative Merits of Membrane Modules		
Unit - III	**Applications of Membrane Process:**	**9**
Principle and Applications of Dialysis and Electro Dialysis; Nano Filtration and Reverse Osmosis, Pervaporation Ultra filtration, Micro filtration.		
Unit - IV	**Other Separation Process I:**	**9**
Principle and Applications of Ion Exchange, Electrophoresis, Dielectrophoresis, Chromatography in large scale Electrophoresis, Dielectrophoresis, Lyophilisation.		
Unit - V	**Other Separation Process II:**	**9**
Principles and Applications of Supercritical Fluid Extraction, Zone melting, Adductive crystallization, Reversible Chemical Complexation, Foam Separation, Thermal Diffusion, Cryoseparations, ,		

Total:45

TEXT BOOK:

1. Seader, J.D., Ernest J., Henley, Keith Roper D., "Separation Process Principles", 3rd Edition, John Wiley & Sons, USA, 2010.

REFERENCES:

1. Coulson, J.M., Richardson, J.F, "Chemical Engineering", 4th Edition, Butterworth- Heinemann, United State of America, 1996.
2. Scott K., Hughes R, "Industrial Membrane Separation Technology", 1st Edition, Blackie Academic and Professional Publications, United State of America, 1996.
3. Ronald W Rousseau, " Handbook of Separation Process Technology", 1st Edition, Wiley India Pvt Ltd, 2008.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	describe the separation processes for selecting optimal process for new and innovative applications and the novel techniques of filtration	Understanding (K2)
CO2	apply the types of membranes and membrane materials and exhibit the understanding of various membrane separation processes	Applying (K3)
CO3	explain the basic principles of common membrane separation processes and its application in process industries	Applying (K3)
CO4	apply the latest concepts like Ion Exchange, Electrophoresis, Dielectrophoresis, Chromatography in chemical process industries	Applying (K3)
CO5	discuss the advancement of recent separation techniques	Applying (K3)

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	2		1	2					3	3	2
CO2	3	3	2	2		1	2					3	3	2
CO3	3	3	3	2		1	2					3	2	2
CO4	3	3	3	3		1	2					3	2	2
CO5	3	2	3	3		1	2					2	3	2

1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy

ASSESSMENT PATTERN - THEORY

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT1	10	30	60				100
CAT2	10	30	60				100
CAT3	10	30	60				100
ESE	10	30	60				100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20CHE11 AIR POLLUTION CONTROL

Programme & Branch	B.TECH. – Chemical Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	NIL	7	PE	3	0	0	3

Preamble	This course delivers the framework of different air pollutants and the controlling equipment	
Unit - I	**Introduction to Air Pollution:**	**9**
Air pollutants – History, air quality standards, monitoring and measurement, sampling and analysis- classifications of pollutants – sources and effects. Regulatory system: Framework in India- clean air act – provisions for recent development		
Unit - II	**Gaseous pollutants and Particulates:**	**9**
Chemical and physical properties of gaseous pollutants- Stack Plumes- models, general characteristics and types. Particulates: Collection mechanism- particle size distribution- collection efficiency.		
Unit - III	**Air Pollution Controlling Equipment:**	**9**
Incinerators, Absorbers, Thermal oxidizers, Gravity settling chambers – classifications, operation, typical applications and suggestions for improvement.		
Unit - IV	**Design of Equipment:**	**9**
Cyclone separators, Electrostatic precipitators, Bag house filters-– design, operations and maintenance, typical applications.		
Unit - V	**Hybrid systems and Air Pollution Survey**	**9**
Hybrid systems – Wet electrostatic precipitators, Dry scrubbers, Electrostatically augmented fabric filters. Air pollution surveying guidelines		

Total:45

TEXT BOOKS:

1. Louis Theodore, Anthony J. Buonicore, "Air Pollution Control Equipment Calculations",1st Edition, Wiley, USA, 2008 for units I,II,III,IV.
2. Rao M.N. and Rao H.V.N, "Air Pollution", 1st Edition, McGraw Hill International edition, India, 2001 for units IV,V.

REFERENCE:

1. Cooper C.D. and Alley F.C, "Air Pollution Control-A Design Approach", 4th Edition, Waveland Pr Inc, United State of America, 2010.
2. C. S. Rao, “Environmental Pollution Control Engineering”, Revised second edition, New Age International, 2007

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	describe the evolution procedure in analyzing the air pollutants based on air quality standards	Understanding (K2)
CO2	explain the characteristics of gaseous pollutants and particulates	Understanding (K2)
CO3	demonstrate the operations and applications of air pollution control equipment	Understanding (K2)
CO4	design air pollution control equipment.	Applying (K3)
CO5	explain the concepts involved in hybrid systems and air pollution survey	Understanding (K2)

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	1	1			3	3						2	2
CO2	3	1	1			3	3						2	2
CO3	3	1	1			3	3						2	2
CO4	3	2	2			3	3						3	2
CO5	3	1	1			3	3						3	2

1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy

ASSESSMENT PATTERN - THEORY

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT1	30	70					100
CAT2	35	65					100
CAT3	10	60	30				100
ESE	20	60	20				100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20CHE12 PROCESS INSTRUMENTATION

Programme & Branch	B.TECH. – Chemical Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	NIL	**7**	**PE**	**3**	**0**	**0**	**3**

Preamble	This course will help the students to be aware of various measurement system used in chemical industries to measure process variables.	
Unit - I	**Principles of Measurement:**	**9**
Measuring Instrument: Introduction and its types- Elements and its function. Transducer: Importance and its classification - Measuring errors: Sources - reduction - quantification of systematic and Random errors. Performance characteristics: Static and Dynamic characteristics		
Unit - II	**Temperature Measurement:**	**9**
Principles of temperature measurement: Thermoelectric effect sensors - Varying resistance devices - Radiation thermometers - Thermography - Thermal expansion methods - Fibre-optic temperature sensors - Selection of temperature transducers.		
Unit - III	**Pressure Measurement:**	**9**
Principles of Pressure Measurement: Manometers - Bourdon tube - Bellows - Diaphragms - Capacitive pressure sensor - Fibre-optic pressure sensors - Resonant-wire devices - Dead-weight gauge - Special measurement devices for low pressures measurement -Selection of pressure sensors.		
Unit – IV	**Flow and Viscosity measurement:**	**9**
Principles of Flow Measurement : Mass flow rate measurement and Volume flow rate measurement - Choice between flow meters for particular applications. Viscosity measurement: Capillary and tube viscometers - Falling body viscometer - Rotational viscometers.		
Unit – V	**Level Measurement:**	**9**
Principles of Level Measurement: Float systems - Pressure measuring devices - Capacitive devices - Ultrasonic level gauge - Radar (microwave) methods - Radiation methods - Vibrating level sensor and Laser methods - Choice between different level sensors.		

Total:45

TEXT BOOK:

1. Alan S Morris, Reza Langari, "Measurement and Instrumentation: Theory and Application", 3rd edition, Academic Press, USA, 2001.

REFERENCES:

1. William C Dunn , "Fundamentals of Industrial Instrumentation and Process Control", 1st edition, McGraw Hill International Edition, New Delhi, 2005.
2. Singh S.K, "Industrial Instrumentation and Control", 2nd edition, McGraw Hill International edition, New Delhi, 2006.

COURSE OUTCOMES: On completion of the course, the students will be able to		BT Mapped (Highest Level)
CO1	describe the type, performance characteristics and error generation of measurement	Understanding (K2)
CO2	explain temperature measurement device applied in chemical industries	Understanding (K2)
CO3	describe various range of pressure measuring system used in process industries	Understanding (K2)
CO4	illustrate flow and viscosity measurement techniques related to production industries	Understanding (K2)
CO5	elaborate level measurement tool adopted in industries	Understanding (K2)

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	1											2	
CO2	3	1											2	
CO3	3	1											2	
CO4	3	1											2	
CO5	3	1											2	

1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy

ASSESSMENT PATTERN - THEORY

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT1	20	80					100
CAT2	20	80					100
CAT3	20	80					100
ESE	20	80					100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20CHE13 FERTILIZER TECHNOLOGY

Programme & Branch	B.TECH. – Chemical Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	NIL	7	PE	3	0	0	3

Preamble	This course offers an insight into the sources and production of different fertilizers	
Unit - I	**Overview of Fertilizer:**	**9**
Synthetic fertilizers, Classification of fertilizers, Role of essential Elements in plant Growth, Macro elements and Micro elements, Application of fertilizers considering Nutrient Balance and types of crop. Development of fertilizer industry; Fertilizer production and consumption in India; Nutrient contents of fertilizers; Secondary nutrients; Synthetic fertilizers, Classification of fertilizers, Feedstock and raw materials for nitrogenous, phosphatic and potassic fertilizers.		
Unit - II	**Nitrogen based Fertilizers:**	**9**
Introduction to Nitric acid: Chemical, physical properties and applications, Manufacturing of Nitric Acid by Pressure ammonia oxidation process and Intermediate pressure ammonia oxidation process, Concentration of Nitric acid by $Mg(NO_3)_2$. Manufacturing of Ammonium nitrate by Prilling process, Ammonium sulphate from Ammonium carbonate and gypsum, Ammonium chloride from Ammonium sulphate and sodium chloride		
Unit – III	**Ammonia & Urea:**	**9**
Introduction to Ammonia: Physical & chemical properties, applications, Synthesis gas by Catalytic partial oxidation Steam Hydrocarbon reforming, Ammonia converters: Design aspect of Single bed and multi-bed converter, Kellogg process and Haldor Topsoe process, Storage and Transportation of Ammonia. Urea: Physical, chemical properties, Manufacturing of Urea by Stamicarbon's CO_2 stripping process, Toyo-Koatsu total recycle process		
Unit - IV	**Potassium Fertilizers:**	**9**
Physical, chemical properties and uses of Potassium Chloride, Potassium nitrate, Potassium sulphate, Manufacturing of potassium chloride from sylvinite, Preparation of Potassium nitrate, Potassium sulphate		
Unit - V	**Miscellaneous Fertilizer and Bio Fertilizers:**	**9**
Manufacturing of NPK, Ammonium Sulphate Phosphate (ASP), Calcium Ammonium Nitrate(CAN), Biofertilizers, Types and preparation of biofertilizers, Nitrogen fixing biofertilizers, Phosphate-solubilizing biofertilizers; liquid fertilizers		

Total:45

TEXT BOOK:

1. Collings G.H., “Commercial Fertilizers”, 5th Edition, Mc Graw Hill, New York, 1995

REFERENCES:

1. Editorial Board, The Fertilizer Association of India, “Handbook of Fertilizer Technology”, 1977
2. Slacks A V., “Chemistry and Technology of Fertilizers”, Interscience, New York, 1966

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	outline the essential plant growth nutrients, components, significance of fertilizers and the industrial manufacturing practices	Understanding (K2)
CO2	describe the physical, chemical properties, manufacturing and applications of nitrogen based fertilizers	Understanding (K2)
CO3	explain the physical, chemical properties, manufacturing and applications of ammonia and urea	Understanding (K2)
CO4	summarize the physical, chemical properties and production of potassium fertilizers	Understanding (K2)
CO5	describe the miscellaneous types of fertilizers and production of bio fertilizers.	Understanding (K2)

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3					2	2					1	1	2
CO2	3					2	2					1	1	2
CO3	3					2	2					1	1	2
CO4	3					2	2					1	1	2
CO5	3					2	2					1	1	2

1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy

ASSESSMENT PATTERN - THEORY

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT1	30	70					100
CAT2	30	70					100
CAT3	30	70					100
ESE	30	70					100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20CHE14 CORROSION TECHNOLOGY

Programme & Branch	B.TECH. – Chemical Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	NIL	7	PE	3	0	0	3

Preamble	To gain knowledge on the principles of corrosion, its testing methods, control measures in specific environments.	
Unit - I	**Types of Corrosion and Testing:**	**9**
Basic principles of corrosion and its control: Forms of corrosion, Uniform, Galvanic, Crevice, Pitting, Inter-granular, Selective leaching, Erosion, Stress corrosion. Hydrogen Blistering and Embrittlement, Cracking, Cavitation and their Fracture Mechanics. Corrosion testing: Classification, Purpose, Material and Specimen, Surface preparation, Measuring and Weighing. Exposure techniques: Duration – Planned interval test; NACE test methods, Slow-Strain-Rate test, Linear Polarization, AC Impedance method.		
Unit - II	**Corrosion Prevention Methods:**	**9**
Corrosion inhibitors, Electroplated coatings, Conversion coatings, Anodizing, Hot dipping, Spray metal coatings, Zinc coating by alloying, Electrophoteric coatings and electro painting, Powder coating. Corrosion minimization by material selection. Cathodic and Anodic protections		
Unit - III	**Corrosion in Specific Environments:**	**9**
Corrosion by organic acids and alkalies. Seawater and Fresh water corrosion on concrete structures, Corrosion in automobiles, Biological corrosion, Halogen corrosion of metals, Corrosion in Petroleum industry, Corrosion in aerospace.		
Unit - IV	**Corrosion in Specific Cases and Control:**	**9**
Corrosion and selection of materials of pulp and paper plants. Corrosion of wet scrubbers in pollution control. Nuclear waste isolation and corrosion by liquid metal and fused salts. Corrosion of surgical implants and prosthetic devices. Corrosion in electronic equipment.		
Unit - V	**Corrosion Inspection and Management:**	**9**
Corrosion inspection methods: visual, liquid penetration, magnetic particle, radiographic, eddy current, ultrasonic, thermography testing. Corrosion management systems. Process maintenance procedures.		

Total:45

TEXT BOOKS:

1. Fontana M.G., "Corrosion Engineering", 1st edition, Tata McGraw Hill Publishing Company Ltd, New Delhi, 2005.
2. Pierre R. Roberge, "Corrosion Inspection and Monitoring", 1st edition, John Wiley and Sons Inc, Canada, 2008. Unit V

REFERENCES:

1. Jones D.A, "Principle and Protection of Corrosion", 1st edition, Prentice Hall of India Pvt. Ltd, India, 1996.
2. Sastri V.S., Ghali E., Elboujdaini M., "Corrosion Prevention and Protection: Practical Solutions", 1st edition, John Wiley & Sons Inc, United State of America, 2007.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	describe the different types of corrosion and their testing methods	Understanding (K2)
CO2	explain the corrosion protection methods for applications in chemical process industries	Applying (K3)
CO3	describe the corrosion in specific environments and its control	Understanding (K2)
CO4	explain the corrosion control methods in industrial applications and case studies	Applying (K3)
CO5	demonstrate corrosion inspection and management practices	Understanding (K2)

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2				2	2						2	1
CO2	3	2				2	2						2	1
CO3	3	2				2	2						2	1
CO4	3	2				2	2						2	1
CO5	3	2				2	2						2	1

1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy

ASSESSMENT PATTERN - THEORY

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT1	20	60	20				100
CAT2	20	60	20				100
CAT3	20	60	20				100
ESE	20	60	20				100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20CHE15 NATURAL GAS ENGINEERING

Programme & Branch	B.TECH. – Chemical Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	NIL	7	PE	3	0	0	3

Preamble	This course offers an insight into the properties, production, application and safety features of Oil and Natural Gas Industry	
Unit - I	**Natural gas fundamentals and exploration:**	**9**
Natural gas origin, classification of sources – conventional and non-conventional / shale gas, composition and classification of natural gas; Properties of natural gas – chemical, physical properties, thermodynamic, Natural gas reservoirs, Natural gas exploration – conventional, non-conventional / shale gas, well deliverability		
Unit - II	**Natural gas transportation and storage:**	**9**
Transportation methods – Pipelines, LNG, CNG, Gas-to-liquids, Gas-to-soild, Gas-to-wire, Underground gas storage – Depleted reservoirs, aquifers, salt caverns		
Unit - III	**Multiphase gas transmission and operation:**	**9**
Multiphase flow terminologies– superficial velocity, mixture velocity, holdup, phase velocity, slip, Mixture-density, viscosity, pressure drop, enthalpy. Multiphase flow regimes- two, three phase and condensate phase. Multiphase pipeline operations – leak detection, pipeline depressurization, pigging. Gas hydrates and prevention techniques.		
Unit - IV	**Natural Gas treatment:**	**9**
Chemical absorption processes– alkanolamine solvents, potassium carbonate solution, Physical Solvent processes – propylene carbonate, dimethyl ether of polyethylene glycol, methanol, Solid bed absorption process- Iron sponge, Zinc oxide, Solid bed adsorption process.		
Unit - V	**Dehydration and Sulfur recovery:**	**9**
Water content determination, Natural Gas Dehydration – Glycol dehydration – TEG, Enhanced TEG, glycol injection, Sufur recovery – Modified Claus process, Direct oxidation process, Tail gas cleanup processes – reduction, sulfur dioxide scrubbing, catalytic oxidation		

Total:45

TEXT BOOK:

1. Saeid Mokhatab, William Poe and John Mak, “Handbook of Natural Gas Transmission and Processing”, 4th Edition, Gulf Professional Publishing, USA, 2019.

REFERENCES:

1. Charles Sheppard, “World Seas: An Environmental Evaluation: Volume III: Ecological Issues and Environmental Impacts”, 2nd Edition, Academic Press, UK, 2019.
2. Primož Potocnik, “Natural Gas”, Intech Open, Croatia, 2010.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	explain the basic properties of natural gas and classify traps based on formation	Understanding (K2)
CO2	demonstrate the techniques involved in exploration and drilling of natural gas	Understanding (K2)
CO3	exemplify the deliverability and flow behaviour in a reservoir	Understanding (K2)
CO4	describe the purification, compression and liquefaction of oil and natural gas for storage and transportation.	Understanding (K2)
CO5	explain the dehydration and sulfur recovering techniques	Understanding (K2)

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	1											2	1
CO2	3	1											2	1
CO3	3	2											3	1
CO4	3	1											2	1
CO5	3	1											2	1

1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy

ASSESSMENT PATTERN - THEORY

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT1	40	60					100
CAT2	40	60					100
CAT3	40	60					100
ESE	40	60					100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20CHE16 NANOTECHNOLOGY AND COMPOSITE MATERIALS FOR CHEMICAL ENGINEERS

Programme & Branch	B.TECH. – Chemical Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	NIL	7	PE	3	0	0	3

Preamble	This course will able to help students to gain knowledge in preparation and application of nanomaterials	
Unit – I	**Overview of Nanomaterials**	**9**
Introduction and Classification, Nanostructure induced effects on properties. Introduction to Fabrication and preparation techniques		
Unit - II	**Characterization of Nanomaterials**	**9**
General classification of characterization techniques, Usage of Microscopy – SEM, TEM, STM & AFM, Usage of Crystallography – XRD & XRF. Spectroscopy – IR, NMR and Raman Spectroscopy.		
Unit - III	**Key nanostructures and applications**	**9**
Nano – Semiconductors, Nanomagnetic Materials, Carbon based Nanomaterials – Bucky ball, CNT, Graphite and Graphene. Templated Nanostructures, Nano catalysts, Biological Nanomaterials – Polypeptides, DNA		
Unit – IV	**Introduction to Composite materials**	**9**
Definition of composite materials, Fibers and Matrices, Key properties of composites. Manufacturing processes – Molding, Forming, 3D assembly and Tape laying, Sandwich composites		
Unit - V	**Applied composites**	**9**
Application of Composite materials – Aerospace construction, Automotives, Wind turbines, Ship building, Ski, Bicycles, Other applications – Pressure gas bottle, Bogie Frame, Offshore installations, Biomechanical applications, Cable car, Applications of Nanocomposites		

Total:45

TEXT BOOKS:

1.	Robert Kelsall, Ian W Hamley and Mark Geoghegan, " Nanoscale Science and Technology", 1st Edition, Wiley, UK, 2005, Unit I, II & III
2.	Daniel Gay, "Composite Materials – Design and applications", CRC Press, Boca Raton, USA, 2014, Unit IV & V

REFERENCE BOOK:

1.	William A. Goddard, "Hand book of Nanoscience, Engineering and Technology ", 1st Edition, CRC Press, United State of America, 2003.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	describe the phenomena of nanosize and the general synthesis techniques	Understanding (K2)
CO2	explain the techniques available for characterization of nanomaterials	Understanding (K2)
CO3	discuss the synthesis characterization and applications of various nanomaterials	Understanding (K2)
CO4	Explain the key features of composites and their manufacturing techniques	Understanding (K2)
CO5	illustrate the important applications of composite and nano composite materials in various sectors	Understanding (K2)

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	1											2	2
CO2	3	1											2	2
CO3	3	1											2	2
CO4	3	2											2	2
CO5	3	2											2	2

1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy

ASSESSMENT PATTERN - THEORY

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT1	30	70					100
CAT2	30	70					100
CAT3	20	80					100
ESE	20	80					100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20CHE17 FUNDAMENTALS OF COMPUTATIONAL FLUID DYNAMICS

Programme & Branch	B.TECH. – Chemical Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	NIL	7	PE	3	0	0	3

Preamble	With the advent of high speed computing, CFD has become an integral part of engineering design, simulation and performance analysis. This course deals with the fundamentals of CFD, grid generation, meshing and solution techniques using finite volume method.	
Unit - I	**Conservation Laws of Fluid Motion and Boundary Conditions:**	**9**
Governing equations of fluid flow and heat transfer: Equations of state -Navier-Stokes equations for Newtonian fluid - conservative form of governing equations of flow - differential and integral forms of general transport equations - classification of physical behavior.		
Unit – II	**Turbulence and its Modeling:**	**9**
Transition from laminar to turbulent flow - effect of turbulence on properties of the mean flow - Reynolds-averaged Navier-Stokes equations and classical turbulence models - mixing length model – k-ϵ model; Turbulent models - Reynolds Stress model and large eddy simulation.		
Unit – III	**Finite Volume Method for Diffusion and Convective-Diffusion Problems:**	**9**
Finite volume method for one-dimensional, two-dimensional and three-dimensional steady state diffusion - steady one-dimensional convection and diffusion- Discretization schemes: the central differencing scheme - Properties of discretization schemes - Assessment of the central differencing scheme for convection-diffusion problems - upwind differencing scheme - Hybrid differencing scheme - power-law scheme.		
Unit – IV	**Solution Algorithms for Pressure-Velocity Coupling in Steady Flows:**	**9**
Staggered grid - momentum equations - SIMPLE algorithm - Assembly of a complete method - SIMPLER, SIMPLEC, and PISO algorithms. Solution of discretized equations: Tri-diagonal matrix algorithm - application of TDMA to two-dimensional and three-dimensional problems.		
Unit – V	**Finite Volume Method for Unsteady Flows:**	**9**
One-dimensional unsteady state heat conduction - implicit method for two-and three-dimensional problems - discretization of transient convection-diffusion equation - solution procedures for unsteady flow calculations - steady state calculations using pseudo-transient approach.		

Total:45

TEXT BOOK:

1. Versteeg H.K. and Malalasekara W, "An Introduction to Computational Fluid Dynamics: The Finite Volume Method", 2nd edition, Pearson Education, India, 2007.

REFERENCE:

1. Anderson John D., "Computational Fluid Dynamics-The Basics with Applications", 1st edition, Tata McGraw Hill Publishing Company Ltd, United State of America, 2012.
2. https://www.ansys.com/en-in/products/fluids/ansys-fluent
https://www.solidworks.com/

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	explain governing equations for fluid flow and heat transfer.	Applying (K3)
CO2	explain the different types of models for turbulence.	Applying (K3)
CO3	apply finite volume method for developing solution of steady state diffusion and convection diffusion problems.	Analyzing (K4)
CO4	describe the solution algorithms for pressure–velocity coupling in steady flows.	Applying (K3)
CO5	apply the knowledge of algorithms in solving unsteady flow heat conduction and convection diffusion processes.	Analyzing (K4)

Mapping of COs with POs and PSOs

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	3	2	2	2							2	2	2
CO2	3	3	2	2	2							2	2	2
CO3	3	3	2	3	2							2	2	2
CO4	2	3	2	3	2							2	2	2
CO5	2	3	2	3	2							2	2	2

1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy

ASSESSMENT PATTERN - THEORY

Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	10	60	30				100
CAT2	10	20	50	20			100
CAT3	10	20	50	20			100
ESE	10	20	50	20			100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20CHE18 PHARMACEUTICAL PROCESS TECHNOLOGY

Programme & Branch	B.TECH. – Chemical Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	NIL	7	PE	3	0	0	3

Preamble	To gain knowledge in formulation and manufacturing of drugs and its quality analysis.	
Unit - I	**Principles and Kinetics:**	**9**
Introduction to drugs and pharmaceutical, application of organic therapeutic agents, pharmaco kinetics-Absorption, Distribution, metabolism and Excretion-mechanism and physico chemical principles.		
Unit - II	**Process Synthesis:**	**9**
Chemical Conversion process- alkylation, carboxylation, condensation and cyclisation, dehydration, esterification, halogenation, oxidation and sulfonation reactions.		
Unit - III	**Drug Delivery Systems:**	**9**
Tablets and capsules -Types of Tablets and capsules -Formulation and Manufacturing; parential solutions, oral liquids, injections and ointments-methods of preparation.		
Unit - IV	**Pharmaceutical Products:**	**9**
Vitamins-Functions, laxatives-classification and uses, analgesics-Types and Mechanisms, antacids and antiseptics-classification, mechanism and applications.		
Unit – V	**Quality Control:**	**9**
Concept of quality control-IPQC tests for tablets, Quality analysis – raw materials, process and finished products. Good Manufacturing Practices-cGMP, FDA regulations.		

Total:45

TEXT BOOKS:

1.	Brahmankar D.M. and Sunil B. Jaiswal, “Bio pharmaceutics and Pharmacokinetics: A Treatise”, 1st Edition, Vallabah Prakashan India, 2017.
2.	Arthur Owen Bentley, "Text book of Pharmaceutics", 8th Edition, All India Traveller Book Seller, India, 2002. Unit IV & V

REFERENCE:

1.	Banker G.S. and Rhodes C.T., "Modern Pharmaceutics", 4th Edition, Marcel Dekker Inc, United State of America, 2002.

COURSE OUTCOMES: On completion of the course, the students will be able to		BT Mapped (Highest Level)
CO1	explain the drug metabolism and pharmaco–kinetic principles	Understanding (K2)
CO2	illustrate the different chemical conversion processes in pharmaceutical industries	Understanding (K2)
CO3	outline the formulation and manufacturing of drug delivery systems	Understanding (K2)
CO4	describe the manufacturing processes of different types of pharmaceutical products	Understanding (K2)
CO5	elaborate the importance of good manufacturing practices and quality control procedures	Understanding (K2)

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	1				1							2	2
CO2	3	1				1							2	2
CO3	3	1				1							2	2
CO4	3	1				1							2	2
CO5	3	1				1							2	2

1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy

ASSESSMENT PATTERN - THEORY

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT1	30	70					100
CAT2	30	70					100
CAT3	30	70					100
ESE	30	70					100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20CHE19 PROCESS OPTIMIZATION

Programme & Branch	B.Tech. – Chemical Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	Engineering Mathematics	7	PE	3	0	0	3

Preamble	This course provides knowledge about the fundamentals of optimization and its applications in process industries.	
Unit - I	**Developing Models for Optimization**	**9**
Scope and hierarchy of optimization, Essential features of Optimization problems, Classification of Models, Building a model, Factorial experimental designs, Degree of freedom.		
Unit – II	**Basic Concepts of optimization**	**9**
Formation of objective function, continuity of functions, NLP problem statement, convexity and applications, Interpretation of objective function based on its Quadratic approximation, Necessary and sufficient conditions for an extremum.		
Unit - III	**Optimization of Unconstrained Functions**	**9**
Methods for one dimensional search, Newton's method and Quasi – Newton methods for uni-dimensional search. Polynomial approximation methods.		
Unit - IV	**Unconstrained Multivariable Optimization**	**9**
Methods using function value only, methods using first derivative, Newton's method, Quasi – Newton methods.		
Unit - V	**Linear Programming and applications of optimization**	**9**
Simplex method, Barrier method, sensitivity analysis, Linear mixed integer programs. Applications of optimization in chemical processes.		

Total: 45

TEXT BOOK:

1. Edgar T.F., Himmelblau D.M. and Ladson L.S., "Optimization of Chemical Processes", 2nd edition, McGraw Hill, New York, 2003.

REFERENCE BOOKS:

1. Urmila M. Diwekar, "Introduction to Applied Optimization", 2nd edition, Springer, 2008.
2. Rao S.S., "Engineering Optimization: Theory and Practice", 4th edition, New Age Publishers, 2011.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	Explain different optimization models in a system.	Understanding (K2)
CO2	Develop and interpret the objective functions of optimization.	Applying (K3)
CO3	Apply unidirectional search methods in solving unconstrained functions.	Applying (K3)
CO4	Solve optimization problems using unconstrained multivariable optimization.	Applying (K3)
CO5	Describe the methods of linear programming and apply optimization techniques to solve chemical engineering problems.	Applying (K3)

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	2	1							3		
CO2	3	3	3	3	1							2		
CO3	3	3	3	2	1							2		
CO4	3	3	3	3	1							2		
CO5	3	3	3	3	1							2		

1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy

ASSESSMENT PATTERN - THEORY

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT1	10	25	65				100
CAT2	10	25	65				100
CAT3	10	30	60				100
ESE	10	30	60				100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100**

20CHE20 NUCLEAR ENGINEERING FOR CHEMICAL ENGINEERS

Programme & Branch	B.TECH. – Chemical Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	NIL	7	PE	3	0	0	3

Preamble	This course offers an insight into the fundamentals and applications of Nuclear engineering	
Unit - I	**Foundations of Nuclear Sciences:**	**9**
Introduction to Nuclear Energy – Binding and Separation Energy, Nuclear Reactions – Classification, Conservation of charge, Q – value for reactions, Radioactivity – Types of radioactive decay, Characteristics, Half life and Decay Chain, Radio – Isotopes		
Unit - II	**Nuclear energetics – I:**	**9**
Characteristics of Nuclear Fission – Fission Products, Neutron Emission, Energy Released; Characteristics of Nuclear Fusion – Energy generation, Nucleogenesis, Conservation of mass, energy and linear momentum, Reaction Threshold Energy		
Unit - III	**Nuclear energetics – II:**	**9**
Nuclear Chain reaction – Controllable and Uncontrollable reaction, Nuclear fuel cycle, Fuel bundle preparation, Moderation of neutrons, selection of moderators, Homogenous and Heterogeneous cores, Neutron Reflectors		
Unit - IV	**Nuclear Reactor Technology:**	**9**
Generation of Nuclear reactor technology, Nuclear Thermal Reactors – Components and steam cycles of BWR, PWR, PHWR, LWR, AGR. Fast Breeder Technology – Fissile material for fast reactors, Breeder Reactor Technologies, Problems with Fusion Reaction, Economics of Nuclear Power		
Unit - V	**Instrumentation and Safety:**	**9**
Detection and Measurement of Radiation – Gas filled detectors, Scintillation detectors, Semi-conductor Ionizing Detectors, Personal Dosimeters. Hazard Assessment – Containment Technology, natural exposure for humans, Health and hereditary effects, Cancer Risks, Personal Protective equipment, Radiation Protection Standards		

Total:45

TEXT BOOK:

1.	J. Kenneth Shultis, Richard E Faw, "Fundamentals of Nuclear Science and Engineering", 3rd Edition, CRC press, USA, 2016.

REFERENCES:

1.	Rüdiger Meiswinkel, Julian Meyer, Jürgen Schnell, "Design and Construction of Nuclear Power Plants", 1st edition, Ernst & Sohn, Germany, 2013.
2.	James H. Rust, "Nuclear Power Safety", 1st Edition, Pergamon Publishers, Paris, 2013.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	explain the fundamental concepts of nuclear reactions and radio-activity	Understanding (K2)
CO2	describe the characteristics of nuclear fission and fusion for energy generation	Understanding (K2)
CO3	explain the nuclear fuel cycle and the preparatory aspects of nuclear reactor	Understanding (K2)
CO4	describe the working and economics of various fission reactors	Understanding (K2)
CO5	illustrate the working of radiation instruments and discuss about the nuclear safety	Understanding (K2)

Mapping of COs with POs and PSOs

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	2					1							
CO2	3	2					1							
CO3	3	2					1							
CO4	3	2					1							
CO5	3	2					1							

1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy

ASSESSMENT PATTERN - THEORY

Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	30	70					100
CAT2	30	70					100
CAT3	30	70					100
ESE	30	70					100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20CHE21 NUMERICAL TECHNIQUES IN CHEMICAL ENGINEERING

Programme & Branch	B.Tech. – Chemical Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	Engineering Mathematics	7	PE	3	0	0	3

Preamble	This course will enable the students to understand and apply various numerical techniques for solving chemical engineering problems	
Unit - I	**Solutions to Transcendental equations and Eigen value problems**	**9**
Solution of equations – iteration method – Newton-Raphson Method – solution of linear system by Gaussian elimination and Gauss-Jordan method – iterative methods – Gauss-Jacobi and Gauss-Seidel methods – inverse of a matrix by Gauss-Jordon method –finding the Eigenvalue of a matrix by power method.		
Unit – II	**Interpolation**	**9**
Lagrange's interpolating polynomials – interpolation with equal intervals – Newton's forward and backward difference formulae – central difference formulae – interpolation with unequal intervals – divided differences – Newton's divided difference formula.		
Unit - III	**Numerical Differentiation and Integration**	**9**
Differentiation using interpolation formulae – numerical integration by trapezoidal and Simpson's 1/3 and 3/8 rules – Romberg's method – two and three point Gaussian quadrature formulae – double integrals using Trapezoidal and Simpson's rules.		
Unit - IV	**Numerical solutions of Ordinary Differential Equations**	**9**
Single-step methods – Taylor series method – Euler method for first order equation – Fourth order Runge-Kutta method for solving first and second order equations – multi-step methods – Milne's and Adam's predictor-corrector methods.		
Unit - V	**Numerical Solutions of Partial Differential Equations**	**9**
Classification of second order PDE - finite-difference approximations to partial derivatives – solution of Laplace and Poisson equations – solution of one-dimensional heat equation – solution of two-dimensional heat equation - solution of wave equation.		

Total: 45

TEXT BOOK:

1. S.S. Sastry, Introductory Methods of Numerical Analysis, 4th edition, PHI Learning Private Limited, New Delhi, 2007.

REFERENCE BOOKS:

1. Kenneth J Beers, "Numerical Methods for Chemical Engineering – Applications in MATLAB" Cambridge University Press, New York, USA, 2007.
2. John H. Mathews and Kurtis D. Fink, "Numerical Methods using MATLAB", 4th edition, PHI Learning Private Limited, New Delhi, 2007.
3. B.S. Grewal, "Numerical methods in Engineering and Science – C,C++, and MATLAB, 2018, Mercury Learning and Information LLC, 2019.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	apply various numerical methods to solve transcendental equations and Eigenvalue problems	Applying(K3)
CO2	utilize interpolation method for solving problems involved in chemical systems	Applying(K3)
CO3	apply the differentiation and integration equations using numerical methods	Applying(K3)
CO4	solve ordinary differential equations using numerical techniques	Applying(K3)
CO5	Develop solutions for partial differential equations used in chemical engineering systems	Applying(K3)

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	2	1									
CO2	3	3	2	2	1									
CO3	3	3	2	3	1									
CO4	3	3	3	3	1									
CO5	3	3	3	3	1									

1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy

ASSESSMENT PATTERN - THEORY

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT1		40	60				100
CAT2		40	60				100
CAT3		40	60				100
ESE		40	60				100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100**

20CHE22 PETROLEUM REFINERY ENGINEERING

Programme & Branch	B.TECH. – Chemical Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	NIL	**7**	**PE**	**3**	**0**	**0**	**3**

Preamble	This course covers classification of petroleum products, purification and upgradation techniques and basic safety measure to be followed in the refinery.	
Unit - I	**Petroleum Formation and Evaluation**	**9**
Origin and formation, Composition of petroleum, Evaluation of petroleum – UOP Characterization factor, Correlation Index, Distillation Characteristics – Crude Assay analysis, TBP apparatus, Average boiling point.		
Unit - II	**Petroleum product fractions, properties and Test methods**	**9**
Thermal properties of petroleum fractions – Specific heat, Heat of Combustion, Latent heat of vaporization, thermal expansion, spontaneous ignition temperature, Viscosity, Thermal conductivity, Test methods – ASTM distillation, Reid vapor pressure, Octane number, Oxidation stability, Sulfur, Carbon content, Pour point, Smoke point, Fire point, Flash point, Aniline point		
Unit - III	**Fractionation and Treatment techniques**	**9**
Dehydration and desalting of crudes, Distillation (ADU, VDU), Production and treatment of LPG, Gasoline – Copper chloride process, Inhibitor sweetening, caustic and methanol, lead doctoring, Merox treatment, sulfuric acid treatment , catalytic desulfurization		
Unit - IV	**Upgradation Processes:**	**9**
Thermal cracking- vis braking, Dubbs two coil process, Catalytic cracking – fixed, moving bed, fluidized bed (FCC), Catalytic reforming, Naphtha cracking, Coking (Delayed, Fluidized), Hydrocracking (single, two stage), Hydrodesulphurization, Alkylation (Sulfuric and Fluoric acid methods), Isomerization (Aluminum chloride method)		
Unit - V	**Asphalt technology, Biodiesel and Oil spill management**	**9**
Asphalt – source, chemical structure, types, Air blowing of Bitumen, Biodiesel production, Oil spill management – Cleaning equipment – Skimmers.		

Total:45

TEXT BOOK:

1. Bhaskara Rao.B.K, "Modern Petroleum Refining Processes", 6th Edition, Oxford and IBH Publishing Company, New Delhi, 2017.

REFERENCES:

1. Nelson.W.L, "Petroleum Refinery Engineering", 4th Edition, McGraw Hill International Edition, New York, 1958.
2. Mark J. Kaiser, Arno deKlerk, James H. Gary and Glenn E.Handwerk, "Petroleum Refining: Technology, Economics, and Markets", 6th Edition, CRC Press, United Kingdom, 2019.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	discuss the formation, classification and properties of petroleum	Applying (K3)
CO2	explain the crude properties and test methods for petroleum	Applying (K3)
CO3	describe the various purification methods for petroleum products	Understanding (K2)
CO4	exemplify the production of LPG, LNG and hydro treatment processes	Understanding (K2)
CO5	discuss the process of isomerization, polymerization and processing of heavy crude	Understanding (K2)

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	1											2	2
CO2	3	1											2	2
CO3	3	1											2	2
CO4	3	1											2	2
CO5	3	1											2	2

1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy

ASSESSMENT PATTERN - THEORY

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT1	20	70	10				100
CAT2	20	70	10				100
CAT3	30	70					100
ESE	20	70	10				100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20CHE23 INDUSTRIAL WASTE WATER TREATMENT

Programme & Branch	B.TECH. – Chemical Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	NIL	7	PE	3	0	0	3

Preamble	To promote understanding of basic and advanced concepts in Industrial waste water treatment technologies	
Unit – I	**Sources and types of Industrial Wastewater:**	**9**
Sources and types of industrial wastewater – Characterization: Physical, Inorganic non metallic constituents, metallic constituents, Organic constituents, Biological Characteristic, Toxicity tests		
Unit – II	**Introduction to process selection:**	**9**
Physical unit operation: Screening, Coarse solid reduction, Mixing and flocculation, Equalization, Gravity separation, Grit removal, Sedimentation, Neutralization, Clarification, Flotation. Role of Chemical unit operations in waste water treatment, Chemical unit Process: Chemical Coagulation, Chemical Precipitation- Heavy metal Removal, Phosphorus removal, Chemical oxidation, Chemical Neutralization and stabilization		
Unit – III	**Biological Treatment:**	**9**
Composition and Classification, Bacterial growth, Microbial growth, Aerobic biological oxidation, biological Nitrification, Anaerobic fermentation and oxidation, Biological removal of heavy metals, Activated sludge process, Trickling Filters, Rotating Biological Contactors, Combined aerobic treatment processes, Anaerobic treatment process, Anaerobic sludge blanket process, Attached growth process		
Unit – IV	**Advanced waste water treatment:**	**9**
Depth filtration, surface filtration Membrane filtration, Adsorption, Ion exchange, advanced oxidation process, Photo catalysis, Wet Air Oxidation, Evaporation. Disinfection Processes: Disinfection with chlorine, Disinfection with chlorine dioxide, Dechlorination, Disinfection with ozone, Ultraviolet radiation Disinfection. Other chemical Disinfection methods		
Unit – V	**Industrial Effluent Treatment Plants:**	**9**
Individual and Common Effluent Treatment Plants – Zero effluent discharge systems -Wastewater reuse – Disposal of effluent on land – Quantification, characteristics and disposal of Sludge. Industrial process description, wastewater characteristics, source reduction options and waste treatment flow sheet for Textiles – Tanneries – Pulp and paper – metal finishing - Pharmaceuticals – Sugar and Distilleries – Food Processing –Fertilizers – Industrial Estates, Indian regulations.		

Total:45

TEXT BOOK:

1.	Metcalf Eddy by George Tchobanoglous, Franklin L. Burton, "Wastewater Engineering: Treatment and Reuse", 1st edition, McGraw Hill Book Co, USA, 2011.

REFERENCE BOOKS:

1.	Eckenfelder, W.W., "Industrial Water Pollution Control", 1st edition, McGraw Hill International edition, United State of America, 1999.
2.	Frank Woodard, "Industrial waste treatment Handbook", 1st edition, Butterworth Heinemann, New Delhi, 2001.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	describe the sources and types of Industrial Wastewater	Understanding (K2)
CO2	apply the principles of physical and chemical unit operations in waste water treatment	Understanding (K2)
CO3	explain the industrial biological waste water treatment techniques	Understanding (K2)
CO4	describe the advanced wastewater treatment techniques used in industries	Understanding (K2)
CO5	demonstrate the operations of various effluent treatment plants	Applying (K3)

Mapping of COs with POs and PSOs

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3						3						3	2
CO2	3	1					3						3	2
CO3	3	1					3						3	2
CO4	3	2					3					1	3	3
CO5	3	2	2				3					1	3	2

1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy

ASSESSMENT PATTERN - THEORY

Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	30	70					100
CAT2	30	70					100
CAT3	30	50	20				100
ESE	30	60	10				100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20CHE24 PIPING ENGINEERING

Programme & Branch	B.TECH. – Chemical Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	18CHT33 - Fluid Mechanics	7	PE	3	0	0	3

Preamble	This course offers an insight into the design, operation and maintenance of pipes and piping networks	
Unit - I	**Piping Fundamentals:**	**9**
Introduction to Piping – Pipe and tube, Classification of Pipes, Piping Materials and Selection criteria, Piping components – Valves, Joints and Fittings. Fluid Flow Problems – Estimation of Major and Minor Losses, Pumping requirements		
Unit - II	**Piping in practice:**	**9**
Piping Network – Series and Parallel pipes, Pipe Network analysis using spreadsheets. piping for pumps and compressor		
Unit - III	**Generic Piping design:**	**9**
Usage of Standard and codes. Piping Design – material compatibility, estimation of optimum diameter, selection of valves and fittings, complexity factor, stress analysis, selection of pipe supports.		
Unit - IV	**Piping Systems:**	**9**
Design considerations for piping systems – water and waste water, steam, compressed air, industrial gases, oil, refrigeration, solid and slurry systems		
Unit - V	**Operation and Maintenance:**	**9**
Inspection of Pipelines – Testing techniques and leak detection. Maintenance – Cleaning, coating, freeze prevention, drag reduction, insulation, Common failures and repair techniques, Piping Plan development		

Total:45

TEXT BOOKS:

1.	Henry Liu, "Pipeline Engineering", 2nd Edition, Lewis Publishers, USA, 2003. Unit I & II
2.	Mohinder L. Nayyar, "Piping Handbook", 7th Edition, Tata McGraw Hill Publishing Company Ltd, USA, 2000. Unit III, IV & V

REFERENCE:

1.	John J Mcketta, "Piping Handbook", 3rd Edition, Marcel Dekker Inc, United State of America, 1992.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	apply the fundamental principles of fluid mechanics to solve fluid flow problems	Applying (K3)
CO2	interpret the piping symbols, codes and sketch a piping layout for a given problem	Applying (K3)
CO3	apply the concepts of generic piping design for optimal design of piping systems	Applying (K3)
CO4	perform the process design of various pipeline systems	Applying (K3)
CO5	demonstrate the techniques involved in inspection and maintenance of pipelines	Applying (K3)

Mapping of COs with POs and PSOs

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	3	1		1							1	3	1
CO2	3	3	1		1							1	3	1
CO3	3	3	1									1	3	1
CO4	3	3	1									1	3	1
CO5	3	2	1									1	3	1

1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy

ASSESSMENT PATTERN - THEORY

Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	10	60	30				100
CAT2	10	60	30				100
CAT3	10	60	30				100
ESE	10	60	30				100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20CHE25 BATTERY AND FUEL CELL TECHNOLOGY

Programme & Branch	B.TECH. – Chemical Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	NIL	8	PE	3	0	0	3

Preamble	This course deals with the fundamentals of electrochemical engineering and its applications.	
Unit - I	**Basics of Electrochemistry:**	**9**
Importance of electrochemical systems: Faraday's law - Current density - Potential and Ohm's law. Cell potential. Electrochemical kinetics: Double layer - Butler–Volmer Kinetic Expression - Influence of Mass Transfer on the Reaction Rate - Current efficiency.		
Unit – II	**Transport phenomena and Electrodes**	**9**
Mobility of electrons in cells, Concentration over potential, Current distribution and membrane transport. Electrode configuration – Porous electrodes, characterization, current distribution, Three phase electrodes, Electrodes with flow		
Unit - III	**Batteries and Fuel cells:**	**9**
Components of a cell - Classification of batteries and cell - Theoretical capacity and state of charge - Cell characteristics and electrochemical performance - Heat efficiency of secondary cells- Charge retention and self-discharge - capacity fade in secondary cells. Fuel cell fundamentals: Types of fuel cells- Current–voltage characteristics and polarizations - Electrode structure - Proton-Exchange Membrane (PEM) fuel cells - Solid Oxide Fuel cells.		
Unit – IV	**Electrochemistry for e-vehicles**	**9**
Introduction to fuel cell stack and super capacitors. Electric and Hybrid vehicles - Objectives, power demand determination, regenerative braking, Battery electric vehicle, Hybrid electric vehicle, Start-Stop hybrid, Fuel Cell Hybrid systems		
Unit – V	**Electro-deposition and Corrosion:**	**9**
Electro-deposition: Fundamentals – Nucleation - Deposit morphology – Additives - Impact of side reactions and resistive substrates. Corrosion: Fundamentals - Thermodynamics of corrosion systems - Localized corrosion - Corrosion protection.		

Total:45

TEXT BOOK:

1. Thomas F.Fuller and John N.Harb, "Electrochemical Engineering", 1st edition, John Wiley & Sons, USA, 2018.

REFERENCE:

1. Allen J.Bard and Larry R. Faulkner, "Electrochemical Methods, Fundamentals and Applications", 2nd edition, John Wiley & Sons Inc, United State of America, 2000.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	explain the basics of electrochemical systems and electrochemical kinetics.	Understanding (K2)
CO2	describe the transport properties of electrochemical systems and electro analytical techniques.	Understanding (K2)
CO3	explain the fundamental properties and classification of batteries and fuel cells.	Understanding (K2)
CO4	describe the technology of electrochemical systems for electric vehicles	Understanding (K2)
CO5	illustrate the concepts of electro-deposition and corrosion prevention.	Understanding (K2)

Mapping of COs with POs and PSOs

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	2										1	2	1
CO2	3	2										1	2	1
CO3	3	2										1	2	1
CO4	3	2										1	2	1
CO5	3	2										1	2	1

1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy

ASSESSMENT PATTERN - THEORY

Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	30	70					100
CAT2	30	70					100
CAT3	30	70					100
ESE	30	70					100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20CHE26 FLUID MOVERS

Programme & Branch	B.TECH. – Chemical Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	NIL	**8**	**PE**	**3**	**0**	**0**	**3**

Preamble	This course helps the student to understand the basic principle, working, construction and applications of various pumps, compressor, fan and blowers in industries.	
Unit – I	**Kinetic Pump:**	**9**
Classification and selection of pumps. Centrifugal pump-Theory, analysis, performance and construction. Multistage pumping. Selection of pump materials. Industrial application		
Unit – II	**Pump Parts:**	**9**
Pump drives and power transmission-pump drives and speed varying devices. Pump sealing-Centrifugal pump packing, mechanical seal and injection type shaft seals. Pump noise measurement-noise measurement techniques, estimating pump noise level and noise control techniques. Pump testing- classification of testing, test procedure and measurement		
Unit – III	**Reciprocating Pump:**	**9**
Displacement pump-Theory, design and construction of Diaphragm, Screw, Jet, Rotary, Lobe, Solid handling and Gear Pump. Multistage pump. Industrial application		
Unit – IV	**Compressor:**	**9**
Compressor Theory- Compressed air and air usage. Compressor-Types and selection. Effect of operating conditions .Thermodynamic compression. Real gas effects. Description and control of surge in centrifugal and axial compressor. Multistage and inter-cooling system. Performance analysis of compressor		
Unit – V	**Fan and Blower:**	**9**
Theory and types of Fan and Blowers. Working Principle of blowers. Cross flow and vortex blowers –Flow pattern and performance. Velocity Triangle and Parametric Calculations: Work, Efficiency and Number of Blades and Impeller sizes. Types, Selection, Law, Performance and efficiency of Fan. Fan less air movers. Vacuum cleaners		

Total:45

TEXT BOOKS:

1. Igor J. Karassik, Joseph P. Messina, Paul Cooper, Charles C. Heald, "Pump Handbook", 4th Edition, McGraw Hill Book Co, New Delhi, 2008.
2. Jonathan Moore, "Hand book of Fluid Movers: Pumps, Compressors, Fans, and Blowers", 1st Edition, Delve Publishing, USA, 2015 for Units IV & V

REFERENCES:

1. Giampaolo Tony, "Compressor Handbook -Principles and Practices", 1st Edition, Fairmount Press Incorporation, United State of America, 2010.
2. Christie J. Geankoplis, "Transport Processes and Separation Process Principles", 4th Edition, Prentice Hall of India Pvt. Ltd, New Delhi, 1993.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	elaborate the types, characteristics, construction and performance of centrifugal pump	Understanding (K2)
CO2	familiarize the drives, parts and power transmission of pumps; testing of pump	Understanding (K2)
CO3	illustrate the types, characteristics, construction and performance of positive displacement pumps	Understanding (K2)
CO4	explain the types, characteristics and performance of compressors	Understanding (K2)
CO5	exhibit familiarity with the types, theory, performance and application of fans and blowers	Understanding (K2)

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	1											3	2
CO2	3	1											3	2
CO3	3	1											3	2
CO4	3	1											3	2
CO5	3	1											3	2

1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy

ASSESSMENT PATTERN - THEORY

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT1	40	60					100
CAT2	30	70					100
CAT3	30	70					100
ESE	30	70					100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20CHE27 ADVANCED PROCESS CONTROL

Programme & Branch	B.TECH. – Chemical Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	NIL	8	PE	3	0	0	3

Preamble	This course provides basic knowledge about the advanced process control techniques in chemical industries	
Unit - I	**Introduction to process control:**	**9**
Principles of measurement and classification of process control instruments; temperature, pressure, fluid flow, liquid level, velocity, fluid density, viscosity. Instrument scaling; sensors; transmitters and control valves		
Unit - II	**Process Automation:**	**9**
Basic concepts - terminology and techniques for process control - control modes - controller design - Tuning process controllers		
Unit - III	**Advanced Control Systems:**	**9**
feed forward, ratio control, Cascade control, split rage control, adaptive control system; MIMO: Degrees of freedom, Alternative loop configurations, interaction of control loops, relative gain array, selection of loops; ; statistical process control; expert system; multivariable control techniques; supervisory control.		
Unit - IV	**Digital Control:**	**9**
Digital Computer, Computer- process interface for data acquisition and control, computer control loops, continuous-time to discrete –time systems, sampling continuous, reconstruction of continuous signal, conversion of continuous to discrete time model		
Unit – V	**Discrete Time Response:**	**9**
z transforms - function ad Applications; discrete time response of dynamic systems, design of digital feedback controllers - Introduction to SCADA		

Total:45

TEXT BOOK:

1.	Stephanopoulos G., Chemical Process Control, Tata McGraw-Hill, New Delhi, 1993.

REFERENCES:

1.	Chidambaram M., Computer Control of Processes, Alpha Science International Ltd, India, 2002.
2.	Nakara B.C. and Choudary K.K., Instrumentation and Analysis, Tata McGraw-Hill, New Delhi, 1993.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	describe the principles of measurement techniques in process industries	Understanding(K2)
CO2	explain the concepts of process control strategies	Understanding(K2)
CO3	elaborate the advanced control techniques used in process control	Understanding(K2)
CO4	explain the digital controllers and discrete time model approaches	Understanding(K2)
CO5	illustrate the discrete time response of dynamic system	Understanding(K2)

Mapping of COs with POs and PSOs

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	3	1										3	1
CO2	3	3	1										3	1
CO3	3	3	2										3	1
CO4	3	3	2										3	1
CO5	3	3	1		1								3	1

1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy

ASSESSMENT PATTERN - THEORY

Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	20	80					100
CAT2	20	80					100
CAT3	20	80					100
ESE	20	80					100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20CHE28 ORES AND MINERAL PROCESSING

Programme & Branch	B.TECH. – Chemical Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	20CHT42 - Mechanical Operations	8	PE	3	0	0	3

Preamble	The student will gain knowledge on the principles of ores and mineral processing.	
Unit - I	**Mineralogy:**	**9**
Studies of important metallic and non-metallic minerals, their characteristics, origin etc. application of non-metallic minerals. Sea as a source of minerals. Status of mineral beneficiation industry in India. Study of some representative beneficiation practices with flow sheets. Sampling methodology and equipment		
Unit - II	**Comminution and Screening:**	**9**
Classification of size reduction equipment. Cylindrical and cylindro conical ball mills, Rod mills, Tube / Pot mills, and their performances, capacities, reduction ratios etc. Dry and Wet Grinding. Open and closed circuit grinding. Work Index calculations. Interlocking and liberation of minerals. Particle size distribution, Sorting, Sizing and Pneumatic classifiers and their performances. Thickeners, Hydro cyclones.		
Unit - III	**Gravity Concentration Techniques:**	**9**
Theory and practice of sedimentation and filtration. Working of Rotary vacuum filters. Principles of Jigging, Tabling and Heavy Media Separation. Processes with equipment used, important controlling factors in operation and application. Beneficiation practice for arsenopyrite containing scheelite.		
Unit – IV	**Froth Flotation:**	**9**
Natural and Artificial Floatability of minerals. Frothers, Collectors, Depressants, Activators / Deactivators, pH Modifiers, etc. Flotation machines. Study of representative sulfide and non-sulfide minerals and non-metallic ores. Multistage flotation and Column Flotation		
Unit – V	**Electrostatic and Magnetic Separation:**	**9**
Principles of Electrostatic and Magnetic Separation (Dry and Wet type). Separation units used in practices and examples in the industries. Calculation of Recovery and ratio of concentration and Mass balance calculations in ore dressing. Industrial set up of Ore Dressing plant		

Total:45

TEXT BOOK:

1.	Barry A Wills and Tim Napier Munn., " Will's Mineral Processing Technology – An Introduction to the Practical Aspects of Ore Treatment and Mineral Recovery", 7th Edition, Butterworth Heinemann - Elsevier Imprint, Amsterdam, 2006.

REFERENCES:

1.	Rutley F., "Elements of Mineralogy", 27th Edition, CBS Publishers and Distributors, New Delhi, 2005.
2.	Gaudin A.M., "Principles of Mineral Dressing", 1st Edition, Tata McGraw Hill Publishing Company Ltd, New York, 2005.
3.	Pryor E.J, "Mineral Processing", 3rd Edition, Kluwer Academic Publishers, New York, 1965.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	explain the sources, beneficiation, sampling methodologies in mineral processing	Understanding (K2)
CO2	describe the various comminution and solid screening techniques	Understanding (K2)
CO3	explain the aspects of gravity concentration techniques	Understanding (K2)
CO4	illustrate the importance of froth flotation in ore processing	Understanding (K2)
CO5	describe the various electro and magnetic separation techniques	Understanding (K2)

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2		1									2	1
CO2	3	2		1									2	1
CO3	3	2		1									2	1
CO4	3	2		1									2	1
CO5	3	2		1									2	1

1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy

ASSESSMENT PATTERN - THEORY

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT1	30	70					100
CAT2	30	70					100
CAT3	30	70					100
ESE	30	70					100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20CHE29 POLYMER TECHNOLOGY

Programme & Branch	B.TECH. – Chemical Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	NIL	8	PE	3	3	0	3

Preamble	This course highlights the importance, properties and production of various polymers	
Unit - I	**Introduction:**	**9+3**
Monomer-functionality and degree of polymerizations- polymers and their classification- Types of polymerization and mechanisms- addition, condensation and copolymerization- bulk, solution, emulsion and suspension polymerizations.		
Unit - II	**Structure and Classification:**	**9+3**
Structure of polymers- linear, branched and cross linked-Characterization of polymers- molecular weight- crystallinity-glass transition and mechanical properties- Ultrasonic waves- Photo degradation- High energy radiation- Oxidative and hydrolytic.		
Unit – III	**Polymers and Applications:**	**9+3**
Polyethylene- poly propylene- polystyrene-polymethyl methacrylate - polyvinyl chloride; polytetrafluoroethylene-polyacrylate- nylon 6- nylon 6,6 and polyesters- Phenol formaldehyde- urea formaldehyde and melamine formaldehyde- epoxy-urethanes and silicones-ion exchange polymers.		
Unit - IV	**Chemical Analysis of Polymer:**	**9+3**
X-ray diffraction- Microscopic technique-Light scattering- SEM- Spectroscopic methods- IR,NMR- Thermal analysis-DSC, DTA and TGA.		
Unit - V	**Introduction to Plastics:**	**9+3**
Anti-oxidants and stabilizers- polymer additives- fillers- plasticizers-colorants- Molding methods-Injection-compression- transfer and blow molding- Processing techniques- Calendaring- casting- extrusion-thermoforming-foaming.		

Lecture:45, Tutorial:15, Total:60

TEXT BOOKS:

1. Rodriguez. F., Cohen, C., Ober, C, Archer, L.A., "Principles of Polymer Systems", 5th Edition, Taylor and Francis, Great Britain, London, 2014 for Units I, II, III & IV.
2. Manas Chanda, Salil K. Roy, “Plastics Technology Handbook”, 5th Edition, CRC Press, United States of America, 2017 for Unit V.

REFERENCE BOOKS:

1. Bahadur P., Sastry N.V., "Principles of Polymer Science", 2nd Edition, Narosa, India, 2002.
2. Stevens M.P., "Polymer Chemistry: An Introduction", 3rd Edition, Oxford University Press, New York, 1999.

COURSE OUTCOMES: On completion of the course, the students will be able to		BT Mapped (Highest Level)
CO1	explain the principles, types and mechanism of polymerization processes	Understanding (K2)
CO2	describe the structure and properties of polymers	Understanding (K2)
CO3	explain the properties and manufacturing processes of polymers	Understanding (K2)
CO4	apply the characterization techniques for polymers using microscopic and spectroscopic instruments	Applying (K3)
CO5	outline the principles and methods of molding plastics	Understanding (K2)

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	1												
CO2	2	1												
CO3	2	1												
CO4	3	2												
CO5	2	1												

1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy

ASSESSMENT PATTERN - THEORY

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT1	30	70					100
CAT2	30	70					100
CAT3	20	60	20				100
ESE	20	70	10				100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20CHO01 DRUGS AND PHARMACEUTICALS TECHNOLOGY
(Offered by Department of Chemical Engineering)

Programme & Branch		Sem.	Category	L	T	P	Credit
Prerequisites	NIL	**5**	**OE**	**3**	**1**	**0**	**4**

Preamble	To gain knowledge in formulation and manufacturing of drugs and its quality analysis.	
Unit - I	**Principles and Kinetics:**	**9+3**
Introduction to drugs and pharmaceutical, application of organic therapeutic agents, pharmaco kinetics-Absorption, Distribution, Metabolism and Excretion-Mechanism and physico chemical principles.		
Unit - II	**Process Synthesis:**	**9+3**
Chemical Conversion process- alkylation, carboxylation, condensation and cyclisation, dehydration, esterification, halogenation, oxidation and sulfonation reactions.		
Unit - III	**Drug Delivery Systems:**	**9+3**
Tablets and capsules, types of Tablets and capsules-Formulation and Manufacturing, parential solutions, oral liquids,injections and ointments-methods of preparation.		
Unit - IV	**Pharmaceutical Products:**	**9+3**
Vitamins-Functions, laxatives-classification and uses, analgesics-Types and Mechanisms, antacids and antiseptics-classification, mechanism and applications.		
Unit - V	**Quality Control:**	**9+3**
Concept of quality control-IPQC tests for tablets, Quality analysis - raw materials, process and finished products. Good Manufacturing Practices-cGMP,FDA regulations.		

Lecture:45, Tutorial:15, Total:60

TEXT BOOK:

1.	Brahmankar D.M. and Sunil B. Jaiswal, "Biopharmaceutics and Pharmacokinetics: A Treatise", 1st Edition, Vallabah Prakashan, India, 2017.

REFERENCES:

1.	Arthur Owen Bentley, "Text book of Pharmaceutics", 8th Edition Edition, All India Traveller Book Seller, New Delhi, 2002.
2.	Banker G.S. and Rhodes C.T, "Modern Pharmaceutics", 4th Edition Edition, Marcel Dekker Inc, New York, 2002.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	explain the drug metabolism and pharmaco–kinetic principles	Understanding (K2)
CO2	illustrate the different chemical conversion processes in pharmaceutical industries	Understanding (K2)
CO3	outline the formulation and manufacturing of drug delivery systems	Understanding (K2)
CO4	describe the manufacturing processes of different types of pharmaceutical products	Understanding (K2)
CO5	elaborate the importance of good manufacturing practices and quality control procedures	Understanding (K2)

Mapping of COs with POs and PSOs

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	3	2	2	2									
CO2	3	3	2	2	2									
CO3	2	3	2	2	2									
CO4	3	3	2	3	2									
CO5	3	3	1	2	2									

1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy

ASSESSMENT PATTERN - THEORY

Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	30	70					100
CAT2	30	70					100
CAT3	30	70					100
ESE	30	70					100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20CHO02 PROCESS AUTOMATION
(Offered by Department of Chemical Engineering)

Programme & Branch		Sem.	Category	L	T	P	Credit
Prerequisites		5	OE	3	1	0	4

Preamble	This course provides basic knowledge about the process automation techniques in process industries	
Unit - I	**Introduction to process instrumentation:**	**9+3**
Principles of measurement and classification of process control instruments; temperature, pressure, fluid flow, liquid level, velocity, fluid density, viscosity. Instrument scaling; sensors; transmitters and control valves;		
Unit - II	**Process Automation:**	**9+3**
Basic concepts - terminology and techniques for process control - control modes - controller design - Tuning process controllers		
Unit - III	**Advanced Control Systems:**	**9+3**
feed forward, ratio control, Cascade control, split rage control, adaptive control system; MIMO: Degrees of freedom, Alternative loop configurations, interaction of control loops, relative gain array, selection of loops; ; statistical process control; expert system; multivariable control techniques; supervisory control.		
Unit - IV	**Digital Control**	**9+3**
Digital Computer, Computer- process interface for data acquisition and control, computer control loops, continuous-time to discrete -time systems, sampling continuous, reconstruction of continuous signal, conversion of continuous to discrete time model		
Unit - V	**Discrete Time Response**	**9+3**
z transforms - function ad Applications; discrete time response of dynamic systems, design of digital feedback controllers - Introduction to SCADA		

Lecture:45, Tutorial:15, Total:60

TEXT BOOK:

1.	Stephanopoulos G., Chemical Process Control, Tata McGraw-Hill, New Delhi, 1993.

REFERENCES:

1.	Chidambaram M., Computer Control of Processes, Alpha Science International Ltd, India, 2002.
2.	Nakara B.C. and Choudary K.K., Instrumentation and Analysis, Tata McGraw-Hill, New Delhi, 1993.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	describe the principles of measurement techniques in process industries	Understanding (K2)
CO2	explain the concepts of process control strategies	Understanding (K2)
CO3	elaborate the advanced control techniques used in process control	Understanding (K2)
CO4	explain the digital controllers and discrete time model approaches	Understanding (K2)
CO5	illustrate the discrete time response of dynamic system	Understanding (K2)

Mapping of COs with POs and PSOs

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	3	1											
CO2	3	3	1											
CO3	3	3	2											
CO4	3	3	2											
CO5	3	3	1		1									

1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy

ASSESSMENT PATTERN - THEORY

Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	20	80					100
CAT2	20	80					100
CAT3	20	80					100
ESE	20	80					100

*** ±3% may be varied (CAT 1, 2 ,3 – 50 marks & ESE – 100 marks)**

20CHO03 RENEWABLE BIO ENERGY RESOURCES
(Offered by Department of Chemical Engineering)

Programme & Branch		Sem.	Category	L	T	P	Credit
Prerequisites	NIL	**5**	**OE**	**3**	**1**	**0**	**4**

Preamble	This course will help students to gain knowledge in the available bio energy and the present conversion techniques.	
Unit - I	**Bio Energy Resources**	**9+3**
Introduction: Sources of Biomass – Crop residue, fuel wood, aquatic biomass, sugar crops, oil crops, animal manure, municipal solid waste and energy forming. Properties of biomass resources		
Unit – II	**Types of bio fuel technologies**	**9+3**
Bio-diesel: Composition, Properties, Extraction, Refining and Trans-esterification. Bioethanol: Production from sugar and starchy crops, Cellulosic biomass, ethanol production systems. Biogas: Technology of hydrolysis, Aerobic and Anaerobic processes		
Unit - III	**Torrefaction and Pyrolysis**	**9+3**
Torrefaction: Introduction, Challenges, Products of Torrefaction, Biochar, Properties of Torrefaction products. Pyrolysis: Types of Pyrolysis, Processes, Bio oil and its properties		
Unit - IV	**Gasification and Liquefaction**	**9+3**
Gasification: Introduction, Types of gasifiers and its applications, Introduction to advanced gasifiers. Liquefaction: Introduction, Indirect, Direct and other biomass liquefaction processes.		
Unit - V	**Biomass Combustion technologies**	**9+3**
Introduction, Types of biomass combustion systems, Applications of biomass combustion systems, Sustainability issues and challenges.		

Lecture: 45, Tutorial:15, Total:60

TEXT BOOK:

1.	Sergio C Capareda, “Introduction to Biomass Energy Conversion”, 1st edition, CRC Press, United Kingdom, 2013

REFERENCE BOOKS:

1.	Mukunda, H.S, "Understanding clean energy and Fuels from biomass", 1st edition, Wiley India Pvt Ltd, New Delhi, 2012.
2.	Nijaguna, B.T, "Biogas Technology", 1st edition, New age International, India, 2002.
3.	Lijun wang, "Sustainable bioenergy production", 1st edition, CRC Press, United State of America, 2014.
4.	Sunggyu Lee, Y.T.Shah, "Bio fuels and bio energy; process and technologies", 1st edition, CRC Press, United State of America, 2012.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	describe the various sources of biomass and their properties	Understanding (K2)
CO2	illustrate the different technologies for production of bio-energy	Understanding (K2)
CO3	explain the technology of torrefaction and pyrolysis of biomass	Understanding (K2)
CO4	demonstrate the process of gasification and liquefaction of biomass	Understanding (K2)
CO5	describe the technology of combustion of biomass	Understanding (K2)

Mapping of COs with POs and PSOs

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	2	2	2			1							
CO2	3	2	2	2			1							
CO3	3	2	2	2			1							
CO4	3	2	2	2			1							
CO5	3	2	2	2			1							

1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy

ASSESSMENT PATTERN - THEORY

Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	30	70					100
CAT2	30	70					100
CAT3	30	70					100
ESE	30	70					100

*** ±3% may be varied (CAT 1,2,3 – 50)**

20CHO04 INTELLIGENT CONTROLLERS
(Offered by Department of Chemical Engineering)

Programme & Branch		Sem.	Category	L	T	P	Credit
Prerequisites	NIL	**5**	**OE**	**3**	**1**	**0**	**4**

Preamble	This course will help students to gain knowledge in the available bio energy and the present conversion techniques.	
Unit - I	**Fuzzy Logic Control**:	**9+3**
Need for FLC, Mamdani type FLC ,steps in the design of FLC, Fuzzification, Decision making Logic, Rule based logic and de-fuzzification interface. Simulation examples, FLC of a reactor, Development of Fuzzy Estimator, Multi level control using Fuzzy Logic. Fuzzy logic tuned PI controller.		
Unit – II	**T-S fuzzy model**:	**9+3**
Model structure, TS model from input output data, TS model from model using linearization method, TS model based control		
Unit - III	**Artificial Neural Network based Control**:	**9+3**
Architecture of ANN, supervised learning, Weights and Hidden Layers, Back Propagation algorithm, Control scheme based on ANN. Simulation examples.		
Unit - IV	**RBFN:**	**9+3**
Radial basis function, Learning in RBFN, Pseudo inverse technique, Gradient descent algorithm, examples, RBFN versus Multi stage network Controller Design for a T-S Fuzzy model ; Linear controllers using T-S fuzzy model.		
Unit - V	**Learning Automata**:	**9+3**
Principles of learning Automata, Steps in Learning Automata(LA) based control, Performance specification, Initial Probability assignment, Reward and penality. Probability modification, Simulation application on a reactor, LA tuned PI controllers.		

Lecture:45; Tutorial : 15; Total: 60

TEXT BOOK:

1.	M.Chidambaram, Computer Control of Processes, Narosa Pub, New Delhi,2002

REFERENCE BOOKS:

1.	Cai,Z-X, Intelligent Control: Principles, Techniques and Applications, Word Scientific, Singapore 1997.
2.	Behera, L. and Indirani Kar, Intelligent systems and control: principles and applications, Oxford University Press, New Delhi, 2009.
3.	M.Chidambaram, Applied Process Control, Allied Publishers, New Delhi, 1998.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	Understand the concept of Fuzzy Logic Control	Understanding (K2)
CO2	Use of T-S model based control	Understanding (K2)
CO3	Develop ANN model and its use for controller	Understanding (K2)
CO4	Development of Radial basis function NN	Understanding (K2)
CO5	Design controllers using Learning automata	Understanding (K2)

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	1		2	3		1
CO2	1		2	3		1
CO3	2		2	3		1
CO4	2		2	3		1
CO5	3		3	3		1

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	30	70					100
CAT2	30	70					100
CAT3	30	70					100
ESE	30	70					100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20CHE05 FOOD AS MEDICINE
(Offered by Department of Chemical Engineering)

Programme & Branch	B.TECH. – Chemical Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	6	OE	3	0	0	3

Preamble	This course will deal about the importance of nutrients and its assimilation for different age groups to prevent diseases.	
Unit - I	**Food and Nutrition:**	**9**
Food groups, food guide pyramid and its importance, foods as a source of nutrients Relationship of nutrition to health, growth and human welfare; Definitions of terms used in nutrition -Recommended dietary allowances; balanced diet; health; functional food; phytochemicals; nutraceuticals; dietary supplements.Nutrition and Diabetes.		
Unit - II	**Energy and Body Composition:**	**9**
Energy -Units, sources and requirements, fuel value of foods, Methods of measuring energy value of food, Energy requirement of body, physical activity and thermogenic effect of food, BMR -methods of measurement, factors affecting BMR. Body composition – Five levels of body composition – body composition techniques. Obesity. Factors to be considered in meal/menu planning. Factors affecting food intake and nutrients use, nutrient needs, nutrition related problems.		
Unit - III	**Nutrition deficiency:**	**9**
Digestion and absorption of carbohydrates, fats and proteins. Carbohydrates -Types, functions, sources, requirement, health conditions affected by carbohydrates, Significance of dietary fibre Lipids -Types, functions, sources, requirement, health problems associated with lipids 7 Proteins -types, functions, sources, requirement, quality evaluation, improvement, deficiency disorders and protein energy malnutrition.		
Unit - IV	**Nutraceuticals in Health care**	**9**
Sources, understanding benefits of nutraceuticals. Scope involved in industry, Indian and global scenario. Eye health ingredients – lutein, zeaxanthin, astaxanthin, beta-carotene, bilberry extracts; Heart health ingredients - omega-3, omega-6, omega-9, beta-glucan, soy protein, phytosterols; Digestive Health Ingredients – prebiotics, probiotics, synbiotics, digestive enzymes, zinc carnosine. Women health ingredients - Vitamin D, iron, calcium, soy isoflavones, folic acid, cranberry extract, lycopene, phytoestrogens.		
Unit - V	**Functional Foods in Health care:**	**9**
Introduction to dietary supplements, Dietary supplements – Need for dietary supplements, supplements forms-tablets, capsules, powders, soft gels, gel caps, liquids. Agnus castus, Aloe vera, Bee products, Chitosan, Echinacea, Garlic, Ginger, Ginkgo biloba, Ginseng, Guarana, Kelp, Milk thistle, Saw palmetto, Spirulina, Chlorella, Hypericum perforatum, Tea extracts, Super Foods.		

Total:45

TEXT BOOK:

1. Mann Jim and Stewart Truswell (Eds), “Essentials of Human Nutrition”, 5th Edition, Oxford University Press, Oxford, 2017.

REFERENCES:

1.	Wildman, RobertE.C.,Robert Wildman, Taylor C. Wallace(Eds)., "Handbook of Nutraceuticals and Functional Foods", 2nd edition, CRC Press, New York, 2007.
2.	John Shi, Chi-Tang Ho and Fereidoon Shahidi., "Asian Functional Foods", 1st Edition, CRC Press, 2005

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	interpret the physiological and metabolic functions of nutrients	Understanding(K2)
CO2	explain the energy value of foods and body composition	Understanding(K2)
CO3	Examine the nutrition requirement based on different age groups	Applying(K3)
CO4	Identify the suitable nutraceutical for different deficiencies	Applying (K3)
CO5	select appropriate functional foods based on their health effects	Applying (K3)

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	1	1		3							3	1
CO2	3	3	1	1		3						1	2	2
CO3	3	3	1	1		3						1	2	2
CO4	3	3	1	1		3						1	3	2
CO5	3	3	1	1		3						1	3	2

1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy

ASSESSMENT PATTERN - THEORY

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT1	20	50	30	0	0	0	100
CAT2	20	50	30	0	0	0	100
CAT3	20	50	30	0	0	0	100
ESE	20	50	30	0	0	0	100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20CHO06 ORGANIC FARMING

(Offered by Department of Chemical Engineering)

Programme & Branch	B.TECH. – Chemical Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	6	OE	3	0	0	3

Preamble	This course introduces the foundations of organic farming and its considerations	
Unit - I	**Organic Farming:**	**9**
Concept and definition, Organic vs Natural farming, Essential Characteristics, Principles, Objectives, Options in organic farming, Management and advantages of organic farming, components of organic farming. Green Manuring: Introduction, definition, objectives, classification, characteristics, choice, forms and Agronomy of green manure crops.		
Unit – II	**Nutrient Management in Organic Farming:**	**9**
Introduction, Concept and definition, different types of manures, Vermicomposting, benefits of vermicompost, applications.		
Unit - III	**Management in organic farming:**	**9**
Pest management: Introduction, Cultural methods, mechanical methods, biological methods. Weed management: Introduction, preventive methods, cultural, mechanical, soil solarization, biological methods, allelopathy.		
Unit – IV	**National Standards:**	**9**
NPOP, National structure, operational structure, National Standards for organic farming. Certification: Introduction, Standards and Regulations, Accreditation Processing method,		
Unit - V	**Economic considerations:**	**9**
Viability of organic farming, marketing and export potential, transition period, major products produced in India by organic farming		

Total:45

TEXT BOOK:

1. Palaniappan SP, Annadurai K, Organic Farming: Theory and Practice, 7th Edition, Scientific Publishers, Jodhpur, India, 2018

REFERENCES:

1. Somasundaram E, Udhaya Nandhini D, Meyyappan M, Principles of Organic Farming, 1st edition, CRC Press, London, 2021
2. Sarath Chandran, Unni MR, Sabu Thomas, Organic Farming- Global Perspectives and Methods, Woodhead Publishing, UK, 2019

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	deduce the importance of organic farming and green manure	Understanding
CO2	explain the process of vermi-composting and its benefits	Understanding
CO3	classify different methods applicable for pest and weed management	Understanding
CO4	enumerate the roll of national standards on organic farming	Understanding
CO5	describe the market and economic consideration of organic farming	Understanding

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1		2			3	3	2	2		1	3		
CO2	1		2			3	3	2	2		1	3		
CO3	1		2			3	3	2	2		1	3		
CO4	1		2			3	3	2	2		1	3		
CO5	1		2			3	3	2	2		1	3		

1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy

ASSESSMENT PATTERN - THEORY

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT1	40	60	--	--	--	--	100
CAT2	40	60	--	--	--	--	100
CAT3	30	70	--	--	--	--	100
ESE	30	70	--	--	--	--	100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20CHE07 COSMETICS AND PERSONAL CARE PRODUCTS

(Offered by Department of Chemical Engineering)

Programme & Branch	B.TECH. – Chemical Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	8	OE	3	0	0	3

Preamble	This course is used to know about the preparation methods and uses of different cosmetics and personal health care products.

Unit - I	**. Introduction to Cosmetics**	**9**

Introduction, examples, uses, types. Lipsticks: Ideal Characteristics, Formulation, types of natural waxes, merits and demerits. Colouring Agents, Preparation of lipsticks, methods of preparation, evaluation of lipsticks, shampoo-types and formulation, preparation methods, evaluation of shampoos. Tooth paste: General requirements, formulation, preparation and evaluation of tooth pastes.

Unit - II	**Types and preparation of powders, creams and hair dryers**	**9**

Introduction, characteristics, formulation and classification of powders, Evaluation of powders, Creams: classification, preparation and evaluation of creams. Hair dryers: types, formulation and evaluation of hair colourant.

Unit - III	**Introduction to Nail Care and herbal cosmetic products**	**9**

Basics- Cleansing- Hand, Foot, and Nail Treatments-Hand and Nail Cream-Hand Lotion-Cuticle Conditioners and Moisturizers-Cuticle Removers; Professional Salon Products- preservice sanitization, manicure and pedicure procedure, Hand Soaks and Foot Soaks; protective colloids; Waterborne nail polish, herbal medicinal plants and their uses in different cosmetic products - Aloe, Neem, Tulsi,Turmeric, Cucumber, Lemon, Orange, Multani Mitti, Sandal, Rose, honey, Glycerine.

Unit -	**Pigment Dispersions and Surfactants in Personal Care Products**	**9**

A Brief Introduction to Pigment; properties; Dispersion process- Pigment Wetting, Particle De-aggregation and De-agglomeration; Dispersion Stabilization; Ways and Benefits of Using Pigments to Formulate Cosmetic Products; Hydrocarbons in Pigmented Products: Color Cosmetics, Petroleum Products, Pigments and Dyes, Mineral Oil, Petrolatum, and Mineral Waxes, Eye Makeup. Surfactants: Adverse Effects of Surfactants; Encapsulation; Nanoparticles in cosmetic industry.

Unit - V	**Consumer Research and Ethics in the Development and Restaging of Personal Care Products**	**9**

Broad Classes of Consumer Research: Primary and Secondary research- Competitive and Business Analysis; Outsourcing the Market Research Function. Ethical responsibilities in formulating, marketing, and using antimicrobial personal products; Ethics, aesthetics, and health; Responsibilities of individuals, organizations; other humans and ourselves; Legal liability, public health approach.

Total: 45

TEXT BOOK:

1. Gaurav Kumar Sharma, Jayesh Gadiya, Meenakshi Dhanawat , A Textbook of Cosmetic Formulations (e-book), , Pothi publishers, 2018.

REFERENCES:

1.	Surfactants in Personal Care Products and Decorative Cosmetics, 3rd edition, edited by Martin J. Schick, Arthur T. Hubbard, Vol 135, CRC press, Taylor & Francis group, 2006.
2.	Innate Immune System of Skin and Oral Mucosa, Properties and Impact in Pharmaceutics, Cosmetics, and Personal Care Products, Edited by Nava Dayan and Philip W. Wertz, John Wiley & sons publications, 2011.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	Learn about various characteristics, preparation methods and evaluation of various	Understanding
CO2	Know about types and preparation of powders, creams and hair dryers and their selection.	Understanding
CO3	Study the treatment technologies for nail care and manufacturing methods of herbal	Understanding
CO4	Learn about pigment dispersion methods and surfactants in personal care products	Understanding
CO5	Describe Consumer Research and Ethics in the Development and Restaging of	Applying

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2		1			2						1		
CO2	1		1			2						1		
CO3	1		1			2						1		
CO4	1					2								
CO5	2					2		1						

1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy

ASSESSMENT PATTERN - THEORY

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT1	50	50					100
CAT2	50	50					100
CAT3	30	30	40				100
ESE	35	35	30				100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20CHE08 BREWING AND ALCOHOL TECHNOLOGY

(Offered by Department of Chemical Engineering)

Programme & Branch	B.TECH. – Chemical Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	8	OE	3	0	0	3

Preamble	This course helps the students to understand the fermentation process for the production of Beer, Whisky Production and Distilled Beverages	
Unit - I	**Introduction to Fermentation and Distillation**	**9**
History and development of Alcoholic Beverages. Fermentation, types of fermentations and role of microorganism and other condition on fermentation. Distillation fundamentals and it types.		
Unit - II	**Distillery Feed Stock**	**9**
Distillery feed Stock. Feed stock selection, parameters influencing selection, fermentable sugars. Criteria for selection of molasses for production of ethanol. Alternative feedstock for the process and feedstock flexibility.		
Unit - III	**Whisky Production**	**9**
Malt and Grain distilling- Raw Materials, Specification and Process Description. Malting, Beating and Mashing.		
Unit - IV	**Beer Production**	**9**
Yeast Handling and Management, Post-Fermentation Treatment of Yeast, Milling of malt and adjuncts, Mashing, Lautering, Wort boiling, Wort aeration and wort colling.		
Unit - V	**Distilled Beverages**	**9**
Rum, Gin, Tequila, Vodka and Brandy - Raw material, Composition and Production.		

Total: 45

TEXT BOOK:

1. K.A. Jacques,T.P. Lyons and D.R. Kelsall, " The Alcohol Textbook ",4th Edition, Nottingham University Press, 2003.

REFERENCES:

1.	A.C. Chatterjee, B.M.Dutt, "Hand Book of Fermentation & Distillation" Poona Maharashtra Sugar Research Foundation", 1977.
2.	A.J.Buglass, "Handbook of Alcoholic Beverages: Technical, Analytical and Nutritional Aspects", 1st Edition, Wiley, 2011.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	familiarize in distillery fermentation and distillation process	Understanding (K2)
CO2	understand distillery feed stock processes	Understanding (K2)
CO3	examine the production of whisky	Applying (K3)
CO4	examine the production of beer	Applying (K3)
CO5	categorize the various types of distillery beverages	Understanding (K2)

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2											3	1
CO2	3	2											3	1
CO3	2	1											2	2
CO4	3	2											3	2
CO5	2	1											3	2

1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy

ASSESSMENT PATTERN - THEORY

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT1	20	40	40				100
CAT2	10	45	45				100
CAT3	10	45	45				100
ESE	20	50	30				100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**