Chemical Engineering - (4 Year B. Tech Programme) - COURSE CURRICULUM - R-20	Total Credits:160

I Year Course structure

Semester - I

Code	Title of the Course	Category	L	T	P	E	O	Total	Max. marks: Sess.	Max. marks: End. Exam	Total Marks	Credits
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	--	50	--
	Total		**17**	**0**	**12**	**5**	**26**	**60**	**400**	**450**	**850**	**20**

Semester - II

Code	Title of the Course	Category	L	T	P	E	O	Total	Max. marks: Sess.	Max. marks: End. Exam	Total Marks	Credits
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	Basic Mechanical Engineering	ES	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	--	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	Biology for Engineers	ES	2	0	0	1	4	7	100	--	100	2
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		**14**	**0**	**6**	**5**	**29**	**54**	**360**	**340**	**700**	**17**

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	Humanities Elective	HS	3	0	0	1	3	7	40	60	100	3
CHE223	Engineering Thermodynamics	EC	3	0	0	1	5	9	40	60	100	3
CHE224	Momentum Transfer	PC	3	0	0	1	6	10	40	60	100	3
CHE225	Numerical Methods for Chemical Engineers	SC	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	SC	0	0	3	0	1	4	50	50	100	1.5
CHE229	Seminars	SC	0	0	2	0	1	3	100	---	100	1
	Total		**18**	**0**	**8**	**6**	**31**	**63**	**440**	**460**	**900**	**22**

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	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	Heat Transfer Lab	PC	0	0	3	0	1	4	50	50	100	1.5
CHE318	Chemical Technology Lab	PC	0	0	3	0	1	4	50	50	100	1.5
CHE319	Quantitative and Verbal Aptitude – I	HS	0	0	3	1	3	7	100	--	100	1.5
CHE310	Summer Internship - I	PR	0	0	0	0	0	0	100	--	100	2
	Total		**18**	**0**	**9**	**7**	**26**	**60**	**540**	**460**	**1000**	**24.5**

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	Mass Transfer Lab	PC	0	0	3	0	1	4	50	50	100	1.5
CHE328	Process Dynamics and Control Lab	PC	0	0	3	0	1	4	50	50	100	1.5
CHE329	Quantitative Aptitude – II & Soft Skills	HS	0	0	3	2	3	8	100	--	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	Chemical Process Economics and Equipment Design	PC	3	0	0	1	6	10	40	60	100	3
CHE415	Process Modeling and Simulation	SC	3	0	0	1	5	9	40	60	100	3
CHE416	Professional Elective-V	PE	3	0	0	1	3	6	40	60	100	3
CHE417	Chemical Reaction Engineering Lab	PC	0	0	3	0	1	4	50	50	100	1.5
CHE418	Process Modeling and Simulation Lab	SC	0	0	3	0	1	4	50	50	100	1.5
CHE419	Project Phase – I	PR	0	0	3	0	3	6	100	--	100	2
CHE410	Summer Internship-II	PR	0	0	0	0	1	1	100	--	100	2
	Total		**18**	**0**	**9**	**6**	**33**	**66**	**540**	**460**	**1000**	**25**

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 (MOOCS)	OE	0	0	0	0	3	3	40	60	100	3
CHE422	Project Phase – II	PR	0	0	9	0	9	18	100	100	200	8
	Total		**0**	**0**	**9**	**0**	**12**	**21**	**140**	**160**	**300**	**11**

R-20 Regulations- list of Electives

CHE 222 Humanity and sciences Elective

CHE 222(A)	Industrial Management
CHE 222(B)	Managerial Economics and Financial Analysis
CHE 222(C)	Operations Research

CHE 226 Professional elective-I

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

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

CO1: Explain the characteristics of scalar and vector valued functions and provide a physical interpretation of the gradient, divergence, curl and related concepts.

CO2: 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.

CO3: Explain analytical methods for solving PDE's like applying separation of variables to solve elementary problems in linear second order partial differential equations (heat and wave equations).

CO4: 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.

CO5: 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**

Scalar and vector point functions – Del applied to scalar point functions–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**

Integration of vectors – Line integral , circulation, work done– Surface integral ,flux– Green's theorem in the plane – Stoke's theorem – Volume integral – Gauss divergence theorem (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 – 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, 18.2, 18.4, 18.5, 18. 6 and 18. 7.

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 BOOK:

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*, 3rdedition, Alpha Science International Ltd., 2002.

4. **George B. Thomas, Maurice D. Weir and Joel Hass, Thomas,** *Calculus*, 13thedition, 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

BIOLOGY FOR ENGINEERS

Course Code – Category: CHE 213 – ES

L	T	P	E	O	Credits: 2
2	0	0	2	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

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.

CHEMICAL PROCESS CALCULATIONS

Course Code – Category: CHE 214 - PC

L	T	P	E	O	Credits: 3
3	1	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's 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. K.V. Narayanan and B. Lakshmikutty, "Stoichiometry and Process Calculations", 5th ed., Prentice Hall of India Pvt Ltd , 2006.

Reference Books:

1. David M. Himmelblau," Basic principles and Calculations in Chemical Engineering", 6th ed., Prentice Hall of India Pvt Ltd, 1995.
2. 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.
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 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:

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

CO1: Analyze limit, continuity and differentiation of functions of complex variables and understand Cauchy-Riemann equations, analytic functionsand various properties of analytic functions.

CO2 : Understand Cauchy's theorem and Cauchy's integral formulas and apply these to evaluate complex contour integrals and represent functions as Taylor and Laurent series and determine their intervals of convergence.

CO3: Be familiar with numerical solution of ordinary differential equations.

CO4: Examine, analyze and compare Probability distributions**.**

CO5: 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:

Complexfunction–Real andimaginary partsof complexfunction–Limit–Continuity and derivative of a complex function–Cauchy-Riemann equations–Analyticfunction–E ntirefunction– Singularpoint–Conjugate function–Cauchy-Riemannequations inpolarform–Harmonicfunctions–Milne-Thomsonmethod–Simpleapplicationstoflowproblems– 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, and Laurent's series(without proofs).

Sections: 20.12, 20.13, 20.14 and 20.16.

Learning Outcomes:

UNIT III **9L + 3T**

NUMERICAL SOLUTIONS 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) – 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, 27.11, 27.12,27.13, 27.14, 27.15, 26.16, 27.17 and 27.18.

Learning Outcomes:

TEXTBOOK:

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, 3rdedition , Alpha Science International Ltd., 2002.

4. **George B. Thomas, Maurice D. Weir and Joel Hass, Thomas**, Calculus, 13th edition , Pearson Publishers.

INDUSTRIAL MANAGEMENT

Course Code – Category: CHE 222 (A) – HS

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

Prerequisites: NIL

Course Objectives:

- To familiarize the students with the concepts of Management.
- To relate the concepts of management with industrial organizations.
- To explain the factors affecting productivity and how productivity can be increased in an Industrial undertaking.

Course Outcomes:

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

1. Understand the concepts of Management.
2. Gain basic understanding of management and to relate the concepts of management with industrial organizations and manage organizations efficiently.
3. Have the basic knowledge of production management and make decisions proficiently.
4. Have the knowledge in maintaining better human relations in the organizations.

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	2	1	1	1
	2	2							1	1	3		1	1	1
	3	2								1	1		1	1	1
	4	2								1	1	1	1	1	1

UNIT I **9L + 3T**

Management: Functions of management –Planning, Organizing, Staffing, Directing Controlling and Coordinating, Levels of management, Role of Manager, Skills of manager, –F.W. Taylor's scientific management and Henry Fayol's principles of management.

Learning Outcomes:

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

Identify the roles of a manager

Understand the principles of management

UNIT II **9L + 3T**

Organization: Meaning of Organization, Principles of organization, Departmentalization, Organization structure (in brief),

Communication: Importance, purpose and forms of communication. Barriers to communication.

Learning Outcomes:

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

Identify the organization structure and flow of organization

Importance of communication

UNIT III **9L + 3T**

Forms of business organizations: Salient features of Sole proprietorship, Partnership, Joint Stock Company, Private limited company and Public limited company, Government enterprises and Co-operative societies.

Learning Outcomes:

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

Identify the different forms of businesses

UNIT IV **9L + 3T**

Production operations management: Production planning and control, Plant location and factors affecting plant location, Plant layout and types of layout (in brief).

Learning Outcomes:

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

Identify the various operations in a plant

Describe the factor affecting plant location

UNIT V **9L + 3T**

Human Resources Management: Basic functions of human resource management. Manpower planning, Recruitment, Selection, Training and Development, Placement, Compensation and Performance appraisal.

Learning Outcomes:

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

Understand the functioning of HR management

Text books:

1. P.C. Tripathi, P.N.Reddy, Principles of Management, 4thEdition, Tata McGraw Hill Companies, New Delhi ,2008. (UNIT I & II)
2. A.R. AryaSri, Managerial Economics and Financial Analysis, TMH Publications, NewDelhi, 2014. (UNIT III)
3. S.C. Sharma and Banga T. R., Industrial Organization & Engineering Economics, khanna Publications, Delhi-6,2006. (UNIT IV & V)

Reference Books:

1. O.P. Khanna, Industrial Engineering and Management, Dhanpat Raj and Sons.

Managerial Economics and Financial Analysis

Course Code – Category: CHE 222 (B) – HS

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

Prerequisites: NIL

Course Objectives:

- To make the students to learn the fundamentals of managerial economics and explain the concepts of costs and break – even analysis.
- To acquaint the students with the different market situations and forms of business organization.
- To impart the knowledge of financial accounting

Course Outcomes:

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

1. Apply the basics of managerial economics such as micro versus macro economics and demand analysis.
2. Describe different types of costs and apply the various costs associated with production to determine break – even point.
3. Analyze different markets and forms of business organization by means of their features, merits and demerits
4. Explain how to manage capital.
5. Understand the basic concepts of accounting and know how to prepare final accounts of a sole proprietor

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	3	1	1	2
	2	3	2	2						1	1	3	1	1	2
	3	3	2	2						1	1	3	1	1	2
	4	3	2	2						1	1	3	1	1	2
	5	3	2	2						1	1	3	1	1	2

UNIT I **9L + 3T**

Introduction to Managerial Economics: Definition; micro and macro economics; demand analysis -demand determinants, law of demand and its exceptions, elasticity of demand-measurements and types.

Learning Outcomes:

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

Describe the demand and expectations relations

UNIT II **9L + 3T**

Cost Analysis: Cost concepts - opportunity cost, fixed vs. variable costs, explicit vs. implicit costs, out of pocket vs. imputed costs; Break Even Analysis -determination of break-even point (simple problems).

Learning Outcomes:

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

Identify the cost concepts

Perform break even analysis

UNIT III **9L + 3T**

Market Structures: Types of competition; features of perfect competition; imperfect competition monopoly, monopolistic competition. Types of Business Organization and Business Cycles: Sole trader; partnership; joint stock company; pubic enterprises

Learning Outcomes:

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

Identify different market structures

UNIT IV **9L + 3T**

Capital –Types and Sources: Fixed and working capital; methods and sources of finance.

Learning Outcomes:

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

Analyse the types and sources of capitals

UNIT V **9L + 3T**

Introduction to Financial Accounting: Final accounts of a sole proprietor - preparation of trading account, profit and loss account, balance sheet (simple problems)

Learning Outcomes:

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

Analyse balance sheet

Describe profit and loss account.

Text books:

1. Managerial Economics and Financial Analysis by A. R. Aryasri; McGraw-Hill Education (India) Private Limited, New Delhi (2015).
2. Engineering Economics, Volume I by Tara Chand; Published By Nem Chand & Bros, Roorke (2007).

Reference Books:

1. Managerial Economics by Varshney & Maheswari; Published by Sultan Chand, 2007.
2. Financial Accounting by Shim &Siegel; Published by Schaum's Outlines, TMH 2007.

Operations Research

Course Code – Category: CHE 222 (C) – HS

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

Prerequisites: Mathematics

Course Objectives:

- The course is intended to identify and develop operational research models.
- Understand the mathematical tools to solve optimisation problems
- Develop a report that describes the model, the solving techniques and analyse the results

Course Outcomes:

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

1. Apply linear programming model and assignment model to domain specific situations.
2. Analyze the various methods under transportation model and apply the model for testing the closeness of their results to optimal results.
3. Apply the concepts of PERT and CPM for decision making and optimally managing projects
4. Analyze the various replacement and sequencing models and apply them for arriving at optimal decisions
5. Analyze the inventory and queuing theories and apply them in domain specific situations

CO – PO – PSO Matrix:

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

UNIT I **9L + 3T**

LINEAR MODEL: Introduction to Operations Research – Linear Programming - Mathematical Formulation – Graphical method – Simplex method – Two – Phase Simplex method ,Big-M method-Duality Simplex method.

Learning Outcomes:

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

Formulate a managerial decision problem into a mathematical model

UNIT II **9L + 3T**

TRANSPORTATION AND ASSIGNMENT MODELS: Transportation model – Initial solution by North West corner method – least cost method – VAM. Optimality test – MODI method and stepping stone method, Assignment model – formulation – balanced and unbalanced assignment problems.

Learning Outcomes:

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

Apply transportation problems in manufacturing industries

Build and solve assignment models and travelling salesmen problems

UNIT III **9L + 3T**

PROJECT MANAGEMENT BY PERT & CPM: Basic terminologies – Constructing a project network – Scheduling computations – PERT - CPM – Resource smoothening, Resource leveling, PERT cost.

Learning Outcomes:

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

Apply project management techniques like CPM and PERT to plan and execute project successfully

UNIT IV **9L + 3T**

REPLACEMENT AND SEQUENCING MODELS: Replacement policies - Replacement of items that deteriorate with time (value of money not changing with time) – Replacement of items that deteriorate with time (Value of money changing with time) – Replacement of items that fail suddenly (individual and group replacement policies), Sequencing models- n job on 2 machines – n jobs on 3 machines – n jobs on m machines, Traveling salesman problem.

Learning Outcomes:

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

Apply replacement and sequencing theory concepts in industry applications

UNIT V **9L + 3T**

INVENTORY AND QUEUING THEORY: Variables in inventory problems, EOQ, deterministic inventory models, order quantity with price break, techniques in inventory management, Queuing system and its structure – Kendall"s notation – Common queuing models –M/M/1: FCFS/∞/∞ – M/M/1: FCFS/n/∞ – M/M/C: FCFS/∞/∞ – M/M/1: FCFS/n/m.

Learning Outcomes:

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

Apply inventory and queuing theory concepts in industry applications

Text books:

1. S.D. Sharma, Operation Research, Kedar N ath Ram Nath Publishers, 2015.
2. Handy A. Taha, Operations Research An introduction, 10th edition, 2017.

Reference Books:

1. Hira D S and Gupta P K, Operations Research, S.Chand & Sons, 2007.
2. Panneerselvan. R., Operation Research, Prentice Hall of India Pvt Ltd. 2006.
3. Kanti Swarup, Gupta P.K., and Manmohan, Operations Research, S.Chand & sons, 2004.

Engineering Thermodynamics

Course Code – Category: CHE 223 – ES

L	**T**	**P**	**Credits: 3**
3	**0**	**0**	**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.

MOMENTUM TRANSFER

Course Code – Category: CHE 224 – 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, 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 € 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.

Numerical Methods in Chemical Engineering

Course Code – Category: CHE 225 – SC

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

Prerequisites: Engineering Mathematics-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 Matrix methods
5. Solve chemical engineering problems involving 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 numericalmethods
- Estimate solutions of algebraic and non-algebraic equations using appropriate numerical

method

- Solving system of nonlinear equations using numericalroutines.

UNIT II **9L + 3T**

Interpolation and Regression: Interpolation with equally spaced: Newton's polynomials – Forward difference and Backward difference, Interpolation with unequally spaced: Lagrange polynomials and Newton's divide difference polynomial.

Regression:least square curve fitting – linear, multi linear, curve fitting by second degree polynomial

Learning Outcomes:

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

- Apply Newton's polynomials and Lagrange polynomials forinterpolation
- Implement the least square regression analysis for curvefitting

UNIT III **9L +3T**

Numerical Differentiation: Newton Forward Difference method and Backward difference method, Cubic Splines Method.

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

Numerical solution of ordinary differential equations: Solution by Taylor's series, Euler Method, Modified Euler method, Runge-Kutta Methods-4^{th} order, Chemical engineering problems involvingODEs

Learning Outcomes:

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

- Implement numerical methods to solveODE
- Apply Trapezoidal and Simpson's rule for numericalintegration

UNIT IV **9L + 3T**

Numerical Linear Algebra: Introduction to Matrix and Matrix properties, Solution of Linear systems: Direct Methods– Gauss elimination method, Gauss – Jordan method LU decomposition method, Iterative Methods – Jacobi's method and Gauss – Seidel method 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 Direct methods
- Solve linear algebraic equations using Iterative methods

UNIT V **9L +3T**

Numerical Solution of PDE: Characterization of PDEs, Solution of Laplace's equation, Heat equation in one dimension - explicit, implicit, Crank-Nicholson method

Learning Outcomes:

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

- Characterize PDE's
- Solve PDEs like Laplaceequation

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, 3rdEdition, 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 – SC

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**
C	**1**	3	3	3	3	3				3	2		3	2	3
O	**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

SEMINARS

Course Code – Category: CHE 229 – SC

L	T	P	E	O	Credits: 1
0	0	2	0	1	Sessional Marks: 100

Prerequisites: English

Course Objectives:

- To provide knowledge in preparing Technical Reports
- To familiarize with the power point presentations
- To enhance communication skills

Course Outcomes:

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

1. Prepare Technical Reports
2. Develop Presentation and Communication Skills

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	2	2			1	3	3		2	2	3
	2	1	1	1	1	2			1	3	3		2	2	3

Seminars are conducted in two phases to evaluate the knowledge, presentation skills of the student. For each presentation 50 marks are allotted to each student by the evaluators. Marks have been awarded based on the performance of the student in terms of presentation skills, communication skills, knowledge on the topic. Finally all the marks obtained in the two phases are averaged to award total marks for the project.