Chemical Engineering - (4 Year B.Tech Programme) - COURSE CURRICULUM R-19 | **Total Credits:160**

I Year Course structure

Semester - I												
Code	**Title of the Course**	**Category**							**Max. marks**		**Total Marks**	**Credits**
			L	**T**	**P**	**E**	**O**	**Total**	**Sess.**	**End. Exam**		
CHE111	Engineering Mathematics – I	BS	3	0	0	1	6	10	40	60	100	3
CHE112	Engineering Physics	BS	3	0	0	1	4	8	40	60	100	3
CHE113	Engineering Chemistry	BS	3	0	0	1	4	8	40	60	100	3
CHE114	Introduction to Chemical Engineering	PC	3	0	0	1	4	8	40	60	100	3
CHE115	Engineering Drawing	ES	2	0	3	1	4	10	40	60	100	3.5
CHE116	Engineering Physics Lab	BS	0	0	3	0	1	4	50	50	100	1.5
CHE117	Engineering Chemistry Lab	BS	0	0	3	0	1	4	50	50	100	1.5
CHE118	Engineering Workshop	ES	0	0	3	0	1	4	50	50	100	1.5
CHE119	Human Values and Professional Ethics (Mandatory non-credit course)	MC	3	0	0	0	1	4	50	0	50	--
	Total		**17**	**0**	**12**	**5**	**26**	**60**	**400**	**450**	**850**	**20**
Semester - II												
Code	**Title of the Course**	**Category**							**Max. marks**		**Total Marks**	**Credits**
			L	**T**	**P**	**E**	**O**	**Total**	**Sess.**	**End. Exam**		
CHE121	Engineering Mathematics – II	BS	3	0	0	1	6	10	40	60	100	3
CHE122	Communicative English	HS	3	0	0	1	4	8	40	60	100	3
CHE123	Physical and Analytical Chemistry	BS	3	0	0	1	5	9	40	60	100	3
CHE124	Basic Electrical and Electronics Engineering	ES	3	0	0	1	5	9	40	60	100	3
CHE125	Problem solving with C	ES	3	0	0	1	6	10	40	60	100	3
CHE126	English Language Lab	HS	0	0	3	0	1	4	50	50	100	1.5
CHE127	Problem solving with C Lab	ES	0	0	3	0	3	6	50	50	100	1.5
CHE128	Environmental Science (Mandatory non-credit course)	MC	3	0	0	0	1	4	50	0	50	--
	Total		**18**	**0**	**6**	**5**	**31**	**60**	**350**	**400**	**750**	**18**

II Year Course structure

Semester - I												
Code	**Name of the Course**	**Category**							**Max. marks**		**Total Marks**	**Credits**
			L	**T**	**P**	**E**	**O**	**Total**	**Sess.**	**End. Exam**		
CHE211	Engineering Mathematics – III	BS	3	0	0	1	6	10	40	60	100	3
CHE212	Organic Chemistry	BS	3	0	0	1	5	9	40	60	100	3
CHE213	Basic Mechanical Engineering	ES	3	0	0	1	5	9	40	60	100	3
CHE214	Chemical Process Calculations	PC	3	0	0	1	6	10	40	60	100	3
CHE215	Mechanical Operations	PC	3	0	0	1	6	10	40	60	100	3
CHE216	Organic Chemistry Lab	BS	0	0	3	0	1	4	50	50	100	1.5
CHE217	Mechanical Operations Lab	PC	0	0	3	0	1	4	50	50	100	1.5
	Total		**15**	**0**	**6**	**5**	**30**	**56**	**300**	**400**	**700**	**18**
Semester - II												
Code	**Name of the Course**	**Category**							**Max. marks**		**Total Marks**	**Credits**
			L	**T**	**P**	**E**	**O**	**Total**	**Sess.**	**End. Exam**		
CHE221	Engineering Mathematics – IV	BS	3	0	0	1	6	10	40	60	100	3
CHE222	Biology for Engineers	BS	3	0	0	1	3	7	100	--	100	3
CHE223	Momentum Transfer	PC	3	0	0	1	6	10	40	60	100	3
CHE224	Chemical Engineering Thermodynamics – I	PC	3	0	0	1	5	9	40	60	100	3
CHE225	Numerical Methods for Chemical Engineers	PC	3	0	0	1	5	9	40	60	100	3
CHE226	Professional Elective - I	PE	3	0	0	1	3	7	40	60	100	3
CHE227	Momentum Transfer Lab	PC	0	0	3	0	1	4	50	50	100	1.5
CHE228	Computational Lab	PC	0	0	3	0	1	4	50	50	100	1.5
	Total		**18**	**0**	**6**	**6**	**30**	**60**	**400**	**400**	**800**	**21**

III Year Course structure

Semester - I												
Code	**Name of the Course**	**Category**							**Max. marks**		**Total Marks**	**Credits**
			L	**T**	**P**	**E**	**O**	**Total**	**Sess.**	**End. Exam**		
CHE311	Open Elective - I	OE	3	0	0	1	2	6	40	60	100	3
CHE312	Chemical Engineering Thermodynamics–II	PC	3	0	0	1	4	8	40	60	100	3
CHE313	Heat Transfer	PC	3	0	0	1	4	8	40	60	100	3
CHE314	Mass Transfer - I	PC	3	0	0	1	4	8	40	60	100	3
CHE315	Chemical Technology	PC	3	0	0	1	4	8	40	60	100	3
CHE316	Professional Elective – II	PE	3	0	0	1	3	7	40	60	100	3
CHE317	Quantitative Aptitude – I & Soft Skills	HS	0	0	3	1	3	7	100	0	100	1.5
CHE318	Heat Transfer Lab	PC	0	0	3	0	1	4	50	50	100	1.5
CHE319	Chemical Technology Lab	PC	0	0	3	0	1	4	50	50	100	1.5
	Total		**18**	**0**	**9**	**7**	**26**	**60**	**440**	**460**	**900**	**22.5**
Semester - II												
Code	**Name of the Course**	**Category**							**Max. marks**		**Total Marks**	**Credits**
			L	**T**	**P**	**E**	**O**	**Total**	**Sess.**	**End. Exam**		
CHE321	Open Elective - II	OE	3	0	0	1	2	6	40	60	100	3
CHE322	Mass Transfer – II	PC	3	0	0	1	4	8	40	60	100	3
CHE323	Chemical Reaction Engineering – I	PC	3	0	0	1	4	8	40	60	100	3
CHE324	Process Dynamics and Control	PC	3	0	0	1	4	8	40	60	100	3
CHE325	Professional Elective - III	PE	3	0	0	1	3	7	40	60	100	3
CHE326	Professional Elective – IV	PE	3	0	0	1	3	7	40	60	100	3
CHE327	Quantitative Aptitude – II & Verbal Aptitude	HS	0	0	3	2	3	8	100	0	100	1.5
CHE328	Mass Transfer Lab	PC	0	0	3	0	1	4	50	50	100	1.5
CHE329	Process Dynamics and Control Lab	PC	0	0	3	0	1	4	50	50	100	1.5
	Total		**18**	**0**	**9**	**8**	**25**	**60**	**440**	**460**	**900**	**22.5**

IV Year Course structure

Semester - I												
Code	**Name of the Course**	**Category**							**Max. marks**		**Total Marks**	**Credits**
			L	**T**	**P**	**E**	**O**	**Total**	**Sess.**	**End. Exam**		
CHE411	Open Elective – III	OE	3	0	0	1	2	6	40	60	100	3
CHE412	Chemical Reaction Engineering – II	PC	3	0	0	1	5	9	40	60	100	3
CHE413	Transport Phenomena	PC	3	0	0	1	6	10	40	60	100	3
CHE414	Process Modeling and Simulation	PC	3	0	0	1	5	9	40	60	100	3
CHE415	Chemical Process Economics and Equipment Design	PC	3	0	0	1	6	10	40	60	100	3
CHE416	Chemical Reaction Engineering Lab	PC	0	0	3	0	1	4	50	50	100	1.5
CHE417	Process Modeling and Simulation Lab	PC	0	0	3	0	1	4	50	50	100	1.5
CHE418	Project Phase – I	PR	0	0	3	0	3	6	100	-	100	2
CHE419	Summer Internship *	PR	0	0	0	0	1	1		100	100	1
	Total		**15**	**0**	**9**	**5**	**30**	**59**	**400**	**500**	**900**	**21**

*There is summer Internship (Industrial Training) at the end of III year II Semester for a minimum of three weeks during summer vacation.
Assessment for the same is made during IV year I semester.

Semester - II												
Code	**Name of the Course**	**Category**							**Max. marks**		**Total Marks**	**Credits**
			L	**T**	**P**	**E**	**O**	**Total**	**Sess.**	**End. Exam**		
CHE421	Open Elective – IV	OE	3	0	0	1	2	6	40	60	100	3
CHE422	Professional Elective – V	PE	3	0	0	1	3	7	40	60	100	3
CHE423	Professional Elective – VI	PE	3	0	0	1	3	7	40	60	100	3
CHE424	Project Phase – II	PR	0	0	9	0	9	18	100	100	200	8
	Total		**9**	**0**	**9**	**3**	**17**	**38**	**220**	**280**	**500**	**17**

* Open Elective can be interdisciplinary/ emerging subjects/ MOOCs that will be decided by the department

R -2019 regulations – List of electives

CHE 226 Professional Elective - I

CHE 226 (A)	Polymer Technology
CHE 226 (B)	Entrepreneur Engineering
CHE 226 (C)	Design Thinking

CHE 316 Professional Elective – II

CHE 316 (A)	Industrial safety
CHE 316 (B)	Fertilizer Technology
CHE 316 (C)	Pharmaceutical Technology

CHE 325 Professional Elective – III

CHE325 (A)	Industrial pollution and control
CHE325 (B)	Membrane technology
CHE325 (C)	Catalysis

CHE 326 Professional Elective – IV

CHE326 (A)	Material Science and Engineering
CHE326 (B)	Petroleum refinery Engineering
CHE326 (C)	Energy engineering

CHE 422 Professional Elective – V

CHE422 (A)	Petrochemicals
CHE422 (B)	Nanotechnology
CHE422 (C)	Industrial management

CHE 423 Professional Elective – VI

CHE423 (A)	Biochemical engineering
CHE423 (B)	Process optimization
CHE423 (C)	Computational fluid dynamics

CHE 311 Open Elective - I

CHE 321 Open Elective - II

CHE 411 Open Elective – III

CHE 421 Open Elective – IV

ENGINEERING MATHEMATICS – III

Course Code – Category: CHE 211 – BS

L	**T**	**P**	**E**	**O**	**Credits: 3**
3	**0**	**0**	**1**	**6**	**Sessional Marks: 40**
End Exam: 3 Hours					**End Exam Marks: 60**

Prerequisites:

Course Objectives:

Course Outcomes:

By the end of the course, student will be able to

1. Explain the characteristics of scalar and vector valued functions and provide a physical interpretation of the gradient, divergence, curl and related concepts.
2. transform line integral to surface integral, surface to volume integral and vice versa using Green's theorem, Stoke's theorem and Gauss's divergence theorem.
3. Explain analytical methods for solving PDEs like applying Separation of Variables to solve elementary problems in linear second order Partial Differential Equations (heat and wave equations).
4. Understand the need for a function or its approximation as an infinite Fourier series to represent discontinuous function which occurs in signal processing and electrical circuits.
5. Find different Fourier transforms of non-periodic functions and also use them to evaluate boundary value problems.

CO – PO – PSO Matrix:

		PO												**PSO**	
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO	**1**	3	1	2	2								1	1	1
	2	3	1	2	2								1	1	1
	3	3	1	2	2								1	2	2
	4	3	1	2	2								1	1	1
	5	3	1	2	2								1	1	1

UNIT I **9L + 3T**

VECTOR DIFFERENTIATION: Scalar and vector point functions – Del applied to scalar point functions: Gradient, directional derivative - Del applied to vector point functions - Physical interpretation of divergence and curl - Del applied twice to point functions - Del applied to products of point functions.

Sections: 8.4, 8.5, 8.6, 8.7, 8.8 and 8.9.

Learning Outcomes:

UNIT II **9L + 3T**

VECTOR INTEGRATION: Integration of vectors – Line integral ,Circulation, work done– Surfaces integral ,flux – Green's theorem in the plane – Stoke's theorem – Volume integral – Gauss divergence theorems (all theorems without proofs) – Irrotational and Solenoidal fields.

Sections: 8.10, 8.11, 8.12, 8.13, 8.14, 8.15, 8.16 and 8.18.

Learning Outcomes:

UNIT III **9L + 3T**

PARTIAL DIFFERENTIAL EQUATIONS AND THEIR APPLICATIONS: Introduction – Formation of partial differential equations by eliminating arbitrary constants and functions – Solutions of a partial differential equations by direct Integration – Linear equations of the first order (Lagrange's linear equations) ;

Applications: Method of separation of variables – Vibrations of a stretched string: Wave equation - One dimensional heat flow equation ($\frac{\partial u}{\partial t} = c^2 \frac{\partial^2 u}{\partial x^2}$), and two dimensional heat flow equation (i.e. Laplace equation : $\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2} = 0$).

Sections: 17.1, 17.2, 17.4, 17.5, 17.8, 17.9, 17.10, 17.11, 18.2, 18.4 and 18.5.

Learning Outcomes:

UNIT IV **9L + 3T**

FOURIER SERIES: Introduction – Euler's formulae – Conditions for a Fourier expansion – Functions having points of discontinuity – Change of interval – Even and odd functions – Half range series - Parseval's formula.

Sections:10.1, 10.2, 10.3, 10.4, 10.5, 10.6, 10.7 and 10.9 .

Learning Outcomes:

UNIT V **9L + 3T**

FOURIER TRANSFORMS: Introduction – Definition – Fourier integral theorem(without proof) - Fourier sine and cosine integrals – Fourier transforms – Properties of Fourier transforms – Convolution theorem - Parseval's identity for fourier transforms - Relation between Fourier and Laplace transforms - Fourier transforms of the derivatives of a function - Applications of transforms to boundary value problems.

Sections: 22.1, 22.2, 22.3, 22.4, 22.5, 22.6, 22.7, 22.8, 22.9 and 22.11.

Learning Outcomes:

Text Books:

1. B. S. Grewal, "*Higher Engineering Mathematics*", 43rd edition, Khanna publishers, 2017.

Reference Books:

1. N P. Bali and Manish Goyal, "A text book of Engineering mathematics" ,Laxmi publications, latest edition.
2. Erwin Kreyszig, "*Advanced Engineering Mathematics*", 10th edition, John Wiley & sons, 2011.
3. R. K. Jain and S. R. K. Iyengar, Advanced Engineering Mathematics, 3rd edition , Alpha Science International Ltd., 2002.
4. George B. Thomas, Maurice D. Weir and Joel Hass, Thomas Calculus, 13th edition, Pearson Publishers.

ORGANIC CHEMISTRY

Course Code – Category: CHE 212 – BS

L	**T**	**P**	**E**	**O**	**Credits: 3**
3	**0**	**0**	**1**	**5**	**Sessional Marks: 40**
End Exam: 3 Hours					**End Exam Marks: 60**

Prerequisites:

Course Objectives:

- To impart knowledge on the basic concepts of organic chemistry.
- To know the importance of Stereo chemical approach of organic reactions.
- To create a basic idea on the mechanisms of organic reactions involving reaction intermediates.
- To understand the Industrial preparation methods of certain organic compounds and their synthetic applications.
- To create awareness on various applications of chemical reagents and biological activity of few organic compounds.

Course Outcomes:

CO No.	**Statement**	**Marks Allotted**				
		Mid -1	**Assign-1**	**CT-1A**	**CT-1B**	**Total Marks**
CO-1	Understand the basics of reaction intermediates and polar effects.	15	4	5	5	**29**
CO-2	Design organic molecules in stereo chemical models	15	4	5	3	**27**
CO-3	Arrive at an idea on mechanism of addition and condensation reactions.	10	2	0	2	**14**
		Marks Allotted				
		Mid -2	**Assign-2**	**CT-2A**	**CT-2B**	**Total Marks**
CO-3	Arrive at an idea on mechanism of addition and condensation reactions.	10	2	2	0	**14**
CO-4	Meet the need to understand the industrial preparation of organic compounds at various conditions.	15	4	5	5	**29**
CO-5	Develop further organic applications using synthetic reagents and understand the biological activity of few organic compounds.	15	4	3	5	**27**

CO – PO – PSO Matrix:

		PO												PSO	
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO	**1**	3	1										1	1	1
	2	3		2									1	1	1
	3	3	1	1	1								1	1	1
	4	3	1	1									1	1	1
	5	3	1	1									1	1	1

UNIT I **12 Periods**

FUNDAMENTALS OF ORGANIC CHEMISTRY: Introduction to organic functional groups-IUPAC Nomenclature. Polar effects – Inductive effect, Mesomeric effect, Electromeric effect and Hyperconjugation with examples; Reaction intermediates & hybridisation- carbocation, carbanion, free-radical, examples. Types of reagents- electrophile, nucleophile. Types of Organic Reactions-Addition, Elimination, Substitution, Rearrangement reactions.

Learning Outcomes :

At the end of this unit the student will be able to

- **Identify** the different function groups and also name them according to IUPAC system (L1)
- **Explain** the reactivity and stability of the organic species based on polar effects (L2)
- **Distinguish** the type of organic reactions the reactants undergo with formation of products (L3)

UNIT II **10 Periods**

STEREOCHEMISTRY OF ORGANIC COMPOUNDS: Stereosisomerism- definition-types. Representation of compounds – Sawhorse projection, Newmann projection, Fisher projection, Wedge formula- examples. Conformational isomerism- examples of ethane, n-butane, cyclohexane & potential energy diagrams. Axial & Equatorial bonds in Cyclohexane. Geometrical isomerism- Cis-trans & E-Z isomerism-sequence rules and examples. R & S configuration- sequence rules-examples. Optical activity- Chirality, Enantiomers, diastereomers, mesomers, racemic mixture, Resolution of racemic mixture.

Learning Outcomes :

At the end of this unit the student will be able to

- **Apply** sequential rules to identify or name the Stereoisomer (L3)
- **Explain** the axial and equatorial bonds in cyclohexane (L2)

● **Identify** the assemtric centre, enantiomers and diasteriomers(L2)

● **Construct or draw** different canonical structures of Ethane and n-Butane(L3)

UNIT III **12 Periods**

CHEMISTRY OF ALCOHOLS, PHENOLS & CARBONYL COMPOUNDS: Industrial preparations of Ethyl alcohol (Molasses), Differences between alcohols- Oxidation, Lucas Test, Catalytic dehydrogenation, Victor-Meyer test. Chemical reactions of phenols- Fries rearrangement, Reimar-Tiemann reaction. Carbonyl compounds: Chemical reactions-Cannizaro, Aldol, Reformatsky and Wittig reactions, Perkin Reaction, Differences between Aldehyde and Ketone.

Learning Outcomes :

● **Apply** The knowledge of Lucas test and Victor mayer test to identify the alcohol whether it is primary, secondary or tertiary alcohol (L3)

● **Expain** the Fries rearrangement, Reimar-Tiemann reaction with mechanism. (L2)

● **Describe** with possible reaction mechanism the chemical nature of carbonyl compounds in Cannizaro and aldol condensation(L2)

● **Distinguish** whether the carbonyl compound is aldehyde or ketone by doing chemical tests (L3)

UNIT IV **12 Periods**

CHEMISTRY OF CARBOXYLIC ACIDS & DERIVATIVES & AMINES: Industrial preparations of Acetic acid, chemical reactions (Hell-Volhard-Zelinsky reaction). Functional derivatives of carboxylic acids- Esters (acid & base catalyzed hydrolysis of Ester, Claisen condensation), amides (Hoffmann Bromamide reaction) and Acid halides (Rosenmunds reduction).

Amines: differences between amines and chemical reactions - Hoffmann elimination, Hinsberg test, Mustard oil test, Carbyl amine reaction. Benzene Diazonium salts and its synthetic applications- Coupling reactions, Schiemann reaction, Sandmayer reaction.

Learning Outcome :

At the end of this unit the student will be able to

● **Explain** the Hoffmann Bromamide reaction and Claisen condensation with mechanism (L2)

● **Enumerate** the synthetic applications of diazonium salts in industrial sector (L2)

● **Describe** with reaction mechanism the Hoffmann elimination (L2)

● **Identify** the nature of amine using Hinsberg test, Mustard oil test (L2)

UNIT V **10 Periods**

HETEROCYCLIC COMPOUNDS & SYNTHETIC APPLICATIONS OF SOME ORGANIC REAGENTS: Preparation, Properties and uses of – Five membered heterocyclic compounds- Pyrrole, Furan, Thiophene. Six membered heterocyclic compounds- Pyridine, Quinoline. Biological activity of Sulpha drugs (Sulphanilamide, Sulphapyridene)

Learning Outcomes :

At the end of this unit the stud e n t will be able to

● **Classify** hetrocyclic compounds (L1)

● **Explain** Biological activity of Sulpha drugs (L2)

● **Explain** the physical and chemical nature of pyradine (L2)

● **Identify** the uses of hetrocyclic compounds in industrial process (L2)

Text Books:

1. Text Book of Organic Chemistry by Arun Bahl & B.S.Bahl, VI Edition, 2015, S. Chand

2. Text Book of Organic Chemistry by Morrison & Boyd, VII Edition, 2010, Pearson

Reference Books:

1. Organic chemistry by Jerry March, Wiley.

2. Text Book of Organic Chemistry by I.L.Finar (Vols.1&2), Pears

BASIC MECHANICAL ENGINEERING

Course Code – Category: CHE 213 – ES

L	**T**	**P**	**E**	**O**	**Credits: 3**
3	**0**	**0**	**1**	**5**	**Sessional Marks: 40**
End Exam: 3 Hours					**End Exam Marks: 60**

Prerequisites:

Course Objectives:

- To provide knowledge on thermodynamic laws.
- To provide knowledge on various types of IC engines.
- To impart knowledge on boilers and use of steam tables.
- To impart knowledge on stress and strain concepts.
- To provide knowledge on stress relations in various types of shells.

Course Outcomes:

By the end of the course, student will be able to

1. Understand the physical significance of thermodynamic laws.
2. Classify IC engines and their applications.
3. Identify the use of boilers in industries.
4. Evaluate stress-strain analysis
5. Understand the design of thin and thick cylinders.

CO – PO – PSO Matrix:

		PO												**PSO**	
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO	**1**	3	1	1	1								1	1	1
	2	3	1												
	3	3	1												
	4	3	1	1									1	1	1
	5	3	1	1									1	1	1

UNIT I **9L + 3T**

Thermodynamics: Laws of Thermodynamics (statements only), Gas laws, Relation between gas constant and specific heat at constant pressure and constant volume. Thermodynamic processes of perfect gases and entropy.

Learning Outcomes:

UNIT II **9L + 3T**

IC Engines: Classification-main component of IC engines, Otto cycle, Diesel cycle and Dual combustion cycle-Air Standard efficiency, working of 2-stroke and 4-stroke engines. Petrol engines and Diesel engines. Power and efficiency of IC engines

Learning Outcomes:

UNIT III **9L + 3T**

Boilers: Properties of steam and use of steam tables, Boilers, classification steam boilers, simple vertical, Cochran locomotive boiler, Babcock and Wilcox boiler, steam generation, Simple problems on Rankine cycle.

Learning Outcomes:

UNIT IV **9L + 3T**

Simple Stress and Strains: Hook's law, stress strain curve for mild steel, Poisson ratio, relation between elastic constants, simple thermal stress.

Learning Outcomes:

UNIT V **9L + 3T**

Thin and Thick Cylinders: Stress in thin cylindrical shells and spherical shells, strains in thin cylindrical shells and spherical shells, Thick cylinders: introduction, Lame's equation.

Learning Outcomes:

Text Books:

1. R.S. Khurmi and J.K. Gupta, *Thermal Engineering*, S.Chand & Co publishers
2. Dr. R.K. Bansal, *Strength of Materials*, edition 6, Laxmi publications.

Reference Books:

1. R.K.Rajput, "*A Text Book of Engineering Thermodynamics*", 4th edition, Laxmi Publications, 2007.

CHEMICAL PROCESS CALCULATIONS

Course Code – Category: CHE 214 – PC

L	T	P	E	O	Credits: 3
3	0	0	1	6	Sessional Marks: 40
End Exam: 3 Hours					End Exam Marks: 60

Prerequisites: Introduction to Chemical Engineering

Course Objectives:

- To master fundamentals of stoichiometry and gas laws.
- To familiarize and to apply material and energy balance for various chemical operations and processes
- Utilize the knowledge of subject for better understanding of core subjects

Course Outcomes:

By the end of the course, student will be able to

1. Solve basic stoichiometry calculations.
2. Evaluate composition of gases at various temperatures and pressures.
3. Apply material balance on various unit operation and processes.
4. Apply energy balance on various unit operation and processes.
5. Implement the concepts of humidity to humidification and dehumidification processes.

CO – PO – PSO Matrix:

		PO												PSO	
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO	**1**	3	1	1		1				1	1		1	2	2
	2	3	2	2		1				1	1		1	2	2
	3	3	2	2		1				1	1		1	2	2
	4	3	2	2		1				1	1		1	2	2
	5	3	1	1						1	1		1	1	1

UNIT I **9L + 3T**

Stoichiometry and composition relationships: The gram-mole and pound-mole, limiting reactant, excess reactant, degree of completion, basis of calculation, weight percent, volume percent and mole percent, density and specific gravity- Baume and API gravity scales.

Learning Outcomes:

At the end of this unit, student will be able to

- Compute the conversion, yield of a chemical reaction
- Estimate density, specific gravity of substances with various scales.

UNIT II **9L + 3T**

Behavior of ideal gases:

Application of the ideal-gas law, Dalton and Amagat laws to gaseous mixtures, composition of gases on dry basis and on wet basis.

Learning Outcomes:

At the end of this unit, student will be able to

- Calculate the properties of ideal gases at different process conditions
- Estimate the compositions in various unit operations

UNIT III **9L + 3T**

Material Balances: Tie substance, yield, conversion, and processes involving chemical reactions, material balance- calculations involving drying, dissolution, and crystallization, processes involving recycle, bypass and purge.

Learning Outcomes:

At the end of this unit, student will be able to

- Formulate material balances on various unit operations.
- Solve mass balance of chemical species over various unit operations involving with and without reactions.

UNIT IV **9L + 3T**

Energy Balances: Effect of temperature on vapor pressure, Antoine equation, vapor pressure plots, vapor pressure of immiscible liquids, ideal solutions and Raoult's law, non-volatile solutes. Heat capacities of gases and gaseous mixtures- effect of temperature on heat capacity of gas,

Kopp's rule, latent heatsof fusion and vaporization, Trouton's rule, Kistyakowsky equation for non-polar liquids. Standard heat of reaction - Laws of thermochemistry,Standard heat of formation, standard heat of combustion, standard heat of reaction and their calculations,effect of temperature on heat of reaction, adiabatic and non-adiabatic reactions, theoretical and actual flame temperatures.

Learning Outcomes:

At the end of this unit, student will be able to

- Formulate energy balances on various unit operations.
- Estimate heat capacities of substances and mixtures
- Estimate heat of reactions at various temperatures of chemical reactions.

UNIT V **9L + 3T**

Humidity: Percentage saturation, relative saturation or relative humidity, dew point, vaporization, condensation, wet and dry bulb temperatures, adiabatic vaporization and adiabatic saturation temperature, humidity charts and its use.

Learning Outcomes:

At the end of this unit, student will be able to

- Calculate Psychometric properties of gases using basic relations.
- Estimate Psychometric properties of gases using humidity charts.

Text Books:

1. Olaf A Hougen, K.M. Watson and R. A. Ragatz, "Chemical Process Principles, Part-I - Material and Energy balances"2nd ed., CBS Publishers and Distributors,1995.

Reference Books:

1. David M. Himmelblau,"Basic principles and Calculations in Chemical Engineering", 6th ed., Prentice Hall of India Pvt Ltd, 1995.
2. . K.V. Narayanan and B. Lakshmikutty, "Stoichiometry and Process Calculations", 5th ed., Prentice Hall of India Pvt Ltd , 2006.
3. B.I. Bhatt and S.M. Vora, "Stoichiometry", 3rded., Tata McGraw Hill Publishing Company Limited, New Delhi, 1996.

MECHANICAL OPERATIONS

Course Code – Category: CHE 215 – PC

L	T	P	E	O	Credits: 3
3	0	0	1	6	Sessional Marks: 40
End Exam: 3 Hours					End Exam Marks: 60

Prerequisites: Introduction to Chemical Engineering

Course Objectives:

1. To familiarize with the characteristics of solids, size reduction aspects, working of various size reduction equipment and their operations.
2. To know about the different screening techniques and screening equipment and other separation methods.
3. To understand the principles of filtration and the working of different filtration equipment.
4. To understand the principles of settling of solids in fluids and sedimentation.
5. To understand the concepts of agitation of liquids and mixing of solids.

Course Outcomes:

By the end of the course, student will be able to

1. Identify the size reduction equipment for various size reduction operations.
2. Apply the screening techniques for different size separations.
3. Analyze the filtration techniques for various filtration operations.
4. Apply the principles of settling in classification of solids.
5. Calculate the power consumption for various mixing operations and identify mixers for cohesive and non cohesive solids.

CO – PO – PSO Matrix:

		PO												PSO	
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO	**1**	3	1	1						1	1		1	1	1
	2	2	1	1						1	1		1	1	1
	3	2	1	1						1	1		1	1	1
	4	2	1	1						1	1		1	1	1
	5	2	1	1						1	1		1	1	1

UNIT I **9L + 3T**

Characteristics of solid particles: shape, size, differential and cumulative screen analyses, specific surface area, particle population, different mean diameters for a mixture of particles. Principles of comminution: Laws of crushing, description and working of size reduction equipment - jaw, gyratory and roll crushers, hammer mills, revolving mills, attrition mills, fluid energy mill, cutting machines, equipment operations, open and closed circuit grinding, wet and dry grinding, Grindability Index.

Learning Outcomes:

At the end of this unit, student will be able to

- Identify the characteristics of particulate solids.
- Calculate different mean diameters for a mixture of particles.
- Suggest different types of size reduction methods such as crushing, grinding milling depending on the type and size of the material**.**

UNIT II **9L + 3T**

Mechanical separations: screening, industrial screens - grizzly, gyratory and vibratory screens, revolving screens - trommels, capacity and effectiveness of screens, magnetic separation, electrostatic separation, froth flotation.

Learning Outcomes:

At the end of this unit, student will be able to

- Calculate the effectiveness of screens.
- Apply the principles on magnetic separation, electrostatic separation, froth flotation techniques

UNIT III **9L + 3T**

Filtration: description and working of filtration equipment, plate and frame filter press, shell and leaf filter, rotary drum filter, filter aid, centrifugal filtration, top suspended batch centrifuge, theory of filtration, washing of cakes.

Learning Outcomes:

At the end of this unit, student will be able to

- Enumerate the theory of filtration.
- Classify the filtration techniques.
- Solve filtration problems based on filtration theory.

UNIT IV **9L + 3T**

Motion of particles through fluids: drag, free and hindered settling, settling velocities, classification, sink and float methods, differential setting methods - jigging, cyclone separators, batch sedimentation, thickeners, flocculation, centrifugal sedimentation, gravity and centrifugal decanters.

Learning Outcomes:

At the end of this unit, student will be able to

- Identify the settling regime and calculate the settling velocities.
- Elucidate the various equipment used for classification of solids.

UNIT V **9L + 3T**

Agitation of liquids: Power consumption in agitated vessels, equipment for mixing of solids and pastes, mixers for dry powders, mixing index.

Storage and conveying of solids: Storage of solids, types of conveyors –belt, chain and screw conveyors, elevators, pneumatic conveyors, size enlargement.

Learning Outcomes:

At the end of this unit, student will be able to

- Select appropriate conveyor from different conveying operations.
- Calculate the power requirements for different mixing operations.
- Classify different mixers for cohesive and non cohesive solids.

Text Books:

1. W.L. McCabe, J.C. Smith and P.Harriot, "Unit Operations of Chemical Engineering", 7th ed., McGraw- Hill Book Co., 2005.
2. J.H.Coulson and J.F.Richardson, "Chemical Engineering -Vol.2" 5th ed., Elsevier Science, 2002 (for topics of trommels, magnetic separators, electrostatic separators and froth flotation).

Reference Books:

1. R.H.Perry,"Chemical Engineer's Hand Book",8th ed., McGraw-Hill Book Co., 2007.
2. Brown et al., "Unit Operations", 1st ed., CBS Publisher,2005.
3. Badger and Banchero, "Introduction to Chemical Engineering", 1st ed.,McGraw-Hill, 2002 (for conveying topic).

ORGANIC CHEMISTRY LABORATORY

Course Code – Category: CHE 216 – BS

L	T	P	E	O	Credits: 1.5
0	0	3	0	1	Sessional Marks: 50
End Exam: 3 Hours					End Exam Marks: 50

Prerequisites:

Course Objectives:

- To improve skills in synthesizing organic compounds using various chemical techniques.
- To enable the students to analyze the functional group in the organic compound through qualitative analysis

Course Outcomes:

CO No.	Statement	Marks Allotted			
		Continuous Assessment	Internal lab	Viva-voce & Record	Total Marks
CO-1	Synthesize and analyze the properties and nature of the organic compound.	10	05	5	**20**
CO-2	Use different types of solvents and reagents in analyzing the functional group of the organic compound.	10	15	5	**30**

CO – PO – PSO Matrix:

		PO												PSO	
		1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO	1	3	2	2	2					1	3		1	1	1
	2	3	2	2	2					1	3		1	1	1

List of Experiments:

CYCLE-1

One step synthesis of organic compounds and determination of melting point:

1. Phthalimide
2. Nerolin
3. m-dinitrobenzene
4. Methyl Orange
5. Micro-Wave (MW) assisted green synthesis of Benzoic acid from Benzamide (Demonstration)

CYCLE-2

Qualitative analysis for the identification of functional group in the organic compound:

1. Demonstration of Qualitative analysis
2. Analysis of Compound -1
3. Analysis of Compound -2
4. Analysis of Compound -3
5. Analysis of Compound -4
6. Analysis of Compound -5
7. Analysis of Compound -6

Prescribed book:-

1. Organic Chemistry Lab Manual prepared by Department of Chemistry.

Reference books:-

2. Vogel's textbook of Practical Organic Chemistry, 5th edition, Pearson education.

MECHANICAL OPERATIONS LABORATORY

Course Code – Category: CHE 217 – PC

L	T	P	E	O	Credits: 1.5
0	0	3	0	1	Sessional Marks: 50
End Exam: 3 Hours					End Exam Marks: 50

Prerequisites: Introduction to Chemical Engineering

Course Objectives:

- To understand the measuring of the average size of the given sample.
- To familiarize with the different crushing and grinding units and the concepts of equipment operation.
- To understand the various separation techniques like screening, froth floatation and sedimentation.

Course Outcomes:

By the end of the course, student will be able to

1. Calculate the average size of a given sample.
2. Operate crushing and grinding equipment.
3. Apply various separation techniques for a given sample.

CO – PO – PSO Matrix:

		PO												PSO	
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO	**1**	3	3	3	3					3	3		1	1	1
	2	3	3	3	3					3	3		1	1	1
	3	3	3	3	3					3	3		1	1	1

List of Experiments:

1. To take a representative sample from a bulk by two methods, viz. Riffle and Cone & Quartering and to find out the average size (volume-surface mean diameter) of the sample.
2. To determine the time of grinding in a ball mill for producing a product with 80% passing a given screen.
3. To verify the laws of crushing using any size reduction equipment like jaw crusher, crushing rolls or ball mill and to find out the work Index (W_i) of the material.

4. To compare open circuit and closed circuit grinding by means of a ball mill.
5. To determine the optimum time of sieving for a given sample of material.
6. To find the effectiveness of sieve.
7. To find the screen effectiveness of a trommel.
8. To separate a mixture of coal into two fractions using sink and float method.
9. To separate a mixture of coal into two fractions using froth flotation technique.
10. To find the size analysis of a given fine sample using beaker decantation method.
11. To obtain batch sedimentation data and to calculate the minimum thickener area under given conditions.
12. To determine the collection efficiency of a cyclone separator.
13. To determine the settling velocities of various particle sizes and densities.

Learning Outcomes:

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

- Determine the volume surface mean diameter of the sample using differential and cumulative analysis methods.
- Determine the effectiveness of a screen.
- Calculate the minimum thickener area.
- Calculate optimum time of sieving for a given sample.
- Separate a mixture of coal into two fractions using sink and float and froth flotation methods .
- Handle various size reduction equipments and verify the laws of crushing.

Text Book:

1. W.L. McCabe, J.C. Smith and P. Harriot, "Unit Operations of Chemical Engineering", 7th ed., McGraw- Hill Book Co., 2005.

Reference Book:

1. R. H. Perry,"Chemical Engineer's Hand Book",8th ed., McGraw-Hill Book Co., 2007.

2. Brown et al., "Unit Operations", 1st ed., CBS Publisher, 2005.

ENGINEERING MATHEMATICS – IV

Course Code – Category: CHE 221 – BS

L	T	P	E	O	Credits: 3
3	0	0	1	6	Sessional Marks: 40
End Exam: 3 Hours					End Exam Marks: 60

Prerequisites: Complex Numbers, Differentiation, Integration, Binomial expansions and partial fractions.

Course Objectives:

Course Outcomes:

By the end of the course, student will be able to

1. Analyze limit, continuity and differentiation of functions of complex variables and Understand Cauchy-Riemann equations, analytic functions and various properties of analytic functions.
2. Understand Cauchy theorem and Cauchy integral formulas and apply these to valuate complex contour integrals and represent functions as Taylor and Laurent series and determine their intervals of convergence.
3. Be familiar with numerical solution of ordinary differential equations.
4. Examine, analyze and compare Probability distributions**.**
5. Analyze the Statistical data by using statistical tests and to draw valid inferences about the population parameters.

CO – PO – PSO Matrix:

		PO												PSO	
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO	**1**	3	1	1	1								1	1	1
	2	3	1	2	2								1	2	2
	3	3	1	2	2								1	2	2
	4	3	1	2	2							1	1	2	2
	5	3	1	2	2							1	1	2	2

UNIT I **9L + 3T**

FUNCTIONS OF A COMPLEX VARIABLE: Complex function, Real and Imaginary parts of Complex function, Limit, Continuity and Derivative of a Complex function, Cauchy-Riemann equations, Analytic function, entire function, singular point, conjugate function, Cauchy-Riemann

equations in polar form, Harmonic functions, Milne-Thomson method, Simple applications to flow problems- Applications to flow problems – some standard transformations(Translation, Inversion and reflection , Bilinear transformations and its fixed points).

Sections: 20.1, 20.2, 20.3, 20.4, 20.5, 20.6 and 20.8.

Learning Outcomes:

UNIT II **9L + 3T**

COMPLEX INTEGRATION & SERIES OF COMPLEX TERMS: Complex integration - Cauchy's theorem - Cauchy's integral formula – Series of complex terms: Taylor's series, Maclaurin's series expansion, Laurent's series (without proofs) Zeros of an analytic function, Singularities of a complex function, Isolated singularity, Removable singularity, Poles, pole of order m, simple pole, Essential singularity.

Sections : 20.12, 20.13, 20.14 , 20.16 and 20.17.

Learning Outcomes:

UNIT III **9L + 3T**

NUMERICAL SOLUTIONS OF ORDINARY DIFFERENTIAL EQUATIONS: Numerical solution of Ordinary Differential equations: Picard's Method, Taylor's series method, Euler's Method, Runge-Kutta Method, Predictor-Corrector Methods, Milne's Method.

Sections: 32.1, 32.2, 32.3, 32.4, 32.7, 32.8 and 32.9

Learning Outcomes:

UNIT IV **9L + 3T**

PROBABILITY AND DISTRIBUTIONS: Introduction – Basic Terminology – Probability and set notations – Addition Law of probability – Independent events – Baye's theorem – Random variable – Discrete probability distribution: Binomial distribution - Continuous probability distributions: Poisson distribution and Normal distribution(mean , variance , standard deviation and their properties without proofs).

Sections: 26.1, 26.2, 26.3, 26.4, 26.5, 26.6, 26.7, 26.8, 26.9, 26.14, 26.15 and 26.16.

Learning Outcomes:

UNIT V **9L + 3T**

SAMPLING THEORY: Introduction – Sampling distribution – Testing a hypothesis – Level of significance – Confidence limits – Test of Significance of Large samples -Test of significance of single mean, difference of means ,single proportion, difference of proportions – Confidence limits for unknown mean – Small samples – Students t-distribution – Significance test of a sample mean – Significance test of difference between sample means – chi square test – Goodness of fit.

Sections:27.1, 27.2, 27.3, 27.4, 27.5, 27.7,27.8, 27.11, 27.12,27.13, 27.14, 27.15, 26.16, 27.17 and 27.18.

Learning Outcomes:

Text Books:

1. B. S. Grewal, "*Higher Engineering Mathematics*", 43rd edition, Khanna publishers, 2017.

Reference Books:

1. N P. Bali and Manish Goyal, "A text book of Engineering mathematics" ,Laxmi publications, latest edition.
2. Erwin Kreyszig, "*Advanced Engineering Mathematics*", 10th edition, John Wiley & sons, 2011.
3. R. K. Jain and S. R. K. Iyengar, Advanced Engineering Mathematics, 3rd edition , Alpha Science International Ltd., 2002.
4. George B. Thomas, Maurice D. Weir and Joel Hass, Thomas Calculus, 13th edition, Pearson Publishers.

BIOLOGY FOR ENGINEERS

Course Code – Category: CHE 222 – BS

L	T	P	E	O	Credits: 3
3	0	0	1	3	Sessional Marks: 100

Prerequisites:

Course Objectives:

- To discuss fundamentals of living organisms and their classification
- To gain knowledge in Biomolecules
- To gain knowledge in Enzymes and Fermentation
- To understand the process of transfer of genetic information
- To recognize the importance of biology and to enable the engineers to solve problems involving biological systems

Course Outcomes:

By the end of the course, student will be able to

1. Summarize the basis of life, classify organisms, and compare prokaryote and eukaryote cells.
2. Outline the chemical nature and functions of various Biomolecules
3. Infer the applications of enzymes and fermentation in industries
4. Illustrate the basic principles of heredity, cell division and gene expression
5. Implement engineering principles to biological systems to build better solutions to mankind

CO – PO – PSO Matrix:

		PO												PSO	
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO	**1**	2	1					1		1	2	1	1		
	2	2	1					1		1	2	1	1		
	3	2	1				1	1		1	2	1	1	1	1
	4	2	1					1		1	2	1	1		
	5	2	1				2	1		1	2	1	1	1	1

UNIT I **9 PERIODS**

LIVING WORLD: Characteristics of living organisms, Cell Theory – Cellular basis of Life, Structure of Prokaryotic and Eukaryotic cell. Five Kingdom Classification (Major Groups &

Principals of Classification with each kingdom, Microorganisms and their importance to mankind.

Learning Outcomes: At the end of the unit the student will be able to

- Explain the basis of life, structure of prokaryotic and eukaryotic cell and compare the major cell types.(L2)
- Classify the major groups of living organisms and identify the basis for their distinction (L2)
- Summarize the importance of microorganisms.(L2)

UNIT II **9 PERIODS**

BIOMOLECULES: Classification, Structure and Functions of Carbohydrates, Proteins, Nucleic acids(DNA, RNA), Lipids.

Learning Outcomes: At the end of the unit the student will be able to

- Interpret the chemical nature and functions of the biomolecules (L2)
- Represent the chemical nature and structure of DNA and RNA- the hereditary material (L2)

UNIT III **9 PERIODS**

ENZYMES AND APPLICATIONS: Classification, Properties, Mechanism of enzyme action, and applications in various process Industries, Fermentation and different fermentative products like ethanol, penicillin and Biogas.

Learning Outcomes: At the end of the unit the student will be able to

- List different types of enzymes (L1)
- Summarize the properties of enzymes and applications of enzymes in industry. (L2)
- Illustrate the basic steps in fermentation and its applications in industry. (L2)

UNIT IV **9 PERIODS**

GENETICS AND MOLECULAR BIOLOGY: Mendel's Laws of inheritance, DNA as a genetic material, Cell Division:- Mitosis and Meiosis, Central dogma – DNA Replication, Transcription, Translation, Concept of genetic code, Single Gene disorders in humans.

Learning Outcomes:

After completing this unit, the student will be able to

- Infer the basic principles of heredity (L2)

- Represent the experiments which helped in identifying the genetic material – the blue print of life(L2)
- Relate the events in cell division to the mechanism of heredity(L2)
- Illustrate how genes are expressed (L2)

UNIT V **9 PERIODS**

BIO-INSPIRED ENGINEERING: (PRINCIPLES & APPLICATIONS): Introduction to biologically-inspired designs (BID for Biomedical and Non-biomedical applications) Human-organs-on-chips, Nanostructures for Drug Delivery , Genetic Algorithms, Artificial neural networks, environmental monitoring, Bio-filters, Bio-robotics, 3D Bio-printing**.**

Learning Outcomes:

After completing this unit, the student will be able to

- Interpret biologically- inspired designs. (L2)
- Apply Artificial neural networks and Genetic Algorithms to biological systems.(L2)
- Infer the importance of biology to engineering through Bio-robotics, 3D Bio-printing (L2)

Text Books:

1. **Dr. P.S. Verma, Dr. V.K. Agarwa**l "*Cell Biology, Genetics, Molecular Biology, Evolution and Ecology*"– S. Chand Publications. (Unit 1&4)
2. **J.L.Jain, S.Jain And N.Jain** *"Fundamentals of biochemistry".* - S.Chand Publishers. (Unit 2&3)

References:

1. **L.E.J.R. Casida "***Industrial Microbiology"* New Age International Publisher.
2. **Lehninger, Nelson, Cox "***Principles of Biochemistry"* CBS Publishers.
3. **W.M. Becker** *"The World of the cell"* Global Edition.

MOMENTUM TRANSFER

Course Code – Category: CHE 223 – PC

L	T	P	E	O	
3	**0**	**0**	**1**	**6**	**Credits: 3**
					Sessional Marks: 40
End Exam: 3 Hours					**End Exam Marks: 60**

Prerequisites: Introduction to Chemical Engineering, Chemical Process Calculations

Course Objectives:

1. To provide an understanding of fluid mechanics and its scope in the chemical industry.
2. To impart fundamental concepts in fluid mechanics with the knowledge of applying basic quantitative laws and the equations of fluid flow.
3. To provide the basic knowledge on compressible fluids, pressure drop, friction factor, Reynolds number and their relations in flow systems.
4. To provide an understanding about flow past immersed bodies and fluidization.
5. To acquaint knowledge on fluid moving machinery and flow measuring devices.

Course Outcomes:

By the end of the course, student will be able to

1. Apply the basic principles of static to fluid systems.
2. Apply quantitative laws to hydrostatic and fluid flow problems.
3. Analyze the velocity distributions, frictional flow patterns in pipes and piping networks.
4. Determine the pressure drop, velocities in packed and fluidized bed columns.
5. Analyze the performance aspects of fluid machinery specifically for pumps and flow metering devices.

CO – PO – PSO Matrix:

		PO												**PSO**	
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO	**1**	3	2	1		1				1	1		1	2	2
	2	3	2	2		1				1	1		1	2	2
	3	3	2	2		1				1	1		1	2	2
	4	3	2	2		1				1	1		1	2	2
	5	3	2	2		1				1	1		1	2	2

UNIT I **9L + 3T**

Basic concepts: Unit systems, units and dimensions, dimensional analysis – Rayleigh's method, Buckingham π theorem, equations of state, similarity.

Fluid statics: Nature of fluids, hydrostatic pressure, pressure distribution in a static fluid, pressure measuring devices.

Learning Outcomes:

At the end of this unit, student will be able to

- Apply dimensional analysis
- Calculate hydrostatic pressure

UNIT II **9L + 3T**

Fluid flow phenomenon: Types of fluids, concept of stream lines, stream tubes, viscosity, rheological properties of fluids, turbulence, flow in boundary layers, its formation and growth in tubes and on plates, boundary layer separation.

Basic equations of fluid flow: Mass balance, steady state energy balance, equation of motion, momentum balance and Bernoulli's equation with the correction factors

Learning Outcomes:

At the end of this unit, student will be able to

- Classify various fluids
- Identify the formation and growth of boundary layer
- Apply mass, momentum and Bernoulli's equation

UNIT III **9L + 3T**

Flow of incompressible fluids: Relation between skin friction - wall shear, laminar flow in pipes, Hagen-Poiseuille equation, turbulent flow in pipes, velocity distribution equation, friction factor, friction from changes in velocity or direction.

Flow of compressible fluids: Basic equations, Mach number, flow through variable area conduits, adiabatic and isothermal frictional flow.

Learning Outcomes:

At the end of this unit, student will be able to

- Calculate pressure drop in laminar and turbulent flow
- Evaluate pressure drop of adiabatic and isothermal frictional flow

UNIT IV **9L + 3T**

Flow past immersed bodies: Flow through beds of solids, motion of particles through fluids, terminal velocity, fluidization, mechanism of fluidization, pressure drop in fluidization, applications of fluidization.

Learning Outcomes:

At the end of this unit, student will be able to

- Calculate terminal velocity
- Estimate pressure drop in packed and fluidized beds
- Classify various kinds of fluidization

UNIT V **9L + 3T**

Transportation and metering of fluids: Pipes, fittings, valves, positive displacement and centrifugal pumps, fans, blowers and compressors, jet ejectors.

Flow measuring devices: venture meter, orifice meter, pitot tube, rotameter, notches and weirs.

Learning Outcomes:

At the end of this unit, student will be able to

- Classify types of pumps and fans
- Calculate capacity, head and power requirement of pumps
- Estimate volumetric flowrate using different flow meters

Textbooks:

1. Warren L.McCabe and Julian C.Smith, "Unit Operations of Chemical Engineering", 7th ed., McGraw Hill, 2005.
2. R. K. Bansal, " A Text Book of Fluid Mechanics and Hydraulic Machines", 8th ed., Laxmi publisher, 2008. (for topics Unit systems, units and dimensions, dimensional analysis,notches and weirs)

Reference Books:

1. De Nevers N., "Fluid mechanics for chemical engineers", 3rd ed., McGraw Hill.
2. J.M.Coulson, J.F.Richardson, "Chemical engineering", 5th ed., Vol –I & II,,Elseveir,1999.
3. Cengel and Cimbala, "Fundamentals of fluid mechanics", 3rded.,McGraw Hill Education,2014.
4. R. K. Rajput, " A Text Book of Fluid Mechanics and Hydraulic Machines", 3rd ed., S. Chand, 2002.

CHEMICAL ENGINEERING THERMODYNAMICS – I

Course Code – Category: CHE 224 – PC

L	T	P	E	O	Credits: 3
3	0	0	1	5	Sessional Marks: 40
End Exam: 3 Hours					End Exam Marks: 60

Prerequisites: Physical Chemistry and Chemical Process Calculations.

Course Objectives:

- To provide knowledge on first law and second law of thermodynamics.
- To impart the relation between Pressure, Volume, Temperature and various heat effects.
- To impart knowledge on different balance equations.

Course Outcomes:

By the end of the course, student will be able to

1. Apply first law of thermodynamics to various systems.
2. Predict the PVT behavior using Virial equations.
3. Calculate heat effects on industrial reactions.
4. Apply second law of thermodynamics to various systems.
5. Develop balance equations on various equipments.

CO – PO – PSO Matrix:

		PO												PSO	
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO	**1**	3	2	1						1	1		1	2	2
	2	3	2	2		1				1	1		1	2	2
	3	3	2	2		1				1	1		1	2	2
	4	3	2	1						1	1		1	2	2
	5	3	2	1						1	1		1	2	2

UNIT I **9L + 3T**

The first law and other basic concepts: Joule's experiments, internal energy, the first law of thermodynamics, thermodynamic state and path functions, enthalpy, steady-flow process, equilibrium, the phase rule, the reversible process, constant-V and constant-P processes, heat capacity.

Learning Outcomes:

At the end of this unit, student will be able to

- Calculate the heat, work and internal energy of closed systems.
- Estimate the enthalpy for open systems

UNIT II **9L + 3T**

Volumetric properties of pure fluids: PVT behavior of pure substances, virial equations, the ideal gas, application of the virial equations, cubic equations of state, generalized correlations for gases, generalized correlations for liquids, molecular theory of fluids, second virial coefficients from potential functions.

Learning Outcomes:

At the end of this unit, student will be able to

- Calculate pressure, volume or temperature using ideal gas and vander waal's law.
- Estimate the pressure and volume using the virial equations.

UNIT III **9L + 3T**

Heat effects: Sensible heat effects, internal energy of ideal gases, microscopic view, latent heats of pure substances, standard heat of reaction, standard of heat of formation, standard heat of combustion, temperature dependence of heat effects of industrial reactions.

Learning Outcomes:

At the end of this unit, student will be able to

- Calculate the heat and enthalpy of industrial reactions.
- Estimate the adiabatic flame temperature of industrial reactions.

UNIT IV **9L + 3T**

The Second Law of Thermodynamics: Statement of the second law, heat engines, thermodynamic temperature scales, thermodynamic temperature and ideal-gas scale, entropy, entropy changes of an ideal gas, mathematical statement of the second law, the third law of thermodynamics, entropy from the microscopic view point, Ideal work, lost work, Thermodynamic analysis of steady state flow process.

Learning Outcomes:

At the end of this unit, student will be able to

- Calculate the heat and work done by a heat engine.
- Estimate the entropy of a system.

UNIT V **9L + 3T**

Thermodynamic Properties of Fluids: Property relations for homogeneous phases, residual properties, two-phase systems, thermodynamic diagrams, generalized property correlations for gases, Thermodynamics of flow processes, Equations of balance, duct flow of compressible fluids, turbines (expanders), compression processes.

Learning Outcomes:

At the end of this unit, student will be able to

- Correlate the thermodynamic properties using Maxwell relations.
- Apply thermodynamics to pumps, compressors and turbines.

Text Books:

1. J. M. Smith, H. C. Van Ness and M. M. Abbott, "Introduction to Chemical Engineering Thermodynamics" 6th ed., McGraw-Hill International Editions, 2000.

Reference Books:

1. Y. V. C. Rao, "Chemical Engineering Thermodynamics", University Press (India) Ltd., Hyderabad, 1997.
2. K. V. Narayanan, "A Text book of Chemical Engineering Thermodynamics", PHI publications, 2009.
3. Michael M. Abbott and Hendrick C.VanNess, "Schaum Outline of Theory and Problems of Thermodynamics", 3rd ed., McGraw-Hill education, 2013.

Numerical Methods in Chemical Engineering

Course Code – Category: CHE 225 – PC

L	T	P	E	O	Credits: 3
3	0	0	1	5	Sessional Marks: 40
End Exam: 3 Hours					End Exam Marks: 60

Prerequisites: Engineering Mathematics-I, II & III, Chemical Process Calculations

Course Objectives:

- To study numerical methods and their applications in chemical engineering
- To develop analytical thinking in solving complex problems.
- To solve chemical engineering problems with numerical analysis techniques

Course Outcomes:

By the end of the course, student will be able to

1. Implement Root finding methods for solution on non-linear algebraic equations.
2. Use Interpolation and regression methods to chemical engineering problems.
3. Apply Numerical differentiation and Integration to solve problems.
4. Solve system of linear algebraic equations by Numerical methods
5. Solve chemical engineering problems involve PDE

CO – PO – PSO Matrix:

		PO												PSO	
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO	**1**	3	2	2		1				1	1		1	2	2
	2	3	2	2		1				1	1		1	2	2
	3	3	2	2		1				1	1		1	2	2
	4	3	2	2		1				1	1		1	2	2
	5	3	2	2		1				1	1		1	2	2

UNIT I **9L + 3T**

Introduction to Numerical approach, Approximation and Concept of Error & Error Analysis

Solution of Algebraic and Transcendental Equations: Bisection method, Iteration method, Newton-Raphson methods, solution to a system of Nonlinear equations.

Learning Outcomes:

At the end of this unit, student will be able to

- Apply error analysis to find the error in subsequent steps of numerical methods

- Estimate solutions of algebraic and non-algebraic equations using appropriate numerical method
- Solving system of nonlinear equations using numerical routines.

UNIT II **9L + 3T**

Interpolation and Approximation: Interpolation and Approximation, Newton's polynomials and Lagrange polynomials, linear regression, polynomial regression, least square regression.

Learning Outcomes:

At the end of this unit, student will be able to

- Apply Newton's polynomials and Lagrange polynomials for interpolation
- Implement the least square regression analysis for curve fitting

UNIT III **9L + 3T**

Numerical Differentiation: Newton Forward Difference method, Errors in Numerical Differentiation, Euler Method, Modified Euler method, Runge-Kutta Methods, Cubic Splines Method, Maximum and Minimum values of a tabulated function, Chemical engineering problems involving ODEs

Numerical Integration: Trapezoidal rule, Simpson's rule, integration with unequal segments, quadrature methods, Chemical engineering problems involving numerical integration.

Learning Outcomes:

At the end of this unit, student will be able to

- Implement numerical methods to solve ODE
- Apply Trapezoidal and Simpson's rule for numerical integration

UNIT IV **9L + 3T**

Numerical Linear Algebra: LU decomposition of matrix, Solution of Linear Systems-Direct Methods, Solution of Linear Systems-Iterative Methods and matrix inversion, Singular Value Decomposition, Chemical engineering problems involving solution of linear algebraic equations.

Learning Outcomes:

At the end of this unit, student will be able to

- Solve linear algebraic equations using numerical routines
- Compute Eigenvalues and Eigenvectors numerically

UNIT V **9L + 3T**

Numerical Solution of PDE: Characterization of PDEs, Solution of Laplace's equation, Heat conduction/diffusion equations explicit, implicit, Crank-Nicholson method

Learning Outcomes:

At the end of this unit, student will be able to

- Characterize PDE's
- Solve PDEs like Laplace equation

Text Books:

1. Sastry, S. S., "Introductory Methods of Numerical Analysis", 5th Ed., PHI Learning Pvt. Ltd., 2012
2. Gupta, S. K., "Numerical Methods for Engineers, New Academic Science, 2012

Reference Books:

1. S.C. Chapra & R.P. Canale, "Numerical Methods for Engineers with Personal Computer Applications", 5th Ed., McGraw Hill Book Company, 2006.
2. R.L. Burden & J. D. Faires, "Numerical Analysis", 7th Ed., Brooks Coles, 2000.
3. Atkinson, K. E., "An Introduction to Numerical Analysis", John Wiley & Sons, 1978.
4. Press, W. H. et al., "Numerical Recipes in C: The Art of Scientific Computing, 3rd Edition, Cambridge University Press, 2007.

POLYMER TECHNOLOGY

Course Code – Category: CHE 226(A) – PE

L	**T**	**P**	**E**	**O**	**Credits: 3**
3	**0**	**0**	**1**	**3**	**Sessional Marks: 40**
End Exam: 3 Hours					**End Exam Marks: 60**

Prerequisites: Organic Chemistry

Course Objectives:

- To provide basic knowledge on polymers and their classification.
- To familiarize with chemistry and methods of polymerization.
- To acquaint knowledge on processing equipment for polymerization.
- To familiarize with the manufacturing processes of different polymer compounds

Course Outcomes:

By the end of the course, student will be able to

1. Classify polymers and determine the molecular weight of a polymer.
2. Interpret the kinetics of polymerization, glass transition temperature and impact of various properties on degradation of polymer.
3. Illustrate methods of polymerization, role of specific promoters/agents on polymerization.
4. Demonstrate various processing equipments used for polymer products.
5. Select suitable manufacturing process for a polymer compound.

CO – PO – PSO Matrix:

		PO												**PSO**	
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO	**1**	2	1							1	1		1	3	2
	2	2	1							1	1		1	3	2
	3	2	1					1		1	1		1	3	2
	4	2	1							1	1		1	3	2
	5	2	1							1	1		1	3	2

SYLLABUS

UNIT I **9 L + 3T**

Introductory Concepts and Fundamentals:

Definitions and concepts of plastics and polymers, comer, co-monomer, mesomer, co-polymer, functionality, visco-elasticity, classification of polymers, methods of determining molecular

weight of polymers: Methods based on colligative properties, Sedimentation velocity method, Sedimentation equilibrium method, Gel-chromatography method, Light scattering analysis method, End-group analysis method; Natural polymers: brief study of rubber, shellac, rosin, cellulose, proteins, Lignin.

Learning Outcome: At the end of the unit, student will be able to

- Classify polymers based on its properties and method of polymerization
- Determine the molecular weight of polymers based on various methods
- Outline natural polymers

UNIT II **9 L + 3T**

Chemistry of Polymerization:

Elementary concepts of addition polymerization, condensation polymerization and co-polymerization, glass transition temperature of polymers, methods of determining glass transition temperature, degradation of polymers due to mechanical, hydrolytic, thermal and backbone effects, Relation of the mechanical, thermal, electrical, physical and chemical properties with the structure of the polymer.

Learning Outcome: At the end of the unit, student will be able to

- Outline the methods and identify the kinetics of polymerization
- Interpret glass transition temperature
- Summarize various properties and its impact on degradation of polymers

UNIT III **9 L + 3T**

Methods of Polymerization:

Mass, solution, emulsion and suspension, role of the initiators, catalysts, inhibitors, solvents, fillers, reinforcing agents, stabilizers, plasticizers, lubricants, blowing agents, coupling agents, flame retardants, photo-degradants and bio-degradable on polymerization

Learning Outcome: At the end of the unit, student will be able to

- Illustrate various methods of polymerization
- Infer the role of specific promoters/agents on polymerization

UNIT IV **9 L + 3T**

Processing Equipment:

Mixing and compounding, extrusion, calendaring, laminating, molding, compression, transfer, injection molding, blow molding.

Learning Outcome: At the end of the unit, the student will be able to

- Demonstrate various processing equipments
- Apply appropriate processing techniques as per the product polymer specifications

UNIT V **9 L + 3T**

Manufacturing Processes of Addition Products:

Polyethylene (LDPE and HDPE), polypropylene, PVC and its copolymers, Polystyrene and its copolymers and PTFE (polytetraflouroethylene)

Manufacturing Processes of Condensation Products:

Polyesters: PMMA, PET, PF, UF and MF resins, epoxy resins.

Learning Outcome: At the end of the unit, the student will be able to

- Choose appropriate manufacturing methods for addition polymer products
- Select appropriate manufacturing methods for condensation polymer products

Text Books:

1. R. Sinha, *Outlines of Polymer Technology: Manufacture of Polymers*, 2004, Prentice Hall India Pvt. Ltd. (UNIT – I, II, III and V).
2. R. Sinha, *Outlines of Polymer Technology: Processing Polymers*, 2004, Prentice Hall India Pvt. Ltd. (UNIT – IV).

Reference Books:

1. Billymeyer, F.W.Jr., *Textbook of Polymer Science*, 3rd edition, 2006, John Wiley & Sons
2. Anil Kumar. Gupta, R.K. *Fundamentals of PolymerEngineering*,2ndEd, 2003, Marcel Dekker.

Entrepreneurship Engineering

Course Code – Category: CHE 226 (B) – PE

L	T	P	E	O	Credits: 3
3	0	0	1	3	Sessional Marks: 40
End Exam: 3 Hours					End Exam Marks: 60

Prerequisites: Nil

Course Objectives:

- To motivate students to start their own enterprise.
- To familiarize the concept and process of Entrepreneurship.
- To impart process and skills of creation and management of entrepreneurial venture.

Course Outcomes:

By the end of the course, student will be able to

1. Identify the competency of an Entrepreneur.
2. Implement teamwork strategies to maximize output from Human Resources.
3. Design Quantitative Models for Organization.
4. Assess Technology Opportunities.
5. Prepare Technology Opportunity Assessment.

CO – PO – PSO Matrix:

		PO												PSO	
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO	**1**	1							2	1	1	2	2	1	1
	2	1								1	1	2	2	1	1
	3	1			1					1	1	2	2	1	1
	4	1	1	1	1					1	1	2	2	1	1
	5	1	1	1	1					1	1	2	2	1	1

UNIT I **9L + 3T**

Introduction

Engineering ethics of entrepreneurship, the transdisciplinary ethical engineer, Ten competencies of Entrepreneurial Engineer, Three principles to manage space, people, money and time, Three Cautions in modelling technical solutions.

Learning Outcomes:

At the end of this unit, student will be able to

- Identify the importance of ethics in entrepreneurship.
- Assess how entrepreneurship can change one's career

UNIT II **9L + 3T**

Pervasive Teamwork

Working together in Groups and Teams, Understanding the difficulties of Teamwork, Three little Keys to Meeting Happiness, A Day in Life of a Typical Problem-Solving Meeting, Structured Brainstorming, Putting Structured Brainstorming to Work.

Learning Outcomes:

At the end of this unit, student will be able to

- Interpret the importance of teamwork.
- Identify the techniques to work in teams.

UNIT III **9L + 3T**

Organization and Leadership

Organization and Leadership Matter, Understanding Human Behavior and Motivation, Human Organizations and their leaders, Organization culture: The gods of management, Quantitative Models for forming Organizations.

Learning Outcomes:

At the end of this unit, student will be able to

- Identify the role and duties of leader in an Organization
- Quantify models for forming Organization.

UNIT IV **9L + 3T**

Assessing Technology Opportunities

Opportunity, Sustainable competitive advantage: The making of good opportunity, Four P's of Competitive Advantage, Five Forces of Sustainability, Financial Mysteries of Opportunity Assessment: Overcoming the Fear of Financials, Prices, Margins and Breaking Even, Time Value of Money.

Learning Outcomes:

At the end of this unit, student will be able to

- Strategize the opportunity to start business venture
- Optimize financial resources.

UNIT V **9L + 3T**

Writing the Technology Opportunity Assessment

Executive Summary, Technology Description, Market Analysis, Preliminary Financial Analysis, Action Plan.

Learning Outcomes:

At the end of this unit, student will be able to

- Summarize technology description to startup.
- Prepare a cashflow projection.

Text Books:

1. David E. Goldberg, "The Entrepreneurial Engineer" JohnWiley& Sciences., New Jersey,2006.
2. Riadh Habash, "Green Engineering-Innovation, Entrepreneurship and Design" Taylor& Francis, CRC press., 2017.

Reference Books:

1. Eric Ries"The Lean Startup", Crown Business.,New York, 2011.
2. Hugh MacLeod, "Ignore Everybody – And 39 Other Keys To Creativity", Penguin Group, 2009.
3. Geoff Colvin, "Talent Is Overrated: What Really Separates World-Class Performers from Everybody Else", Portfolio hardcover, 2008

DESIGN THINKING

Course Code – Category: CHE 226 (C) – PE

L	T	P	E	O	Credits: 3
3	0	0	1	3	Sessional Marks: 40
End Exam: 3 Hours					End Exam Marks: 60

Prerequisites: Nil

Course Objectives:

- To provide a framework to the problem solvers and design thinkers.
- To sharpen the creative skills of an individual.

Course Outcomes:

By the end of the course, student will be able to

1. Identify the real problem.
2. Identify the constraints for producing a solution.
3. Design a robust approach for the problem.
4. Develop a viable solution.
5. Evaluate the problem, procedure and solution.

CO – PO – PSO Matrix:

		PO												PSO	
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO	**1**	1	3							1	1	2	3	2	2
	2	1		3						1	1	2	3	2	2
	3	1		3	3					1	1	2	3	2	2
	4	1		3	3					1	1	2	3	2	2
	5	1		3	3		3	3	3	1	1	2	3	2	2

UNIT I **9L + 3T**

Introduction: Real Problem vs. wrong solution, right frame of mind, taking risks, paradigm shift, creativity and working together in teams.

Problem definition: First four steps, defining the real problem: exploring the problem, using the present state / desired state technique, Duncker diagram, statement / restatement technique & Evaluating the problem definition; the next four steps.

Learning Outcomes:

At the end of this unit, student will be able to

- Analyze the right problems and wrong solutions.
- Define a real problem.

UNIT II **9L + 3T**

Generating solutions: Mental blocks, blockbusting, brainstorming: Osborn's checklist, random stimulation, other people's view & futuring; fishbone diagram, brain writing, analogy and cross fertilization and incubation ideas.

Learning Outcomes:

At the end of this unit, student will be able to

- Solve the real problems.
- Identify the techniques to generate a solution.

UNIT III **9L + 3T**

Deciding the course of action: Situation analysis: evaluation criteria & Pareto analysis & diagram; K.T. problem analysis and troubleshooting, design analysis and potential problem analysis.

Learning Outcomes:

At the end of this unit, student will be able to

- Analyze the situation and problem.
- Investigate the potential problem and design.

UNIT IV **9L + 3T**

Implementing the solution: Approval, planning: allocation of time and resources (Gantt chart), coordination and deployment, critical path, necessary resources; carry through, follow up, problem statements that change with time and experimental projects.

Learning Outcomes:

At the end of this unit, student will be able to

- Plan the implementation process of the solution.
- Allocate minimum resources and experiments to maximize the efforts.

UNIT V **9L + 3T**

Evaluation: General guidelines, ethical considerations, safety considerations and case studies.

Learning Outcomes:

At the end of this unit, student will be able to

- Identify the true solution based on social considerations.
- Apply the knowledge gained to the case studies.

Text Books:

1. H. Scott Fogler and Steven E. LeBlanc, “Strategies for Creative Problem Solving” Prentice-Hall Inc., New Jersey, 1995.

Reference Books:

1. Walter Brenner and Falk Uebernickel “Design thinking for Innovation”, Springer, 2016.
2. Andrew Samuel and John Weir, “Introduction to engineering design”, Elsevier, 2015.

MOMENTUM TRANSFER LABORATORY

Course Code – Category: CHE 227 – PC

L	T	P	E	O	Credits: 1.5
0	0	3	0	1	Sessional Marks: 50
End Exam: 3 Hours					End Exam Marks: 50

Prerequisites: Momentum Transfer

Course Objectives:

- To improve skills in measuring the flow rates.
- To familiarize with the operation of different pumps.

Course Outcomes:

By the end of the course, student will be able to

1. Measure the flow rate and pressure drops by using different flow measuring devices.
2. Draw the characteristic curves for various pumps.

CO – PO – PSO Matrix:

		PO												PSO	
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO	**1**	2	3	3	3					3	2		1	2	2
	2	2	3	3	3					3	2		1	2	2

List of Experiments:

1. Determination of orifice coefficient.
2. Determination of venturi coefficient.
3. To study the coefficient of contraction for a given open orifice.
4. To study the coefficient of discharge in a V – notch.
5. Friction losses in fluid flow in pipes.
6. Calibration of rotameter.
7. Measurement of point velocities (Pitot tube).
8. Identification of laminar and turbulent flows (Reynolds apparatus).
9. Verification of Bernoulli equation.
10. Pressure drop in a packed bed for different fluid velocities.
11. Pressure drop and void fraction in a fluidized bed.
12. To study the characteristics of a centrifugal pump.
13. To study the characteristics of a reciprocating pump.

Reference Books:

1. Warren L.McCabe and Julian C.Smith, “Unit Operations of Chemical Engineering”, 7th ed., McGraw Hill, 2005.
2. Cengel and Cimbala, “Fundamentals of fluid mechanics”, 3rd ed., McGraw Hill Education, 2014.

COMPUTATIONAL LABORATORY

Course Code – Category: CHE 228 – PC

L	T	P	E	O	Credits: 1.5
0	0	3	0	1	Sessional Marks: 50
End Exam: 3 Hours					End Exam Marks: 50

Prerequisites: Chemical Process Calculations

Course Objectives:

- To improve Programming skills and analytical skills.
- To utilize programming skills to solve chemical engineering problems

Course Outcomes:

By the end of the course, student will be able to

1. Identify the suitable algorithm to solve chemical engineering problems.
2. Demonstrate their programming skills to solve numerical problems

CO – PO – PSO Matrix:

		PO												PSO	
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO	**1**	3	3	3	3	3				3	2		3	2	3
	2	3	3	3	3	3				3	2		3	2	3

List of Experiments

Use of C/C++ /Python/MATLAB/any open source tool like SCILAB is allowed to solve problems:

1. Introduction to programming
2. Handling of arrays and matrices
3. Scripts and functions
4. Programming using loops
5. Programming using conditional statements

   Numerical methods
6. Solution of linear algebraic equations
7. Solution of a non-linear equations

8. Numerical integration
9. Interpolation and Approximation
10. Solution of ODEs
11. Solution of PDEs

Chemical engineering problem solving

12. Property estimation for a given compound
13. Solving equation of state
14. Mass balances without recycle streams
15. Mass balances with recycle streams
16. Energy balance problems

Reference Books:

1. Sastry, S. S., “Introductory Methods of Numerical Analysis”, 5th Ed., PHI Learning Pvt. Ltd., 2012
2. Gupta, S. K., "Numerical Methods for Engineers”, New Academic Science, 2012
3. Balagurusamy, E., “Numerical Methods”, Tata McGraw-Hill Education, 2017