SETHU INSTITUTE OF TECHNOLOGY

(An Autonomous Institution)
Pulloor, Kariapatti – 626 115, Virudhunagar District
(An Autonomous Institution affiliated to Anna University, Chennai)

Estd : 1995

CURRICULUM & SYLLABI

B.TECH. - CHEMICAL ENGINEERING

REGULATION 2019
CHOICE BASED CREDIT SYSTEM

Approved in the Academic Council Meeting on 29.10.2020

CHAIRMEN

ACADEMIC COUNCIL

CHAIRMAN
ACADEMIC COUNCIL
Sethu Institute of Technology
Pulloor, Kariapatti - 625 115

HEAD OF THE DEPARTMENT

DEPARTMENT OF CHEMICAL ENGINEERING

Chairperson
Board of Studies
Chemical Engineering
Sethu Institute of Technology,
Pulloor, Kariapatti - 626 115.

SETHU INSTITUTE OF TECHNOLOGY

VISION

- To promote excellence in technical education and scientific research for the benefit of the society

MISSION

- To provide quality technical education to fulfill the aspiration of the student and to meet the need of the industry
- To provide holistic learning ambience
- To impart skills leading to employability and entrepreneurship
- To establish effective linkage with industries
- To promote research and development activities
- To offer service for the development of society through education and technology

CORE VALUES

- Quality, Commitment, Innovation, Team work, Courtesy.

QUALITY POLICY

- To provide quality technical education to the students
- To produce competent professionals and contributing citizens
- To contribute for the up-liftment of the society

DEPARTMENT OF CHEMICAL ENGINEERING

VISION

To be an eminent department producing competent Chemical Engineers for the benefit of industry and society

MISSION

- To provide academic excellence through quality technical education to meet the needs of changing technology
- To set up state-of -the art facilities and promote teaching learning and research activities
- To develop entrepreneurial skills and employability opportunities
- To establish collaboration with industries for technology transfer
- To facilitate center of excellence in research and create an environment for nurturing innovative capabilities
- To address societal needs by imparting professional and ethical values

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

PEO-I

Our graduates will possess strong knowledge to solve real time problems in Chemical and allied industries. **(Core Competency/Technical Accomplishments)**

PEO-II

Our graduates will have the ability to solve contemporary issues with ethical values and professional skills. **(Professionalism)**

PEO-III

Our graduates will exhibit proficiency through sustained learning to adapt changes in technologies. **(Life Long Learning)**

PROGRAMME SPECIFIC OUTCOME (PSOs)

Graduates will be able to

- Achieve deep knowledge in various unit processes and operations, reaction engineering to design chemical engineering equipment integrating safety procedures.
- Develop mathematical models of real time problems including design of experiments, study and interpretation of data to provide valid conclusions in Chemical engineering.

PROGRAMME OUTCOMES (POs)

Engineering Graduates will be able to:

- Apply the knowledge of mathematics, sciences and engineering fundamentals to solve complex engineering problems (**Engineering knowledge)**.
- Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural and engineering sciences (**Problem analysis)**.
- Design solutions for complex engineering problems and design system components that meet the specified needs with appropriate consideration for public health and safety, cultural, societal and environmental concerns (**Design/development of solutions)**.
- Conduct investigations on complex engineering problems in design and analysis of unit operations and processes using research based knowledge and methods including design of experiments, analysis and interpretation of data and synthesis of information to attain valid conclusions (**Conduct investigations of complex problems)**.
- Apply appropriate techniques and modern simulation tools to solve engineering problems (**Modern tool usage)**.
- Apply reasoning informed by the contextual knowledge to assess societal, health, safety,

legal and cultural issues and the consequent responsibilities relevant to the engineering practice (**The engineer and society)**.

- Understand the impact of the engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development (**Environment and sustainability)**.
- Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice (**Ethics)**.
- Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary environments (**Individual and team work)**.
- Communicate effectively with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions (**Communication)**.
- Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments (**Project management and finance)**.
- Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change (**Life-long learning)**.

PROGRAMME SPECIFIC CRITERIA

- The curriculum must provide a thorough grounding in basic sciences including chemistry, physics and biology, with advanced level content as appropriate to the objectives of the program.
- The curriculum must include engineering application of basic sciences to design, analyze and control physio-chemical and biological processes considering safety aspects.

Estd1995

SETHU INSTITUTE OF TECHNOLOGY

Pulloor, Kariapatti –626115

(An Autonomous Institution)

ISO 9001-2008
FS 70973

B.TECH. Degree Programme

CHOICE BASED CREDIT SYSTEM

CURRICULUM (Regulations2019)

BACHELOR OF TECHNOLOGY IN CHEMICAL ENGINEERING

OVERALL COURSE STRUCTURE COMPARISON

S.NO	CATEGORY	SIT		AICTE		ANNA UNIV R -2019	
1.	HUMANITIES & SCIENCE	9	6%	12	8%	17	10%
2.	BASIC SCIENCE	27.5	17%	25	16%	23	14%
3.	ENGINEERING SCIENCE	18	11%	24	15%	22	13%
4.	PROFESSIONAL CORE	63.5	39%	48	30%	68	40%
5.	PROFESSIONAL ELECTIVE	18	11%	18	11%	21	12%
6.	OPEN ELECTIVE	12	7%	18	11%	6	4%
7.	PROJECTS	14	9%	15	9%	13	8%
	TOTAL	**162**	**100%**	**160**	**100%**	**170**	**100%**

COURSECREDITS–SEMESTERWISE

Branch	I	II	III	IV	V	VI	VII	VIII	TOTAL
CH	**20.5**	**16.5**	**21**	**23**	**22.5**	**23**	**21.5**	**14**	**162**

SEMESTER I

COURSE CODE	COURSE TITLE	CATEGORY	L	T	P	C
THEORY						
19UEN101	English for Technical Communication	**HS**	2	0	0	2
19UMA102	Engineering Mathematics-I	**BS**	3	1	0	4
19UPH103	Engineering Physics	**BS**	3	0	0	3
19UCY104	Engineering Chemistry	**BS**	3	0	0	3
19UCS108	Problem Solving and Python Programming	**ES**	3	0	0	3
19UME109	Engineering Graphics	**ES**	3	1	0	4
PRACTICAL						
19UGS112	Basic Sciences Laboratory	**BS**	0	0	2	1
19UME111	Engineering Practices Laboratory	**ES**	0	0	3	1.5
19UCS110	Problem Solving and Python Programming Laboratory	**ES**	0	0	3	1.5
MANDATORY						
19UGM131	Induction Programme	**HS**	0	0	0	P/F
TOTAL			**17**	**2**	**8**	**23**

SEMESTER II

COURSE CODE	COURSE TITLE	CATEGORY	L	T	P	C
THEORY						
19UEN201	Communication Skills for Professionals	**HS**	0	0	2	1.5
19UMA207	Calculus, Complex Analysis, Transform Techniques	**BS**	3	1	0	4
19UPH203	Material Physics	**BS**	3	0	0	3
19UCY204	Environmental Science	**BS**	3	0	0	3
19UCH205	Introduction to Chemical Engineering	**PC**	3	0	0	3
19UEE226	Basic Electrical and Electronics Engineering	**ES**	3	0	0	3
PRACTICAL						
19UGS210	Energy Science and Environmental Science Laboratory	**BS**	0	0	3	1.5
19UEE221	Basic Electrical and Electronics Engineering Laboratory	**ES**	0	0	3	1.5
TOTAL			**17**	**1**	**8**	**20.5**

SEMESTER III

COURSE CODE	COURSE TITLE	CATEGORY	L	T	P	C
THEORY						
19UMA326	Transform Techniques and Partial Differential Equations	**BS**	3	1	0	4
19UCH302	Process Chemistry	**ES**	3	0	3	4.5
19UCH303	Heat Power Engineering	**PC**	3	0	0	3
19UCH304	Fluid Flow Operations	**PC**	2	1	3	4.5
19UCH305	Chemical Process Calculations	**PC**	2	1	0	3
19UCH306	Engineering Materials for Process Industries	**PC**	2	0	0	2
MANDATORY						
19UGM332	Biology for Engineering Applications	**BS**	2	0	0	P/F
		TOTAL	**17**	**3**	**6**	**21**

SEMESTER IV

COURSE CODE	COURSE TITLE	CATEGORY	L	T	P	C
THEORY						
19UMA423	Numerical Methods	**BS**	3	1	0	4
19UCH402	Chemical Engineering Thermodynamics	**PC**	2	1	0	3
19UCH403	Heat Transfer	**PC**	2	1	3	4.5
19UCH404	Mechanical Operations	**PC**	3	0	3	4.5
19UCH405	Chemical Process Industries	**PC**	3	0	0	3
19UCH406	Mass Transfer - I	**PC**	2	1	0	3
PRACTICAL						
19UCH407	Seminar	**P**	0	0	2	1
19UGS431	Reasoning and Quantitative Aptitude	**BS**	0	0	2	1
MANDATORY						
19UGM431	Gender Equality	**HS**	1	0	0	P/F
		TOTAL	**15**	**4**	**10**	**24**

SEMESTER V

COURSE CODE	COURSE TITLE	CATEGORY	L	T	P	C
THEORY						
19UCH501	Process Economics and Management	**HS**	2	0	0	2
19UCH502	Mass Transfer - II	**PC**	2	1	0	3
19UCH503	Chemical Reaction Engineering - I	**PC**	2	1	0	3
PE - I	Professional Elective - I	**PE**	3	0	0	3
PE - II	Professional Elective - II	**PE**	3	0	0	3
OE - I	Open Elective - I	**OE**	3	0	0	3
PRACTICAL						
19UCH507	Chemical Reaction Engineering Lab	**PC**	0	0	3	1.5
19UCH508	Mass Transfer Lab	**PC**	0	0	3	1.5
19UGS533	Interpersonal Skills Lab	**HS**	0	0	3	1.5
MANDATORY						
19UCH509	Creative Thinking and Innovation	**HS**	0	0	2	1
		TOTAL	**16**	**2**	**9**	**22.5**

SEMESTER VI

COURSE CODE	COURSE TITLE	CATEGORY	L	T	P	C
THEORY						
19UCH601	Chemical Reaction Engineering - II	**PC**	2	1	0	3
19UCH602	Process Instrumentation Dynamics and Control	**PC**	2	1	3	4.5
19UCH603	Process Equipment Design	**PC**	3	1	0	4
PE - III	Professional Elective - III	**PE**	3	0	0	3
OE - II	Open Elective - II	**OE**	3	0	0	3
PRACTICAL						
19UCH606	Process Computation Lab	**PC**	0	0	3	1.5
19UGS632	Soft Skills and Communication Lab	**HS**	0	0	3	1.5
19UCH607	Technical Project and product Development	**P**	0	0	8	4
MANDATORY						
19UGM635	Indian Constitution	**HS**	0	0	1	0
		TOTAL	**16**	**3**	**18**	**24.5**

SEMESTER VII

COURSE CODE	COURSE TITLE	CATEGORY	L	T	P	C
THEORY						
19UME701	Project Management and Finance	**PC**	3	1	0	4
19UCH702	Transport Phenomena	**PC**	3	1	0	4
19UCH703	Process Modeling and Simulation	**HS**	3	1	0	4
PE - IV	Professional Elective - IV	**PE**	3	0	0	3
PE - V	Professional Elective - V	**PE**	3	0	0	3
OE - III	Open Elective - III	**OE**	3	0	0	3
PRACTICAL						
19UCH707	Process Design and Simulation Lab	**PC**	0	0	3	1.5
19UCH708	Summer Internship	**P**	0	0	2	1
MANDATORY						
19UGM731	Professional Ethics and Human Values	**HS**	2	0	0	2
		TOTAL	**17**	**2**	**15**	**24.5**

SEMESTER VIII

COURSE CODE	COURSE TITLE	CATEGORY	L	T	P	C
THEORY						
PE - VI	Professional Elective - VI	**PE**	3	0	0	3
OE - IV	Open Elective - IV	**OE**	3	0	0	3
PRACTICAL						
19UCH803	Project Work	**P**	0	0	16	8
		TOTAL	**6**	**0**	**16**	**14**

HUMANITIES & SOCIAL SCIENCES (HS)

S.NO	COURSE CATEGORY	COURSE CODE	COURSE TITLE	L	T	P	C
1	**HS**	19UEN101	English for Technical Communication	2	0	0	2
2	**HS**	19UGM131	Induction Program	0	0	0	0
3	**HS**	19UEN201	Communication Skills for Professionals	0	0	2	1.5
4	**HS**	19UGM431	Gender Equality	1	0	0	0
5	**HS**	19UCH501	Process Economics and Management	2	0	0	2
6.	**HS**	19UGM507	Creative Thinking and Innovation	1	0	0	1
7	**HS**	19UGS533	Interpersonal Skills Lab	0	0	3	1.5
8	**HS**	19UGM635	Indian Constitution	0	0	1	0
9	**HS**	19UGS632	Soft Skills and Communication Lab	0	0	3	1.5
10	**HS**	19UGM731	Professional Ethics and Human Values	2	0	0	2
11	**HS**	19UME701	Project Management and Finance	3	0	0	3
						TOTAL	**14.5**

BASIC SCIENCES (BS)

S.NO	COURSE CATEGORY	COURSE CODE	COURSE TITLE	L	T	P	C
1.	**BS**	19UMA102	Engineering Mathematics-I	3	1	0	4
2	**BS**	19UPH103	Engineering Physics	3	0	0	3
3	**BS**	19UCY104	Engineering Chemistry	3	0	0	3
4	**BS**	19UGS112	Basic Sciences Laboratory	0	0	2	1
5	**BS**	19UMA207	Calculus, Complex Analysis and Transform Techniques	3	1	0	4
6	**BS**	19UPH203	Material Physics	3	0	0	3
7	**BS**	19UCY204	Environmental Science	3	0	0	3
9	**BS**	19UGS210	Energy Science and Environmental Science Lab	0	0	3	1.5
10	**BS**	19UMA326	Transform Techniques and Partial Differential Equations	3	1	0	4
11	**BS**	19UGM332	Biology for Engineering Applications	2	0	0	0
11	**BS**	19UMA423	Numerical Methods	3	1	0	4
12	**BS**	19UGS431	Reasoning and Quantitative Aptitude	0	0	2	1
						TOTAL	**31.5**

ENGINEERING SCIENCES (ES)

S.NO	COURSE CATEGORY	COURSE CODE	COURSE TITLE	L	T	P	C
1	**ES**	19UCS108	Problem Solving and Python Programming	3	0	0	3
2	**ES**	19UME109	Engineering Graphics	3	1	0	4
3	**ES**	19UME111	Engineering Practices Lab	0	0	3	1.5
4	**ES**	19UCS110	Problem Solving and Python Programming Laboratory	0	0	3	1.5
5	**ES**	19UEE226	Basic Electrical and Electronics Engineering	3	0	0	3
6	**ES**	19UEE221	Basic Electrical and Electronics Engineering Lab	0	0	3	1.5
7	**ES**	19UCH302	Process Chemistry	3	0	3	4.5
						TOTAL	**19**

PROFESSIONAL CORE (PC)

S.NO	COURSE CATEGORY	COURSE CODE	COURSE TITLE	L	T	P	C
1	**PC**	19UCH205	Introduction to Chemical Engineering	3	0	0	3
2	**PC**	19UCH303	Heat Power Engineering	3	0	0	3
3	**PC**	19UCH304	Fluid Flow Operations	2	1	0	4.5
4	**PC**	19UCH305	Chemical Process Calculations	2	1	0	3
5	**PC**	19UCH306	Engineering Materials for Process Industries	2	0	0	2
6	**PC**	19UCH402	Chemical Engineering Thermodynamics	2	1	0	3
7	**PC**	19UCH403	Heat Transfer	2	1	3	4.5
8	**PC**	19UCH404	Mechanical Operations	3	0	3	4.5
9	**PC**	19UCH405	Chemical Process Industries	3	0	0	3
10	**PC**	19UCH406	Mass Transfer - I	2	1	0	3
11	**PC**	19UCH502	Mass Transfer - II	2	1	0	3
12	**PC**	19UCH503	Chemical Reaction Engineering - I	2	1	0	3
13	**PC**	19UCH508	Chemical Reaction Engineering Lab	0	0	3	1.5
14	**PC**	19UCH509	Mass Transfer Lab	0	0	3	1.5
15	**PC**	19UCH601	Chemical Reaction Engineering - II	2	1	0	3

16	**PC**	19UCH602	Process Instrumentation Dynamics and Control	2	1	3	4.5
17	**PC**	19UCH603	Process Equipment Design	3	1	0	4
18	**PC**	19UCH607	Process Computation Lab	0	0	3	1.5
19	**PC**	19UCH701	Transport Phenomena	3	1	0	4
20	**PC**	19UCH702	Process Modeling and Simulation	3	1	0	4
21	**PC**	19UCH708	Process Design and Simulation Lab	0	0	3	1.5
						TOTAL	**65**

PROJECT (P)

S.NO	COURSE CATEGORY	COURSE CODE	COURSE TITLE	L	T	P	C
1	**P**	19UCH409	Seminar	0	0	2	1
2	**P**	19UCH507	Creative Thinking and Innovation	0	0	2	1
3	**P**	19UCH609	Technical Project and Product Development	0	0	8	4
4	**P**	19UCH709	Summer Internship	0	0	2	1
5	**P**	19UCH803	Project Work	0	0	16	8
TOTAL							**15**

PROFESSIONAL ELECTIVE (PE)

S.NO	COURSE CATEGORY	COURSE CODE	COURSE TITLE	L	T	P	C
Chemical Engineering Allied Courses							
1	**PE**	19UCH901	Petroleum Refining Engineering	3	0	0	3
2	**PE**	19UCH902	Polymer Technology	3	0	0	3
3	**PE**	19UCH903	Fertilizer Technology	3	0	0	3
4	**PE**	19UCH904	Food Science and Technology	3	0	0	3
5	**PE**	19UCH905	Drugs and Pharmaceutical Technology	3	0	0	3
6	**PE**	19UCH906	Oil and Natural Gas Engineering	3	0	0	3
7	**PE**	19UCH907	Computational Fluid Dynamics	3	0	0	3
8	**PE**	19UCH908	Chemical Process Plant Safety	3	0	0	3
Energy and Environmental Engineering							
9	**PE**	19UCH909	Air Pollution and Control	3	0	0	3
10	**PE**	19UCH910	Waste Water Treatment and Recycling	3	0	0	3
11	**PE**	19UCH911	Solid Waste Management	3	0	0	3
12	**PE**	19UCH912	Alternative Energy Technology	3	0	0	3
13	**PE**	19UCH913	Environmental Impact Assessment	3	0	0	3
Process Engineering							
14	**PE**	19UCH914	Bio Process Engineering	3	0	0	3

15	**PE**	19UCH915	Fermentation Technology	3	0	0	3
16	**PE**	19UCH916	Process Optimization	3	0	0	3
17	**PE**	19UCH917	Data Science for Engineers	3	0	0	3
18	**PE**	19UCH918	Pilot Plant and Scale Up studies	3	0	0	3
19	**PE**	19UCH919	Quality Management for Chemical Engineers	3	0	0	3
Modern Chemical Technology							
20	**PE**	19UCH920	Fluidization Technology	3	0	0	3
21	**PE**	19UCH921	Instrumental Methods of Analysis	3	0	0	3
22	**PE**	19UCH922	Nano Technology	3	0	0	3
23	**PE**	19UCH923	Extractive Metallurgy	3	0	0	3
24	**PE**	19UCH924	Modern Separation Processes	3	0	0	3
25	**PE**	19UCH925	Electrochemical Engineering	3	0	0	3
26	**PE**	19UCH926	Nuclear Science and Technology	3	0	0	3
						TOTAL	**78**

LIST OF PROFESSIONAL ELECTIVES – PE

(SEMESTER WISE)

SL.NO.	COURSE CATEGORY	COURSE CODE	COURSE TITLE	L	T	P	C
Professional Elective – I (V Semester)							
1	**PE**	19UCH901	Petroleum Refining Engineering	3	0	0	3
2	**PE**	19UCH909	Air Pollution and Control	3	0	0	3
3	**PE**	19UCH915	Fermentation Technology	3	0	0	3
4	**PE**	19UCH921	Instrumental Methods of Analysis	3	0	0	3
Professional Elective – II (V Semester)							
1	**PE**	19UCH902	Polymer Technology	3	0	0	3
2	**PE**	19UCH903	Fertilizer Technology	3	0	0	3
3	**PE**	19UCH910	Waste Water Treatment and Recycling	3	0	0	3
4	**PE**	19UCH925	Electrochemical Engineering	3	0	0	3
Professional Elective – III (VI Semester)							
1	**PE**	19UCH904	Food Science and Technology	3	0	0	3
2	**PE**	19UCH917	Data Science for Engineers	3	0	0	3
3	**PE**	19UCH911	Solid Waste Management	3	0	0	3
4	**PE**	19UCH923	Extractive Metallurgy	3	0	0	3

5	**PE**	19UCH914	Bio Process Engineering	3	0	0	3
Professional Elective – IV (VII Semester)							
1	**PE**	19UCH908	Chemical Process Plant Safety	3	0	0	3
2	**PE**	19UCH905	Drugs and Pharmaceutical Technology	3	0	0	3
3	**PE**	19UCH906	Oil and Natural Gas Engineering	3	0	0	3
4	**PE**	19UCH926	Nuclear Science and Technology	3	0	0	3
Professional Elective – V (VII Semester)							
1	**PE**	19UCH924	Modern Separation Processes	3	0	0	3
2	**PE**	19UCH907	Computational Fluid Dynamics	3	0	0	3
3	**PE**	19UCH922	Nano Technology	3	0	0	3
4	**PE**	19UCH912	Alternative Energy Technology	3	0	0	3
5	**PE**	19UCH920	Fluidization Technology	3	0	0	3
Professional Elective – VI (VIII Semester)							
1	**PE**	19UCH913	Environmental Impact Assessment	3	0	0	3
2	**PE**	19UCH916	Process Optimization	3	0	0	3
3	**PE**	19UCH919	Quality Management for Chemical Engineers	3	0	0	3
4	**PE**	19UCH918	Pilot Plant and Scale Up studies	3	0	0	3

OPEN ELECTIVE (OE)

S.NO	COURSE CATEGORY	COURSE CODE	COURSE TITLE	L	T	P	C
V Semester							
1	**OE - I**	19UCH951	Corrosion Science and Engineering	3	0	0	3
VI Semester							
2	**OE - II**	19UCH952	Energy Storage Systems	3	0	0	3
VII Semester							
3	**OE - III**	19UCH953	Industrial Waste Management	3	0	0	3
VIII Semester							
4	**OE - IV**	19UCH954	Waste to Energy Conversion	3	0	0	3
						TOTAL	**12**

LIST OF EMPLOYABILTY COURSES

S. NO	COURSE CODE	COURSE TITLE	CATEGORY	L	T	P	C
1	19UMA102	Engineering Mathematics –I	**BS**	3	1	0	4
2	19UPH103	Engineering Physics	**BS**	3	0	0	3
3	19UCY104	Engineering Chemistry	**BS**	3	0	0	3
4	19UCS108	Problem Solving and Python Programming	**ES**	3	0	0	3
5	19UME109	Engineering Graphics	**ES**	3	1	0	4
6	19UGS112	Basic Sciences Laboratory	**BS**	0	0	2	1
7	19UME111	Engineering Practices Lab	**ES**	0	0	3	1.5
8	19UCS110	Problem Solving and Python Programming Lab	**ES**	0	0	3	1.5
9	19UGM131	Induction Programme	**HS**	0	0	0	0
10	19UMA207	Calculus, Complex Analysis, Transform Techniques	**BS**	3	1	0	4
11	19UPH203	Material Physics	**BS**	3	0	0	3
12	19UCY204	Environmental Science	**BS**	3	0	0	3
13	19UCH205	Introduction to Chemical Engineering	**PC**	3	0	0	3
14	19UEE226	Basic Electrical and Electronics Engineering	**ES**	3	0	0	3

15	19UGS210	Energy Science and EVS Lab	**BS**	0	0	3	1.5
16	19UEE221	Basic Electrical and Electronics Engineering Lab	**ES**	0	0	3	1.5
17	19UMA326	Transform Techniques and Partial Differential Equations	**BS**	3	1	0	4
18	19UCH302	Process Chemistry	**ES**	3	0	3	4.5
19	19UCH303	Heat Power Engineering	**PC**	3	0	0	3
20	19UCH304	Fluid Flow Operations	**PC**	2	1	3	4.5
21	19UCH305	Chemical Process Calculations	**PC**	2	1	0	3
22	19UCH306	Engineering Materials for Process Industries	**PC**	2	0	0	2
23	19UGM332	Biology for Engineering Applications	**BS**	2	0	0	0
24	19UMA423	Numerical Methods	**BS**	3	1	0	4
25	19UCH402	Chemical Engineering Thermodynamics	**PC**	2	1	0	3
26	19UCH403	Heat Transfer	**PC**	2	1	3	4.5
27	19UCH404	Mechanical Operations	**PC**	3	0	3	4.5
28	19UCH405	Chemical Process Industries	**PC**	3	0	0	3
29	19UCH406	Mass Transfer – I	**PC**	2	1	0	3
30	19UCH409	Seminar	**P**	0	0	2	1
31	19UCH502	Mass Transfer – II	**PC**	2	1	0	3
32	19UCH503	Chemical Reaction Engineering - I	**PC**	2	1	0	3

33	19UCH508	Chemical Reaction Engineering Lab	**PC**	0	0	3	1.5
34	19UCH509	Mass Transfer Lab	**PC**	0	0	3	1.5
35	19UCH601	Chemical Reaction Engineering - II	**PC**	2	1	0	3
36	19UCH602	Process Instrumentation Dynamics and Control	**PC**	2	1	3	4.5
37	19UCH603	Process Equipment Design	**PC**	3	1	0	4
38	19UCH607	Process Computation Lab	**PC**	0	0	3	1.5
39	19UCH701	Transport Phenomena	**PC**	3	1	0	4
40	19UCH702	Process Modeling and Simulation	**PC**	3	1	0	4
41	19UCH708	Process Design and Simulation Lab	**PC**	0	0	3	1.5
42	19UCH901	Petroleum Refinery Engineering	**PE**	3	0	0	3
43	19UCH902	Polymer Technology	**PE**	3	0	0	3
44	19UCH903	Fertilizer Technology	**PE**	3	0	0	3
45	19UCH906	Oil and Natural Gas Engineering	**PE**	3	0	0	3
46	19UCH908	Chemical Process Plant Safety	**PE**	3	0	0	3
47	19UCH909	Air Pollution and Control	**PE**	3	0	0	3
48	19UCH910	Waste Water Treatment and Recycling	**PE**	3	0	0	3
49	19UCH913	Environmental Impact Assessment	**PE**	3	0	0	3
50	19UCH914	Bio Process Engineering	**PE**	3	0	0	3
51	19UCH916	Process Optimization	**PE**	3	0	0	3
52	19UCH918	Pilot Plant and Scale Up studies	**PE**	3	0	0	3
53	19UCH920	Fluidization Technology	**PE**	3	0	0	3

54	19UCH921	Instrumental Methods of Analysis	**PE**	3	0	0	3
55	19UCH922	Nano Technology	**PE**	3	0	0	3
56	19UCH923	Extractive Metallurgy	**PE**	3	0	0	3
57	19UCH924	Modern Separation Processes	**PE**	3	0	0	3
58	19UCH925	Electrochemical Engineering	**PE**	3	0	0	3
59	19UCH926	Nuclear Science and Technology	**PE**	3	0	0	3

LIST OF ENTREPRENEURSHIP COURSES

S. NO	COURSE CODE	COURSE TITLE	CATEGORY	L	T	P	C
1	19UCH501	Process Economics and Management	**HS**	3	0	0	3
2	19UCH904	Food Science and Technology	**PE**	3	0	0	3
3	19UCH905	Drugs and Pharmaceutical Technology	**PE**	3	0	0	3
4	19UCH907	Computational Fluid Dynamics	**PE**	3	0	0	3
5	19UCH911	Solid Waste Management	**PE**	3	0	0	3
6	19UCH912	Alternative Energy Technology	**PE**	3	0	0	3
7	19UCH915	Fermentation Technology	**PE**	3	0	0	3
8	19UCH919	Quality Management for Chemical Engineers	**PE**	3	0	0	3

LIST OF SKILL AND DEVELOPMENT COURSES

S. NO	COURSE CODE	COURSE TITLE	CATEGORY	L	T	P	C
1	19UEN101	English for Technical Communication	**HS**	2	0	0	2
2	19UEN201	Communication Skills for Professionals	**HS**	0	0	2	1.5
4	19UGM431	Gender Equality	**HS**	1	0	0	0
5	19UGS431	Reasoning and Quantitative Aptitude	**BS**	0	0	2	1
6	19UGM507	Creative Thinking and Innovation	**HS**	1	0	0	1
7	19UGS533	Interpersonal Skills Lab	**HS**	0	0	3	1.5
8	19UGM635	Indian Constitution	**HS**	0	0	1	0
9	19UGS632	Soft Skills and communication Lab	**HS**	0	0	3	1.5
10	19UCH609	Technical Project and Product Development	**P**	0	0	8	4
11	19UGM731	Professional Ethics and Human Values	**HS**	2	0	0	2
12	19UME701	Project Management and Finance	**HS**	3	0	0	3
13	19UCH709	Summer Internship	**P**	0	0	2	1
14	19UCH803	Project Work	**P**	0	0	16	8

INTERDISCIPLINARY COURSE

S.NO	COURSE CATEGORY	COURSE CODE	COURSE TITLE	CREDITS	OFFERING DEPARTMENT
1.	**Interdisciplinary**	19UCH954	Waste to Energy Conversion	3	**CHEMICAL** and CIVIL
2.	**Interdisciplinary**	19UCH917	Data Science for Engineer	3	**CHEMICAL** AND CSE

ONE CREDIT COURSES

S. NO	COURSE CATEGORY	COURSE CODE	COURSE NAME	CREDITS
1.	**OC**	19UCH861	MATLAB for Chemical Engineering	1
2.	**OC**	19UCH862	Simulation on Process Fundamentals	1
3.	**OC**	19UCH863	Sugarcane Processing and its Products	1
4.	**OC**	19UCH864	Dry Cement Manufacturing Process	1
5.	**OC**	19UCH865	Reclamation of Waste Lubricating Oils and its Products.	1
6.	**OC**	19UCH866	Pollution Control Engineering	1
7.	**OC**	19UCH867	Enzymes for Environmental Applications	1
8.	**OC**	19UCH868	Reclamation of Press Mud Wax	1
9.	**OC**	19UCH869	Sensors for Air Pollution	1
10.	**OC**	19UCH870	Waste Recycling from Pulp and Textile Mills	1
11.	**OC**	19UCH871	Membrane Technology	1
12.	**OC**	19UCH872	Pyrotechnics	1

19UEN101 – ENGLISH FOR TECHNICAL COMMUNICATION

(Common to All Branches except CSBS) **L T PC**
2 0 0 2

OBJECTIVES:

- To enhance the vocabulary of students
- To strengthen the application of functional grammar and basic skills
- To improve the language proficiency of students

UNIT I **8**

Listening –Formal and informal conversations and comprehension. **Speaking-** introducing oneself – exchanging personal and social information-**Reading** – Skimming and Scanning. **Writing–**Sentence Formation, Formal Letters (Permission/Requisition) - **Grammar** - Parts of Speech - Tense - **Vocabulary Development** – Technical Word Formation- Prefix- suffix - Synonyms and Antonyms-Phrases and Clauses.

UNIT II **8**

Listening– Telephonic Conversations**. Speaking**– Pronunciation rules with Stress pattern. **Reading** – comprehension-pre-reading, post-reading- comprehension questions **Writing** – Punctuation rules, paragraph writing- topic sentence- main ideas- free writing, short narrative descriptions, Precise writing, Developing Hints - Report Writing (Industrial, Accident)- **Grammar** – Voice **Vocabulary Development**- Words from other languages in English.

UNIT III **7**

Listening – Motivational speech by Great Speakers **Speaking**–Narrating daily events - retelling short stories. **Reading** – Newspaper reading. **Writing** – Job application letter - Transformation of Information (Transcoding)–**Grammar** Subject-Verb Agreement (Concord),— **Vocabulary Development –**Same word in different parts of speech

UNIT IV **7**

Listening – Understating the instruction. **Speaking**-Intonation and preparing dialogue on various formal and informal situation **Reading** –Note Making from given text - **Writing**– Creating coherence, Essay writing with proper introduction and conclusion, Giving Instruction (Guidance/Procedure) -**Grammar**–Spot the Errors in English, **Vocabulary Development**– One word substitution.

TOTAL = 30 PERIODS

COURSE OUTCOMES

After successful completion of this course the students will be able to:

- Apply grammar effectively in writing meaningful sentences and paragraphs.
- Exhibit reading skills and comprehension to express the ideas in the given text.
- Develop writing skills to present the ideas in various formal situations.
- Develop oral fluency to express the ideas in various formal situations.
- Exhibit writing skills to prepare reports for various purposes.

TEXT BOOK:

KN Shoba, Lourdes Joavani Rayen, **Communicative English,** New Delhi, Cambridge University Press, 2017

REFERENCE BOOKS:

1. Raman, Meenakshi, Sangeetha Sharma, **Business Communication**, New Delhi, Oxford University Press, 2014.

2. Lakshminarayanan.K.R, **English for Technical Communication**, Chennai, Scitech Publications (India) Pvt. Ltd, 2004.

3. Rizvi. Asraf M, **Effective Technical Communication**, New Delhi, Tata McGraw-Hill Publishing Company Limited, 2007.

19UMA102 **ENGINEERING MATHEMATICS – I**

(Common to All Branches-Except CSBS) L T PC
3 1 0 4

OBJECTIVES:

- To make the students capable of identifying linear equations based problems (Eigen Value) from practical areas and obtain the Eigen value oriented solutions in certain cases.
- To widen the students' knowledge base on linear algebra, growth rate computation and application of integrals.
- Able to integrating various types of functions using various integration methods.
- To familiarize the students with the basic rules of differentiation and use them to find derivatives of products and quotients of functions
- To apply these mathematical concepts (matrix theory, differentiation and integration) in engineering field.

UNIT I : MATRICES **8 + 3**

Eigen value and eigenvector of a real matrix – Characteristic equation – Properties – Cayley-Hamilton theorem (excluding Proof) – Orthogonal reduction – (transformation of a symmetric matrix to diagonal form) – Quadratic form – Reduction of quadratic form to canonical form by orthogonal transformation

UNIT II : DIFFERENTIAL CALCULUS **9 + 3**

Introduction – Definition of derivatives – Limits and Continuity – Differentiation techniques (Product rule, Quotient rule, Chain rule) – Successive differentiation (n^{th} derivatives) – Leibnitz theorem (without proof) – Maclaurin's series – Physical Applications (Newton's law of cooling– Heat flow problems, Rate of decay of radioactive materials - Chemical reactions and solutions, Ohm's law, Kirchoff's law – Simple electric circuit problems)

UNIT III : FUNCTIONS OF SEVERAL VARIABLES **9 + 3**

Partial derivatives – Euler's theorem for homogenous functions – Total derivatives – Differentiation of implicit functions – Jacobian – Taylor's expansion – Maxima and Minima – Method of Lagrangian Multipliers.

UNIT IV : INTEGRAL CALCULUS **8 + 3**

Definitions and concepts of integrals – Methods of integration (Decomposition method, Substitution method, Integration by parts) – Definite integrals – Properties and problems – Reduction formulae – Beta and Gamma functions.

UNIT V : MULTIPLE INTEGRALS **8 + 3**

Double integration – Cartesian and Polar coordinates – Change of order of integration – Area as a double integral - Change of variables between Cartesian and Polar coordinates – Triple integration in Cartesian coordinates – Volume as triple integral.

SUPPLEMENT TOPIC (for internal evaluation only) **3**

Evocation /Application of Mathematics, Quick Mathematics – Speed Multiplication and Division Applications of Matrices.

TOTAL : 45 (L) + 15 (T) = 60

COURSE OUTCOMES:

After the successful completion of this course, the student will be able to

- Compute Characteristic Equation, Characteristic roots and use the applicability of Cayley – Hamilton theorem to find the Inverse of matrix which is very important in Engineering and applications.(CO1) AP – K3.
- Determine the limit of indiscriminate functions applicable to word problems and Engineering problems.(CO2) AP – K3
- Analyze functions using limits, continuity and derivatives to solve problems involving these functions.(CO2) AP – K3
- Apply Differentiation techniques to solve Maxima and Minima for given functions with several variables.(CO3) AP – K3
- Use the Lagrange multiplier method to predict extreme values of functions with constraints and to find the absolute maximum and minimum of a function on different domains.(CO3) AP – K3
- Learn the evaluation policy of some special function like Gamma, Beta function and their relation which is helpful to evaluate some definite integral arising in various branch of Engineering.(CO4) AP – K3
- Apply integration to compute Multiple integrals, Area and Volume in addition to change of order and change of variables.(CO5) AP – K3
- Demonstrate basic concepts and to solve the complex Engineering problems using Matrix, Differentiation and Integration.(CO1, 2, 4) AP – K3

TEXT BOOKS:

1. BALI N. P and MANISH GOYAL, "A Text book of Engineering Mathematics", Laxmi Publications (P) Ltd, New Delhi, 8th Edition, (2011).
2. VEERARAJAN.T "Engineering Mathematics" Tata McGraw Hill Publishing Company, New Delhi, 2008.
3. GREWAL. B.S, "Higher Engineering Mathematics", Khanna Publications, New Delhi, 42nd Edition, (2012).

REFERENCE BOOKS:

1. RAMANA B.V, "Higher Engineering Mathematics", Tata McGraw Hill Publishing Company, New Delhi, 11th Reprint, (2010).
2. GLYN JAMES, "Advanced Engineering Mathematics", Pearson Education, New Delhi, 7th Edition, (2007).
3. JAIN R.K and IYENGAR S.R.K," Advanced Engineering Mathematics", Narosa Publishing House, New Delhi, 3rd Edition, (2007).
4. BHARATI KRISHNA TIRTHAJI, "Vedic Mathematics - Mental Calculation", Motilal Banarsi Dass Publications, New Delhi, 1st Edition, (1965).

5. KREYSZIG. E, “Advanced Engineering Mathematics”, John Wiley & Sons, New York, 10th Edition, (2011).
6. P.SIVARAMAKRISHNA DAS, E.RUKMANGADACHARI “Engineering mathematics”, volume 1, Pearson Edison New Delhi, 2nd Edition, (2013).

19UPH103 - ENGINEERING PHYSICS

(Common to All Branches-Except CSBS)

L T P C
3 0 0 3

OBJECTIVES:

- To develop the research interest in crystal physics
- To use the principles of Lasers and its types
- To apply principles of Quantum physics in engineering field
- To develop knowledge on properties of materials

UNIT I : CRYSTAL STRUCTURE **12**

Introduction – Classification of solids –Space lattice –Basis-Lattice parameter – Unit cell – Crystal system –Miller indices –d-spacing in cubic lattice - Calculation of number of atoms per unit cell – Atomic radius-Coordination number – Packing factor for SC, BCC, FCC and HCP structures – crystal imperfection –Point defects-Line defects-Surface defects-Volume defects Burger vector.

UNIT II : PHOTONICS **10**

Introduction- Principles of Laser- Characteristics of laser -Spontaneous and stimulated emission –Population inversion – Einstein's A and B coefficients - Pumping methods – Basic components of Laser - Types of lasers – Nd -YAG laser - CO_2 laser –Holography –Construction and Reconstruction of hologram – Industrial and Medical Applications.

UNIT III : QUANTUM MECHANICS **13**

Introduction - Black body radiation – Planck's law of radiation - Wien's displacement law-Rayleigh Jeans law-– Compton Effect – Theory and experimental verification – Matter waves-Schrodinger's wave equation – Time dependent – Time independent equation – Particle in 1-D dimensional box

UNIT IV : PROPERTIES OF SOLIDS **10**

Introduction - Elasticity- Stress and Strain - Hooke's law – Three moduli of elasticity –stress-strain curve – Poisson's ratio –Factors affecting elasticity –Bending moment – Depression of a cantilever –Young's modulus byuniform bending –I- shaped girders.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

After the successful completion of this course, the student will be able to

CO1: Identify the seven types of crystal structures and illustrate unit cell characteristics and crystal defect [Understand]
CO2: Compare the different types of lasers and analyse the role of lasers in medical and industrial applications [Understand]
CO3: Apply the wave and particle nature of matter using Quantum mechanics [Apply]
CO4: Describe the elastic behavior of various materials. [Understand]
CO5: Apply fundamental knowledge to solve Engineering problems [Apply]
CO6: Apply the theory for the analysis of mechanical and optical properties of solids [Apply]

TEXT BOOKS:

1. Dr. Mani.P, "Engineering Physics", Dhanam Publications, Edition ,2018, Chennai.
2. Rajendran.V, "Engineering,Physics", Tata Mc-Graw Hill Publishing Companylimited, New Delhi, Revised Edition 2018.
3. Palanisami P.K., "Physics For Engineers", Scitech Publications (India), Pvt Ltd., Chennai, 2018.

REFERENCE BOOKS:

1. Raghuvenshi G.S., "Engineering Physics", PHI Learning Private Limited, New Delhi, Revised Edition 2018.
2. Arul doss .G., "Engineering Physics", PHI Learning Limited, New Delhi, Revised Edition 2018.
3. Marikani .A., "Engineering Physics", PHI Learning Private Limited, New Delhi, Revised Edition 2017.
4. Sankar B.N., and Pillai .S.O., "A Text book of Engineering Physics", New Age International Publishers Private Limited, New Delhi, Revised Edition 2017.
5. Avadhanulu M.N. and Kshirsagar P.G., "A Textbook: of Engineering Physics", S.Chand & Company Ltd., New Delhi, 2018.

19UCY104 - ENGINEERING CHEMISTRY

(Common to Mechanical & Chemical Engineering) **L T PC**
3 0 0 3

OBJECTIVES:

- To gain the knowledge on Chemical bonding and types.
- To acquire on basic chemical reactions.
- To make the students conversant with boiler feed water requirements related problems and water treatment techniques.
- To understand the principles and control methods of corrosion.

UNIT I: CHEMICAL BONDING **11 Hrs**

Chemical Bonding: Electronic Configuration– Ionic Bond - Covalent Bond – Metallic bond –Aufbau principle, Pauli Exclusion principle, Valence bond theory applications and its limitations, Various types of hybridization (sp, sp^2,sp^3) (C_2H_2, C_2H_4, CH_4) -bond strength and bond energy - Hydrogen bonding, Vander Waals forces.

UNIT II: BASIC CHEMICAL REACTION ANDCHEMICAL KINETICS **11 Hrs**

Study of basic types of reaction- Displacement and Redox Reactions – Basic properties of Acids, Bases andSalt.

Chemical Kinetics: Basic definitions, Differential equation view of rate - Rate constant, Rate law - Reaction order 1^{st} and 2^{nd} order kinetics - Determination of kinetics from rate laws, Half-life.

UNIT III: WATER AND ITSTREATMENT TECHNOLOGIES **11 Hrs**

Hardness of water – types – expression of hardness (Problems) – units – estimation of hardness of water by EDTA– boiler troubles (scale and sludge) – Internal treatment (phosphate, colloidal, sodium aluminate and calgon conditioning) – External treatment-Ion exchange process- zeolite process – desalination of brackish water – Reverse Osmosis.

UNIT IV: CORROSION AND ITS PREVENTION TECHNIQUES **12 Hrs**

Introduction- Definition- Types –Chemical corrosion (Dry corrosion, mechanism and its Example)-Electrochemical corrosion (Wet corrosion, mechanism and its Types – Galvanic & Differential aeration Corrosion- Pitting, crevice & Wire fence corrosion). Corrosion prevention - Cathodic protection and Protective coatings – Paint, Electro plating – Gold plating.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

After the successful completion of this course, the student will be able to

- Describe the fundamental concepts of chemical bonds. (Understand)
- Explain the basic chemical reaction and chemical kinetics of first and second order reaction. (Understand)
- Apply the knowledge of water treatment techniques to remove the hardness of water. (Apply)

- Explain the concept of corrosion and the prevention techniques. (Understand)

TEXT BOOKS:

1. Jain P.C. and Monica Jain, "Engineering Chemistry", DhanpatRai Publishing Company (P)Ltd., New Delhi, 2010
2. Dr.Sunita Rattan, "A Textbook of Engineering Chemistry" S.K.Kataria& Sons., New Delhi,2013.
3. Pradeep. T "A textbook of Nanoscience and Nanotechnology", Tata McGraw - Hill education private ltd, 2012.

REFERENCE BOOKS:

1. Physical chemistry – Samuel Glasstone, Macmillan II edition, 1969.
2. Physical Chemistry – P.L. Sony, Sulthan Chand & Sons, Delhi - 6.
3. A. K. Kaw, Mechanics of Composite Materials, CRC Press, New Delhi 2005.
4. S. C. Sharma, Composite materials, Narosa Publications, New Delhi, 2000.

19UCS108 - PROBLEM SOLVING AND PYTHON PROGRAMMING

(Common to ALL Branches-Except CSBS) **L T PC**
3 0 0 3

OBJECTIVES:

- To impart the concepts in problem solving for computing
- To familiarize the logical constructs of programming
- To illustrate programming in Python.

UNIT I: INTRODUCTION **9**

Definition and basic organization of computers – classification of computers – Software – Types of software – types of programming paradigms - Translators: compiler and interpreter – Problem solving tools: Algorithms – Flowchart – Pseudo code.

UNIT II: INTRODUCTION TO PYTHON **9**

Introduction to python – features of python – modes of working with python. Values and data types: numbers, Boolean, strings; variables, expressions, statements, tuple assignment, precedence of operators, comments – print function- conversion of algorithm in to program – Solving simple problems involving arithmetic computations and sequential logic to solve.

UNIT III: CONTROL CONSTRUCTS **9**

Flow of execution – control structures: conditional (if), alternative (if-else), chained conditional (if-elif-else); Iteration: state, while, for, break, continue, pass – Solving problems involving decision making and iterations

UNIT IV: FUNCTIONS AND PACKAGES **9**

Functions - function definition and use, flow of execution, parameters and arguments; parameters, local and global scope, function composition-Anonymous or Lambda Function, recursion -packages.

UNIT V: LISTS, TUPLES, DICTIONARIES AND STRINGS **9**

Lists: list operations, list slices, list methods, list loop, mutability, aliasing, cloning lists, listparameters; Tuples: tuple assignment, tuple as return value; Dictionaries: operations and methods; advanced list processing - list comprehension - Strings: string slices; immutability, string functions and methods, string module

TOTAL: 45 PERIODS

COURSE OUTCOMES:

After the successful completion of this course, the student will be able to

- Utilize problem solving tools in solving computing problems [Apply]
- ·Solve mathematical expressions involving sequential logic in python [Apply]
- Solve problems using python using decision structure and looping constructs [Apply]
- Write modular programs using functions and packages [Apply]
- Manipulate data using List, Tuples, Dictionaries and strings [Apply]

TEXT BOOKS:

1. Ashok NamdevKamthane& Amit Ashok Kamthane, "Problem solving and python programming", McGraw Hill Education, 2018 (copyright)
2. Anurag Gupta & G P Biswas, "Python Programming – Problem solving, packages and libraries", McGraw Hill Education, 2020 (copyright).

REFERENCE BOOKS:

1. John V Guttag, " Introduction to Computation and Programming Using Python", Revised and expanded Edition, MIT Press , 2013
2. Robert Sedgewick, Kevin Wayne, Robert Dondero, "Introduction to Programming in Python: An Inter-disciplinary Approach, Pearson India Education Services Pvt. Ltd., 2016.
3. Timothy A. Budd, "Exploring Python||, Mc-Graw Hill Education (India) Private Ltd., 2015.
4. Kenneth A. Lambert, "Fundamentals of Python: First Programs||, CENGAGE Learning, 2012.
5. Charles Dierbach, " Introduction to Computer Science using Python: A Computational ProblemSolving Focus, Wiley India Edition, 2013.
6. Paul Gries, Jennifer Campbell and Jason Montojo, "Practical Programming: An Introduction to Computer Science using Python 3||, Second edition, Pragmatic Programmers, LLC, 2013.

19UME109 - ENGINEERING GRAPHICS

(Common to ALL Branches Except CSBS) **L T PC**

3 1 0 4

OBJECTIVES:

- To develop student's graphic skill for communication of concepts, ideas and design of engineering products and expose them to existing national standards related to technical drawings.
- To impart knowledge in development of surfaces and isometric projections.

CONCEPTS AND CONVENTIONS (NOT FOR EXAMINATION) **4**

Importance of Graphics in Engineering Applications – Use of Drafting Instruments – BIS Conventions and Specifications – Size, Layout and Folding of Drawing Sheets – Lettering and Dimensioning-Introduction to Plane Curves, Projection of Points, Lines and Plane Surfaces

UNIT I: PROJECTION OF SOLIDS **12**

Projection of simple solids like prisms, pyramids, cylinder and cone with axis is parallel, perpendicular and inclined to one of the plane.

UNIT II: SECTION OF SOLIDS **10**

Section of solids - simple position with cutting plane parallel, perpendicular and inclined to one of theplane.

UNIT III: DEVELOPMENT OF SURFACES **10**

Development of lateral surfaces of simple and truncated solids - Prisms, pyramids, cylinders and cones - Development of lateral surfaces of sectioned solids.

UNIT IV: ISOMETRIC PROJECTIONS **12**

Principles of isometric projection – isometric scale – isometric view - isometric projectionsof simple solids and cut solids.

UNIT V: ORTHOGRAPHIC PROJECTION **12**

Representation of Three Dimensional objects – General principles of orthographic projection-Need for importance of multiple views and their placement – First angle projection – layout views –Developing visualization skills of multiple views (Front, top and side views) from pictorial views of objects

TOTAL 45 (L) + 15 (T) = 60 PERIODS

COURSE OUTCOMES:

After the successful completion of this course, the student will be able to

- Apply the knowledge of First angle projection to draw the projection of different solids.(Apply)
- Draw the section of solids with true shape of the section. (Apply)
- Draw the development of lateral surface of regular and sectioned solids.(Apply)

- Draw the isometric of simple solids and sectioned solids.(Apply)
- Sketch the orthographic views from the given pictorial (isometric) view.(Apply)

TEXT BOOKS:

1. Natarajan K.V., "A Text book of Engineering Graphics", Dhanalakshmi Publishers, (2006).
2. Bhatt N.D., "Engineering Drawing", Charotar Publishing House,(2012).

REFERENCE BOOKS:

1. Venugopal K., and Prabhu Raja V.,"Engineering Graphics", New Age International (P) Limited,(2008).
2. Gopalakrishnan K.R., "Engineering Drawing" (Vol.I&II), 23rd Edition, Subhas Publications.(2012).
3. DhananjayA.Jolhe,"Engineering Drawingwith an introduction to Auto CAD", Tata McGraw Hill Publishing Company Limited,(2012).
4. Saravanan M, Bensan Raj J, Ganesh Kumar S, " Engineering Graphics", JBR Trisea Publishers, Nagercoil, 2020

19UGM131 - INDUCTION PROGRAMME

(Common to ALL Branches)

L T P C
0 3 0 0

OBJECTIVES:

- To rejuvenate the Body and Mind
- To strengthen Attitude and soft skills
- To practice Moral values of life.

UNIT-I : PHYSICAL ACTIVITY **10Hrs**

Zumba-Bokwa Fitness – Yoga – Mediation – Fine Arts

UNIT-II : CREATIVE ARTS

Painting – Class Painting – Wall Painting – Art from waste **5Hrs**

UNIT-III : UNIVERSAL HUMAN VALUES & EMINENT SPEAKERS **5Hrs**

Ethical values – Ambition and Family Expectation, Gratitude, Competition and Excellence– Belief – Morality of life – Guest Lecture by Eminent personality

Unit-IV : LITERARY

Elocution - Essay writing Competition - Impromptu Session - Dance and singing competition

Unit-V : PROFICIENCY MODULES **15Hrs**

Toastmaster club meet

Unit-VI : INDUSTRIAL & LOCAL VISIT **8Hrs**

Vaigai Dam – Theni - VOC- Port-Tuticorin - Madurai Radio City-Madurai - Aavin Milk –Madurai-NSS Activities.

Unit-VII : FAMILIARIZATION OF THE DEPARTMENT AND INNOVATION **2Hrs**

Department Introduction and Purpose of Course - Eminent speakers – Scope and Feature of the Course - Latest Innovation

Total = 45 periods

(3 Weeks Model curriculum As per AICTE)

COURSE OUTCOMES:

After the successful completion of this course, the student will be able to

- Practice physical activities regularly.
- Implement creativity in drawing and waste material.
- Communicate their ideas effectively.
- Identify inputs and outputs of different industry process.
- Describe the scope and features of their programme of study.

Reference Book:

- Student Induction Programme: A Detailed Guide by AICTE, New Delhi.

19UCS110 - PROBLEM SOLVING AND PYTHON PROGRAMMING LABORATORY

(Common to ALL Branches except CSBS)

L T P C
0 0 3 1.5

OBJECTIVES:

- To familiarize with programming environment
- To familiarize the implementation of programs in Python

LIST OF EXPERIMENTS

Problems involve Sequential logic and Decision Making

1. Write a Python program to process the mark processing system (Record has the following Fields: Name, Reg_no, Mark1, Mark2, Mark3, Mark4, Total, average). Print the student details and find the total and average mark.

2. Write a Python program to compute the +2 Cutoff mark, given the Mathematics, physics and Chemistry marks. Acollege has decided to admit the students with a cut off marks of 180. Decide whether the student is eligible to get an admission in that college or not.

3. Apizza in a circular shape with 8 inches and which is placed in a square box whose side length is 10 inches. Find how much of the box is "empty"?

4. A person owns an air conditioned sleeper bus with 35 seating capacity that routes between Chennai to Bangalore. He wishes to calculate whether the bus is running in profit or loss state based on the following scenario:

- Amount he spent for a day for diesel filling is: Rs. 15,000
- Amount he spent for a day for Driver and cleaner beta is: Rs. 3,000
- Ticket amount for a Single person is Rs: 950
- If all the seats are filled, what would be the result?
- If only 15 seats are filled, what would be the result?

5. Consider the person 'X' has some amount in his hand and the person 'Y' has some amount in his hand. If they wish to exchange the amount among them, how they can exchange the amount by using the third party 'Z'.

Problems involve iterations

6.Aman is blessed with a duck that can lay golden eggs. First day it lays one egg, in second day it lays two eggs, in third day it lays three eggs, and it continues to lay eggs in an incremental manner dayby day. Now calculate how many golden eggs that duck lays till 'n'th day.

7.Four People A,B,C,D are sitting in a Circular arrangement. In how many ways their seating can be arranged.

8.The Greek theater shown at the right has 30 seats in the first row of the center section. Each row behind the first row gains two additional seats. How many seats are in the 5th row in the center section?

Problem involve functions and recursive functions

9. Write a program that accepts the lengths of three sides of a triangle as inputs. The program output should indicate whether or not the triangle is a right triangle. (Recall from the Pythagoras theorem that in a right triangle, the square of one side equals the sum of the squares of other two sides)

10. Agame has to be made from marbles of five colors, yellow, blue, green, red and Violet where five marbles has to be kept one upon another. Write a python program using recursion, to find how many ways these marbles can be arranged.

11. Tower of Hanoi is a mathematical puzzle where we have three rods and n disks. The objective of the puzzle is to move the entire stack to another rod, obeying the following simple rules: Here is a high-level outline of how to move a tower from the starting pole, to the goal pole, using an intermediatepole:

1. Move a tower of height-1 to an intermediate pole, using the final pole.
2. Move the remaining disk to the final pole.
3. Move the tower of height-1 from the intermediate pole to the final pole using original pole

Problems involve fitness and Nested List

12. In a class of 50 numbers of students, 6 students are selected for state cricket academy. Sports faculty of this school has to report to the state cricket academy about the selected students' physical fitness. Here is one of the physical measures of the selected students'; Height in cm is given for those 6 selected students [153,162,148,167,175,151]. By implementing functions, do the following operations.

(i) State academyselector has to check whether the given height is present in the selected students list or not.
(ii) State academy selector has to order the height of students in an incremental manner.
(iii) State academyselector has to identify the maximum height from the list.

Problems involve Dictionary and Tuples

Dictionary

13. A university wishes to create and maintain the details of the students such as Rollno, Regno, Name, Dept, Batch, Contact_no, Nativity(Indian/NRI) as key value pairs. Do the following operations:

(i) Display the complete student details on giving Rollno as input.
(ii) Display the complete student details whose nativity belongs to NRI.
(iii) Display the complete student details whose department is CSE.

Tuples

14. A librarian wishes to maintain books details such as ISBN, Book Name, Author Name, Year published, Publisher Name. He wishes to retrieve the book details in the following scenario:

(i) Retrieve the complete details of the book on giving ISBN.
(ii) Retrieve the details of the book which published after the year 2015.
(iii) Retrieve the details of the book whose author name is 'Andrew'.
(iv) Retrieve the details of the book that name of the book is 'Python'

Problems involve Strings

15. A musical album company has 'n' number of musical albums. The PRO of this company wishes to do following operations based on some scenarios:

(i) Name of the album starts with's'or'S'.
(ii) Name of the album which contains 'jay' as substring.
(iii) Check whether the album name presents in the repository or not.
(iv) Count number of vowels and consonants in the given album name.

TOTAL: 45 Periods

COURSE OUTCOMES:

After the successful completion of this course, the student will be able to

- Formulate algorithms for simple problems and translate the algorithms to a working program [Apply]
- Formulate algorithms and programs for arithmetic computations and sequential logic [Apply]
- Write iterative programs using control constructs[Apply]
- Develop programs using functions, packages and use recursion to reduce redundancy[Apply]
- Represent data using lists, tuples, dictionaries and manipulate them through a program [Apply]

HARDWARE/ SOFTWAREREQUIRED FORABATCHOF30 STUDENTS

HARDWARE
LAN SYSTEM WITH 30 NODES (OR) STANDALONE PCS – 30 NOS

SOFTWARE
OS – UNIX CLONE (License free Linux)
EDITOR – IDLE

19UME111 - ENGINEERING PRACTICES LABORATORY

(Common to Mech, EEE, Civil, Chemical and Agriculture)

L T P C
0 0 3 1.5

OBJECTIVES:

- To demonstrate the plumbing and carpentry works.
- To train the students to perform welding, fitting and drilling operations.
- To demonstrate residential house wiring, fluorescent lamp wiring, measurement of earth resistance, colour coding of resistors, logic gates and soldering.

GROUP - A (CIVIL & MECHANICAL)

CIVIL ENGINEERING PRACTICE

LIST OFEXPERIMENTS:

1) Studyof pipeline joints, its location and functions: valves, taps, couplings, unions, reducers, and elbows in household fittings.
2) Preparation of plumbing line sketches for water supply and sewage works.
3) Hands-on-exercise: Basic pipe connections–Mixed pipe material connection Pipe connections with different joining components.
4) Demonstration of plumbing requirements of high-rise buildings.
5) Studyof the joints in roofs, doors, windows and furniture.
6) Hands-on-exercise: Wood work, cutting, planning and joints bysawing –Half lap joint

MECHANICAL ENGINEERING PRACTICE

LIST OF EXPERIMENTS:

1) Preparation of arc welding of butt joints, lap joints and tee joints.
2) Drilling Practice.
3) Sheet metal model making – Trays, funnels, etc.
4) Different type of fittings-'V' type, 'L' Type
5) Studyof Lathe Machine tool.
6) Studyof Plastic Injection Moulding.
7) Study ofMoulding.

Aminimum of five experiments shall be offered in GROUP-A(CIVIL& MECHANICAL)

GROUP - B (ELECTRICAL & ELECTRONICS)

ELECTRICAL ENGINEERING PRACTICE

LIST OFEXPERIMENTS:

(a) Residential house wiring using switches, fuse, indicator, lamp and energy meter and Stair case wiring.
(b) Fluorescent lampwiring.
(c) Measurement of resistance to earth of electrical equipment.

ELECTRONICS ENGINEERING PRACTICE

LIST OF EXPERIMENTS:

(a) Studyof Electronic components and equipments – Resistor, colour coding measurement of AC Signal parameter (peak-peak, rms, period, frequency) using CRO.
(b) Studyof logic gates AND, OR, EX-OR and NOT Gate.
(c) Soldering practice – Components, Devices and Circuits – Using general purpose PCB.

Total: 45 Periods

COURSE OUTCOMES:

After the successful completion of this course, the student will be able to

- Apply the basic knowledge of plumbing to make simple house hold pipe line connections. (Apply)
- Fabricate the given components using carpentry, sheet metal, fitting & welding equipment/tools. (Understand)
- Perform the drilling operations. (Apply)
- Apply basic electrical engineering knowledge for house wiring practice. (Apply)
- Apply the knowledge of basic electrical engineering to practice soldering using general purpose PCB.(Apply)

EQUIPMENT REQUIREMENT

CIVIL ENGINEERING

Sl No.	Name of the Equipment	Quantity Required
1.	Assorted components for plumbing consisting of metallic Pipes, plastic pipes, flexible pipes, couplings, unions, Elbows, plugs and other fittings	5 Sets
2.	Carpentry vice (fitted to workbench)	15 Nos
3.	Standard working tools	15 Sets
4.	Models of industrial trusses, door joints, furniture joints	5 each
5.	Power tool rotary hammer	2 Nos
6.	Demolition hammers	2 Nos
7.	Planer	2 Nos
8.	Hand drilling machine	2 Nos
9.	Jigsaw	2 Nos

MECHANICAL ENGINEERING

Sl No.	Name of the Equipment	Quantity Required
1.	Arc welding transformer with cables and holders	5 Nos
2.	Welding booth with exhaust facility	5 Nos
3.	Welding accessories like welding shield, chipping hammer, wire brush, etc.	5 Sets
4.	Oxygen and acetylene gas cylinders, blow pipe and other welding Outfit	2 Nos
5.	Vice	5 Nos
6.	Hacksaw frame and blade	5 Nos
7.	Files	5 Nos
8.	Study-purpose items: Centre Lathe, pattern, cope & drag box and moulding tools	Each 1 No

ELECTRICAL ENGINEERING

Sl No.	Name of the Equipment	Quantity Required
1.	Assorted electrical components for house wiring	15 Sets
2.	Electrical measuring instruments	10 Sets
3.	Megger (250V/500V)	1 No
4.	Study purpose items: Iron box, fanand regulator, emergency lamp	One Each
5.	Power Tools: (a) Range Finder (b) Digital Live-wire detector	 2 Nos 2 Nos

ELECTRONICS ENGINEERING

Sl No.	Name of the Equipment	Quantity Required
1.	Logic trainer kit	2 Nos
2.	CRO, AFO	2 Each
3.	Small multipurpose PCBs	10 No
4.	Soldering guns	10 No
5.	Multimeters	5 No
6.	Assorted electronic components for making circuits	Required Quantity

19UGS112 - BASIC SCIENCES LABORATORY

(Common to All Branches-Except CSBS)

L	T	P	C
0	0	2	1

PHYSICS LABORATORY

OBJECTIVES:

- To create scientific Temper among the students.
- To know how to execute experiments properly, presentation of observations and arrival of conclusions.
- To view and realize the theoretical knowledge acquired by the students through experiments

LIST OF EXPERIMENTS
(Common to All Branches)

1. Laser – Determination of particle size and wavelength of Laser source. using DiodeLaser.
2. Ultrasonic Interferometer - Determination of velocity of sound and compressibility of liquid.
3. Poiseuille's method - Determination of Coefficient of viscosityof liquid.
4. Spectrometer – Determination of dispersive power of a prism.
5. Air Wedge method - Determination of thickness of a thin wire.
6. Uniform bending method – Determination of Young's modulus of the given rectangular beam.

• **Aminimum of FIVE experiments shall be offered**

TOTAL: 30 Periods

COURSE OUTCOMES:

After the successful completion of this course, the student shall be able to

- Apply the principles of Optics, Laser physics and Mechanics to determine the Engineering properties of materials (AP)
- Analyze the given liquid sample to determine the viscosity and compressibility of the liquid (AN)
- Apply the principles of spectroscopy to determine the properties using prism (AP)

CHEMISTRY LABORATORY

OBJECTIVES:

- To impart knowledge on basic concepts in applications of chemical analysis
- Train the students to handle various instruments.
- To acquire knowledge on the chemical analysis of various metal ions.

LIST OF EXPERIMENTS
(Common to All Branches-Except CSBS)

1. Preparation of molar and normal solutions of the following substances – Oxalic acid , Sodium Carbonate , Sodium Hydroxide and Hydrochloric acid
2. Conductometric Titration of strong acid with strong base
3. Conductometric Titration of Mixture of Acids
4. Estimation of Iron by potentiometry
5. Determination of Strength of given acid using pH metry
6. Determination of molecular weight of polymer by viscometry
7. Comparison of the electrical conductivity of two samples-conductometric method
8. Estimation of copper in brass by EDTA method

• A minimum of FIVE experiments shall be offered for every course

TOTAL: 30 Periods

COURSE OUTCOMES:

At the end of the course, the student will able to

- Prepare solutions on various concentrations. (Apply)
- Analyze the given solution quantitatively using chemical and electro analytical methods.(Analyze)
- Determine the amount molecular weight of the given substances.(Apply)

19UEN201 –Communication Skills for Professionals

L	T	P	C
1	1	0	1.5

OBJECTIVES:

- Improve their oral expression and thought
- Develop their confidence and ability to speak in public
- Develop their capacity for leadership

5 Oral Projects

Project 1: SELF INTRODUCTION & DELIVER A SPEECH BEFORE AUDIENCE (Time: 5 to 7 minutes)

To Speak in front of an audience with courage.

- Make your message clear, with supporting material.
- Create a strong opening and conclusion.

Project 2: SPEAK ON THE CHOSEN CONTENT (Time: 5 to 7 minutes)

- Select a general topic and bring out specific purposes.
- Avoid using notes.
- Use symbolic ideas to develop your ideas.

Project 3: USE EFFECTIVE BODY LANGUAGE & INTONATION (Time: 5 to 7 minutes)

- Use appropriate posture, gestures, facial expressions and eye contact to express your ideas.
- Use proper intonation and adequate speech module.

Project 4: PRESENT YOUR TOPIC WITH VISUAL AIDS (Time: 5 to 7 minutes)

- Persuade your points with suitable illustration, specific facts, examples
- Use suitable visual aids to present your topic with confidence.

Project 5: GRASP THE ATTENTION OF THE AUDIENCE (Time: 5 to 7 minutes)

- Influence your listeners by adopting holistic viewpoint.
- Use emotions, stories, and positive quotes in your speech.

Total Hours =30 periods

COURSE OUTCOME

After successful completion of this course the students will be able to:

CO-1	*Apply Language skills to write and speak effectively*	*C-K6*
CO-2	*Select the right words and sentence to communicate ideas clearly and accurately*	*C-K6*
CO-3	*Exhibit good postures and proper attire to present the ideas effectively*	*C-K6*
CO-4	*Present the ideas effectively using visual aids.*	*C-K6*
CO-5	*Communicate with clarity and present the ideas effectively to the audience*	*C-K6*

Reference Book:

1. Competent Communication- A Practical Guide to becoming a better speaker, Toastmasters International, USA.

2. Norman Lewis – Word Power Made Easy, Pocket Book Publication, 2019.

Internal and External Assessment plan
Internal Assessment plan

S.No	Criteria	Marks
1	Submission of 5 Project scripts	5x2= 10 marks
2	Prepared speech based on the Projects	5x5= 25 marks
3	Performance in other Roles 1.TMOD 2.Speech Evaluator 3.Table Topic Speaker and Master 4.General Evaluator 5.JIG and TAG Team member	5x3= 15 marks
	Total	**50 marks**

External Assessment plan

S.No	Criteria	Marks
Prepared speech based on the Toastmasters Projects (5-7 minutes)		
1	Confident, Eye Contact, Body Language	5 marks
3	Content and clarity	20 marks
4	Command over Language	15 marks
5	Error free language	10 marks
	Total	**50 marks**

Internal =50 marks
External =50 marks
Total =100 marks
Minimum Pass Mark =50 marks

19UMA207	**CALCULUS, COMPLEX ANALYSIS AND TRANFORM TECHNIQUES (COMMON TO CHEMICAL, AGRI, BIO MED AND BIO TECH)**	**L**	**T**	**P**	**C**
		3	**1**	**0**	**4**

OBJECTIVES :

- To develop an understanding of the basics of vector calculus comprising of gradient, divergence and curl, and line, surface and volume integrals and the classical theorems involving them.
- To acquaint the student with the concepts of analytic functions and their interesting properties which could be exploited in a few engineering areas, and be introduced to the host of conformal mappings with a few standard examples that have direct application.
- To make the student to acquire sound knowledge of Laplace transform techniques and its applications in getting the solution of certain linear differential equations

UNIT I SOLUTIONS OF ORDINARY DIFFERENTIAL EQUATIONS 8 + 3

Higher order linear differential equations with constant coefficients – Method of variation of parameters – Cauchy's and Legendre's linear equations – Applications of ODE (Bacterial growth, Population growth, Decayed problems).

UNIT II VECTOR CALCULUS 8 + 3

Gradient Divergence and Curl – Directional derivative – Irrotational and Solenoidal vector fields –Vector integration – Green's theorem in a plane, Gauss divergence theorem and Stokes' theorem (excluding proofs) – Simple applications involving cubes and rectangular parallelopiped.

UNIT III COMPLEX VARIABLES 8 + 3

Functions of a complex variable – Analytic function – Necessary and Sufficient Conditions (excluding Proofs) – Harmonic function - Properties of an analytic function – Harmonic conjugate – Construction of analytic functions – Conformal mapping- simple Transformations: w = z+c, cz, 1/z, and Bilinear transformation.

UNIT IV COMPLEX INTEGRATION 9 + 3

Statement and applications of Cauchy's integral theorem, Cauchy's integral formula and Cauchy Residue Theorem – Taylor's and Laurent's expansions – Applications of residue theorem to evaluate real integrals – Unit circle and semi-circular contour (excluding Poles on the real axis).

UNIT V LAPLACE TRANSFORM 9 + 3

Existence conditions – Transform of elementary functions – Basic properties – Transform of derivatives and integrals – Transform of unit step function, impulse function and periodic function - Inverse Laplace transform – Convolution theorem (excluding Proof) –Solution of linear ODE of second order with constant coefficients.

SUPPLEMENT TOPIC (for internal evaluation only) **3**

Evocation / Application of Mathematics.

TOTAL : 45 (L) + 15 (T) = 60 Periods

COURSE OUTCOMES:

After the successful completion of this course, the student will be able to

- Apply the knowledge of higher order ordinary differential equations in real life engineering problems.(CO1) AP – K3
- Apply the concept of vector identities in problem solving and evaluate the line, surface and volume integrals.(CO2) AP – K3
- Apply the knowledge of standard techniques of complex variables and mapping for evaluating analytically.(CO3) AP – K3
- Apply the knowledge of singularities, residues and applying in complex integration.(CO4) AP – K3
- Apply the knowledge concept of Laplace transform and solve the problems with periodic function, convolution and Ordinary Differential Equation.(CO5) AP – K3
- Understands the concept of particular integral, scalar potential, poles and periodic function. (CO6) U – K1

TEXT BOOKS:

1. VEERARAJAN.T "Engineering Mathematics" Tata McGraw Hill Publishing Company, New Delhi, 2008.
2. BALI N. P and MANISH GOYAL, "Text book of Engineering Mathematics", Laxmi Publications (P) Ltd., New Delhi, 3rd Edition, (2008).
3. GREWAL. B.S, "Higher Engineering Mathematics", Khanna Publications, New Delhi, 43rd Edition, (2014).

REFERENCE BOOKS:

1. RAMANA B.V, "Higher Engineering Mathematics", Tata McGraw Hill Publishing Company, New Delhi, 11th Reprint, (2010).
2. BROWN J.W. and CHURCHIL R.V." Complex Variable and Applications" 7th Edition McGraw Hill Publishing Company 2004.
3. JAIN R.K and IYENGAR S.R.K, "Advanced Engineering Mathematics", Narosa Publishing House Pvt. Ltd., New Delhi, 3rd Edition, (2007).
4. INCE E.L "Ordinary Differential Equations", Dover Publications, 1958.

CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2
CO.1	3			1								1	2	
CO.2	3			1								1	2	
CO.3	3			1								1	2	
CO.4	3			1								1	2	
CO.5	3			1								1	2	
CO.6	3			1								1	2	

19UPH203 **L T P C**
3 0 0 3

MATERIALPHYSICS

(Common to Chemical & Mechanical Branches)

OBJECTIVES :

- To improve Cold work properties by increasing ductility and retaining most of the hardness.
- To cover the fundamental scientific principles for the different synthesis techniques and assembly of the advanced materials.
- To achieve an understanding of principles of thermodynamics and to be able to use it for physical systems like boiler, pressure vessels etc.,

UNIT I STRENGTHENING MECHANISM 13

Introduction - Strengthening mechanisms in metals-Work hardening-Solid solution strengthening –Precipitation hardening-Grain boundary strengthening- Transformation hardening-Strengthening mechanisms in amorphous materials-Polymer-Glass-Composite strengthening-Fiber reinforcement- Tensile strength-Anisotropy -Laminar reinforcement-Mechanical Testing methods-Applications

UNIT II THERMAL PHYSICS 10

Introduction-Law of Thermodynamics-Entropy-Thermal conduction, convection and Radiation-Newton's law of cooling- Searle's apparatus and Lee's disc apparatus for determination of thermal conductivity-Thermal Expansion- Applications: Heat exchangers-Refrigerators-solar collector.

UNIT III NEW ENGINEERING MATERIALS 12

Introduction-Metallic glasses– preparation – properties & applications -Shape memory alloys– preparation – properties & applications - Ceramic Materials: Introduction - Classification – Methods of Processing – Slip casting - Isostatic pressing - Gas pressure bonding -Properties – Application.

UNIT IV NANO MATERIALS 10

Introduction to Nano materials –Various forms-Nano Dots-Nano rods-Nano fluids-Nano colloidal-Fullerene-Fabrication methods – Top-down and bottom up approach –Chemical Vapour deposition - ball milling - Carbon nanotubes-structure-properties –Applications.

TOTAL:45PERIODS

COURSE OUTCOMES:

After the successful completion of this course, the student will be able to

CO1: Analyze the suitable strengthening mechanism to improve the properties of materials relevant to industrial application [Analyze]

CO2: Describe the laws of thermodynamics from both a macroscopic and microscopic point of view [Understand]

CO3: Apply the strategies of new engineering materials and their manufacturing methods encountered in mechanical engineering.[Apply]

CO4: Analyze the various form of nanomaterials for engineering and industrial applications (Analyze)

CO5: Apply the s
trengthening mechanism and testing methods involved in metals, non-metals and polymers. (Apply)

CO6: Analyze the principles of material physics to develop new projects in the field of nanotechnology and strengthening mechanism of new engineering materials. (Analyze)

TEXT BOOKS:

1. V. Raghavan, Material Science and Engineering : A First Course, 5th Ed, Prentice-Hall of India, 2018.
2. W.D. Callister (Jr.), Materials Science and Engineering : An Introduction, 6th Ed., 2018.

REFERENCE BOOKS:

1. Dr. Mani.P ,"Material science ", Dhanam Publications, Chennai Revised Edition, 2018
2. Pillai S.O, "Solid State Physics", New Age Inc, Revised Edition 2018.
3. Kingery W.D., Bowen H.K. and Dr. Uhlmann, "Introduction to Ceramics', Forth Edition, Wiley and sons, Revised Edition 2016.
4. Raghavan.V, "Material Science and Engineering", Prentice Hall of India Private Limited, New Delhi, Revised Edition 2018.
5. Vijayakumari, "Engineering Physics", Vikas Publishing, New Delhi, Revised Edition 2016.

CO/PO/PSO MAPPING

Mechanical Engineering

Ref: 3- Strong 2- Medium 1- Weak

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2										2	2	
CO2	2	2										2	2	
CO3	2	2										2		
CO4	3											2		
CO.5	2	2										2		
CO.6	3	2										2		

19UCY204 ENVIRONMENTALSCIENCE L T PC

(COMMON TOALL BRANCHES) 3 0 0 3

OBJECTIVES

- To understand the concepts of Environment and ecosystem.
- To acquire knowledge about the impact of environmental pollution.
- To understand the importance of environmental issues in the society.
- To gain knowledge about the impact of environment related to human health.
- To gain knowledge in alternative energies.

UNIT I: ENVIRONMENTAND ECOSYSTEMS 9

Definition, scope and importance of environment – Need for public awareness – Concept of ecosystem–Structure and function of ecosystem–Producers, consumers and decomposers-Food chains, food webs and ecological pyramids – Introduction, types, characteristic features, structure and function of the (a) Forest ecosystem (b) Aquatic ecosystems (c) Grassland ecosystem.

UNIT II: ENVIRONMENTALPOLLUTION 9

Definition – Causes, effects and control measures of: (a) Air pollution (b) Water pollution (c) Soil pollution (d) Marine pollution (e) Noise pollution (f) Thermal pollution
- pollution case studies - Role of an individual in prevention of pollution –Disaster management: floods, earthquake, cyclone and landslides.

UNIT III: SOCIAL ISSUES ANDTHEENVIRONMENT 9

Water conservation, rain water harvesting, watershed management – Climate change, global warming, acid rain, ozone layer depletion, nuclear accidents and holocaust, case studies. Environmental laws/Acts, (EPA).

UNIT IV: HUMAN POPULATION ANDTHEENVIRONMENT 9

Population growth, variation among nations – Population explosion – Human rights – Family welfare programme – Environment and Human Health – Human Rights - Value education – HIV / AIDS – Women and child welfare – Role of information technology in environment and human health.

UNIT V: FUTURE POLICYAND ALTERNATIVES 9

Introduction to future policy and alternatives-fossil fuels-nuclear energy-solar energy-wind energy - hydroelectric energy-geothermal energy - tidal energy – sustainability - green power-nanotechnology.

Total: 45 Periods

OUTCOMES

After successful completion of this course the students will be able to:

- Understand the basic concept of structure and function of ecosystem (Understand)
- Apply the knowledge of various pollution types to prevent the ecosystem and Environment (Apply)
- Analyze the environmental problem to report the social issues and the environment. (Analyze)
- Compare the suitable methods for conservation and sustainable development of natural resources (Analyze)
- Apply the principles of value education with respect to human population to preserve environment (Apply)
- Analyze the current energy crisis and suggest a suitable sustainable alternatives that promotes social health and environmental prospects. (Analyze)

TEXT BOOKS

1. Anubha Kaushik, kaushik C.P., "Environmental Science and Engineering",Third Edition, New Age International, New Delhi, 2009.
2. Benny Joseph "Environmental Science and Engineering", Tata Mc-Graw Hill, New Delhi, 2006.

REFERENCE BOOKS:

1. Gilbert M.Masters, 'Introduction to Environmental Engineering andScience', Pearson Education,Upper saddle River, New Jersey, 2008.
2. Miller T.G. Jr., Environmental Science", Wadsworth PublishingCompany, Belmont, California, 2005.
3. De A.K., "Environmental Chemistry", Wiley Eastern Ltd., New Delhi,2001.
4. Trivedi R.K., Goel P.K., "Introduction to Air Pollution", Techno-Science Publication, Jaipur,2005.

19UCH205	INTRODUCTION TO CHEMICAL ENGINEERING	L	T	P	C
		3	0	0	3

Objective:

- The student should be able to learn historical overview of chemical engineering and the basics of Unit Operations & Process, Materials and Energy Balance, Fluid Mechanics, Heat Transfer, Mass Transfer, Chemical Kinetics, Measuring devices and Computer application in chemical engineering

Module		Topics	L
I	A	**Introduction:** Chemistry, Chemical Engineering and Chemical Technology. Historical overview of chemical engineering; Chemical Engineering in Everyday life; Personalities of Chemical Engineering; Greatest achievements in Chemical Engineering; Representation of a Chemical Process in terms of Flow sheet - Unit Operation and Unit Process; Scale of chemical Processes	**9**
II	A	**Basic Calculations and Fluid Flow:** Units and Dimensions, Basic Chemical Calculations, Material and Energy Balance, Flow of fluids: Introduction, nature of fluid, viscosity, velocity profile, flow field, types of fluid motion, laminar and turbulent flow, Pumps.	**9**
III	A	**Heat and Mass Transfer:** Heat transfer: Conduction, convection and radiation. Flow arrangement in heat exchangers and Heat Transfer Equipments. Mass transfer: Diffusion, mass transfer operation, absorption, Distillation, Liquid- Liquid Extraction, Humidification and dehumidification, Drying, Crystallization, Adsorption	**9**
IV	A	**Chemical Kinetics & Measuring devices:** Introduction, Thermodynamics reviews, Rate of equation, Catalysis, reactors. Measuring devices – Density, Viscosity, Humidity, pH, Chemical Composition, Temperature, Pressure, Flow meters and Liquid level.	**9**
V	A	**Computers and Application:** The use of Mathematics and Computer in Chemical Engineering; Chemical Engineering Software, Role of Chemical Engineers in the area of Food, Medical, Energy, Environmental, Biochemical, Electronics etc. Paradigm shifts in Chemical Engineering; Opportunities for Chemical Engineers; Future of Chemical Engineering.	**9**
		Total Hours	**45**

Course Outcomes		**Bloom's Level**
CO1	Ability to understand the basic of chemical Engineering concept like fluid flow, heat transfer , mass transfer, chemical kinetic, measuring device and computer applications.	Understand
CO2	Ability to apply the knowledge to solve the problem in basic concept of chemical engineering.	Apply
CO3	Ability to analyse various fundamentals of chemical engineering problems	Analyze
CO4	Ability to investigate fundamental process in chemical engineering	Evaluate

CO5	Ability to formulate and develop models using chemical enginering	Design
CO6	Ability to conduct experiments using modern tools	Modern tool usage

Text Books

1. Ghosal, S.K, Sanyal S.K. and Dutta.S, "Introduction to Chemical Engineering" TMH Publications, New Delhi, 1998
2. Badger W.L. and Banchero J.T., "Introduction to Chemical Engineering", 6th Edition, Tata McGraw Hill, 1997.
3. Dryden, C.E., "Outlines of Chemicals Technology", Edited and Revised by Gopala Rao, M. and M.Sittig, 2nd Edition, Affiliated East-West press, 1993.
4. Randolph Norris Shreve, George T. Austin, "Shreve'e Chemical Process Industries", 5th Edition, McGraw Hill, 1984

Reference Books

1. McCabe, W.L., Smith, J. C. and Harriot, P. "Unit operations in Chemical Engineering", McGraw Hill, 7th Edition, 2001
2. Finlayson, B. A., Introduction to Chemical Engineering Computing, John Wiley & Sons, New Jersey, 2006
3. Pushpavanam, S, "Introduction to Chemical Engineering", PHI Learning Private Ltd, New Delhi, 2012
4. 4. Bhatt B. I. and Vora, S. M, "Stoichiometry", 4th edition, McGraw Hill, 2004

Complied by	**Dr. C. Marimuthu/ Mr. M. Dharmaprabhu**
Recommended by BoS on	
Approved by Academic Council on	

19UEE226	**BASIC ELECTRICAL AND ELECTRONICS ENGINEERING** (COMMON TO MECH,CIVIL,CHEMICAL & AGRI)	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

OBJECTIVES :

- This course facilitates the students to get a comprehensive exposure to electrical and electronics engineering.

UNIT I DC AND AC CIRCUITS 9

Direct currents and voltages, power, Kirchhoffs Laws, Alternating current and voltage, Peak, RMS and average values, circuit elements R,L &C, Phasor Diagram, impedance, real and reactive power in single phase circuits.

UNIT II DC MACHINES AND TRANSFORMERS 9

DC machines Construction, principle of operation and applications, Single phase transformer – construction, principle of operation, Applications.

UNIT III AC MACHINES 9

Synchronous and Induction machines -Construction, Principle of operation, and applications.

UNIT IV SPECIAL MACHINES 9

AC Servo Motor, Stepper Motor, Linear induction motor and Universal Motor – Construction, Principle of operation and applications.

UNIT V INTRODUCTION TO ELECTRONICS 9

Diode- PN Diode, Zener Diode, BJT Configurations, Rectifiers, Data acquisition system- ADC, DAC – principles of operation.

TOTAL: 45

PERIODS

COURSE OUTCOMES:

After the successful completion of this course, the student will be able to

- Apply the basic laws of electrical circuits to linear circuit problems.[Apply]
- Summarize the working principle and construction of DC machines and transformers.[Understand]
- Explain the principle of operation and construction of AC machines. [Understand]
- Explain the working principle and construction of Special machines. [Understand]
- Illustrate the characteristics of basic semiconductor devices. [Understand]

REFERENCE BOOKS:

1. V K Mehta and Rohit Mehta, **"**Principles of Electrical Engineering and Electronics", S. Chand Publishing, New Delhi, 2019
2. Arumugam M. and Premkumar N., "Electric circuits theory", Khanna Publihsers, 7th edition, NewDelhi,2007.
3. Kothari D.P. Nagrath I.J, "Electric Machines", Tata McGraw Hill, 2009.
4. K. Venkataratnam, Special Electrical Machines, Universities Press, 2014.
5. R.J.Smith, R.C.Dorf, Circuits devices and systems, 5th edition, John Wiley and sons,2001.
6. Malvino, A.P, Leach D.P and Gowtham Sha, Digital Principles and Applications, 6th Edition,
   Tata McGraw hill, 2007.

19UGS210	ENERGY AND ENVIRONMENTAL SCIENCE LABORATORY	L	T	P	C
		0	0	3	1.5

Objectives:

- To analyze the Band gap, moment of inertia, thermal conductivity and rigidity modulus of the materials.
- To gain knowledge in PHOTONICS.

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PHYSICS LABORATORY
(COMMON TO ALL BRANCHES)

LIST OF EXPERIMENTS

1. Determination of Energy band gap of a semiconductor.
2. Torsion pendulum – Determination of Moment of inertia of a metallic disc and rigidity modulus of a given metallic wire.
3. Spectrometer - Determination of wavelength of mercury spectrum using grating.
4. Laser – Determination of numerical aperture and acceptance angle of an optical fiber
5. Newton's rings – Determination of radius of curvature of a convex lens
6. Lee's Disc - Determination of thermal conductivity of a bad conductor.
7. Determination of Solar cell characteristics using optical transducers kit.

- **A minimum of FIVE experiments shall be offered**

CHEMISTRY LABORATORY
ENVIRONMENTAL SCIENCE LABORATORY

OBJECTIVES:

- Apply the theoretical concepts to perform lab experiments**.**
- To assess the water quality parameters.
- To acquire knowledge on water quality parameters for the analysis of industrial effluents.

LIST OF EXPERIMENTS (Common to All Branches)

1. Estimation of hardness of water by EDTA method.
2. Estimation of alkalinity of water sample.
3. Estimation of Chloride in water sample (Argentometric method)
4. Determination of DO in water
5. Estimation of chromium in tannery wastes
6. Estimation of available chlorine in bleaching powder
7. Estimation of iron by Spectrophotometry.
8. Determination of acidity of industrial effluents.

COURSE OUTCOMES:

After the successful completion of this course, the student shall be able to

CO1 - Apply the principles of Light and Elasticity to determine the Engineering properties of materials (Apply)
CO2 - Analyze the thermal conductivities of different bad conductors (Analyze)
CO3 - Analyze the Characteristics of a semiconductor (Analyze)
CO4 -Apply the basic knowledge of water quality testing for environmental sustainability. (Apply)
CO5 - Analyze the water quality parameters for industrial effluents to prevent water pollution. (Analyze L4)
CO6 - Estimate the quality of water that suits for domestic and industrial applications (Apply).

A minimum of FIVE experiments shall be offered **TOTAL: 30 Periods**

19UEE221	BASIC ELECTRICAL AND ELECTRONICS ENGINEERING LABORATORY (COMMON TO CHEMICAL & AGRI)	L	T	P	C
		0	0	3	1.5

OBJECTIVES :

- This course facilitates the students to get a basic practical exposure to electrical and electronics engineering.

LIST OF EXPERIMENTS

1. Verification of Ohm's Law
2. Verification of Kirchoff's Laws.
3. Measurement of Electrical Quantities voltage, current, power ad power factor in RLC Circuits.
4. Load test on electrical motor.
5. Study of Batteries.
6. Characteristics of PN Junction Diode.
7. Characteristics of Zener Diode.
8. Characteristics of BJT.
9. Study of UPS.
10. Study of Electrical and Electronic software packages.
11. Field visit to College EB Section.

TOTAL: 45 PERIODS

COURSE OUTCOMES

After the successful completion of this course, the student will be able to

- Solve the electrical parameters in a circuit using Ohm's law and Kirchhoff's laws. [Apply]
- Demonstrate the behavior of RLC circuits with electrical quantities and Explain the load handling capacity of electrical motor.[Understand]
- Interpret the basic construction, working and types of Batteries and select suitable battery for particular applications. [Apply]
- Illustrate the characteristics of Semiconductor diodes and Transistor and develop power supply circuits. [Apply]
- Interpret the basic structure and working of UPS and outline the electrical &electronics software tools.[Understand]

19UMA326	TRANSFORM TECHNIQUES AND PARTIAL DIFFERENTIAL EQUATIONS (COMMON TO AGRI, CHEMICAL, BIO MED AND BIO TECH)	L	T	P	C
		3	1	0	4

OBJECTIVES :

- To make the student knowledgeable in formulating certain practical problems in terms of partial differential equations, solve them and physically interpret the results.
- To familiarize the students to formulate and identify certain boundary value problems encountered in engineering practices, decide on applicability of the Fourier series method of solution, solve them numerically and interpret the results.
- To acquaint the student with the basics of Z - transform in its applicability to discretely varying functions, gained the skill to formulate certain problems in terms of difference equations and solve them using the Z - transform technique bringing out the elegance of the procedure involved.

UNIT I FOURIER SERIES 9 + 3

Dirichlet's conditions – General Fourier series – Odd and even functions – Half range sine series – Half range cosine series – Complex form of Fourier Series – Parseval's identity – Harmonic analysis - Application of Fourier series - Gibb's Phenomenon.

UNIT II FOURIER TRANSFORM 9 + 3

Fourier integral theorem (without proof) – Fourier transform pair – Sine and Cosine transforms – Properties – Transforms of simple functions – Convolution theorem – Parseval's identity - Application of Fourier Transform.

UNIT III Z-TRANSFORM AND DIFFERENCE EQUATIONS 9 + 3

Z-transform – Elementary properties – Inverse Z-transform – Convolution theorem – Initial and Final value Theorems - Formation of difference equations – Solution of difference equations.

UNIT IV PARTIAL DIFFERENTIAL EQUATIONS 9 + 3

Formation of partial differential equations – Singular integrals -- Solutions of standard types of first order partial differential equations – Lagrange's linear equation -- Linear partial differential equations of second and higher order with constant coefficients of both homogeneous and non-homogeneous types.

UNIT V APPLICATIONS OF PARTIAL DIFFERENTIAL EQUATIONS 9 + 3

Introduction of Partial differential equations - Solutions of one dimensional wave equation – One

dimensional equation of heat conduction – Steady state solution of two-dimensional heat equation (Insulated edges excluded) – Fourier series solutions in Cartesian coordinates.

TOTAL : 45 (L) + 15 (T) = 60 Periods

COURSE OUTCOMES:

After the successful completion of this course, the student will be able to

- Apply the knowledge of Fourier series for the given function or Discrete data and compute the Periodic function arising in the study of Engineering problems.(CO1) AP – K3
- Apply the knowledge of Fourier transform and its properties which are used to transform signals between time and frequency domain.(CO2) AP – K3
- Apply the acquired knowledge of Z transform and its properties inverse Z transform and difference equations .(CO3) AP – K3
- Apply the knowledge of partial differential equation in solving linear and higher order partial differential equation.(CO4) AP – K3
- Apply the knowledge of PDE in solving linear, higher order and one dimensional Wave, Heat flow equation.(CO5). AP – K3
- Understand the basic concept of periodic , non-periodic function and nature of partial differential equation. (CO6) U-K2

TEXT BOOKS:

1. GREWAL B.S, "Higher Engineering Mathematics", Khanna Publishers, New Delhi, 42nd Edition, (2012).
2. KANDASAMY.P, THILAGAVATHY.K, and GUNAVATHY.K, Engineering Mathematics III, S.Chand & Company Ltd., New Delhi, 3rd Edition, (1996).
3. VEERAJAN.T, "Higher Engineering Mathematics", Yes Dee Publishing Pvt. Limited, 2015.

REFERENCE BOOKS:

1. BALI N.P., MANISH GOYAL and WATAINS, "Advanced Engineering Mathematics", Firewall Media (An imprint of Laxmi Publication Private limited) New Delhi, 7th Edition, (2009).
2. RAMANA.B.V, "Higher Engineering Mathematics" Tata McGraw Hill, New Delhi, 11th Reprint (2010).
3. GLYN JAMES, "Advanced Modern Engineering Mathematics", Pearson Education, New Delhi, 3rd Edition, (2007).
4. ERWIN KREYSZIG, "Advanced Engineering Mathematics", Wiley India, 10th Edition, (2011).

CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2
CO. 1	3			1								1	2	
CO. 2	3			1								1	2	
CO. 3	3			1								1	2	
CO. 4	3			1								1	2	
CO. 5	3			1								1	2	
CO. 6	3			1								1	2	

19UCH302	PROCESS CHEMISTRY	L	T	P	C
		3	0	0	3

Objective:

- To make the students to understand the basics of organic chemistry reactions and do the structural analysis of biological compounds to utilize sustainability ideas and tools to identify green chemistry innovation.
- To learn the surface and interfacial phenomena relevant to the thin film coatings, solid surfaces and colloids for better processing of different industrial products, intermediates and raw materials.

Module		Topics	L
I	A	**Unit Process:** Definitions – reagents- mechanism – catalyst – illustrations of the following unit process – nitration – halogenation – oxidation & reduction – esterification.	9
II	A	**Carbohydrates:** Introduction–Classification, Structure and Chemical Properties of monosaccharides- Glucose, fructose, disaccharides-Sucrose and polysaccharides-starch and cellulose, industrially used Carbohydrate derivatives – structure and properties of artificial sweeteners - Saacharin and Aspartame	9
	B	**Aminoacids:** Classification, Preparation-Strecker, Gabriel phthalimide and physical andchemical properties.	
III	A	**Synthetic Applications of Organic Compounds:** Synthetic applications of Grignard reagents, Organolithium, Organolead and Organozine- syntheitic applications of active methylene compounds-malonic ester and acetoacetic ester.	9
	B	**Dyes:** Colour and constitution - classification of dyes based on their chemical structure and their applications. Important dyes -Maritus yellow, Congo red, Bismarck brown, Auramine - O, Crystal violet, Magenta, Uranine, Indigo, Thioindigo and Alizarin (preparation and uses only).	
IV	A	**Introduction to Colloids:** Surfaces and Interfaces, Surface and Interface – Molecular Origin, the work of cohesion and adhesion, Interaction forces and potential, chemical and physical interaction, classification of physical forces. Van der Waals force, interaction between surface and particles	9
	B	Electrostatic forces and electric double layer, DLVO theory, Hamaker constant, Boltzmann distribution, Debye length, specific ion adsorption, ion adsorption, Stern layer, Electrostatic, steric and electrosteric stabilization, Zeta potential.	
V	A	**Chemical Kinetics:** Rate of chemical reactions. Determination of order and molecularity of a reaction. Calculation of rate constants. Theories of reactionrates. Consecutive, Parallel and opposing reactions - reactions in solutions - catalysis - homogeneous and heterogeneous catalysis, enzyme catalysis, applications of catalysis.	9
		Total Hours	45

Course Outcomes		Bloom's Level
CO1	Ability to understand the fundamental principles of organic chemistry that include chemical bonding, nomenclature and structural isomerism	Understand
CO2	Apply the knowledge of Process chemistry to solve the industrial problem	Apply
CO3	Ability to analyse the properties such as, reactivity and stability of an organic molecule based on structure, including structural conformation.	Analyze

CO4	Ability to Investigate the surface properties of the solid, their isotherms and surface area calculation.	Evaluate
CO5	Ability to formulate and develop models related to organic and physical chemistry in process industry	Create
CO6	Ability to conduct experiments using modern tools	
Laboratory Organic chemistry preparation # Heading mantle # Condenser # RB flask Semi micro analysis # Test tube # Boiling tube Physical chemistry experiments #Redox (permanganimetry) #Conductometric titration #Potentiometric titration #Ester hydrolysis		**30 Hrs**

Text Books

1. Tiwari K.S. Vishnoi N.K. and Marhotra S.N., A text book of Organic Chemistry, II Edition, Vikas Publishing House Pvt.Ltd., (1998), New Delhi.
2. Robert Thornton Morrison and Robert Neilson Boyd, " Organic Chemistry", 6th Edition, Prentice- Hall of India (P) Ltd NewDelhi (2002)
3. Puri .B.R., Sharma. L.R., Pathania M.S., Elements of Physical Chemistry, Second Edition, Vishal Publishing company,Jalandhar, fourth edition 2013.

Reference Books

1. Jerry March, Advanced Organic Chemistry - Reactions, Mechanisms and Structure 7th Edition, John Wiley & Sons, NewYork, 2015.
2. Soni .P.L., Charmarha.O.P, Dash.U.N, Textbook of Physical Chemistry, Twenty Second Edition, S.Chand and Sons, NewDelhi, 2012.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Memorize the mechanisms of nitration and halogenation of benzene.
2. Remember various catalysis and regents involved in substitution as well as in addition reactions.
3. Explain why benzene does not undergo addition reactions.
4. Execute the electrophilic substitution of benzene to other aromatic systems.

Course Outcome 2 (CO2):

1. Explain in detail about disaccharides with neat diagram
2. Give a brief note on glycolysis pathway
3. Define basic amino acids and acidic amino acids.
4. How amino acids are classified based on their occurrence? Explain.

How the end group analysis of protein helped us to find the nature of bonded amino acids? Justify.

Course Outcome 3 (CO3):

1. Applications of a new diorganozinc reaction to the synthesis active methylene compounds.
2. Discuss various synthetic applications of Grignard reagents.
3. Classify the dye according to its structure and method of application and illustrate the preparation of the following dyes.1. congo dye 2. melachite green
4. Give reasons for the presence or absence of colour in the following

A) $C_6H_5N=NC_6H_5$ (Red) B) C_6H_6 (Colourless) C) $NaO_3SC_6H_4N=NC_6H_4N(CH_3)_2$ (Orange)	
Course Outcome 4 (CO4): 1. Remember the terms adsorptions and catalysis 2. Select suitable theory for monolayer adsorption. 3. To Understand one component system of Water and Sulphur and their phase transitions. 4. Concern the concepts of Vapour pressure & boiling point on ideal and non-ideal solutions	
Course Outcome 5 (CO5): 1. Study of first order, second order, third order, zero order and pseudo order reactions 2. Chain reactions, branched chain reactions 3. Concept of activation energy and influence of ionic strength in rates of reactions. 4. Derive the kinetics of First order unimolecular reactions	

Complied by	**Dr. M. Sethuram, AP(Sr.G)/Chemical**
Recommended by BoS on	**05.09.2020**
Approved by Academic Council on	

Course Outcomes	**Skill**	**PO**	**Blooms**	**Assessing tools**
Ability to understand the fundamental principles of organic chemistry that include chemical bonding, nomenclature and structural isomerism	Remember/Understand		L1/L2	Assignment/Exam/ Quiz/ Seminar
Apply the knowledge of Process chemistry to solve the industrial problem	Apply		L3	Assignment/ Exam/ Quiz
Ability to analyse the properties such as, reactivity and stability of an organic molecule based on structure, including structural conformation.	Analyse		L4	Assignment/ Exam/ Quiz
Ability to Investigate the surface properties of the solid, their isotherms and surface area calculation.	Investigation		L5	Exam/ Quiz/Assignment/Seminar
Ability to formulate and develop models related to organic and physical chemistry in process industry	Design		L6	Assignment/Exam/Seminar
Ability to conduct experiments using modern tools	Modern Tools			Lab/Seminar

19UCH303	HEAT POWER ENGINEERING	L	T	P	C
		2	1	0	3

OBJECTIVE

This Course provides the basic concept of heat power engineering PVT behaviour of fluids, thermodynamic property relations and their application to fluid flow, power generation and refrigeration processes.

MODULE		TOPICS	L Hrs
I	A	**Laws of Thermodynamics:** Thermodynamic systems-closed, open and isolated. Property, state, path and process, work, Energy. Zeroth, First and Second laws of Thermodynamics (Basic concepts only), Internal energy, Specific heat capacity and Enthalpy. Heat Engine, Heat Pump, Refrigerator.	9
II	A	**Thermodynamic Cycles:** Carnot Cycle, Internal combustion engines: Otto, Diesel and Combined cycle; Gas Turbine Power Plant: Brayton and Steam Power plant: Rankine cycles – determination of cycle efficiency.	9
III	A	**Boilers:** Types and classification of boilers: water tube, fire tube, coal, oil and gas fired boilers; Stoker fired, pulverized and fluidized bed boilers. Mountings and accessories. Performance and efficiency calculation of boilers.	9
IV	A	**Properties of Steam:** Properties of steam, Mollier chart, determination of dryness fraction of steam- Different types of calorimeters. Concept of Steam distribution systems. steam traps- types and their characteristics. Energy conservation opportunities in steam systems.	9
V	A	**Turbines and Vacuum Systems:** Steam turbines- types and principles: Reaction and impulse turbines; Application of co-generation principles in process industries. Gas turbines- principle and working. Production of Vacuum: Systems and Equipment – Compression and Vacuum Pumps, Steam Ejectors; Instrumental methods of Vacuum measurement.	9
		Total Hours	45

Text Books

1. Rajput R.K., "Thermal Engineering", 9th Edition, Laxmi Publications, 2010.
2. Rudramoorthy R., "Thermal Engineering", 4th Edition, Tata McGraw Hill Publishing Company, New Delhi, 2006.

Reference Books

1.Kothandaraman, C.P., Domkundwar and Domkundwar, "Course in Thermodynamics and Heat Engines", 3rd Edition, Dhanpat Rai & Sons, New Delhi, 2011.
2. Ballaney P.L., "Thermal Engineering", Khanna Publishers, New Delhi, 2005.

COURSE OUTCOMES

The students have the

CO1	Ability to understand the fundamental concepts of heat and power engineering as per the requirement of Chemical Engineering.
CO2	Ability to demonstrate the principles of heat and power engineering solve complex problems of heat flow.
CO3	Ability to analyse various heat flows.
CO4	Ability to investigate and select steam for various industrial applications.
CO5	Ability to formulate and develop models related to heat power engineering.
CO6	Ability to conduct experiments using modern tools

Course Outcomes Mapping with Bloom's Taxonomy and Programme Outcomes

Course Outcome		Skill	PO	Bloom's Taxonomy	Assessment Tools to measure CO
CO1	Ability to understand the fundamental concepts of heat and power engineering as per the requirement of Chemical Engineering.	Remember/ Understand	-	L1/L2	Exam/Assignment/ Seminar/Quiz
CO2	Ability to demonstrate the principles of heat and power engineering solve complex problems of heat flow.	Apply		L3	Exam/Assignment/ Seminar/Quiz/Lab/ Project
CO3	Ability to analyse various heat flows.	Analyze		L4	Exam/Assignment/ Seminar/Quiz/Lab/ Project
CO4	Ability to investigate and select steam for various industrial applications.	Investigate		L5	Mini Project/Assignment/ Quiz/Lab/Exam
CO5	Ability to formulate and develop models related to heat power engineering.	Design		L6	Assignment/Lab/Exam/Seminar
CO6	Ability to conduct experiments using modern tools	Modern Tools		-	Lab/Project

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Determine the number of degrees of freedom when a binary mixture is in equilibrium with its vapour.
2. Explain briefly the Zeroth law of thermodynamics.
3. Findthe phase rule as applicable to a non-reacting system.
4. A spherical balloon of diameter 0.5 m contains a gas at 1 bar and 300 K. the gas is heated and the balloon is allowed to expand. The pressure inside the balloon is found to vary linearly with the diameter. What would be the work done by the gas when the pressure inside reaches 5 bar?

Course Outcome 3 (CO3):

1. State the Van-Laar Equation.
2.Derive ansignificance of Co-existence equation.
3.Water (1) – hydrazine (2) system forms an azeotropes containing 58.5% (mol) hydrazine at 393 K and 101.3 KPa. Calculate the equilibrium vapour composition for a solution containing 20 % (mol) hydrazine. The relative volatility of water with reference to hydrazine is 1.6 and may be assumed to remain constant in the temperature range involved. The vapour pressure of hydrazine at 393 K is 124.76 KPa?
4. Explain about the Zero Area Method for checking/analyze the thermodynamics consistency of VLE data.

Course Outcome 4 (CO4):

1. Explain about the Standard Free Energy and how it is related to equilibrium constant?
2. Derive an expression for the effect of temperature and pressure on equilibrium constant and compare theexpression.

3.How can I calculate the volume of steam produced at 373K at 101325 pa in a closed vessel.
4.How can I neglect heat of dilution from heat of reaction in isothermal titration calorimetry.

Course Outcome 5 (CO5):

1. Obtain the capacity of a refrigerator. .
2. Explain about the “throttling process”.
3. How to choose the optimal pressures for the extractions of a regenerative rankine cycle.
4. How Can the exhaust pressure for a steam turbine is selected.

19UCH304	FLUID FLOW OPERATIONS	L	T	P	C
		2	1	3	4.5

Objective:

To make the students understand the system of units and impart the knowledge of applying basic quantitative laws and equation of fluid flow. To enable to handle important engineering tasks of moving fluids through process equipment and measuring & controlling fluids in flow.

MODULE		TOPICS	L (Hrs)
I	A	**Fundamentals of fluids and fluid properties:** Introduction and significance of Fluid Mechanics in Chemical Engineering. Fluid **P**roperties, Types of fluids- Newton's law of Viscosity Newtonian and Non-Newtonian fluids.	9
	B	**Fluid Statics:** Pascal's law, Hydrostatic equation and its applications; hydrostatic forces on plane surfaces -total pressure and centre of pressure, buoyancy and meta centre, pressure measurement.	
II	A	**Fluid Dynamics** Types of fluid flows - Basic equations governing fluid flow, Equation of Continuity and its application, Equation of motion – Bernoulli's equation and its application in fluid flow, Significance of Navier - Stoke's equation.	9
	B	**Boundary layer flow:** Boundary layer and its definition – displacement thickness – momentum thickness - energy thickness.	
III	A	**Flow through pipes**: Loss of energy in pipes major and minor energy losses – pipes in series and parallel –equivalent pipe	9
	B	**Dimensional Analysis And Similitude**: Fundamental and secondary dimensions. Dimensional homogeneity – Rayleigh and Buckingham Pi methods – relationship between dimensional analysis and similitude - use of dimensional analysis for scale up studies.	
IV	A	**Fluidization:** Fluidization- Conditions for fluidization- Minimum fluidization velocity-Types of fluidization- Expansion of fluidized bed-Applications of fluidization. Continuous fluidization; slurry and pneumatic transport	9
V	A	**Transportation of fluids**: Pumps –Classification and working principle of Centrifugal Pumps and Positive Displacement Pumps– performance characteristics and sizing of pumps, selection of pumps, Compressors and Fans	9
		Total Hours	45
Laboratory ➢ Pipe Friction ➢ Orifice Meter ➢ Venturi meter ➢ Rectangular notch ➢ Minor Losses in pipes ➢ Fluidized Bed			30

- Packed Bed
- Centrifugal Pump
- Reciprocating Pumps

Text Books

1. M. White, Fluid Mechanics, 8th Edition, Tata-McGraw Hill, 2016.
2. V. Gupta and S. K. Gupta, Fundamentals of Fluid Mechanics, 2nd Edition, New Age International 2011.
3. W. L. McCabe, J. C. Smith and P. Harriot, Unit Operations of Chemical Engineering, 7th Edition, McGraw-Hill International Edition 2006.
4. O. Wilkes, Fluid Mechanics for Chemical Engineers, Prentice Hall of India, 2005.
5. R. W. Fox, P. J. Pritchard and A. T. McDonald, Introduction to Fluid Mechanics, 7th Edition, Wiley-India 2010.
6. Fluid Mechanics for Chemical Engineers, McGraw Hill Noel de Nevers, 3rd Edition, McGraw Hill, New York, 2004.

Reference Books

1. James O Wilkes and Stacy G Bike, "Fluid Mechanics for Chemical Engineers' Prentice Hall PTR (International series in Chemical Engineering) (1999)
2. Rajput, R.K., "A Text book of Fluid Mechanics and Hydraulic Machines" ,S.Chand and Co., New Delhi, 2008.
3. Bansal, R.K., "Fluid Mechanics and Hydraulic Machines", Laxmi Publications, New Delhi, 2005
4.. Modi, P.N. and Seth, S.M., "A Text book of Fluid Mechanics and Hydraulic Machines", Standard Book House, New Delhi, 2007

COURSE OUTCOMES

The students will have the

CO1	Ability to define, understand and explain the fundamental concepts of fluids and its mechanics
CO2	Ability to apply the principles of fluid statics and dynamics and solve problems of fluids flow
CO3	Ability to analyse various fluid flows
CO4	Ability to investigate and select pipes for various industrial applications
CO5	Ability to formulate and develop models using dimensional analysis
CO6	Ability to conduct experiments using modern tools

Course Outcomes Mapping with Bloom's Taxonomy and Programme Outcomes

Course Outcome		Skill	PO	Bloom's Taxonomy	Assessment Tools to measure CO
CO1	Ability to define, understand and explain the fundamental concepts of fluids and its mechanics	Remember/ Understand		L1/L2	Exam/Assignment/Seminar/Quiz
CO2	Ability to apply the principles of fluid statics and dynamics and solve problems of fluids flow	Apply		L3	Exam/Assignment/Seminar/Quiz/Lab/Project
CO3	Ability to analyse various fluid flows	Analyze		L4	Exam/Assignment/Seminar/Quiz/Lab/Project
CO4	Ability to investigate and select pipes for various industrial applications	Investigate		L5	Mini Project/Assignment/Quiz/Lab/Exam
CO5	Ability to formulate and develop	Design		L6	Assignment/Lab

	models using dimensional analysis				/Exam/Seminar
CO6	Ability to conduct experiments using modern tools	Modern Tools		-	Lab/Project

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Determine Mass density, Specific volume, and Specific weight of liquid whose specific gravity is 0.85.
2. The space between two square flat plate is filled with oil. Each side of the plate is 60cm. The thickness of the oil film is 12.5 mm, the upper plate which moves at 2.5 m/sec requires a force of 10 kgf to maintain the speed. Determine dynamic viscosity of oil in poise, Kinematic viscosity of oil in stokes, if the specific gravity of oil is 0.95.
3. Find the surface tension of soap bubble of 40 mm, when the inside pressure of the bubble 2.5N/m^2above atmospheric pressure.
4. Two plates are placed at a distance of area 0.15mm,lower plate is fixed with upper plate having the surface area of 1m2 pulled at 0.3m/s. Find the force and power required to maintain the speed of fluid separating them having viscosity 1.5Poise.

Course Outcome 2 (CO2):

1. State Pascals Law.
2. Derive Euler's equation of motion and hence deduce Bernoulli's equation.
3. A horizontal venturimeter with inlet and throat diameter 300 mm and 100mm respectively is used to measure the rate of flow. The pressure intensity at the inlet is 130 kN/m^2 and the vaccum pressure at the throat is 350mm of mercury. Assuming 3% head lost between inlet and throat, find the coefficient of discharge.

Course Outcome 3 (CO3

1. The stream function is given by ψ =5x-6y, Calculate the velocity components and also magnitude and direction of the resultant velocity at any time.
2. Explain briefly the different types of flow
3. Determine the rate of flow of water through the pipe of diameter 20 cm and length 50m with one end of the pipe is connected to a tank and the other end is open to atmosphere. The pipe is horizontal and the height of water in the tank is 4m above the centre of the pipe. Consider all the minor losses and take f = 0.009
4. Three pipes of length 800 m, 500 m, and 400 m and of diameter 500 mm, 400 mm, and 300 mm respectively connected in series. These pipes are to be replaced by a single pipe of length 1700 m. Find the diameter of the single pipe.

Course Outcome 4 (CO4):

1. The rate of flow of water through the horizontal pipe is 0.25m^3/s. The diameter of the pipe changes from 200mm to 400 mm. The pressure intensity in the smaller pipe is 11.772N/cm^2. Find i) Loss of head due to sudden enlargement, ii) pressure intensity in large pipes.
2. Horizontal pipe of diameter 300mm is attached to another pipe of diameter 250mm by means of flange. The ratio of flow of water is 0.5m^3/s. The pressure intensities in the large and small pipe are given as 14.32N /cm^2 and 11.58N/cm^2 respectively. Calculate the head loss and the coefficient of contraction.

Course Outcome 5 (CO5):

1. Using Buckingham π Theorem, Show that the velocity through a circular orifice is given by $V = \sqrt{2}gH\ \varphi\ (D/H, \mu/\rho vH)$ where, H=head, D=diameter of the orifice, μ=coefficient of viscosity, ρ mass density, g= acceleration due to gravity.
2. Find an expression for the drag force on smooth sphere of diameter D,moving with a uniform v V in a fluid density ρ and dynamic viscosity μ.
3. List out the various types of model Laws and explain any three. Obtain Scale ratio for velocity, time for the models governed by equality of Froude's number.
4. Write the application of Dimensional analysis for scale up industries.
5. State the concept of Fluidization.
6. Define Pump and its classification.

Course Outcome 6 (CO6):

1. A 7.2m high and 15m long spill way discharges 94 m^3/s under a head of 2m. If a 1:9 scale model of this spill way is to be constructed, determine the model law to be used model dimensions, head at spill way and discharge in the model, if the model experiences a force of 764N. Determine from the prototype.
2. Sketch the characteristics curves of centrifugal pumps.

19UCH305 CHEMICAL PROCESS CALCULATIONS		L	T	P	C
		3	0	3	3

AIM

To study the basics principles and the calculation techniques used in the chemical industry.

OBJECTIVES

This course aims to acquire a concept of degree of freedom and its application to solution of mass and energy balance equations for single and network of units.

MODULE	TOPICS	L Hrs
I	**UNITS AND DIMENSIONS** Basic and derived units, Ideal and real gas laws - Gas constant - calculations of pressure, volume and temperature using ideal gas law. Use of partial pressure and pure component volume in gas calculations, applications of real gas relationship in gas calculation and Stoichiometric principles.	9
II	**MATERIAL BALANCE** **WITHOUT CHEMICAL REACTION:** Application of material balance to unit operations - distillation, evaporation, drying, extraction and mixing/blending. **WITH CHEMICAL REACTION:** Material balance for the systems involving chemical reaction - Limiting and excess reactants – yield and selectivity. Recycle and Purging	9
III	**HUMIDITY AND SATURATION** Humidification and Dehumidification: Basic concepts - Calculation of absolute,molal, relative and percentage humidities –use of Psychrometric chart.	9
IV	**ENERGY BALANCE** Heat capacity of solids, liquids, gases and solutions, evaluation of enthalpy. Heat of reaction, formation, combustion, solution and mixing. Effect of pressure and temperature on heat of reaction.	9
V	**COMBUSTION** Fuels and combustion; Calculation of theoretical and excess air from combustion of solid, liquid and gaseous fuels. Composition of flue gases by Orsat analyzer	9
	Total Hours	45

Course Outcomes		Bloom's Level
CO1	Ability to understand the conversion factor and basic concept of various unit operations and combustion, heat capacity.	Remember/Understand
CO2	Ability to apply the stoichiometric principles for solving the material, energy balance, humidification and combustion problems.	Apply
CO3	Ability to analyse the suitable basis for material balance and energy balance problems and analyse the psychrometric chart, orsat analyzer.	Analyse
CO4	Ability to evaluate the complex problems involving with and without chemical reaction with the combustion calculation by using Orsat analyzer.	Evaluate

CO5	Ability to formulate the steady state material balance and energy balance for the unit operations and to compute the concentration degree of saturation and solve combustion problems.	Create
CO6	Ability to design the solution for various unit operations involving with and without chemical reaction,combustion problems by using ASPEN,HYSIS,CHEMCAD softwares.	Modern Tools

Text Books

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

Reference Books

1. Hougen O.A., Watson K. M. and Ragatz R. A., ―Chemical Process Principles. Part I. Material and Energy Balances‖, 2nd Edition, John Wiley & Sons, New York, 1956.
2. Bhatt B.L and Vora S.M., ―Stoichiometry‖, 4th Edition, Tata McGraw Hill Publishing Company, New Delhi, 2004.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Derive the relationship between partial pressure, Mole fraction of component gas to total pressure
2. A chemist is interested in preparing 500 ml of 1 normal, 1 molar and 1 molal solution of sulphuric acid. Assuming the density of sulphuric acid solution to be 1.075 g/cm3 , calculate the quantities of sulphuric acid to be taken to prepare these solutions
3. A natural gas has the following by volume : CH4 = 82%, C2H6 = 12% and N2 = 6%. Calculate the density of gas at 288 K (150C) and 101.325 kPa and composition in weight percent.
4. A gaseous mixture has the following composition by volume CO_2 =8%, CO=14%, O_2= 6%, H_2O=5%, CH_4=1% and N_2 = 66% Calculate (i) Average molecular weight of gas mixture (ii) Density of gas mixture at 303K (300 C) and 101.325 KPa

Course Outcome 2 (CO2):

1. An evaporator is fed with 15000 kg/h of a solution containing 10% NaCl, 15% NaOH and rest water. In the operation water is evaporated and NaCl is precipitated as crystals. The thick liquor leaving the evaporator contains 45% NaOH, 2% NaCl and rest water. calculate (a) kg/h water evaporated (b) kg/h salt evaporated (c) kg/h thick liquor
2. It is desired to have a mixed acid containing 40% HNO3 , 43% H2SO4 and 17% water by weight. Sulphuric acid of 98% by weight is readily available. Calculate (a) the strength of nitric acid and weight ratio of sulphuric acid to nitric acid.
3. Formaldehyde is produced by dehydrogenation of methanol

   $$CH_3OH \longrightarrow HCHO + H_2$$

   The per pass conversion is 67%. The product leaving the reactor is fed to separation unit battery where formaldehyde is separated from methanol and hydrogen. The separated methanol is recycled to reactor. If the production rate of formaldehyde is 1000 kg/h. Calculate (a) combined feed ratio (B) flow rate of methanol required to the process as fresh feed.
4. In manufacture of HCl, gas containing 20% HCl and 80% air by volume enters an absorption tower at a temperature of 323K and pressure of 99.325 kPa 98% of HCl is absorbed in water and remaining gas leaves the tower at a temperature of 293 K and a pressure of 97.22 kPa. Calculate (a) the weight of HCl absorbed/ removed per m3 of gas entering the system and (b) the volume of gas leaving per m3 of gas entering the system

Course Outcome 3 (CO3):

1. The dry bulb temperature and dew point of ambient air were found to be 302K (29oC) and 291K (18oC) respectively, Barometer reads 100Kpa. Calculate:
   - The absolute Molal humidity
   - The absolute humidity.
   - % Relative Humidity.
   - % Saturation.
   - Humid Heat
   - Humid Volume.

   Data: Vapor pressure of water at 291K = 2.0624KPa, Vapor pressure of water at 302K = 4.004KPa.

2. A mixture of benzene and dry air at a temperature of 303K (30^{o}C) and a pressure of 101.325 kPa is found to have a dew point of 288K (15^{o}C). Calculate

   a) Percentage by volume of benzene.b) Moles of benzene per mole dry air.

   Data: Vapor pressure of benzene at 288K = 7.999kPa

3. An air (b)- water(a) sample has a dry bulb temperature of 500 C and wet bulb temperature of 350 C. Estimate its properties at a total pressure of 1 atm

   1 atm= 1.0133x105 N/m2 Molecular weight of air = 28.84

   (a) Nv' (Chart) = 0.03 kg W.v/Kg.d.a

   (b) % humidity (Chart) = 35%

   % relative saturation = Partial pressure/ vapour pressure.

4. A gas mixture containing benzene vapor is saturated at 101.325kPa and 323K (50oC). Calculate the absolute humidity if the other component of the mixture in (a) nitrogen and (b) carbon dioxide.

Data: vapor pressure of benzene at 323K = 36.664kPa.

Course Outcome 4 (CO4):

1. A stream of nitrogen flowing at a rate of 100kmol/hr is heated from 303K (30oC)to 373K (100^{o}C). Calculate the heat that must be transferred.

   Data: Cp^o for Nitrogen = 29.5909 -5.141X 10-3 T +11.1829X10-6 T2 - 4.968 X 10-9T3

2. A stream of carbon di oxide flowing at a rate of 100kmol/min is heated from 298 K (25^{o}C) to 383 K (110^{o}C). Calculate the heat that must be transferred using Cp^odata.

Data: $Cp^o = a + bT + cT^2 + dT^3$, KJ/kmol.K

Gas	a	b X 10^3	c X 10^6	d X 10^9
CO_2	21.3655	64.2841	-41.0506	9.7999

3. Calculate the standard heat of formation of liquid ethyl acetate at 298K.

   Data:

   Standard heat of formation of CO2 (g) = -393.51 KJ/mol

   Standard heat of formation of H2O (l) = -285.83 KJ/mol

   Standard heat of combustion of liquid ethyl acetate C4H8O2 = ΔH^oc = -2230.91 KJ/mol.

4. Toluene is to be heated from 290 K (17^{o}C) to 350 K (77^{o}C) at the rate of 250 g/s. calculate the heat to be supplied to toluene using the heat capacity data given below.

Data:

$Cp^o = a + bT + cT^2 + dT^3$, KJ/kmol.K

Gas	a	b X 10^3	c X 10^6	d X 10^9
Toluene	1.8083	812.223	-1512.67	1630.01

Course Outcome 5 (CO5):

1. Crude oil is analyzed to contain 87% carbon, 12.5% hydrogen and 0.5% sulphur (by weight). Calculate the net calorific value of the crude oil at 298K (25°C)
   Data: Gross Calorific value of crude oil at 2989K is 45071KJ/Kg oil.
   Latent heat of water vapor at 298K (25oC) = 2442.5 KJ/Kg.
2. A natural gas contains 85% methane and 15% ethane by volume. Calculate the GHV of this fuel in KJ/Kg from the standard heats of combustion of methane and ethane.

$$CH_4 + 2O_2 \longrightarrow O_2 + 2H_2O$$

Std. Heat of Combustion = -802.62 KJ/mol

$$C_2H_6 + 3.5\ O_2 \longrightarrow 2CO_2 + 3H_2O$$

Std. Heat of Combustion = -1428.64 KJ/mol

3. The Orsat analysis of the flue gases from a boiler chimney, by volume is as given below:
   CO2 : 11.4%, O2 : 4.2% and N2 : 84.4%
   Assuming Complete Combustion,i)Calculate the % excess air. ii)Find the C:H ratio in the fuel**.**
4. The analysis of a refinery gas by volume is:

H_2: 74%, CH_4 : 13.5%, C_2H_6: 7.4%, C_3H_8 : 3.6%, C_4H_{10} : 1.2% C_5H_{12}: 0.3%.

Data:

Component	GCV, KJ/mol	NCV, KJ/mol
CH_4	890.65	802.62
C_2H_6	1560.69	1428.64
C_3H_8	2219.17	2043.11
C_4H_{10}	2877.40	2657.32
n-C_5H_{12}	3535.77	3271.67

Standard Heat of Formation of H2O (g) = -241.82KJ/mol
Standard Heat of Formation of H2O (l) = -285.83 KJ/mol
Specific volume of the natural gas at 298K (25°C) and 101.3kPa = 24.465 m^3/kmol.
Calculate the GCV and NCV of the refinery gas in KJ/mol, KJ/kg, KJ/m^3

Course Outcomes	**Skill**	**PO**	**Blooms**	**Assessing tools**
Ability to understand the conversion factor and basic concept of various unit operations and combustion, heat capacity.	Remember/Understand	--	L1/L2	Assignment/Exam/ Quiz/ Seminar
Ability to apply the stoichiometric principles for solving the material, energy balance, humidification and combustion problems.	Apply	PO1	L3	Assignment/ Exam/ Quiz
Ability to analyse the suitable basis for material balance and energy balance problems and analyse the psychrometric chart, orsat analyzer.	Analyse	PO2	L4	Assignment/ Exam/ Quiz
Ability to evaluate the complex problems involving with and without chemical reaction with the combustion calculation by using Orsat analyzer.	Evaluate	PO3	L5	Exam/ Quiz/ Assignment/Seminar
Ability to formulate the steady state material balance and energy balance for the unit operations and to compute the concentration degree of saturation and solve combustion problems.	Create	PO4	L6	Assignment/Exam/ Seminar
Ability to design the solution for various unit operations involving with and without chemical reaction,combustion problems by using ASPEN,HYSIS,CHEMCAD softwares.	Modern Tools	PO5		Lab/Seminar

19UCH306 ENGINEERING MATERIALS FOR PROCESS INDUSTRIES	L	T	P	C
	2	0	0	2

Objective:

- Impart the knowledge and implementation of material structure, processing, properties, and performance of all classes of materials used in engineering systems.
- To impart knowledge on different engineering materials for the construction of process industries.
- Ability to analyze any problem in a simple and logical manner and to predict the physical phenomena and thus lay the foundation for engineering applications.

Module		Topics	L
I		**ENGINEERING METALLURGY & STRUCTURE OF MATERIALS** Properties of materials: Mechanical, Physical & Chemical properties. Industrial Engineering Materials – Ferrous & Non Ferrous metals & alloys – Introduction to various heat treatment processes & Mechanical properties - tension test, hardness test - brinnel, vickers, rockwell, micro hardness test - shore scleroscope. Impact test, fracture - grifiths' theory, fracture toughness, embrittlement phenomena. Fatigue and creep.	9
II		**Stainless Steels:** Special steels and alloys-grades, general criterion of selection of material of construction in process industries and its applications.	9
III		**Non Ferrous Metals:** Nickel, Aluminium, Copper, Chromium, Lead, Titanium, Zinc, magnesium and their alloys; applications in process industries.	9
IV		**Organics and Composites:** Polymers, Resins, Composites, Refractories, Glass, Wood, Rubber, Silicones and Carbon as material of construction in chemical process industries**.**	9
V		**Materials for Special Applications:** Metallic glasses and oxides for high temperature applications; Bio materials- bio ceramics and polymers; materials for biomedical, space and cryogenics; Introduction to Sour service.	9
		Total Hours	45

Course Outcomes		Bloom's Level
CO1	Ability to define, understand and explain the structure and properties of engineering materials.	Remember/ Understand
CO2	Ability to comprehend the criterion for selection of materials for chemical process industries	Apply
CO3	Ability to gain an insight into the properties nonferrous metals and its alloys for application in chemical process industries	Analyse
CO4	Apply the knowledge about various materials used in chemical process industries	Evaluate
CO5	Construct and to select materials for high temperature and Sour service	Create

Text Books

1. James A. Lee, ― Materials of Construction for Chemical Process Industries‖, Mc Graw Hill, 1950.

2. V.Raghavan, “Materials Science and Engineering: A first course”, V Edition, Prentice Hall of India, 2004.

Reference Books

1. Frank Rumford, ―Chemical Engineering Materials, Nabu Press, 2013.
2. Khurmi R.S., Strength of Materials, Third Edition Reprint, S.Chand and Company Ltd, 2015.
3. Agrawal B.K., ―Introduction to Engineering Materials‖, Tata McGraw Hill, 1988.

Course Level Assessment Questions	
Course Outcome 1 (CO1): 1. What are the factors which affect the selection of materials for engineering purposes? 2. Explain the criteria of selecting the materials in process industries. 3. Explain about creep in materials? 4. What is the preliminary information required to specify materials? 5. Describe briefly failure analysis method	
Course Outcome 2 (CO2): 1. What are the different compositions of carbon steel? 2. Differentiate LD process and the open herath process in detail. 3. Examine the different types of stainless steel 4. Explain the Bessemer process briefly. 5. Discuss briefly about the crucible process.	
Course Outcome 3 (CO3): 1. What are the different properties of Aluminium? 2. Explain the concept of extraction of Lead from earth’s core. 3. What are the different copper alloys are there? 4. Explain the bayer process for the production of Aluminium 5. Describe the pyrometallurgical treatment of zinc process.	
Course Outcome 4 (CO4): 1. What are the major groups of ceramics. 2. Explain the concept of processing of plastics 3. What are the different characteristics of rubber? 4. What is the functional classification of ceramics? 5. Describe the different structure of silicones.	
Course Outcome 5 (CO5): 1. What are the different properties of metallic glasses? 2. Explain the concept of biopolymers and unique properties of bio polymers. 3. What are the different applications of biomaterials? 4. What are metallic oxides and its properties 5. Describe sour service methods	

Course Outcomes	Skill	PO	Blooms	Assessing tools
Ability to define, understand and explain the structure and properties of engineering materials.	Remember/Understand		L1/L2	Assignment/Exam/ Quiz/ Seminar
Ability to comprehend the criterion for selection of materials for chemical process industries	Apply		L3	Assignment/ Exam/ Quiz
Ability to gain an insight into the properties nonferrous metals and its alloys for application in chemical process industries	Analyse		L4	Assignment/ Exam/ Quiz
Apply the knowledge about various materials used in chemical process industries	Investigation		L5	Exam/ Quiz/Assignment/Seminar
Construct and to select materials for high temperature and Sour service	Design		L6	Assignment/Exam/Seminar

Course Code	Course Name	L	T	P	C
19UGM332	Biology for Engineering Applications (Common to Agri, Civil, Chem, ECE, EEE & IT)	2	0	0	P/F

OBJECTIVES:

- To provide a basic understanding of biological mechanisms of living organisms and the human biology from the perspective of engineers.
- To encourage engineering students to think about solving biological problems with engineering principles and tools.

Module – 1	INTRODUCTION AND CLASSIFICATION	5

Introduction to Biology – Comparison of Biology and Engineering – Eye and Camera – Bird flying and Aircraft – Brownian motion and Thermodynamics – Classification – Unicellular or multicellular – Unicellular: Bacteria, Protozoa, Yeast – Multi Cellular: Animals, Humans, Plants, fungi etc. – Ultra structure: prokaryotes or eukaryotes – Habitat: aquatic or terrestrial.

Module – 2	DIGESTIVE & RESPIRATORY SYSTEMS – ENZYME	6

Study of digestive – Respiratory systems and their functions –.Enzyme – Classification of Enzyme – Mechanism of Enzyme activity – Enzymes for Industrial Applications: Waste management – Food
processing industry – Beverages – Pharmaceutical – Paper Industry etc.

Module – 3	GENETICS AND BIO MOLECULES (Basics only)	7

Basics of Genes – DNA structure – Genes and hereditary – Genetic Code – Coding and decoding Genetic information – Gene Mapping – Gene Interactions – Mutations – Genetic disorders – Gene therapy – Biomolecules: Carbohydrates, lipids, nucleic acids, proteins. Biological Applications in Engineering: Genetic Algorithm – Computer Application in Genetic Engineering – Genetic Programming –
Genetic Computers.

Module – 4	NERVOUS SYSTEM AND CELL SIGNALING	7

Central Nervous System: Brain and Spinal Cord – Peripheral Nervous System – Sensory Division – Motor Division – Neurons – sensory, motor, and interneurons – Signals – Transfer of Information – Bio Signals – Electrocardiography (ECG) – Electroencephalography (EEG) – Electromyography (EMG) – Electrooculography (EOG) – X-ray – CT Scan – MRI scan – Biological Applications in Engineering –
Neurons and Neural Network.

Module – 5	BIOLOGY AND ITS INDUSTRIAL APPLICATION	5

Bioreactors – Biopharming – Recombinant vaccines – Cloning – Drug discovery – Bioremediation – Biofertilizer – Biocontrol – Biofilters – Biosensors – Biopolymers – Bioenergy – Biomaterials – Biochips.

TOTAL : 30 PERIODS

COURSE OUTCOMES:

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

CO1	Explain the fundamentals of living things, their classification, cell structure and biochemical constituents.	Understand

CO2	Apply the concept of plant, animal and microbial systems and growth in real life situations	Apply
CO3	Analyze biological engineering principles and procedures needed to solve societal issues.	Analysis

TEXT BOOKS

1. R.C.Dubey, "A Text book of Biotechnology", S. Chand Higher Academic Publications, 2013.
2. R. Khandpur, "Biomedical instrumentation - Technology and applications", McGraw Hill Professional, 2004.

REFERENCE BOOKS

1. Arthur T. Johnson, "Biology for Engineers", CRC Press, Taylor and Francis, 2nd Edition, 2019.
2. Cecie Starr, Ralph Taggart, Christine Evers and Lisa Starr, "Cell Biology and Genetics (Biology: The unity and diversity of life Volume I)", Cengage Learning, 12th Edition, 2008.
3. Gerard J. Tortora and Bryan H.Derrickson, "Principles of Anatomy and Physiology",15th Edition,Wiley publications, 2016.

19UMA423 **NUMERICAL METHODS** **L T P C**

(COMMON TO CIVIL, CHEMICAL AND BIO. TECH) **3 1 0 4**

OBJECTIVES :

- To acquaint the student with the roots of nonlinear (algebraic or transcendental) equations, solutions of large system of linear equations and Eigen value problem of a matrix can be obtained numerically where analytical methods fail to give solution.
- To familiarize the student with the methods discussed on interpolation which will be useful in constructing approximate polynomial to represent the data and to find the intermediate values, when huge amounts of experimental data are involved.
- To make the student acquire sound knowledge in applications of numerical methods in various fields, solving practical technical problems using scientific and mathematical tools when available in Engineering.

UNIT I SOLUTION OF ALGEBRAIC, TRANCENDENTAL EQUATIONS AND EIGENVALUE PROBLEMS **9 + 3**

Iteration method – Newton-Raphson method – Gauss Elimination method – Pivoting – Gauss Jordan methods –iterative methods : Gauss Jacobi method ,Gauss Seidel method - Eigen values of a matrix by Power method – Jacobi's method for a real symmetric matrix.

UNIT II INTERPOLATION AND APPROXIMATION **9 + 3**

Lagrange's interpolation – Newton's divided difference interpolation – Newton's forward and backward difference interpolation –cubic spline.

UNIT III NUMERICAL DIFFERENTIATION AND NUMERICAL INTEGRATION **9 + 3**

Derivatives from difference tables – Divided differences and finite differences – Numerical integration by Trapezoidal and Simpson's 1/3 and 3/8 rules – Romberg's method – Two point and Three point Gaussian quadrature formulae - Double integrals using Trapezoidal and Simpson's rules.

UNIT IV NUMERICAL SOLUTIONS OF ORDINARY DIFFERENTIAL EQUATIONS **9 + 3**

Single step methods: Taylor series method – Euler method for first order equation – Fourth order Runge – Kutta method for solving first and second order equations – Multistep methods: Milne's and Adam's predictor and corrector methods.

UNIT V NUMERICAL SOLUTIONS OF PARTIAL DIFFERENTIAL EQUATIONS **9 + 3**

Finite difference solution of second order ordinary differential equation – Finite difference solution of one dimensional heat equation by explicit and implicit methods – One dimensional wave equation and two dimensional Laplace and Poisson equations.

TOTAL : 45 (L) + 15 (T) = 60 Periods

COURSE OUTCOMES:

After the successful completion of this course, the student will be able to

- Apply various techniques to solve linear, nonlinear equations and Eigen value problems of a Matrix by Numerically.(CO1) AP – K3
- Apply Interpolation technique for equal and unequal intervals to find new data points within the range of known data points. (CO2) AP – K3
- Apply the Numerical techniques of Differentiation and Integration for Engineering Problems.(CO3) AP – K3
- Apply the knowledge of numerical techniques and methods for solving first and second order Ordinary Differential Equation.(CO4) AP – K3
- Apply the knowledge of Partial Differential Equation with initial and boundary conditions by using certain techniques with engineering applications.(CO5). AP – K3
- Understand the knowledge of parabolic, elliptic, eigenvalues and ordinary differential equation. (CO6) U-K2

TEXT BOOKS:

1. SASTRY S.S., "Introductory methods of Numerical Analysis", Prentice Hall of India, New Delhi, 4th Edition, (2008).
2. SRIMANTAPAL "Numerical methods Principles Analysis and Algorithm", Edition 2009, Oxford press, New Delhi.
3. IYENGAR S.R.K , JAIN R.K. , MAHIDEN KUMAR JAIN " Numerical Methods for Scientific and Engineering Computations" New Age International Publishers 7th Edition 2019.

REFERENCE BOOKS:

1. KANDASAMY.P, THILAGAVATHY.K and GUNAVATHY.K, "Numerical Methods", S.Chand Co. Ltd., New Delhi, (2003).
2. GERALD C.F. and WHEATELEY P.O., "Applied Numerical Analysis", Pearson Education, New Delhi, 6th Edition, (2006).
3. GREWAL B.S. and GREWAL J.S., "Numerical methods in Engineering and Science", Khanna Publishers, New Delhi, 9th Edition, (2007).
4. CHAPRA S. C and CANALE R. P. "Numerical Methods for Engineers", Tata McGraw-Hill, New Delhi, 5th Edition, (2007).
5. SANKAR RAO.K, "Numerical Methods for scientists and engineers", Prentice Hall of India, New Delhi, 3rd Edition, (2007).

CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2
CO. 1	3			1								1	2	
CO. 2	3			1								1	2	
CO. 3	3			1								1	2	
CO. 4	3			1								1	2	
CO. 5	3			1								1	2	
CO. 6	3			1								1	2	

19UCH402	CHEMICAL ENGINEERING THERMODYNAMICS	L	T	P	C
		2	1	0	3

Objective:

- To make the students tounderstand the laws of thermodynamics, PVT behaviour of fluids and thermodynamic property relations
- To enable him to handle important engineering tasks,to the treatment of properties of solution, phase equilibria, and Chemical reaction equilibria.

Prerequisite

19UCH303 -Heat Power Engineering

Module	Topics	L
I	**Laws of Thermodynamics**	**9**
A	**Laws of Thermodynamics:** Basic concepts; Zeroth law;Temperature scales; first law- Joule's experiment, internal energy,applications to cyclic process, non-flow and flow processes;	
B	Second Law: Statements of the second law of thermodynamics - heat engines, Carnot cycle and theorem, Thermodynamic temperature scale, Entropy and its calculations; Third Law of thermodynamics.	
II	**P-V-T Behaviour and Thermodynamic Properties of Pure Fluids**	**9**
A	**P-V-T Behaviour of Pure fluids:** Mathematical representation of PVT behaviour; Process involving ideal gas; Equation of state for Ideal gas and real gas;compressibility Charts ; Principle of corresponding states.	
B	**Thermodynamic Properties of Pure Fluids**: Thermodynamic properties; Basic energy relations; thermodynamic property relations – Maxwell relations – partial derivatives and Jacobian method;	
III	**Properties of Solutions**	**9**
A	**Partial molar properties:** Partial molar properties-Determination;chemical potential; fugacity and activity coefficients;Gibbs-Duhem equation.	
B	**Property Changes of Mixing:**Property Changes of Mixing-Free Energy Changes ,Volume Change , Enthalpy Change and Entropy Change; Excess Properties-Excess Gibbs Free Energy	
IV	**Phase Equilibria and its Correlations**	**9**
A	**Phase Equilibria:** Phase equilibrium and stability; criteria for equilibrium between phases in single and multi-component non-reacting systems; vapour-liquid equilibrium of binary ideal and non-ideal solutions; azeotropes;	
B	**Correlations and Prediction:** VLE at low pressure Activity coefficient models, VLE at high pressure and multi component system; Thermodynamic consistency test for VLE data.	
V	**Chemical Reaction Equilibria**	**9**
A	**Reaction Constant**:Criteria of Chemical Reaction Equilibrium; Equilibrium Constant- relationship between Standard free energy change, Effect of Temperature on equilibrium constant, and its evaluation.	

B	**Homogeneous chemical reactions:** homogeneous chemical reactions -thermodynamic analysis and prediction of equilibrium compositions, Phase Rule for Reacting System

Total Hours	**45**

	Course Outcomes	**Bloom's Level**
On successful completion of this course the student should		
CO1	Ability to understand the fundamental terminologies of thermodynamic laws, Energies, Behaviour of pure fluids & solution and equilibriums.	Remember/ Understand
CO2	Ability to solve the internal energy, heat engine, enthalpy, entropy problems and also apply the partial molar properties, and Equilibrium to describe VLE.	Apply
CO3	Ability to analysis the flow and non-flow process, thermodynamic properties by using of partial differentiation and Jacobians method and stability criterion for phase and chemical reaction equilibrium	Analyse
CO4	Ability to compare the various process involved in ideal and non-idealsolutions and also evaluate the thermodynamic properties of solution and various equilibrium for homogeneous and heterogeneous system.	Evaluate
CO5	Ability to write the mass, energy and entropy balances for flow process and equilibrium stability condition and also develop the model of partial molar properties for solution, and heat engine cycles.	Create
CO6	Ability to conduct experiments using modern tools such as MAT lab and Aspen plus	Modern tools

TEXT BOOKS:

1. Smith, J.M., Van Ness, H.C and Abbot M.M "Introduction to Chemical Engineering Thermodynamics ", McGraw Hill Publishers, VI edition, 2003
2. Narayanan, K.V. A Textbook of Chemical Engineering Thermodynamics Prentice Hall India, 2004

REFERENCES:

1. Kyle, B.G., "Chemical and Process Thermodynamics III Edition", Prentice Hall of India Pvt. Ltd., 1999.
2. Elliott J.R., Lira, C.T., "Introductory chemical engineering thermodynamics", Prentice Hall, 1998
3. Rao, Y.V.C., "Chemical Engineering Thermodynamics" Universities Press, 2005
4. Pradeepahuja," Chemical Engineering Thermodynamics", PHI Learning Ltd (2009).
5. GopinathHalder," Introduction to Chemical Engineering Thermodynamics", PHI Learning Ltd (2009).

Course Level Assessment Questions		
Course Outcome 1 (CO1):Remember/ Understand	**Bloom's level**	**Module**
1. State Zeroth law of thermodynamics.	(R)	**1**
2. State Clausius inequality.	(R)	**1**
3. State Carnot's theorem.	(R)	**1**
4. What do you understand by the term 'Internal Energy'?	(R)	**1**
5. Why is the specific heat at constant pressure Cp always greater than that at constant volume Cv?	(U)	**1**
Course Outcome 2 (CO2):Apply		
1.Heat is transferred to 10 kg of air which is initially at 100kPa and 300 K until its temperature reaches 600 K. Determine the change in internal energy, the change in	(AP)	**1**

enthalpy, the heat supplied, and the work done in the following processes. (a) Constant volume process and (b) Constant pressure process. Assume that air is an ideal gas for which the P-V-T relation is PV=nRT. Take C_P=29.099 kJ/KmolK , C_V=20.785 kJ/Kmol K and molecular weight of air=29.		
2.Calculate the entropy change when 1 kmole of an ideal gas at 300 K and $10*10^5$ N/m^2 expands through a throttle to a pressure of $1*10^5$ N/m^2 both pressure being maintained constant during the process by suitable means.	(AP)	**1**
3.Calculate ΔU and ΔH in KJ for 1 mol of water, as it is vapourised at the constant temperature of 373 K and constant pressure of 101.3 Kpa. The specific volume of liquid and vapour at these condition are $1.04*10^{-3}$ and 1.675 m^3/kmol respectively 1030 KJ heat is added to water for this change?	(AP)	**1**
4.Liquid CO_2 at 233 K has a pressure of $1.005*10^3$Kpa and a specific volume of $0.9 * 10^{-3}$ m^3/kg. Assume that CO_2 is a saturated liquid at these conditions and its enthalpy is zero. Latent heat of vapourisation of CO_2 is 320.5 KJ/kg and the specific volume of saturated vapour is $38.2 * 10^{-3}$ m^3/kg. Calculate the internal energy of saturated liquid and enthalpy of saturated vapour?	(AP)	**1**
5.An ideal gas is undergoing a series of three operations: the gas heated at constant volume from 300 K and 1 bar to a pressure of 2 bar . It is expanded in a reversible adiabatic process to a pressure of 1 bar. It is cooled at constant pressure of 1 bar to 300 K. Determine the heat and work effect for each step. Assume C_P= 29.3 KJ/kmol K.	(AP)	**2**
Course Outcome 3 (CO3):Analyse		
Derive the first law of thermodynamics for flow processes	(AN)	**1**
1. Prove that a Carnot engine has the maximum efficiency and that the efficiency is independent of the working fluid	(AN)	**1**
2. Derive the thermal efficiency for kelvin Planck statement and Clausius statement	(AN)	**1**
3. Prove the equivalence of the Kelvin-Planck and Clausius statements of the second law of thermodynamics	(AN)	**1**
4. Derive the following equation of state for real gases (i)Redlich-Kwong soave equation (ii)Peng-Robinson equation (iii)Virial Equations(iv) Benedict webbrubin equation	(AN)	**2**
5. Derive Mawell's relations using the method of partial derivatives	(AN)	**2**
Course Outcome 4 (CO4):Evaluate		
1. Compare and Prove that a Carnot engine has the maximum efficiency then other heat engine, and that the efficiency is independent of the working fluid	(E)	**1**
2. Compare the thermal efficiency for kelvin Planck statement and Clausius statement	(E)	**1**
3. Judge that the equivalence of the Kelvin-Planck and Clausius statements of the second law of thermodynamics.	(E)	**1**
4. Compare the Entropy changes in isothermal mixing of ideal gas and Adabatic mixing of ideal gas	(E)	**1**
5. Compare with a neat diagram, the PV and PT behaviour of a pure substance.	(E)	**2**
Course Outcome 5 (CO5):Create		
1. Write the Mass Balance and Energy Balance equation For flow process open system.	(C)	1
2. Combine the heat engine and heat pump, and predict that any device violate it statement it also violate its other statement	(C)	1
3. Write the Mathematical representation of PVT behaviour for pure fluids by using MAT lab	(C)	2

4. Draw the mnemonic diagram of Maxwell equation by using aspen plus.	(C)	2
5. Develop the model for explain the partial molar properties	(C)	3

Course Outcomes	**Skill**	**PO**	**Blooms**	**Assessing tools**
Ability to understand the fundamental terminologies of thermodynamic laws, Energies, Behaviours of pure fluids & solution and equilibriums.	Remember/Understand	-	L1/	Assignment/Exam/ Quiz/ Seminar
Ability to solve the internal energy, heat engine, enthalpy, entropy problems and also apply the partial molar properties, and Equilibrium to describe VLE.	Apply		L3 L2	Assignment/ Exam/ Quiz
Ability to analysis the flow and non-flow process, thermodynamic properties by using of partial differentiation and Jacobians method and stability criterion for phase and chemical reaction equilibrium	Analyse		L4	Assignment/ Exam/ Quiz
Ability to compare the various process involved in ideal and non-ideal solutions and also evaluate the thermodynamics properties of solution and various equilibrium for homogeneous and heterogeneous system	Investigation		L5	Exam/ Quiz/ Assignment/Seminar
Ability to write the mass, energy and entropy balances for flow process and equilibrium stability condition and also develops the model of partial molar properties for solution, and heat engine cycles.	Design		L6	Assignment/Exam/ Seminar
Ability to conduct experiments using modern tools such as MAT lab and Aspen plus	Modern Tools		--	Lab/Seminar

19UCH403	HEAT TRANSFER	L	T	P	C
		3	0	3	4.5

AIM

To study the basics and applications of conduction, convection and radiation heat transfer in the areas pertaining to chemical engineering.

OBJECTIVES

To enable the students to learn heat transfer by conduction, convection and radiation and heat transfer equipments like evaporator and heat exchanger.

MODULE	TOPICS	L Hrs
I	**CONDUCTION** Basic concepts – conduction - convection and radiation – Laws – General equation of heat conduction – Heat transfer composite walls - composite cylinders and composite spheres – Critical thickness of insulation- Extended surfaces – types and applications of fins – Fin efficiency and effectiveness – Fin performance.	9
II	**CONVECTION** Laminar flow over a flat plate – Turbulent flow over a flat plate – Flow over cylinders – Internal flow through pipes – annular spaces –Natural convection in vertical and horizontal surfaces- Condensation and Boiling – Filmwise and dropwise condensation – Film condensation on a vertical plate – Boiling – Nucleate boiling.	9
III	**RADIATION** Concept and nature of thermal radiations - Concept of Black and grey bodies; Stefan Boltzmann, Kirchhoff's, Planck's and Wien laws; Radiation between surfaces – configuration factor; radiation shield	9
IV	**HEAT EXCHANGERS** Types of heat exchangers; LMTD; use of correction factor charts; Fouling factors; surface area calculations for double pipe and shell and tube heat exchangers; effectiveness and number of transfer units. Special type of Heat Exchangers	9
V	**EVAPORATORS** Introduction – Types of Evaporators – Design of Evaporators – Vapor Recompression methods single effect evaporator- Multiple Effect Evaporators – Vapor Recompression methods	9
	Total Lecture Hours	45

Course Outcomes		Bloom's Level
CO1	Ability to understand the concept of conduction, convection, radiation and principle of heat exchangers.	Remember/Understand
CO2	Ability to apply the equation for conduction, convection, radiation in heat exchange equipment.	Apply
CO3	Ability to analyze the use of heat exchange equipment for particular industry by using the laws of heat transfer.	Analyse
CO4	Ability to select the appropriate evaporators with application of laws.	Evaluate
CO5	Ability to Design the heat exchange equipment and evaporators.	Create
CO6	Ability to solve the heat transfer coefficient by using softwares	Modern tools

Laboratory

1. Performance studies on Cooling Tower
2. Batch drying kinetics using Tray Dryer
3. Heat transfer in Open Pan Evaporator
4. Stefan-Boltzmann Experiment
5. Heat Transfer through Packed Bed

30 Hrs

6. Heat Transfer in a Double Pipe Heat Exchanger 7. Heat Transfer in Shell and Tube Heat Exchanger 8. Heat Transfer by Natural Convection 9. Heat Transfer by Forced Convection 10. Heat Transfer in a Condenser 11. Heat Transfer in Helical Coils 12. Heat Transfer in Agitated Vessels 13. Heat Transfer in a Bare and Finned Tube Heat Exchanger	

Course Outcomes

CO1	Determine Stefan Boltzmann constant at different temperatures
CO2	Assess the heat transfer coefficient for natural and forced convection systems, double pipe heat exchanger / shell and tube heat exchanger and condensers
CO3	Develop temperature profile in unsteady state heat transfer system
CO4	Evaluate the convective and radioactive heat transfer coefficients using radiation experiment
CO5	Appraise the fin efficiency and estimate the steam economy in an evaporator

Text Books

1.McCabe W.L., Smith J.C. and Harriot P.," Unit Operations in Chemical Engineering", 7th Edition, McGraw Hill International Edition , New York , 2006

2.Yunus A.Cengel., " Heat Transfer: A Practical Approach", 2nd Edition , McGraw Hill, 2003.

Reference Books

1.Dutta Binay K., " Heat Transfer Principles and Application", Prentice Hall of India, New Delhi,2001.

2.Coulson J.M. and Richardson J.F., " Chemical Engineering", Volume I, 4th Edition, Asian Books Pvt.Ltd.,1998.

Course Level Assessment Questions

Course Outcome 1(CO1):

1. Define Conduction
2. Illustrate the requirements of Insulating materials.
3. Derive the one dimensional steady state conduction through One Plane Wall and Composite wall.
4. A 50 mm diameter pipe of Cross sectional area and with walls 3mm thick covered with two concentric layers of lagging,innerlayer having thickness 25mm and k=0.08W/m.K and outer layer having thickness of 40mm and k=0.04W/m.K. Estimate the rate of heat loss per meter length of pipe,if the temperature inside the pipe 550K and outside surface temperature is 330K.Thermal conductivity for pipe is 45W/m.K

Course Outcome 2 (CO2):

1. State Newton's Law of Cooling.
2. List out the some Dimensional numbers used in Heat Transfer.
3. Derive the overall Heat Transfer Coefficient when the metal wall resistence is very small in comparison with the resistence of fluid films.
4. Determine the inside heat transfer coefficient for a oil flowing at a rate of 0.5kg/sec through a tube of 19mm inside diameter is heated from 311 to 327K by condensing steam at 373K.

Course Outcome 3 (CO3):

1. State Stefan Boltzman Law in radiation.
2. Define Kirchoffs law and Plancks law.
3. Explain the concept of Black body
4. A 50mm i.d iron pipe at 423K passing through a room in which surrounding are at temperature 300K. If the emissivity of the pipe metal is 0.8,what is the next interchange of radiation energy per meter length of pipe? The outside dia of pipe is 60mm.

Course Outcome 4 (CO4):

1. Compare between Single Pass and Multi pass shell and tube heat exchanger.
2. List the equipments of heat Exchanger.
3. Explain in detail about Shell and Tube heat exchanger.
4. It is require to cool 250kg/hr of hot liquid with inlet temperature of 399K using a parallel flow arrangement. 1000kg/hr cooling water is available for cooling purpose at temperature of 283K.Calculate the outlet temperature of hot liquid and water at effectiveness of heat exchanger,if the U is 1160W/m^2K and Heat transfer surface is 0.25m^2

Course Outcome 5 (CO5):

1. List out the effects of properties of solution on Evaporation operation.
2. State Capacity and Economy of Evaporators.
3. Explain with a neat sketch about Horizontal tube Evaporator.
4. An Evaporator operating at atmosphere pressure 101.325kPa is fed at the rate of 10000kg/hr of weak liquor containing 4% Caustic soda. Think Liquor leaving the evaporator contains 25% caustic soda. Find the Capacity of Evaporator.

Course Outcomes	**Skill**	**PO**	**Blooms**	**Assessing tools**
Ability to understand the concept of conduction, convection, radiation and principle of heat exchangers.	Remember/ Understand	--	L1/L2	Assignment/Exam/ Quiz/ Seminar
Ability to apply the equation for conduction, convection, radiation in heat exchange equipment.	Apply	PO1	L3	Assignment/ Exam/ Quiz
Ability to analyze the use of heat exchange equipment for particular industry by using the laws of heat transfer.	Analyse	PO2	L4	Assignment/ Exam/ Quiz
Ability to select the appropriate evaporators with application of laws.	Investigation	PO3	L5	Exam/ Quiz/ Assignment/Seminar
Ability to Design the heat exchange equipment and evaporators.	Design	PO4	L6	Assignment/Exam/ Seminar
Ability to solve the heat transfer coefficient by using softwares	Modern Tools	PO5		Lab/Seminar

19UCH404	MECHANICAL OPERATIONS	L	T	P	C
		3	0	3	4.5

AIM

To study the behaviour of solid particles as per the requirement of Chemical Engineering

OBJECTIVES

The students will be in a position to understand that the industrial processes contain a coordinated series of separation operations and they will be in a position to decide the best process needed for a particular process industry.

MODULE	TOPICS	L Hrs
I	**INTRODUCTION TO PARTICULATE SOLIDS** Particle Shape, Size, Mixed Particle Sizes and Size Analysis – Cumulative and Differential Analysis –Various Mean Diameters – Screen Analysis Standard Screens- General characteristics of solids, their behaviour under different external forces, agglomeration, techniques for size analysis.	9
II	**SIZE REDUCTION** Size Reduction – Principles of Comminution - Energy and Power Requirements in Comminution -Mechanical Efficiency-Laws of Crushing-Size Reduction Equipments – Crushers- Grinders-Cutting Machines – Open and Closed Circuit Operation.	9
III	**MECHANICAL SEPARATIONS** Screening and Screening equipment, effectiveness of screens, gravity settling, sedimentation, thickening, centrifugal separation, impingement methods, industrial dust removing equipment with special reference to electrostatic and magnetic separators, heavy media separations, floatation.	9
IV	**FILTRATION** Filtration Equipment – Filter Presses – Leaf Filter – Rotary Continuous Filters – Filter Media – Filter Aids – Principles of Cake Filtration – Specific Cake Resistance - Filter Medium Resistance. Constant Pressure Filtration– Principles of Centrifugal Filtration- Ultra Filtration, Membrane Filtration, Bio Filtration.	9
V	**AGITATION AND CONVEYING OF SOLIDS** Principles of Agitation – Agitation vessel –Impellers – Flow Pattern in Agitated Vessel - Power Consumption in Agitated vessel- Calculation of power. Conveyors,-Pneumatic conveyor, Belt conveyor, Screw Conveyor.	9
	Total Hours	45

Course Outcomes		Bloom's Level
CO1	Ability to understand the characteristics of solids and principle of size reduction.	Remember/Understand
CO2	Ability to apply the laws and power used for unit operations.	Apply
CO3	Ability to analyse various equipments for separation and filtration.	Analyse
CO4	Ability to investigate and select equipments for agitation and transportation of solids.	Evaluate
CO5	Ability to solve the problems created by filtration, agitation and size reduction equipments.	Create
CO6	Ability to design the unit operation equipment as per the requirement	Modern Tools

Laboratory — **30 Hrs**

1.Study of crushing strength of solid materials using jaw crusher
2.Study of crushing strength of solid materials using crushing rolls
3.Study of crushing strength of solid materials using ball mill

4. Study of characterization of filtration using to Filter Press. 5. Study of characterization of solid materials using leaf Filter. 6. Study of separation of fine particles using cyclone separator. 7. Study of separation of fine particles using sedimentation 8. Study of separation of fine particles using Air Elutriator. 9. Study of separation of solid particles using Drop Weight crusher. 10. Study of separation of fine particles using screens and determination of effectiveness of factor.	

Course Outcomes	
CO1	Estimate crushing characteristics, power requirements and constants of crushing laws using Jaw Crusher, Roll Crusher & Ballmill.
CO2	Analyze the average particle size and separation of fine particles using Sieve analysis, Cyclone separator and Air Elutriator.
CO3	Estimate specific cake and filter medium resistance using Plate and Frame Filter and Leaf filter press.
CO4	Determine the separation of fine particles using Drop weight Crusher.
CO5	Calculate the minimum area required by using Batch Sedimentation.

Text Books

1. Mc Cabe, Smith and Harriott, Unit Operations of Chemical Engineering, McGraw Hill, New York, 2002.

Reference Books

1. C. L. Narayanan & Bhattacharya Mechanical Operation for chemical Engineering, Khanna Publishers, 2003.
2. JM Coulson & JF Richardson, Chemical Engineering, Volume 2 (Particle Technology & Separation Processes), Butterworth – Heinemann Publishing Ltd., 4th Edition, 1996

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. How increase in surface area can be achieved
2. Define Sphericity and Agglomeration.
3. Explain the techniques for size analysis.
4. Where screen analysis applied to a crushed quartz,the density of the particle is 0.00265g/mm^3 and shape factor 2. Sphericity will be 0.511.
5. For a material between 4 mesh and 200 mesh the particle size . Calculate specific surface area,surface mean diameter,number of particles,average particle size,and volume mean diameter

Course Outcome 2 (CO2):

1. Explain the various laws of Size reduction.
2. Diameter of ball mill 500mm. Diameter of ball 40mm. Operating speed is 50% of the critical speed of ball mill. Calculate the operating speed of Ball mill.
3. What will be the power required to crush 150 tonns/hr of limestone if 50% of feed passes 50mm screen and 80% of the product at 3.145mm out screen. Work index 12.74
4. Find the critical speed of ball ill by using the data. Diameter of ball mill 450mm.Diameter of ball 25mm

Course Outcome 3 (CO3):

1. Derive the material balance over the screen and find out the effectiveness factor.
2. Differentiate Ideal Screen and Actual screen.
3. A screen with aperature of 6 mesh BSS is treating a feed with 66% of +6 mesh screen and producing an oversize fraction containing 89% of +6 mesh particles. If the undersize fraction contains 2% of +6 mesh particles, Calculate the Effectiveness of screen.
4. With a neat sketch explain the working principle of dust removing equipment.

Course Outcome 4 (CO4):

1. Describe the theory of filtration with reference to compressible and uncompressible cakes
2. How scraper effectively used in rotary vacuum filters

3. Explain the centrifugation operation and different centrifuges in chemical industry.
4. Discuss the special filtration operations in special reference to membrane and ultra filtration.

Course Outcome 5 (CO5):

1. Differentiate between mixing and agitation.
2. Derive the power consumption in Impeller based on Reynolds number.

A flat blade turbine with 6 blades is installed centrally in vertical tank. A tank is 1.5 m in dia. The turbine is 0.5m in diameter and positioned from 0.5m from the bottom of tank. The tank is filled to a depth of 1.5m with rubber latex compound at 65C having a viscosity of 1200poise and density 1129kg/m3. The turbine operated at 95rpm. Calculate the power.

3. Explain with neat sketch about the working of Liquid-Liquid mixing equipment.

Course Outcomes	**Skill**	**PO**	**Blooms**	**Assessing tools**
Ability to understand the characteristics of solids and principle of size reduction.	Remember/Understand	--	L1/L2	Assignment/Exam/ Quiz/ Seminar
Ability to apply the laws and power used for unit operations.	Apply	PO1	L3	Assignment/ Exam/ Quiz
Ability to analyse various equipments for separation and filtration.	Analyse	PO2	L4	Assignment/ Exam/ Quiz
Ability to investigate and select equipments for agitation and transportation of solids.	Investigation	PO3	L5	Exam/ Quiz/ Assignment/Seminar
Ability to solve the problems created by filtration, agitation and size reduction equipments.	Design	PO4	L6	Assignment/Exam/ Seminar
Ability to design the unit operation equipment as per the requirement	Modern Tools	PO5		Lab/Seminar

19UCH405	CHEMICAL PROCESS INDUSTRIES	L	T	P	C
		3	0	0	3

Objective:

- Develop understanding of manufacturing process flow drawing for the manufacturing chemical processes, its applications and major engineering problems encountered in the process
- To gain Knowledge on various aspects of production engineering and understand the practical methods of production in a chemical factory.

Module		Topics	L
I	A	**PAPER & CARBOHYDRATES INDUSTRIES:** Paper & Pulp – Wood extracts, Manufacture of Pulp – Kraft Process, Conversion of pulp into paper. Manufacture of Raw Sugar, Refined Sugar- By-products of sugar Industry. Manufacture of Starch and starch derivatives - Dextrin	9
II	A	**INORGANIC CHEMICAL INDUSTRIES:** Methods of production of Sulfur & Sulphuric Acid, Caustic Soda, Sodium Chloride, Nitrogen and Phosphorous based products – Manufacture of Ammonia, Urea, Phosphate rock beneficiation, Phosphoric acid, and Potassium sulphate, Single triple super Phosphate, Bio fertilizers.	9
III	A	**CEMENT & OIL BASED INDUSTRIES:** Cement types – Properties of cements, Manufacture of Portland Cement, Overall factors in cement industries, Vegetable oil extraction methods. Refining of vegetable oils. Hydrogenation of Oils. Soaps and Detergents, Manufacture of white and yellow Glycerine	9
IV	A	**SURFACE COATINGS & GLASS INDUSTRIES:** Constituents of paints & varnishes and their functions. Manufacture of pigments such as White lead, Zinc oxide and Titanium dioxide. Raw materials for Glass Industries. Production of glass by tank furnace - shaping and forming of articles from glass.	9
V	A	**PETROLEUM & PETROCHEMICAL INDUSTRIES:** Petroleum Refinery products Petroleum Conversion processes – Pyrolysis and Cracking, Natural and synthetic fibres- Manufacture of Nylons, ABS, Viscose Rayon, Cellulose Acetate, PVC, NBR, SBR	9
		Total Hours	**45**

Course Outcomes		**Bloom's Level**
CO1	Ability to understand the importance of pulping and explain the manufacturing process of paper, sugar & starch.	Remember/ Understand
CO2	Ability to understand the manufacturing principles of inorganic chemicals and fertilizers	Apply
CO3	Design the production methodology of cement and oil industries and analyse the efficiency of the products.	Analyse
CO4	Ability to understand the manufacturing process of pigments and industrial glass manufacturing process.	Evaluate
CO5	Evaluate the manufacturing process of Petroleum and petrochemical industries with applications	Create

Text Books

1. Gopala Rao M. and Marshall Sittig, ―Dryden's Outlines of Chemical Technology‖, 3rd Edition, East-West Press, New Delhi, 2008.
2. Austin G.T., ―Shreve's Chemical Process Industries‖, 5th Edition, McGraw-Hill International Book Company, Singapore, 2012.
3. Shukla, S.D. Pandey, G.N.: A Text Book of Chemical Technology, Vol. I, Vikas, New Delhi, (1994).

Reference Books

1. Mark W.V. and Bhatia S.C., ―Chemical Process Industries‖, Volume - I and II, 2nd Edition, CBS Publishers and Distributors, New Delhi, 2007.
2. Kent J.A., ―Riggel's Hand Book of Industrial Chemistry‖, Van Nostrant Reinhold, 1974.
3. Srikumar Koyikkal,"Chemical Process Technology and Simulation",PHI Learning Ltd(2013).
4. Stephenson, R.M. : Introduction to Chemical Process Industries, Van Nostrand, New Jersy, (1966).

Course Level Assessment Questions	
Course Outcome 1 (CO1): 1. Describe the term unit operations & unit processes 2. Outline the manufacturing of chemical pulp by Kraft process with a neat diagram. 3. Explain the manufacturing process of paper from pulp with a neat diagram 4. Describe the manufacturing process of sugar from sugarcane with a neat process diagram. 5. List the various applications of starch and with a neat sketch describe the starch production.	
Course Outcome 2 (CO2): 1. Examine the production of sulphuric acid by contact or chamber process with suitable diagram. 2. Differentiate the manufacturing process of hydrochloric acid 3. Design a layout for the production of urea and its end applications. 4. Describe the manufacturing process of single & triple super phosphates. 5. Demonstrate the production of bio fertilizers.	
Course Outcome 3 (CO3): 1. Examine the production of Portland cement and its end applications with suitable diagram. 2. Differentiate the manufacturing process of yellow glycerine and white glycerine. 3. Design a layout for hydrogenation of oil and the production of various vegetable oils 4. Describe the manufacturing soaps and discuss the history of production of soaps in india. 5. Demonstrate the production of detergents with its chemical reactions	
Course Outcome 4 (CO4): 1. Examine the production of paints and constituents of paints with a neat diagram 2. Differentiate the manufacturing process of Titanium oxide and Zinc oxide 3. Design a layout for the production of pigments and its end applications 4. Describe the process of shaping and forming in the production of glass. 5. Demonstrate the production of glass and ceramics and its uses.	

Course Outcome 5 (CO5):

1. Examine the petroleum conversion process and its chemical reactions
2. Differentiate the manufacturing process of NBR & SBR
3. Design a layout for the production of furfural and its end applications.
4. Describe the manufacturing process of Natural Rubbers and Synthetic rubbers.
5. Demonstrate the production of various petroleum refinery products

Course Outcomes	**Skill**	**PO**	**Blooms**	**Assessing tools**
Ability to understand the importance of pulping and explain the manufacturing process of paper, sugar & starch.	Remember/ Understand		L1/L2	Assignment/Exam/ Quiz/ Seminar
Ability to understand the manufacturing principles of inorganic chemicals and fertilizers	Apply		L3	Assignment/ Exam/ Quiz
Design the production methodology of cement and oil industries and analyse the efficiency of the products.	Analyse		L4	Assignment/ Exam/ Quiz
Ability to understand the manufacturing process of pigments and industrial glass manufacturing process.	Investigation		L5	Exam/ Quiz/Assignment/Seminar
Evaluate the manufacturing process of Petroleum and petrochemical industries with applications	Design		L6	Assignment/Exam/Seminar

19UCH406		MASS TRANSFER I	L	T	P	C
			2	1	0	3
MODULE		**TOPICS**			**L Hrs**	
I	**A**	**Introduction** Classification of mass transfer operations, Choice of separation method, Methods of conducting mass transfer operations, Diffusion and its types, Fick's first and second law of diffusion.			**9**	
	B	**Molecular Diffusion in Fluids:** Molecular and eddy diffusion, Ficks first law, Concept of N & J Flux, Steady state molecular diffusion in gases and liquids, Concept of fluids at rest and in laminar flow, Diffusivity measurement and prediction in fluids, Concept of effective diffusivity, multi-component diffusion, Diffusion in solids and its applications.				
II	**A**	**Mass Transfer Coefficients:** Eddy diffusion, Concept of mass transfer co-efficients, Mass transfer in laminar and turbulent regions, F and k type mass transfer coefficients, Theories of mass transfer, Mass transfer in laminar and turbulent flow, Dimensionless groups in mass transfer and their significance, Analogies: Reynolds, Chilton- Colburn and Taylor – Prandtl analogy, Analogy between Momentum, Heat and Mass transfer.			**9**	
	B	**Interphase Mass Transfer:** Concept of equilibrium, Diffusion between phases, Individual mass transfer coefficients, Relationship between individual and overall mass transfer co-efficient, Co-current and counter-current operations, Equilibrium and operating line concept.				
III	**A**	**Humidification** Basic concepts and terminologies, Adiabatic saturation process and theory of wet bulb temperature, Psychometric chart for Humidification and dehumidification calculations, humidification operations			**9**	
	B	Theory and design of cooling towers, dehumidifiers and humidifiers using enthalpy transfer unit concept, practical applications in chemical industry.				
IV	**A**	**Drying** Principles, Equilibrium in drying, Classification of dryers, Types of moisture content, Drying rate curves, Mechanism of moisture movement in solid, Mechanism of batch drying, continuous drying, Drying rate and time calculations for drying.			**9**	
	B	Various drying equipments and their applications, Design of dryer, Classification and selection of industrial dryers, Advance drying techniques.				
V	**A**	**Crystallization** Principles of crystallization, Equilibrium and yields, Saturation, Super saturation, Nucleation, Theory of homogeneous and heterogeneous nucleation, Law of crystal growth and growth coefficients, Caking of			**9**	

		crystals.	
	B	Classification of crystallizers, design of batch crystallizers and continuous crystallizers, Design calculations involving material and energy balances, Application of crystallization process in industry.	
		Total Hours	**45**

Text Books

1. Treybal, R. E., "Mass Transfer Operations", 3rd Edition, McGraw-Hill,1981.
2. Geankoplis, C.J., "Transport Processes and Unit Operations", 4th Edition, Prentice HallInc., NewJersey, 2003.
3. Narayanan K.V. and Lakshmikutty, B "Mass Transfer – Theory and Applications", 1st Edition, CBS Publishers & Distributors Pvt Ltd, New Delhi, 2014.

Reference Books

1. McCabe, W.L., Smith, J.C. and Harriot, P.,"Unit Operations in Chemical Engineering", 7th Edition., McGraw-Hill, 2005.
2. Coulson, J.M. and Richardson, J.F., "Chemical Engineering" Vol. I and II, 4th Edition, Asian Books Pvt. Ltd., India, 1998.
3. Seader J.D. and Henley E.J., "Separation Process Principles", 2nd Ed., John Wiley, 2006

COURSE OUTCOMES

The students have the

CO1	Ability to define, understand and explain the fundamental concepts of mass transfer principles
CO2	Ability to apply mass transfer concepts and solve complex problems in mass transfer operations
CO3	Ability to analyze various technological methods used in mass transfer processes
CO4	Ability to investigate and select mass transfer equipment for various industrial applications
CO5	Ability to design mass transfer equipments used in chemical industries
CO6	Ability to conduct experiments using modern tools: ANSYS - ICEM CFD, CFX, FLUENT.

Course Outcomes Mapping with Bloom's Taxonomy and Programme Outcomes

Course Outcome		Skill	PO	Bloom's Taxonomy	Assessment Tools to measure CO
CO1	Ability to define, understand and explain the fundamental concepts of mass transfer principles	Remember/ Understand	-	L1/L2	Exam/Assignment/Seminar/Quiz
CO2	Ability to apply mass transfer concepts and solve complex problems in mass transfer operations	Apply		L3	Exam/Assignment/Seminar/Quiz/Lab/Project
CO3	Ability to analyze various technological methods used in mass transfer processes	Analyze		L4	Exam/Assignment/Seminar/Quiz/Lab/Project
CO4	Ability to investigate and select mass transfer equipment for various	Investigate		L5	Mini Project/Assignment/Quiz/Lab/Ex

	industrial applications				am
CO5	Ability to design mass transfer equipments used in chemical industries	Design		L6	Assignment/Lab /Exam/Seminar
CO6	Ability to conduct experiments using modern tools: ANSYS - ICEM CFD, CFX, FLUENT.	Modern Tools		-	Lab/Project

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Explain about diffusivity in liquids and gases
2. Show that $J_A = -J_B$
3. Define the term 'Psychrometric ratio' and explain its significance
4. Explain the various regions of drying with a neat rate curve
5. Explain different techniques of achieving super saturation with suitable examples

Course Outcome 2 (CO2):

1. A mixture of air and water is at a total pressure of 900 mm Hg. The percentage saturation is 40%. Estimate the absolute humidity and relative saturation. The vapour pressure of water at the given condition is 300 mm Hg.
2. A wet solid is to be dried from 80 to 10% moisture, wet basis. What is the moisture to be evaporated per 1000kg of dried product?
3. A solution of sodium carbonate available at a temperature of 40^{o}C with a solute content of 30%. Find out the weight of $Na_2CO_3.10H_2O$ crystal formed if 2000 kg of this solution is cooled to 10^{o}C. Also find out the yield. Solubility at 10^{o}C is 12.5 g Na_2CO_3/10 g of water.
4. A crystal of copper sulfate $CuSO_4.5H_2O$ falls through a large tank of pure water at 20^{0}C. Estimate the rate at which the crystal dissolves by calculating the flux of $CuSO_4$ from the crystal surface to the bulk solution. Molecular diffusion occurs through a film of water uniformly 0.0305 mm thick surrounding the crystal. At the inner side of the film, adjacent to the crystal surface, the concentration of $CuSO_4$ is 0.0229 mole fraction $CuSO_4$ (density of solution = 1193 kg/m^3). The outer surface of the film is pure water. The diffusivity of $CuSO_4$ is 7.29 X10^{-10} m^2/s.
5. In a wetted wall column carbon dioxide is being absorbed from air by water flowing at 2 atm pressure and 25^{0}C. The mass transfer coefficient k_y has been estimated to be 6.78 X10^{-5} kmol/(m^2.s.mole fraction).Calculate the rate of absorption if the partial pressure of carbon dioxide at the interface is 0.2 atm and the air is pure. Also determine k_y and k_g.

Course Outcome 3 (CO3):

1. Give an account for the counter current and co-current process by drawing the equilibrium and operating line
2. Elaborate the theory of wet bulb temperature and derive an equation to determine wet bulb depression.
3. In an experimental study of absorption of ammonia by water in a wetted wall column, the overall gas phase mass transfer coefficient, K_G was estimated as 2.72x10^{-4} kmol/m^{2}s.atm. At one point in the column the gas contained 10 mol% ammonia and the liquid phase concentration was 6.42 x 10^{-2} kmol NH_3/m^3 of solution. Temperature is 293K and the total pressure is 1 atm. 85% of the resistance to mass transfer lies in gas phase. If Henry's law constant is 9.35 x 10^{-3} atm.m^3/kmol, calculate the individual film coefficient and the interfacial composition
4. A batch of the solid, for which the following table of data applies, is to be dried from 30% to 6% moisture under conditions identical to those for which the data were tabulated. The initial weight of the wet solid is 300 kg and the drying surface is 1m^2/10 kg dry weight. Determine the time for drying.

X x 100 (kg moisture/kg dry solid)	45	35	25	20	18	16	14	12	10	9	8	7	6.4

N x 100 (kg moisture evaporated/hr.m^2)	30	30	30	30	26.6	23.9	20.8	18	15	9.7	7	4.3	2.5

5. Under constant drying conditions, a filter cake takes 7 hours to reduce its moisture content from 30% to 10% on wet basis. The critical moisture is 14% and the equilibrium moisture 4% both on dry basis. Assuming the rate of drying in the falling rate period to be directly proportional to the free moisture content, estimate the time required to dry the cake from 30% to 6% moisture on wet basis

Course Outcome 4 (CO4):

1. Compare and contrast packed column with plate column used in industries
2. In an apparatus for the absorption of SO_2 in water at one point in the column the concentration of SO_2 in gas phase was 10% by volume and was in contact with a liquid containing 0.35% SO_2 by weight. Pressure and temperature are 1atm and 303 K respectively. The overall gas phase phase mass transfer coefficient is 7.36×10^{-10} kmole/m^2.s.(N/m^2). Of the total resistance 50% lies in the gas phase and 50 % in the liquid phase.

Equilibrium Data:

kg SO_2 /100 kg water	0.2	0.3	0.5	0.7
Partial pressure of SO_2, mm Hg	29	46	83	119

3. Explain with a neat sketch the construction and operation of induced draft cooling tower and its significance in chemical processes.
4. In an experimental study of absorption of ammonia by water in a wetted wall column, the overall gas phase mass transfer coefficient, K_G was estimated as 2.72×10^{-4} kmol/m^2s.atm. At one point in the column the gas contained 10 mol% ammonia and the liquid phase concentration was 6.42×10^{-2} kmol NH_3/m^3 of solution. Temperature is 293K and the total pressure is 1 atm. 85% of the resistance to mass transfer lies in gas phase. If Henry's law constant is 9.35×10^{-3} atm.m^3/kmol, calculate the individual film coefficient and the interfacial composition
5. A commercial drier needed 7 hours to dry a moist material from 33% moisture content to 9% on bone dry basis. The critical and equilibrium moisture content were 16% and 5% on bone dry basis respectively. Determine the time needed to dry the material from a moisture content of 37% to 7% on bone dry basis if the drying conditions remain unchanged.

Course Outcome 5 (CO5):

1. Write a note on Mixed Suspension- Mixed Product Removal (MSMPR) model in the design of crystallizer
2. A plant requires 2000 kg/min of cooling water to flow through its distillation equipment condensers. The water will leave the condensers at 50^0C. It is planned to design a counter current cooling tower in order to cool this water to 30^0C from 50^0C for reuse, by contact with air. Air is available at 30^0C DBT and 24^0C WBT. 30% of excess air will be used and the make up water will enter at 15^0C. For the packing to be used, the value of mass transfer coefficient is expected to be 2500 Kg/hr.m^3.ΔY, provided the minimum liquid rate and gas rates are 12,000 and 10,000 kg/h. m^2 respectively. Determine the diameter of the cooling tower and make up to be used.

Temp ^{0}C	20	30	40	50	55
Enthalpy, KJ/kg	60.735	101.79	166.49	278.72	354.92

3. How much feed is required when 10000 kg of crystal as $FeSO_4.7H_2O$ is produced per hour by a simple vacuum crystallizer. The feed containing 40 parts of $FeSO_4$ per 100 parts of total water, enters the crystallizer at 80^{o}C. The crystallizer vacuum is such that crystallizer temperature of 30^{o}C can be produced.

Data: Saturated solution at 30^{o}C contains 30 parts of $FeSO_4$ per 100 parts of total water vapour enthalpy is 612 cal/g (neglect superheat). The enthalpies of saturated solution, the crystals leaving the crystallizer and feed are: -1.33, -50.56 and 26.002 cal/g.

4. Explain the design of cooling towers and the steps involved in the design of cooling towers

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	19UGS431 - REASONING AND QUANTITATIVE APTITUDE	L	T	P	C
		1	0	0	1

OBJECTIVES :

1. To make the student acquire sound knowledge of the characteristic of quantitative and qualitative aptitude.
2. To familiarize the student with various principles involved in solving mathematical problems.
3. To develop an understanding of the basic concepts of reasoning skills.

UNIT I	QUANTITATIVE APTITUDE	8

Ratio and Proportion - Averages – Percentages – Problems on ages – Profit and Loss – Simple and Compound Interest -– Time – Speed –Distance - Time and Work – Permutation and Combination - Alligation or Mixture – Probability – Clocks – Calendars.

UNIT II	VERBAL AND NON VERBAL REASONING	7

Analytical Reasoning – Circular and Linear arrangement – Direction problems – Blood relations – Analogy – Odd Man Out – Venn Diagrams - Data Sufficiency – Data interpretation — Syllogism - Coding – Decoding.

TOTAL = 15 Periods

COURSE OUTCOMES:

After the successful completion of this course, the student will be able to

- Select an appropriate technique to solve the quantitative problems within the stipulated time. (Apply)
- Apply Verbal and Non Verbal Reasoning skills to solve the problems based on the logical and analytical reasoning. (Apply)
- Analyse the direction to solve equations involving one are more unknowns. (Analyse)

WEBSITES:

www.m4maths.com, www.indiabix.com, www.fresherworld.com, www.campusgate.co.in, www.indianstudyhub.in, www.tcyonline.com.

TEXT BOOKS:

1. Dr. R.S.AGARWAL, "Quantitative Aptitude", S. Chand Publications, New Delhi, 20th Edition, (2013).
2. ABIJIT GUHA, "Quantitative Aptitude for Competitive Examinations", Tata McGraw Hill Publication, New Delhi, 4th Edition, (2011).
3. R.V.Praveen, "Quantitative Aptitude and Reasoning", PHI Learning Pvt. Ltd., Delhi, 2nd Edition, (2013).

REFERENCE BOOKS:

1. ASHISH AGGARWAL, "Quick Arithmetic", S. Chand Publications, New Delhi, 6th Revised Edition, (2014).
2. Dr.V.A.SATHGURUNATH'S "A Guide for Campus Recruitment", Sagarikka Publications, Thiruchirapalli, 3rd Edition, (2011).

19UGM431 - GENDER EQUALITY

Objectives:

- To introduce basic concepts relating to gender and to provide logical understanding of gender roles.

UNIT I GENDER SENSITIZATION

Definition of gender, Perspectives-Gender sensitive approach- Gender and sex- Social construction of gender and gender roles- Socialisation- institutions of socialization- changing content and context of gender-need for re-socialization. Gender Stereotyping and Gender Discrimination

UNIT II GENDER EQUALITY AND CONSTITUTION

Indian constitution related to equality - Fundamental rights - Directive principles of state policy - right to equality - rights against exploitation - cultural and educational rights - the right to constitutional remedy - University Declaration of Human Rights - Enforcement of Human Rights for Women and Children - Role of Cells and Counselling Centres- Internal Complaints Committee - Legal AID cells, Help line, State and National level Commission

UNIT III GENDER ROLES & EQUALITY

Gender & Morality – Structural and functionalist views of Gender- Gender in the Classroom- Beyond access for girls and boys- Gender equality in schools- Gender equality and adult basic education- Developing capacity to achieve gender equality in education- Individuality and removal of gender stereotypes- Respect for each other's-Promote equal Opportunity

REFERENCES:

1. Sheila Aikman and Elaine Unterhalter, "Practising Gender Equality in Education", Oxfam GB, 2007.
2. Pasadena and Hackensack, "Gender roles and Equality", Salem Press,2011.

19UCH501 PROCESS ECONOMICS AND MANAGEMENT			L	T	P	C
AIM: This course provides the basic concept of cost estimation, feasibility analysis, management, organization and quality control that will enable the students to perform as efficient managers at Industries.			**2**	**1**	**0**	**3**
MODULE		**TOPICS**				**L Hrs**
I	**A**	**UNIT – I** Economics – Basics Concepts and Principles – Demand and Supply – Law of demand and Supply –Determinants – Market Equilibrium – Circular Flow of Economic activities and Income.				**9**
II	**A**	**UNIT – II** National Income and its measurement techniques. Inflation – Causes of Inflation – Controlling Inflation – Business Cycle. Forms of business – Management Functions: Planning, Organizing, Staffing, Leading and Controlling - Managerial Skills - Levels of Management - Roles of manager.				**9**
III	**A**	**UNIT – III** Marketing - Core Concepts of Marketing - Four P‘s of Marketing – New product development – ProductLife Cycle - Pricing Strategies and Decisions.				**9**
IV	**A**	**UNIT – IV** Operations Management - Resources - Types of Production system - Site selection, Plant Layout, Steps in Production Planning and Control – Inventory - EOQ Determination.				**9**
V	**A**	**UNIT – V** Accounting Principles – Financial Statements and its uses – Depreciation: Straight Line and Diminishing Balance Method – Break Even Analysis – Capital Budgeting: Meaning – Types of decisions – Methods (Theory).				**9**
		Total Hours				**45**

Text Books

1. Economics and Management For Engineers,Compiled by Department of Management studies, Kongu Engineering College, McGraw-Hill Education, India, 2013.

Reference Books

1. Jeff Madura, ―Fundamentals of Business‖, Cengage Learning Inc., India, 2007.

COURSE OUTCOMES

The students have the

CO1	Ability to estimate market equilibrium and interpret national income calculation and inflation issues.
CO2	Ability to categorize the forms of business and analyze the functions of Management.
CO3	Ability to appraise marketing management decisions.
CO4	Ability to apply appropriate operation management concept in business situations.
CO5	Ability to Interpret at apply financial and accounting statements.
CO6	Ability to conduct experiments using modern tools.

Course Outcomes Mapping with Bloom's Taxonomy and Programme Outcomes

Course Outcome		Skill	PO	Bloom's Taxonomy	Assessment Tools to measure CO
CO1	Ability to estimate market equilibrium and interpret national income calculation and inflation issues.	Remember/ Understand	-	L1/L2	Exam/Assignment/Seminar/Quiz
CO2	Ability to categorize the forms of business and analyze the functions of Management.	Analyze	PO2	L3	Exam/Assignment/Seminar/Quiz/Lab/Project
CO3	Ability to appraise marketing management decisions.	Understand	-	L4	Exam/Assignment/Seminar/Quiz/Lab/Project
CO4	Ability to apply appropriate operation management concept in business situations.	Apply	PO1	L5	Mini Project/Assignment/Quiz/Lab/Exam
CO5	Ability to Interpret at apply financial and accounting statements.	Apply	PO1	L6	Assignment/Lab/Exam/Seminar
CO6	Ability to conduct experiments using modern tools.	Modern Tools	PO5	L3	Lab/Project

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Write a note on to calculate national income?
2. Explain the equilibrium level of national income?
3. Derive the national income calculation with example?
4. With a neat sketch, explain the working principle of calculation equilibrium consumption?
5. Distinguish between the two types of equilibrium consumption bringing out their essential features.

Course Outcome 2 (CO2):

1. Derive the categories of management? Obtain an expression for these measures.
2. A factory is making a pipe fitting by (a) costing, (b) forging. The cost data is as follows:

S.No	Item	Casting	Forging
1.	Material cost/price in Rs.	2	2

2.	Time required to make one fitting	3 hrs	48 minutes
3.	Labour rate	0.80/hr	0.80/hr
4.	Over-heads	25% of labour cost	150% of labour cost

3. Explain how will you find out the functions of management?
4. What are the forms of business cycle?
5. Discuss in detail about the services in high demand?

Course Outcome 3 (CO3):

1. A project expected to have cash flow for the five years as follows after all expenses and taxes the initial fixed capital investment is 1000000 and the working capital investment is 15% of the fixed capital investment.
2. By investing 96000 in automatic machines,number of operations are reduced.saving in labour is estimated to be a Rs.4/hr. find the rate of return.the salvage value after 8 years is estimated to be a Rs.16000.the unit works for 24 hrs and 300 days/year.
3. A mining company estimates that it can increase a sales if it procure a new machine to cut more. The installed cost of new machine is Rs.3000000.the extra expenditure per year is Rs.1750000 and extra income is 75% of installed cost per year.the salvage value of after 12 years is expected to be 12.5% of installed cost.what is the rate of return?
4. What decisions do make marketing management functions?
5. How do you evaluate marketing? Explain the different methodologies with suitable examples?

Course Outcome 4 (CO4):

1. What are the concepts of operations management?
2. What is the role of operations management in a business?
3. State Operation management with example.
4. How is Operations Management linked to other business functions?

Course Outcome 5 (CO5):

1. How do you interpret financial statements?
2. What is interpretation in accounting?
3. Why there is a need to understand interpret and analyze financial statement reports?
4. Show that interpret income statement and balance sheet?

19UCH502	MASS TRANSFER II	L	T	P	C
		2	1	0	3

OBJECTIVES

The course is aimed to

- Impart knowledge on mass transfer operations and mechanism
- Understand mass transfer in absorber, distillation column, liquid-liquid and solid-liquid extraction and to have the ability to design mass transfer equipment for industrial applications

MODULE		TOPICS	L Hrs
I	A	**ABSORPTION** Equilibrium and operating line concept in absorption calculations; types of contactors, design of packed and plate type absorbers; Operating characteristics of stage wise and differential contactors, concepts of NTU, HTU and overall volumetric mass transfer coefficients; multicomponent absorption; mechanism and model of absorption with chemical reaction; thermal effects in absorption process.	9
II	A	**DISTILLATION** Vapour-Liquid Equilibria, Raoult's law and deviations from ideality, methods of distillation: Flash distillation, differential or simple distillation, steam distillation, multistage continuous rectification, Total reflux, minimum reflux ratio, optimum reflux ratio, Choice and effect of pressure in distillation column Design calculations by McCabe-Thiele and Ponchon-Savarit methods, Murphree stage and overall efficiency.	9
III	A	**LIQUID-LIQUID EXTRACTION** Equilibrium in ternary systems; equilibrium stage wise contact calculations for batch and continuous extractors, differential contact extraction equipment - spray, packed and mechanically agitated contactors and their design calculations; pulsed extractors, centrifugal extractors.	9
IV	A	**SOLID-LIQUID EXTRACTION (LEACHING)** Solid-liquid equilibria; leaching equipment-batch and continuous types; calculation of number of stages.	9
V	A	**ADSORPTION** Theories of adsorption of gases and liquids; industrial adsorbents, adsorption equipment for batch and continuous operation; design calculation of ion-exchange resins; principle of ion-exchange; industrial equipment.	9
		Total Hours	45

Text Books

1. Treybal, R. E., "Mass Transfer Operations", 3rd Edition, McGraw-Hill,1981.
2. McCabe, W.L., Smith, J.C. and Harriot, P.,"Unit Operations in Chemical Engineering", 7th Edition., McGraw-Hill, 2005.
3. Narayanan K.V. and Lakshmikutty, B "Mass Transfer – Theory and Applications", 1st Edition, CBS Publishers & Distributors Pvt Ltd, New Delhi, 2014.

Reference Books

1. Geankoplis, C.J., "Transport Processes and Unit Operations", 4th Edition, Prentice HallInc., NewJersey, 2003.
2. Coulson, J.M. and Richardson, J.F., "Chemical Engineering" Vol. I and II, 4th Edition, Asian Books Pvt. Ltd., India, 1998.
3. Seader J.D. and Henley E.J., "Separation Process Principles", 2nd Ed., John Wiley, 2006

COURSE OUTCOMES

The students have the

CO1	Ability to define, understand and explain the fundamental concepts in all mass transfer operations
CO2	Ability to apply mass transfer concepts and solve complex problems in mass transfer operations
CO3	Ability to analyze various technological methods used in mass transfer industrial processes
CO4	Ability to investigate and select mass transfer equipment for various industrial applications
CO5	Ability to design mass transfer equipments used in chemical industries
CO6	Ability to conduct experiments using modern tools.

Course Outcomes Mapping with Bloom's Taxonomy and Programme Outcomes

Course Outcome		Skill	PO	Bloom's Taxonomy	Assessment Tools to measure CO
CO1	Ability to define, understand and explain the fundamental concepts in all mass transfer operations	Remember/ Understand	-	L1/L2	Exam/Assignment/Seminar/Quiz
CO2	Ability to apply mass transfer concepts and solve complex problems in mass transfer operations	Apply	PO1	L3	Exam/Assignment/Seminar/Quiz/Lab/Project
CO3	Ability to analyze various technological methods used in mass transfer industrial processes	Analyze	PO2	L4	Exam/Assignment/Seminar/Quiz/Lab/Project
CO4	Ability to investigate and select mass transfer equipment for various industrial applications	Investigate	PO4	L5	Mini Project/Assignment/Quiz/Lab/Exam
CO5	Ability to design mass transfer equipments used in chemical industries	Design	PO3	L6	Assignment/Lab/Exam/Seminar
CO6	Ability to conduct experiments using modern tools.	Modern Tools	PO5	L3	Lab/Project

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Write a note on pressure drop in packed towers for absorption
2. Explain the principle of steam distillation
3. Derive Kremser equation for the continuous counter-current extraction operation.
4. With a neat sketch, explain the working principle of various leaching equipments
5. Distinguish between the two types of adsorption phenomena bringing out their essential features

Course Outcome 2 (CO2):

1. Derive an equation for finding out the height of a packed column operating in a counter current method. Obtain an expression for the determination of the height of the absorption tower.
2. In a binary mixture the vapor pressure of A is 800 mm Hg and that of B is 400 mm Hg. Estimate the vapor composition in equilibrium with the liquid if the composition in liquid phase is 50 mole % A.

3. Explain how will you find out the final composition of the solute in the raffinate for immiscible solvent and diluents in single and multistage cross current extraction.

4. 0.8 kg/s of seeds containing 30% by wt. of oil are extracted on a counter-current unit and 95% of the oil recovered in a solution containing 50% by wt. oil. Calculate the number of stages of the final conc. from stage one (over flow) twice final conc. from stage N counter flow.

5. Discuss in detail about the commercial adsorbents available in the market for various industrial applications

Course Outcome 3 (CO3):

1. An air-ammonia mixture containing 5% ammonia by volume is absorbed in water in a packed column operated at 200C and 1 atm pressure. So as to recover 98% NH3. If the inert gas flow rate in the column is 1200 kg/m2.hr. calculate

(i) The minimum mass velocity of water from this column.

(ii) The number of transfer units in the column taking the operating liquid rate to be 1.25 times the minimum.

(iii) The height of the packed tower taking the overall transfer coefficient KG a to be 128 kg moles/ m3.hr.atm. The relationship for equilibrium in the column is y = 1.154 x, where y and x are in mole fraction units.

2. A feed mixture of A and B (45 mole %A and 55 mol % B) is to be separated into a top product containing 96 mol %A and bottom product having 95 mol % B. The feed is 50% vapour and reflux ratio is 1.5 times the minimum. Determine the number of ideal trays required and the location of feed tray. Given α AB = 2.8.

3. A solution of 5% acetaldehyde in toluene is to be extracted with water in a five-stage co-current unit. If 25 kg of water/100 kg feed is used, find the amount of acetaldehyde extracted and the final concentration. (Both by theoretical and graphical method)

The equilibrium relation is given by:

(kg acetaldehyde/kg water) = 2.20 (kg acetaldehyde/kg toluene).

4. 1.6 kg/s of sand-salt mixture containing 62.5% sand is leached with 0.5 kg/s of water in a counter-current. The residue from each stage containing 0.25 kg water per kg insoluble solid. Find the number of stages such that the sand from the final stage contains 10% salt when dried.

5. The equilibrium decolourization data for a certain system using activated carbon is given by the equation

$$Y = 0.004\ X^2$$

where Y is g colouring impurity/kg impurity free solution and x is g colouring impurity/kg pure activated carbon.

Calculate the amount of activated carbon required per 1000 kg of impurity free solution to reduce the impurity concentration from 1.2 to 0.2 g/kg of impurity free solution using (i) a single stage operation and (ii) a two-stage cross-current operation with intermediate composition of 0.5 g of coloring impurity per kg of impurity free solution.

Course Outcome 4 (CO4):

1. NH3 is absorbed from a gas by water in a scrubber under atm pressure. The initial NH3 content in the gas is 0.04kmole / kmole of inert gas. The recovery of NH_3 by absorption is 90%. The water enters the tower free from NH_3. Estimate the

(i) Concentration of NH3 in the existing liquid if the actual water used is 1.5 times minimum.

(ii) Number of theoretical stages required If the height of a transfer unit is 0.5 m estimate the height

of column.

x: 0.005 0.01 0.0125 0.015 0.02 0.023

y: 0.0045 0.0102 0.0138 0.0183 0.0273 0.0327 where x and y are mole ratios.

2. A mixture of 40% A and 60% B is to be separated by distillation using a reflux ratio 3.5 so as to form an overhead product containing 95 mol% of A and a bottom product containing 95 mol% of B. The feed is saturated vapour. The relative volatility of A to B is 2.5. Determine the following:

(i) Minimum reflux ratio

(ii) Number of theoretical plates

(iii) Minimum number of theoretical plates

3. 1000 kg/hr of a dioxane-water mixture containing 25% dioxane (by weight) is to be continuously extracted in counter fashion with benzene to remove 95% of the dioxane. Assume benzene and water are immiscible with each other. The equilibrium data are as follows:

Wt % dioxane in water phase	5.1	18.9	25.2
Wt % dioxane in benzene phase	5.2	22.5	32.0

(i) Calculate the minimum solvent required in kg/hr and (ii) If 900 kg/hr of solvent is used, calculate the number of theoretical stages required.

4. Nicotine in water containing 1%Nicotine is to be extracted with kerosene at 200°C water. Water and kerosene are insoluble. Estimate the percentage extraction of Nicotine for the following cases.

(i) If 100 kg of feed solution is extracted in a single stage with 150 kg of solvent.

(ii) If 100 kg of feed solution is extracted in three theoretical stages using 50kg of fresh solvent in each stage.

Equilibrium data: X‘	0	0.00101	0.00246	0.00502	0.00751	0.00998	0.0204
Y‘	0	0.00081	0.001962	0.00456	0.00686	0.00913	0.0197

5. An aqueous solution is colored by small amounts of impurity which is to be removed by adsorption on activated carbon. The color intensity which is proportional to the concentration of the colored substance was measured on an arbitrary scale. It is desired to reduce the color to 10 % of its original value, 9.6. Estimate the amount of adsorbent used for single stage.

Kg of carbon/ kg of solution	0	0.001	0.004	0.008	0.02	0.04
Equilibrium color	9.6	8.6	8.3	4.3	1.7	0.7

Course Outcome 5 (CO5):

1. It is desired to recover 98% ammonia from air-ammonia mixture containing 2% ammonia at 20 C and at 1 atm by scrubbing with water in a tower packed with 2.54 cm rasching rings. If the gas flow rate is 19.5 kg/m^2.min at the inlet and liquid flow rate is 1.8 times the minimum. Estimate the height of packed tower for countercurrent operation. Absorption is assumed to be isothermal. The equilibrium relation is given by y = 0.764 x, where y, x are gas and liquid phase composition of ammonia in mole fraction respectively. The overall mass transfer coefficient is 1.04 kg mole/m^3atm.min

2. A continuous distillation column is to be designed 7000kg/hr of liquid mixture with 60% methanol and 40 mole% water into an overhead product containing 90 mole% methanol and water product 95 mole% water. Reflux ratio of 2 times the minimum value is used. Assume relative volatility of methanol and water is 3. Calculate (i) the moles of overhead of water product. (ii) Number of ideal trays and feed tray if the feed is at boiling point.

3. A solution containing 20 mass per cent of acetone in water is to be extracted using

monochlorobenzene (MCB) containing 0.5% acetone by weight by counter current extraction process. MCB and water may be considered to be immiscible within the operating range. The equilibrium data are as follows:

Kg of acetone Per Kg of water	0.0258	0.0739	0.1605	0.267
Kg of acetone Per Kg of MCB	0.0288	0.0704	0.156	0.237

4. 2 kg/s of a solid containing 30% by mass a water soluble component is to be leached in a counter – current unit . Given that the recovery is 98% and that the under flow from each stage contains 0.5 kg water / kg insoluble solid . Find :

(A) The number of stages required if the water flow rate is 1.6 kg/s .

(B) The water flow rate if the number of stages is 3 .

5. Design a fixed bed adsorber with ion-exchange resins as packing materials with two stages used for treatment process in industry. Assume the equilibrium and other data applicable for the system.

Course Outcome 6 (CO6):

1. Develop MATLAB simulation studies for the flow through fractional distillation column
2. Design and simulate the single stage extraction device using MATLAB SIMULINK
3. A soluble gas is absorbed in water using packed tower. The equilibrium relationship is $Y_e = 0.06\ X_e$ and terminal conditions are

	Top	Bottom
X	0	0.08
Y	0.001	0.009

If the individual height of transfer units based on liquid phase and gas phase respectively are H_x = 0.24 m and Hy = 0.36 m, determine the height of packing. Simulate the absorption tower using ASPEN software for the given conditions.

19UCH503 CHEMICAL REACTION ENGINEERING I	L	T	P	C
	2	1	0	3

AIM

To study about reactions and the factors influence the rate of reaction and to design various reactors.

OBJECTIVES

Students will be introduced and developing an understanding on

- Basic Concepts of Kinetics and Rate Laws
- Design and Rating of Ideal Reactors including heat effects
- Interpretation of Rate data
- Design and Rating of Reactors involving multiple reactions including heat effects
- Analysis of Non-ideal flow behavior in Reactors

MODULE	TOPICS	L Hrs
I	**FUNDAMENTAL CONCEPTS AND DEFENITIONS** Reaction – Classification of reaction, rate and stoichiometry, rate law, rate equation, rate constant, activation energy, elementary and non elementary reactions, molecularity and order of reaction	4
II	**CHEMICAL KINETICS** Theories of reaction rates, Interpretation of batch reactor data: constant volume system. Integral method, Differential method, analysis of data for reversible and irreversible reactions, reaction mechanism, variable volume system	**7**
III	**ISOTHERMAL IDEAL REACTOR DESIGN OF SINGLE REACTIONS** Design of ideal batch reactor, ideal mixed flow reactor, ideal plug flow reactor- size comparison of single reactors for single reactions	6
IV	**MULTIPLE REACTORS** Multiple reactor systems – equal sized MFR in series – unequal sized MFR in series – Plug flow reactors in series (or) in parallel – reactors of different types in series	6
V	**SPECIAL REACTORS** Design of recycle reactor, Design of autocatalytic reactor	5
VI	**DESIGN OF MULTIPLE REACTIONS** Design of parallel (simultaneous) reactions CSTR, PFR – Design of series (consecutive) reactions CSTR, PFR – Design of combined series and parallel reactions.	6
VII	**NON ISOTHERMAL REACTORS** Adiabatic reactors – rate of heat exchange for different reactors – optimum temperature progression – operation of batch and continuous reactors.	6
VIII	**NON – IDEAL REACTORS** Basics of non- ideal flow, Residence time distribution, relationship between C, E, F curves, Modelling of non- ideal reactors – one parameter and two parameter models, conversion in non – ideal reactors.	5
	Total Hours	**45**

Text Books

1. O. Levenspiel, Chemical Reaction Engineering, 3rd ed., Wiley Publications, 2006.

Reference Books

1. H.S. Fogler, Elements of Chemical Reaction Engineering, 5 th ed., Prentice Hall India Pvt. Ltd., New Delhi, 2016.

2. G. F Froment, K.B Bischoff and J.D Wilde, “Chemical Reactor Analysis and Design”, Wiley, New York, 2010

3. J.M. Smith, Chemical Engineering Kinetics, 8 th ed., McGraw-Hill, 2008.

Course Outcomes		Bloom’s Level
CO1	Describe the concepts and carryout findings on activation energy, rate constant, order and	Remember

	molecularity.	
CO2	Calculate design parameters of various single and multiple reactor system	Apply
CO3	Ability to categorize reactors for various industrial applications	Analyze
CO4	Judge reactor system for a particular reaction to achieve maximum conversion, selectivity and yield	Evaluate
CO5	Construct models to study the conversion of non – ideal reactors	Apply
CO6	Design various ideal isothermal reactors, special reactors using software	Create

Course Outcomes Mapping with Bloom's Taxonomy and Programme Outcomes

Course Outcome		Skill	PO	Bloom's Taxonomy	Assessment Tools to measure CO
CO1	Describe the concepts and carryout findings on activation energy, rate constant, order and molecularity.	Remember/Understand	-	L1/L2	Exam/Assignment/Seminar/Quiz
CO2	Calculate design parameters of various single and multiple reactor system	Apply	PO1	L3	Exam/Assignment/Seminar/Quiz/Lab/Project
CO3	Ability to categorize reactors for various industrial applications	Analyze	PO2	L4	Exam/Assignment/Seminar/Quiz/Lab/Project
CO4	Judge reactor system for a particular reaction to achieve maximum conversion, selectivity and yield	Investigate	PO4	L5	Mini Project/Assignment/Quiz/Lab/Exam
CO5	Construct models to study the conversion of non – ideal reactors	Design	PO3	L6	Assignment/Lab/Exam/Seminar
CO6	Design various ideal isothermal reactors, special reactors using software	Modern Tools	PO5	L3	Lab/Project

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. What is an ideal batch reactor?
2. What are the methods by which we can maintain low concentration of CA in parallel reactions?
3. Give the energy balance equation for an adiabatic reaction.
4. What is pulse input and step input method?
5. Discuss in detail the tanks in series model to predict the conversion from the RTD data
6. Discuss in detail about RTD measurement by step input method with various plots obtained
7. Derive the performance equation of plug flow reactor and give the graphical representation of performance equation

Course Outcome 2 (CO2):

1. An elementary liquid phase reaction A+B→ P with $-r_A$ = 500 l/mol min and $C_{AO}=C_{BO}$=.01mol/l is carried out in a tubular reactor whose volume is 0.1 l and V_O is 0.05 l/min. Find the fractional conversion of reactants that can be achieved?

2. For the parallel reactions A→ R, r_R= 1,A→S , $r_S = 2C_A$ A→T ,$r_T=1C_A^2$ with C_{AO} = 2 gmol/lit.what will be the fractional yield of S when fractional concentration is 0.5

3. It is proposed to operate a batch reactor for converting A--→R. This is a liquid phase reaction with the stoichiometry A--→R. Evaluate the time required to drop the concentration of A from C_{AO} = 1.3 mol/lit to C_{Af}=0.30 mol/lit? The rate versus concentration data is

C_A (mol/lit)	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	1.0	1.3	2.0
$-r_A$	0.1	0.3	0.5	0.6	0.5	0.25	0.10	0.06	0.05	0.045	0.042

4. Liquid reactant A decomposes as per the following reactions in parallel

A-→R

A-→S(desired)

A-→T

With $r_R = 1$, $r_S = 2 C_A$ and $r_T = C_A^2$ and $C_{AO} = 2$ in a feed. Determine the maximum concentration of desired product that can be obtained in a mixed flow reactor

5. The first order irreversible liquid phase reaction is carried out in a mixed flow reactor. The density of the reaction mixture is 1.2g/cm^3 and the specific heat is 0.9cal/g.c. the volumetric flow rate is 200 cm^3/s and the reactor volume is 10lit. $k = 1.8\times10^5 e^{-12000/RT}$. If the heat of reaction is -46000cal/mol and feed temperature is 293k (20^{o}C). What are possible temperature and pressure for stable, adiabatic operation for a feed concentration of 4mol/lit.

Course Outcome 3 (CO3):

1. A liquid phase reaction with stoichiometry A→R is carried out in a plug flow reactor whose rate versus concentration data is given below is studied. Determine the size of the plug flow reactor required to achieve 80%conversion of a feed stream of 1000 mol A/hr at C_{AO}= 1.5 mol/l

C_A, mol/l	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	1.0	1.3	2.0
$-r_A$, (mol/l .min)	0.1	0.3	0.5	0.6	0.5	0.25	0.10	0.06	0.05	0.045	0.042

2. A homogenous liquid phase reaction with stoichiometry and kinetics A→S, $-r_A = k C_A^2$ takes place in a mixed flow reactor and results in 50% conversion.

i) find the conversion if this reactor is replaced by another mixed flow reactor having volume 6 times that of the original reactor.

ii) find the conversion if the original reactor is replaced by a plug flow reactor of same size.

3. The following reactions are observed when an olefin is epoxidized with dioxygen:

alkene + O2 ===> epoxide

epoxide + O2 ===> CO2 + H20

alkene + O2 ===> CO2 + H20

Derive the rate expression for this mixed-parallel series-reaction network and the expression for the percent selectivity to the epoxide.

Course Outcome 4 (CO4):

1. Reactant A in the liquid phase reacts to produce R and S by the following reactions in parallel:

A→R

A→S

Both these reactions of first order. A feed with C_{AO}= 1, C_{RO}=0 and C_{SO}= 0 enters in two mixed flow reactors (τ 1 = 2 min and τ 2=5 min) the composition within the first reactor is C_{A1}= 0.40, C_{R1}=0.40 and C_{S1}=0.2.find the composition of exit stream from the second reactor.

2. Reactant A decomposes as follows

A-→R

A-→S

A-→T, the rate equations are: $r_R = 1$, $r_S = 2 C_A$, $r_T = CA^2$. Determine the maximum concentration of desired product that can be obtained in a mixed flow reactor and plug flow reactor for R is the desired product and $C_{AO} = 2$.

3. In a laboratory, ethanol is esterified to produce ethyl acetate and water at 1 atm according to the reaction

$$CH_3COOH+C_2H_5OH \rightarrow CH_3COOC_2H_5+H_2O.$$

What is the equilibrium constant for this reaction at 100 ^{o} C? Find the composition of mixture if initially 1 mole of acetic acid and 1 mole of ethanol were present.

Course Outcome 5 (CO5):

1. The data given below represent a continuous response to a pulse input into a closed vessel which is to be used as a chemical reactor. Calculate the mean residence time of fluid in the vessel and tabulate and construct E curve.

T, min	0	5	10	15	20	25	30	35
C pulse, g/lit.	0	3	5	5	4	2	1	0

2 Consider an axially-dispersed PFR accomplishing a first-order reaction. Compute the dimensionless concentration profiles for L/dp 5 and 50 and show that at isothermal conditions the values for = 50 are nearly those from a PFR. Assume Pe 2. dp = 0.004 m and k/u = 25 m^{-1} .

19UCH507	CHEMICAL REACTION ENGINEERING LAB	L	T	P	C
		0	0	3	1.5

AIM

To provide real time understanding on basic concepts on various types of reactors

OBJECTIVES

- Chemical Engineering lab provides students the first hand experience of verifying various theoretical concepts learnt in theory courses.
- To determine experimentally the kinetics and rate constants of reactions in different types of reactors.

LIST OF EXPERIEMENTS

1. Batch reactor – equimolar constant volume system
2. Combined Flow Reactor analysis
3. Photochemical reactor analysis
4. Assessment of Adiabatic batch reactor performance
5. RTD studies in PFR
6. Plug flow reactor analysis
7. Mixed flow reactor analysis
8. Packed bed reactor analysis
9. Sono chemical reactor analysis
10. RTD studies in MFR

		Total Hours	**60**
Course Outcomes		**Bloom's Level**	
CO1	Calculate the rate constant experimentally in a batch reactor	Analyze	
CO2	Develop skills to use the right reactor among single, multiple, recycle reactor, etc. schemes.	Create	
CO3	illustrate temperature dependence of rate constant in reactors	Apply	
CO4	Demonstrate the non-ideal behaviour and residence time distribution in PFR and CSTR.	Apply	
CO5	Calculate the conversion of reactor arranged in series.	Analyze	
CO6	Calculate the rate constant using sono and photo chemical reactors.	Apply	

19UCH508	MASS TRANSFER LABORATORY	L	T	P	C
		0	0	3	1.5

AIM

To determine experimentally certain physical properties of fluids and solids

OBJECTIVES

To train the students to develop sound working knowledge on different types of mass transfer equipments.

TOPICS

LIST OF EXPERIMENTS

1. Verifying the Raleigh's equation for the given system using simple distillation setup.
2. Determination of the diffusivity of the given liquid to air
3. Verifying the law of vapor pressure in immiscible liquids- steam distillation setup.
4. Determination of vaporization efficiency (Ev) and Thermal efficiency (Et) of the given system using steam distillation apparatus.
5. Evaluation of drying characteristics for the given sample in tray dryer.
6. Determine the percentage recovery in ternary system for three component benzene acetic acid and water.– liquid- liquid extraction.
7. Verifying adsorption isotherms by Batch Adsorption tests.
8. Determination of height of packed column and theoretical plates for binary system – packed bed distillation column.
9. Conduction of Simple /Co-current /Counter – current Leaching studies.
10. Determination of efficiency of the cooling tower.
11. Determination of drying characteristics in a rotary dryer.
12. Conduction of batch drying test and estimation of the mass transfer coefficient and psychometric Ratio.

	Total Hours	**30**

List of Equipments:

1. Simple Distillation
2. Steam Distillation
3. Rotary Dryer
4. Liquid-Liquid Extraction Column
5. Tray Dryer

6. Packed Bed Distillation Column
7. Cooling Tower
8. Air Diffusion Column
9. Leaching Studies
10. Adsorption Studies
11. Open pan Evaporator

COURSE OUTCOMES	
CO1	Evaluate the performance and design parameters for various distillation operations
CO2	Determine the drying rates of wet solids and to determine the critical moisture & equilibrium moisture content in different regimes of drying.
CO3	Apply the concepts of mass transfer and thermodynamics to design and operation of mass transfer experiments
CO4	Estimate the separation efficiency of various mass transfer equipments.

19UGS533-Interpersonal Skills Lab

List of Exercises

Part - A : Communication and Leadership Projects

I) Speech Projects

1. The Open up Speech (Prepared Speech)
2. Speech Organizing to the Point (Prepared Speech)
3. Table Topics Speech

II) Evaluation Projects

4. Speech Evaluation
5. TAG (Timer, Ah Counter and Grammarian) Evaluation

III) Leadership Roles

6. Speech Master of the Day
7. General Evaluator
8. Table Topics Master

Part - B : Problem-Solving and Decision- Making Project

IV) Quality Circle Project

Course Outcomes:

After the successful completion of the course students will be able to:

1. Communicate orally with fluency and clarity in a given contextual situation (Responding - Affective Domain)
2. Evaluate a speech and offer constructive evaluation of the speech (Evaluating - Cognitive Domain)
3. Adapt themselves to work in a group as a member or a leader for efficiently executing the given task (Organization – Affective Domain)
4. Analyze a problem and find appropriate solution (Analyze - Cognitive Domain)
5. Take decision by organizing relevant information and defining alternatives (Create - Cognitive Domain)
6.

19UCH509	CREATIVE THINKING AND INNOVATION	L	T	P	C
		0	0	2	1

PREAMBLE:

Creativity is vital in nearly every industry and occupation. Creativity and innovation are key to generation of new ideas and methods of improving goods and services for customer satisfaction. This course enhances the creative thinking and innovation skills of the students. Being creative helps one to be a better problem solver in all areas of life and work.

COURSE OBJECTIVES:

- To develop next generation Entrepreneurs and Creative Leaders to resolve live challenges.
- To transform innovative ideas into successful businesses
- To use a range of creative thinking tools to develop Out of the Box Ideas

Course Content

Introduction to Creativity and Innovation- Creative Techniques - Problem Identification through Brain Storming - Solution Identification through Creative Techniques - Presentation on the Innovative Idea - Market Analysis - Revenue and Business Model - Preparation of promotional aids - Customer Feedback Analysis.

List of Activities:

Duration	What does the Faculty do?	What do the students do?
Week 1	Explains creativity and innovation	Team Formation (Team Size: 3)
Week 2	Explains the Creative Techniques (Through Video / Presentation)	Discovering Consumer Need through Need Analysis (Customer Segment)
Week 3	Facilitates the brain storming	Problem Identification through brain storming
Week 4	Facilitates problem solving	Identify the solution for the chosen problem through creative techniques
Week 5	Evaluates the presentation	Presentation on the Innovative Idea and Value Proposition
Week 6	Evaluates the presentation	Presentation on the Innovative Idea and Value Proposition
Week 7	Explains about the Market Research	Market Analysis after the explanation

	/ Competitor Analysis, Revenue Model and Business Model	
Week 8	Facilitates the students work	Preparation of Innovation Development Plan, Business Development Plan and Financial Plan
Week 9	Facilitates the students work	Preparing product promotional material
Week 10	Facilitates the students work	Improvement through Feedback

Total Hours: 30 Periods

Assessment Pattern

1. Internal Assessment: Presentation on the Innovative Idea
2. End Semester Assessment:
    - Submission of Business Plan
    - Presentation on My Startup Idea (Evaluator : From Industry)

19UCH601 CHEMICAL REACTION ENGINEERING II	L	T	P	C
	2	1	0	3

AIM

To study about heterogeneous reactions and the factors influence the rate of reaction and to design various reactors.

OBJECTIVES

- Development of Kinetic model for Heterogeneous reactions giving emphasis on various types of reactions like non catalytic, catalytic, liquid-liquid reaction, liquid-gas reactions in isothermal, adiabatic or non isothermal conditions. ˆ
- Development of design strategy for Heterogeneous reactions considering different types of reactors for example fixed bed tubular reactor, fluidized bed reactor, packed bed reactors etc. Reactor design for reactions operating under isothermal, adiabatic or non-isothermal conditions.

MODULE	TOPICS	L Hrs
I	**INTRODUCTION TO HETEROGENOUS REACTIONS AND CATALYTIC REACTIONS** Heterogeneous reactions, Rate equation for heterogeneous reactions, Nature of catalysts, determination of surface area and pore volume distribution, general mechanism of solid catalysed fluid phase reactions, adsorption isotherm – rates of adsorption and desorption – surface reaction analysis of rate equation –rate controlling steps, Catalyst preparation methods.	**14**
II	**GAS-SOLID CATALYTIC REACTORS** Diffusion within catalyst particles, effective thermal conductivity, mass and heat transfer within catalyst pellets, effectiveness factor, Thiele modulus , Packed bed reactors	**9**
III	**GAS-SOLID NON CATALYTIC REACTORS** Gas solid non catalytic reaction. Reaction kinetics, Shrinking Core Model and Progressive conversion model, Controlling resistances (diffusion through gas film, ash layer and chemical reaction controlling), rate controlling steps; time for Complete Conversion for Single and Mixed Sizes, design of fluid –particle reactors	**9**
IV	**FLUID- FLUID REACTORS** Kinetics and design of Fluid- Fluid Reactions. Rate equation, Kinetic regimes for absorption combined with chemical reaction. Various cases of mass transfer with chemical reaction, Factors to select the contactor, Tower Reactor Design.	**9**
V	**FERMENTORS AND CATALYST DEACTIVATION** Batch, Plug flow and Mixed flow fermentor , Types of catalyst deactivation – Determining the order of deactivation – Catalyst regeneration methods	4
	Total Hours	**45**

Text Books

1. O. Levenspiel, Chemical Reaction Engineering, 3rd ed., Wiley Publications, 2006.

Reference Books

1. H.S. Fogler, Elements of Chemical Reaction Engineering, 5 th ed., Prentice Hall India Pvt. Ltd., New Delhi, 2016.
2. G. F Froment, K.B Bischoff and J.D Wilde, "Chemical Reactor Analysis and Design", Wiley, New York, 2010
3. J.M. Smith, Chemical Engineering Kinetics, 8 th ed., McGraw-Hill, 2008.

Course Outcomes		Bloom's Level
CO1	Learn fundamentals of heterogeneous reactions and determine characterization of properties of catalyst	Understand/Remember
CO2	Calculate the design parameters of fluid-solid non-catalytic, catalytic reactors and fluid-fluid reactors.	Apply
CO3	Select reactors for industrial operation	Analyze
CO4	Evaluate the effectiveness factor and Thiele modulus in solid catalysed reactions	Evaluate
CO5	Formulate and solve engineering problems associated with small-scale and large-scale bioprocesses	Create
CO6	Design reactors for heterogeneous reactions using software	Apply

Course Outcomes Mapping with Bloom's Taxonomy and Programme Outcomes

Course Outcome		Skill	PO	Bloom's Taxonomy	Assessment Tools to measure CO
CO1	Learn fundamentals of heterogeneous reactions and determine characterization of properties of catalyst	Remember/Understand	-	L1/L2	Exam/Assignment/Seminar/Quiz
CO2	Calculate the design parameters of fluid-solid non-catalytic, catalytic reactors and fluid-fluid reactors.	Apply	PO1	L3	Exam/Assignment/Seminar/Quiz/Lab/Project
CO3	Select reactors for industrial operation	Analyze	PO2	L4	Exam/Assignment/Seminar/Quiz/Lab/Project
CO4	Evaluate the effectiveness factor and Thiele modulus in solid catalysed reactions	Evaluate	PO4	L5	Mini Project/Assignment/Quiz/Lab/Exam
CO5	Formulate and solve engineering problems associated with small-scale and large-scale bioprocesses	Create	PO3	L6	Assignment/Lab/Exam/Seminar
CO6	Design reactors for heterogeneous reactions using software	Modern Tools	PO5	L3	Lab/Project

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Discuss in detail about catalyst and catalyst components.

2. Explain in detail the assumptions and steps followed in BJH Method

3. What are heterogeneous reactions?

4. State Eley-Rideal mechanism

Course Outcome 2 (CO2):

1. The irreversible reaction

$A(g) + B(s) \longrightarrow R(g)$ …….(first order w.r.t. A)

Takes place on a flat surface. Dilute A diffuses through a stagnant gas film on to a plane surface consisting of B. on the surface, A reacts with B to produce gaseous R which then diffuses back into the main gas stream. Develop the overall rate expression for these gas solid reactions.

2. Determine the amount of catalyst needed in a packed bed reactor whose v_o= 1000 l/hr with C_{AO}= 1mol/l with X_A= 0.80 for a second order reaction with k = 2 (l^2/g.mol.h).

3. Find the time for complete conversion of particle with 2mm dia with conversion of 0.875 for a time of 1 s when the rate controlling step is a chemical reaction

4. The results of the kinetic runs on the reaction A--→ R made in an experiemental packed bed reactor using a fixed feed rate F_{AO}= 10 kmol/hr are as follows:

W,Kg catalyst	1	2	3	4	5	6	7
X_A	0.12	0.20	0.27	0.33	0.37	0.41	0.44

i) find the reaction rate at 40% conversion

for a feed rate of 400 kmol/hr to large scale packed bed reactor,

ii)find the amount of catalyst needed for 40% conversion

Course Outcome 3 (CO3):

1. Nitrogen was employed to determine the surface area of 1.0 g sample of silica gel and results obtained shown in table below. The sample of silica gel was maintained at the normal boiling point of liquid nitrogen (77K) .One molecule of nitrogen occupies 16.2 * 10^{-20} m^2 area of plane surface. Calculate the specific surface area of silica gel by the BET method. The saturated vapour pressure p_o of nitrogen at 77 K is 101.3 Kpa.

Equillibrium pressure (Kpa)	5.0	6.3	7.5	9.0	11.2
Volume adsorbed (STP) * 10^6 (m^3)	6.7	7.0	7.2	7.4	7.7

2. Gaseous reactant A decomposes on a solid catalyst as per the following reaction: A→R with $-r_A = kC_A^2$ a pilot plant tubular reactor packed with 2 litre of catalyst is fed with 2 m^3/hr of pure A at 300^OC and 20 atm,65% of A is converted. It is desired to treat 100 m^3/hr of feed gas at 40 atm and 300^oC consisting of 60 %A and 40% diluents in a large plant to achieve 85%conversion of A. Find the internal volume of the reactor needed.

3. Calculate the amount of catalyst needed in a packed bed reactor to achieve 80% conversion of 1000 m^3/hr of pure gaseous A (C_{AO} = 1000 mol/m^3)for:

A-→R $-r_A = 50\ C_A/(1+0.02\ C_A)$

4. In a plug flow reactor ,carbon monoxide and hydrogen are passed over nickel catalyst to generate methane

$CO+3H_2 \leftarrow CH_4 + H_2O$ the rate equation is

→

$-r = 1.1\ P_{CO}\ P_{H2}^{0.5}/\ (1+1.5\ P_{H2})$, The reaction is carried out under isothermal conditions at 1 atm.CO and H_2 are fed in stoichiometric proportion with 1 mol/hr of CO. Calculate the amount of catalyst needed to achieve 20 % conversion of CO

Course Outcome 4 (CO4):

1. Spherical particle of zinc sulphide of size R = 1mm are roasted in an 8% oxygen stream at 900°C and 1 atm. The reaction proceeds according to shrinking core model as

$2\ ZnS + 2\ O_2 \text{ ----------} \rightarrow 2\ ZnO + 2\ SO_2$

Using the following data calculate

i) The time required for complete conversion of a particle.

ii) The relative resistance of ash layer diffusion.

Data: $\rho_B = 0.0425$ mol/cm^3, k = 2.2 cm^2/s, D = 0.08 cm^2/s

2. Spherical solid particles containing B are roasted at constant temperature in an oven by gas of constant composition. Solids are converted to give a firm non flaking products according to shrinking core model from the following conversion data determine the rate controlling mechanism

Data:

dp, mm	X_B	t, s
2	0.875	1
1	1	1

Course Outcome 5 (CO5):

1. Solids of unchanging size (R = 0.3 mm) are reacted with gas in a steady flow laboratory-scale fluidized bed reactor according to the shrinking-core model (SCM) with the reaction steps to be rate controlling. Following result is obtained in the laboratory scale reactor.

For F_o = 10 g/s, W = 1000 g: $\ddot{X} = 0.75$.

Design a commercial scale fluidized bed reactor (i.e., Determine W) to treat 4t/h of solids of size R = 0.3 mm to 98% conversion. [1 t = 1000 kg].

2. Iron ore of density $\rho_B = 4.6$ g/cm^3 and size R = 5 mm is reduced as per the following reaction by pure hydrogen gas.

$4H_2 + Fe_3O_4 \text{ ------} \rightarrow 4\ H_2O + 3Fe$

Estimate the time required for 98% conversion of a particle from oxide to metal in a hydrogen environment constant hydrogen pressure of 1 atm. and at 600^o C

The rate is proportional to the concentration of hydrogen gas.

The first order reaction is rate constant is given by

K" = 1.93 x 10^5 $e^{-12000/T}$, cm/s

Hydrogen diffusion coefficient $D_e = 0.03$ cm^2/s

Film diffusion coefficient, K_g = 10 cm/s. At. Wt. : Fe = 56, O = 16.

19UCH602 PROCESS INSTRUMENTATION DYNAMICS AND CONTROL		L	T	P	C
		2	1	3	4.5
MODULE	**TOPICS**			**L Hrs**	
I	**UNIT I** Motivation to Chemical Process Control, Mathematical description of chemical processes, Formulating Process Models, Laplace Transforms, Properties of Laplace Transforms, Solution of ODE using Laplace Transforms, Standard input forcing functions, State – Space representation, transform domain models, Impulse response models, Inter relationship between process model forms.			**9**	
II	**UNIT II** Open-loop systems, first order systems and their transient response for standard input functions, first order systems in series, linearization and its application in process control, second order systems and their dynamics; transportation lag, FOPDT Model, Skogestaad's rule for FOPDT and SOPDT, Lead- Lag systems			**9**	
III	**UNIT III** Closed loop control systems, development of block diagram for feed-back control systems, servo and regulatory problems, transfer function for controllers and final control element, principles of pneumatic and electronic controllers, control valves, transient response of closed-loop control systems and their stability, Root locus diagram			**9**	
IV	**UNIT IV** Introduction to frequency response of closed-loop systems, control system design by frequency response techniques, Bode diagram, stability criterion, tuning of controller settings, Nyquist Stability Criterion			**9**	
V	**UNIT V** Introduction to advanced control systems, cascade control, feed forward control, Controllers for Inverse response Smith predictor controller, control of distillation towers and heat exchangers, introduction to computer control of chemical processes.			**9**	
	Total Hours			**45**	
Experiments for Hands on training					
	List Of Experiments 1. Response of first order system 2. Response of second order system 3. Response of Non-Interacting level System 4. Response of Interacting level System 5. Open loop study on a level system 6. Open loop study on a flow system 7. Open loop study on a thermal system 8. Closed loop study on a level system 9. Closed loop study on a flow system 10. Closed loop study on a thermal system				

	11. Tuning of a level system 12. Tuning of a flow system 13. Tuning of a thermal system 14. Flow co-efficient of control valves 13. Characteristics of different types of control valves	
	Total Hours	**45**

Text Books

1. Stephanopoulos, G. (1984). *Chemical process control* (Vol. 2). New Jersey: Prentice hall.
2. Ogunnaike, B. A., & Ray, W. H. (1994). *Process dynamics, modeling, and control* (Vol. 1). New York: Oxford University Press.
3. Coughanowr, D. R., & Leblanc, S. E. (2009). Introductory concepts. *Process Systems* Analysis and Control, *3rd Ed*, 1-6.

Reference Books

1. Seborg, D. E., Mellichamp, D. A., Edgar, T. F., & Doyle III, F. J. (2010). Process dynamics and control. John Wiley & Sons.
2. Bequette, B. W. (2003). Process control: modeling, design, and simulation. Prentice Hall Professional.
3. Riggs, J. B., & Karim, M. N. (2006). Chemical and Bio-process Control: James B. Riggs, M. Nazmul Karim. Prentice Hall.
4. Luyben, W. L., Tyréus, B. D., &Luyben, M. L. (1998). Plantwide process control (Vol. 43). New York: McGraw-Hill.

COURSE OUTCOMES

On the completion of the course students are expected to

CO1	Understand the need to develop mathematical description of a chemical process as a prerequisite to process design and to control the process.
CO2	Develop transient models for chemical processes using material and/or energy balance equations by incorporating constitutive relationships and seek their solution using Laplace Transforms
CO3	Represent a physical system using FOPDT model and estimate parameters in FOPDT model.
CO4	Convert a process and instrumentation diagram to a control block diagram
CO5	Understand Frequency response of control systems and tune the PID controllers
CO6	Appreciate the performance augmentation of PID controllers by using advanced control strategies such as Cascade, Feed forward, Dead time compensation

Course Outcomes Mapping with Bloom's Taxonomy and Programme Outcomes

Course Outcome		Skill	PO	Bloom's Taxonomy	Assessment Tools to measure CO
CO1	Understand the need to develop mathematical description of a chemical process as a prerequisite to process design and to control the process.	Remember/ Understand	-	L1/L2	Exam/Assignment/Seminar/Quiz
CO2	Develop transient models for chemical processes using material and/or energy balance equations by incorporating constitutive relationships and seek their solution using Laplace Transforms	Apply	PO 2	L3	Exam/Assignment/Seminar/Quiz /Lab/Project
CO3	Develop a physical system using FOPDT model and estimate parameters	Analyze /	PO 3	L4	Exam/Assignment/Seminar/Quiz

	in FOPDT model.				/Lab/Project
CO4	Convert a process and instrumentation diagram to a control block diagram on MATLAB	Investigate / Modern Tools	PO 2	L5	Mini Project/Assignment/Quiz/Lab/Exam
CO5	Analyze and an Evaluate Frequency response of control systems and tune the PID controllers by Using Modern Tools (Like MATLAB, SCiLAB)	Design / Modern Tools	PO 4	L6	Assignment/Lab /Exam/Seminar
CO6	Appreciate the performance augmentation of PID controllers by using advanced control strategies such as Cascade, Feed forward, Dead time compensation	Evaluate / Modern Tools	PO 5	L6	Lab/Project

19UCH603	PROCESS EQUIPMENT DESIGN	L	T	P	C
		3	1	0	4

Objective:

To understand and develop skills in the design of processes and equipments in chemical process industries.

MODULE	TOPICS	L (Hrs)
I	**Design of Heat Exchanger:** Types of Heat exchanger, Design of Double pipe heat exchanger, Shell and tube heat exchanger, Reboilers and Condensor.	9
II	**Design of mass transfer equipments:** Design of Cooling Towers, Dryers, Crystallizers and Evaporators	9
III	**Design of Separation processes:** Design of Absorption Column, Distillation Column and Extraction Column	9
IV	**Design of Reactors & pressure vessels:** Design of Packed bed reactors, Storage vessels for solids, liquids and gases	9
V	**Standards and Codes:** Design of Plant Layout, BIS & ASTM Standards and Codes, Pipe line design, Materials of construction and selection of process equipments	5
VI	**Process Hazards and Safety Measures in Equipment Design:** Process Hazards, Safety measures, Safety measures in equipment design, Pressure relief devices.	4
	Total Hours	**45**

Text Book(s):

1. Walas, S. M - Process Equipment Selection and Design – Butterworths – London -1989
2. Coulson J.M., Richardson J.F., Backhurst J.R. and Harker J.M., Sinott, Coulson and Richardson's Chemical Engineering, Volume VI - Butter worth Heinemann - Oxford – 2002(5thEdition)

Reference(s):

1. Perry, R. H - Chemical Engineers' Handbook - McGraw Hill - New York – 1998(7th Edition)
2. Stanley M. Walas, Chemical Process Equipment – Selection and Design, Butterworth Heinemann Publications.
3. M. V. Joshi and V.V. Mahajani , Process Equipment Design, 3rd Edition, Mc Millan India Ltd. 2000
4. Timmerhaus, K. D., Peters, M. S., and West, R. E - Plant Design and Economics for Chemical Engineers - Mc Graw Hill, New York - 2002(5thEdition)

COURSE OUTCOMES

The students will have the ability to

CO1	Ability to understand the concepts involved in design process equipments involved in chemical industry.
CO2	Ability to understand the materials used in chemical processing industries
CO3	Ability to apply skills in design of chemical engineering industry equipments.
CO4	Ability to analyse essential elements involved in chemical engineering process and plants
CO5	Ability to design process equipments and modify the design of existing equipment to new process
CO6	Ability to design chemical industry equipment using modern tools

Course Outcomes Mapping with Bloom's Taxonomy and Programme Outcomes					
Course Outcome		**Skill**	**PO**	**Bloom's Taxonomy**	**Assessment Tools to measure CO**
CO1	Ability to understand the concepts involved in design process equipments involved in chemical industry.	Remember/ Understand	PO1-PO12	L4	Exam/Assignment/ Seminar/Quiz
CO2	Ability to understand the materials used in chemical processing industries	Remember/ Understand	PO1-PO12	L4	Exam/Assignment/ Seminar/Quiz/Lab/ Project
CO3	Ability to apply skills in design of chemical engineering industry equipments.	Apply	PO1-PO12	L4	Exam/Assignment/ Seminar/Quiz/Lab/ Project
CO4	Ability to analyse essential elements involved in chemical engineering process and plants	Analyse	PO1-PO12	L4	Mini Project/Assignment/Quiz/Lab/Exam
CO5	Ability to design process equipments and modify the design of existing equipment to new process	Design	PO1-PO12	L4	Assignment/Exam/ Seminar
CO6	Ability to design chemical industry equipment using modern tools	Modern Tools	PO1-PO12	L3	Seminar/Mini Project/ Lab

19UCH606 PROCESS COMPUTATION LABORATORY	L	T	P	C
	0	0	3	1.5

AIM

To apply the knowledge of differential equations of mathematical model for various chemical Engineering system

OBJECTIVES

Students will solve chemical engineering problems from core courses using C and MATLAB programming and also using computational tools.

TOPICS

LIST OF EXPERIMENTS

1. Roots of nonlinear equations iterative methods.
2. Direct solution for set of linear equations.
3. Iterative solution for set of linear equations
4. Regression analysis.
5. Numerical integration.
6. Numerical solution of ordinary differential equations.
7. Predictor and corrector methods
8. Rating of shell and tube heat exchanger
9. Rating of Distillation column
10. Simulation of PFR and CSTR.
11. Simulation of Recycle Processes.

	Total Hours	30

COURSE OUTCOMES

CO1	Students are able to mathematical equations of every Chemical Engineering system.
CO2	Analyze the model and the equation to get output results and analyzed the performance of the system
CO3	Calculate the parameter by simulation using Computational tools
CO4	Analyze and estimate the chemical engineering problems

19UCH607	TECHNICAL PROJECT AND PRODUCT DEVELOPMENT	L	T	P	C
		0	0	8	4

AIM

To introduce the basis of process and product design along with the requirements of a good product development.

OBJECTIVES

- To help students to identify the need for developing newer technologies for industrial / societal needs
- To help the students to understand the research activities happening around the globe.
- To get hands on experience in knowing about various analytical instruments
- To guide students to propose and implement relevant technology for the development of the prototypes / products
- To make the students learn to the use the methodologies available for analyzing the developed prototypes / products

MODULE	TOPICS	L Hrs
I	Steps involved: 1. Strategies to identify the societal and industrial problems that need to be solved 2. SWOC analysis of the available technologies to overcome the problem 3. Possible technology revolution in the next 5 – 10 years 4. Analysis of the problems of present and future 5. Challenges in sustainable prototype / product development 6. Design of specific workflow in developing the prototype / product 7. Validation of the developed prototype / product 8. Analysis of the prototype/product with respect to social, economical, environmental relevance (The proposed contact hours are for discussion on the projects) (Projects to be done by a group of 3– 4 students)	
	Total Hours	**75**

Course Outcomes		**Bloom's Level**
CO1	Apply the fundamental concept learnt during the theory courses to solve industrial problems	Apply
CO2	Review the current status based on the information available in the literature or data obtained in the laboratory/ industry	Apply
CO3	Carry out material and energy balance for process calculations	Analyze
CO4	Design equipment for chemical process industries to develop the art of using relevant technology for product development	Apply
CO5	Evaluate the economics of a process through cost estimation	Evaluate
CO6	Hypothesize industrial problem, design process to carry out the process in an economically feasible way	Create

19UGS632 SOFT SKILLS LABORATORY

L	T	P	C .
0	0	3	1.5

COURSE OBJECTIVES:

• To develop a requisite knowledge in Communication skills and Soft skills.
• To enhance the students' acumen in honing the skills to meet the Global changes and Industrial needs.

SYLLABUS:-

Unit I -SPEAKING SKILLS 9 Hours
Conversational Skills - Self Introduction - Group Discussion - Public Speaking - Presentation Skills

Unit II – WRITING SKILLS 9 Hours
Letter Writing – Report Writing – Email Writing – Job Application – Resume Preparation

Unit III – READING AND LISTENING SKILLS 9 Hours
Reading Comprehension – Enriching Vocabulary – Error Spotting – Listening and Note Taking

Unit IV – SOFTSKILLS 9 Hours
Professional Ethics – Interpersonal Skills – Stress Management – Leadership Qualities – Time Management – Conflict Resolution

Unit V – INTERVIEW SKILLS 9 Hours
Types of Interview – Body Language – Professional Grooming – Basic Etiquette
TOTAL:45 (L) = 45 PERIODS

COURSE OUTCOMES:

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

CO – 1: Demonstrate oral presentations and fluent speaking through reading and listening. (Apply)
CO – 2: Exercise effective reading and comprehension of various articles using enhanced vocabulary.
CO – 3 Attainthe ability to write academic papers, essays, official documents and summaries. (Apply)
CO – 4: Apply correct usage of English grammar in writing, fluent speaking and comprehending. (Understand)
CO – 5: Exhibit enhanced performance in interactions and interviews. (Understand)

REFERENCE BOOKS:

1. Skills for Success, Listening and Speaking – Level 4 by Brooks and Margret – Oxford University Press, Oxford 2011 Edition.
2. Professional Communication by Raman, Meenakshi and Sangeetha Sharma – Oxford University Press, 2014 Edition.
3. Developing Soft Skills by Sherfield, Robert M, R J Montgomery and Patricia G Moody – PearsonEducation Publishers.

19UGM635-INDIAN CONSTITUTION

Pre-requisites: Nil

Course Objectives:

- The students will be exposed to fundamental rights & duties in Indian Constitution.
- The students will be given knowledge on the components of the parliamentary system to prepare for the process of their career development.
- The student will have knowledge on powers and functions of Local bodies and Indian polity to appear for various competitive exams such as UPSC, TNPSC and RRB…
- The student will know about the functions of judiciary and electoral process followed in the country.

UNIT I INTRODUCTION ON INDIAN CONSTITUTION

Preamble - Salient features of the Constitution of India. Fundamental Rights - its restriction and limitations in different Complex Situations. Directive Principles of State Policy (DPSP) - Fundamental Duties: its Scope and significance in Nation building - Constitution components: schedule, parts and articles of constitution- important Amendments of constitution.

UNIT II PARLIAMENTARY SYSTEM

Parliamentary System – parliamentary system of other countries - Indian parliamentary system-Federal System – LS and RS, Centre-State Relations-Election of member of parliaments- Union Executive - President, Prime Minister, Union Cabinet. State Legislature -State Executives –election of MLA- Governor, Chief Minister, State Cabinet.

UNIT III JUDICIARY AND ELECTION COMMISSION

Supreme Court of India: Structure, Power and Functions of Supreme Court-- Judicial Reviews - Judicial Activism. High Court and Subordinate Courts: Structure, Power and Functions. – Lok adhalats. Elections- Electoral Process - Election Commission of India - Election Laws – Emergency Provisions - types of Emergencies and its consequences.

UNIT IV LOCAL ADMINISTRATION

Local Administration: Powers and functions of Municipalities and Panchayats System-Panchayat Raj- Co–operative Societies and Constitutional and Non-constitutional Bodies.

COURSE OUTCOMES:

On completion of this course, students will be,

CO1: able to apply knowledge of the fundamental rights and duties prescribed by Indian Constitution to prepare for various competitive examinations.

CO2: able to manage complex societal issues in society with the knowledge of judiciary and local administration.

CO3: able to interpret the societal, health, safety, legal and cultural issues with understanding of parliamentary system and electoral process through self-learning skills.

CO4: able to understand the ethical responsibilities of municipalities, panchayats and co-operative societies.

CO5: able to understand and distinguish the functioning of the parliamentary system followed in various countries.

TEXT BOOKS:

1) Shubham Singles, Charles E. Haries, et al., “Constitution of India and Professional Ethics” by Cengage Learning India Private Limited, 2018.

2) Subhash C. Kashyap,”Our Constitution: An Introduction to India’s Constitution and constitutional Law”, NBT, 2018.

3) Brij Kishore Sharma,“Introduction to the Constitution of India”, PHI Learning Pvt. Ltd., New Delhi, 2011.

4) M.V.Pylee, “An Introduction to Constitution of India”, Vikas Publishing, 2002.

5) Durga Das Basu, “Introduction to the Constitution on India”, Prentice Hall, 2001.

15UME701	PROJECT MANAGEMENT AND FINANCE (Common to CHEM,MECH, CSE,ECE, EEE, IT,)	L	T	P	C
		3	0	0	3

OBJECTIVES :

- To impart knowledge to find solutions and approaches for various projects.
- To familiarize the utilization of project within time, resource and financial constraints.

UNIT I	PROJECT MANAGEMENT CONCEPTS	9

Concept and characteristics of a project, importance of project management, types of project, project organizational structure, project life cycle, Statement of Work, Work Breakdown Structure.

UNIT II	PROJECT PLANNING	9

Project Planning and Scheduling techniques - developing the project network using CPM/PERT, Limitations of CPM/PERT, Precedence Diagramming Method, constructing diagram and computations using precedence diagramming method, PERT/CPM simulation, reducing project duration.

UNIT III	RESOURCE SCHEDULING & CRITICAL CHAIN SCHEDULING	9

Resource Scheduling - Resource allocation method, splitting and multitasking, Multi project resources scheduling - Critical Chain Scheduling -Concept of critical chain scheduling - critical chain scheduling method, application of Critical chain scheduling and limitations.

UNIT IV	PROJECT QUALITY MANAGEMENT	9

Concept of project quality, responsibility for quality in projects, quality management at different stages of project, tools and techniques, Quality Management Systems, TQM in projects - Project Performance Measurement and Control - Monitor and assess project performance, schedule, and cost. Earned Value Management, performance measurement methods to monitor, evaluate and control planned cost and schedule performance - Project Closure/ Termination - Meaning of closure/ termination, project audit process, termination steps, final closure.

UNIT V	FINANCIAL ACCOUNTING	9

Balance sheet and related concepts - Profit & Loss Statement and related concepts - Financial Ratio Analysis - Cash flow analysis - Funds flow analysis – Comparative financial statements. Investments - Average rate of return - Payback Period - Net Present Value - Internal rate of return.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

After successful completion of this course the students will be able to:

1. Analyze different types of projects and identify the suitable project for the given constraints. (Analyze)
2. Analyze and identify Critical Path using PERT/CPM for the given project. (Analyze)
3. Analyze Theory of Constraints, Multi project scheduling and heuristic methods for allocating resources to a project. (Analyze)
4. Apply the knowledge of Quality Management and TQM Concepts to different stages of project and design a suitable Quality Management System. (Apply)
5. Investigate the financial data such as balance sheet, income expenditure statement, cash flow statement and budget to interpret, synthesize to provide valid solution for a variety of business problems. (Analyze)

TEXT BOOKS:

1. Prasanna Chandra, "'Fundamentals of Financial Management' ", Tata Mcgraw-Hill Publishing Ltd, 2005.
2. Jack Meredith, Samuel J.Mantel, "Project Management- A Managerial Approach", John Wiley and Sons.

REFERENCE BOOKS:

1. Clifford F Gray, Erik W Larson, "Project Management-The Managerial Process", Tata Mcgraw-Hill Publishing Co Ltd.
2. John M Nicholas, "Project Management For Business And Technology", Prentice Hall of India Pvt Ltd.
3. Paresh Shah, "Basic Financial Accounting for Management", Oxford University Press, 2007.

COURSE ARTICULATION MATRIX:

CO/PO/PSO MAPPING

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

Subject	POs												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
15UME701	3	3		3	3	3			3	3	3	3	3	3

Ref: 3 - Strong 2 - Medium 1 - Weak

19UCH701 TRANSPORT PHENOMENA	L	T	P	C
	3	0	0	3

AIM

To analyze the movement of different physical quantities such as momentum, energy and mass in any chemical or mechanical process and combines the basic principles (conservation laws) and laws of various types of transport.

OBJECTIVES

These transport phenomena occur frequently and most of the time simultaneously in industrial problems. All type of transport phenomena can be explained by similar transport and conversion laws. Physical properties which are used to describe transport laws like kinematic viscosity, thermal diffusivity or mass diffusivity play similar role. The mathematical requirements for solving problems related to transport phenomena are more or less similar.

UNIT	TOPICS	L Hrs
I	**INTRODUCTION TO TRANSPORT PHENOMENA** Classification of Transport Processes, Conservation Laws, Vector and Tensor Calculus, Fundamental concepts in momentum transfer, shell balance, governing equations and relevant boundary conditions.	7
II	**MOMENTUM TRANSFER PHENOMENA** Shell balance and boundary conditions; Momentum flux and velocity distribution in flow of a falling film, flow through circular tube, Hagen poiseuille law, flow through an annulus and adjacent flow of two immiscible fluids. Time derivatives and vector notation, Equation of continuity, Equation of Motion, Navier- stokes equation.	11
III	**HEAT TRANSFER PHENOMENA** Fourier's law of heat conduction**,** Analogy between heat and momentum transfer, Shell heat balance and boundary conditions to heat transport**,** Heat Conduction with Electrical heat source, Heat conduction with Nuclear heat source and Viscous Heat Sources; Heat Conduction – Composite Walls and Cooling Fin and effectiveness of Fin; Forced and Free Convection.	9
IV	**MASS TRANSFER PHENOMENA** Fick's law of diffusion**,** Definitions of concentrations, velocities and mass fluxes. Boundary conditions in mass transfer, Diffusion – Stagnant Gas Film, Heterogeneous and Homogeneous Chemical Reactions, Falling Liquid Film (Gas Absorption), Film theory, Penetration theory, Boundary layer theory, Macroscopic balance to solve steady and Unsteady state problems.	9
V	**ANALOGIES & SIMILITUDE ANALYSES WITH APPLICATIONS** Mathematical treatment of the similarities between heat, mass and momentum transfer, similarity parameters, and relevant analogies, Solution of coupled heat, mass and momentum transfer problems based on analogy, capillary tube model, Dynamic similarity, Equation of change for entropy; Application of generalized Maxwell – Stephan's equations; Mass transport across selectively permeable membrane and porous media	9
	Total Hours	**45**

Course Outcomes	Bloom's Level
On the completion of the course students are expected to	

CO1	Understand and relate transport properties of molecular transfer of momentum, energy and mass transport.	Remember / Understand
CO2	Solve and physically interpret one-dimensional steady state momentum transfer, heat conduction and species diffusion problems	Analyze
CO3	Make use of Navier-Stoke's equation with right boundary conditions to examine the problems related to fluid, heat and mass transfer	Evaluate
CO4	Evaluate the interphase transport properties for internal flow and external flow and estimate powere that required for fluid flow	Analyze
CO5	simultaneous heat, mass and momentum transfer analysis	Apply
CO6	Investigate and solve industrial problems along with appropriate approximations and boundary conditions	Evaluate

Course Outcomes Mapping with Bloom's Taxonomy and Programme Outcomes

	Course Outcome	**Skill**	**PO**	**Bloom's Taxonomy**	**Assessment Tools to measure CO**
CO1	Understand and relate transport properties of molecular transfer of momentum, energy and mass transport.	Remember / Understand	-	L1/L2	Exam/Assignment/Seminar/Quiz
CO2	Solve and physically interpret one-dimensional steady state momentum transfer, heat conduction and species diffusion problems	Analyze	PO2	L3	Exam/Assignment/Seminar/Quiz/Lab/Project
CO3	Make use of Navier-Stoke's equation with right boundary conditions to examine the problems related to fluid, heat and mass transfer	Evaluate	PO4	L5	Exam/Assignment/Seminar/Quiz/Lab/Project
CO4	Evaluate the interphase transport properties for internal flow and external flow and estimate powere that required for fluid flow	Analyze	PO4	L3	Mini Project/Assignment/Quiz/Lab/Exam
CO5	simultaneous heat, mass and momentum transfer analysis	Apply	PO1	L4	Assignment/Lab/Exam/Seminar
CO6	Investigate and solve industrial problems along with appropriate approximations and boundary conditions	Evaluate	PO4	L5	Lab/Project

Text Books

1. D Bird R. B, Stewart W.E., Lightfoot E.W., 'Transport Phenomena', John Wiley, 2ndEd., 2000.

2. Brodkey R. S., Hershey H. C., 'Transport Phenomena', McGraw-Hill International Edition, 1988.

3. Wilty J.R., Wilson R.W., Wicks C.W., 'Fundamentals of Momentum, Heat and Mass Trasport', 2nd

Ed., John Wiley, New York, 1973.

Reference Books

1. Wilty J.R., Wilson R.W., Wicks C.W., 'Fundamentals of Momentum, Heat and Mass Trasport', 2nd Ed., John Wiley, New York, 1973.

2. R.W.Fahien, “Elementary Transport Phenomena”, McGraw-Hill, New York, 1983.

3. J.R.Welty., R.W Wilson and C.W wicks, Roger.G.E ., Wilson R.W, Fundamental of Momentum, Heat and Mass Transfer V th edn, John Wiley, New York, 2007.

19UCH702 PROCESS MODELING AND SIMULATION	L	T	P	C
	3	2	0	4

Aim

Understanding the fundamental of modeling and simulation, system analysis and evaluation.

Objective

To understand the basics of model construction.

To learn about solving model equations and validation of the models.

MODULE	TOPICS	L Hrs
I	**UNIT I INTRODUCTION** Introduction to modeling and simulation, classification of mathematical models, conservation equations and auxiliary relations.	12
II	**UNIT II STEADY STATE LUMPED SYSTEMS** Degree of freedom analysis, single and network of process units, systems yielding linear and nonlinear algebraic equations, flowsheeting – sequential modular and equation oriented approach, tearing, partitioning and precedence ordering, solution of linear and non-linear algebraic equations.	12
III	**UNIT III UNSTEADY STATE LUMPED SYSTEMS** Analysis of liquid level tank, gravity flow tank, jacketed stirred tank heater, reactors, flash and distillation column, solution of ODE initial value problems, matrix differential equations, simulation of closed loop systems	12
IV	**UNIT IV STEADY STATE DISTRIBUTED SYSTEM** Analysis of compressible flow, heat exchanger, packed columns, plug flow reactor, solution of ODE boundary value problems.	12
V	**UNIT V UNSTEADY STATE DISTRIBUTED SYSTEM** Analysis laminar flow in pipe, sedimentation, boundary layer flow, conduction, heat exchanger, heat transfer in packed bed, diffusion, packed bed adsorption, plug flow reactor, hierarchy in model development, classification and solution of partial differential equations - Empirical modeling, parameter estimation, population balance and stochastic modeling.	12
	Total Hours	60

Text Books

1. Franks, R. G. E., “Mathematical Modelling in Chemical Engineering“, John Wiley, 1967.
2. Luyben, W.L., "Process Modelling Simulation and Control", McGraw-Hill Book Co.,1973.

3. **Reference Books**

1. Felder, R. M. and Rousseau, R. W., “Elementary Principles of Chemical Processes“,John Wiley, 2000.
2Ramirez, W., "Computational Methods in Process Simulation", 2nd Edn.,Butterworths, New York, 2000.

COURSE OUTCOMES

On the completion of the course students are expected to

CO1	Understand the need to develop mathematical description of a chemical process as a prerequisite to process design and to control the process.
CO2	Develop transient models for chemical processes using material and/or energy balance equations by incorporating constitutive relationships

CO3	Represent a process system using model and estimate parameters in simulation model.
CO4	Construct a process and instrumentation diagram to a process system.
CO5	Analyze the systems of lumped and distributed systems.
CO6	Develop a empirical modeling population and parameters in stochastic modelling

Course Outcomes Mapping with Bloom's Taxonomy and Programme Outcomes

Course Outcome		Skill	PO	Bloom's Taxonomy	Assessment Tools to measure CO
CO1	Understand the need to develop mathematical description of a chemical process as a prerequisite to process design and to control the process.	Remember/ Understand	-	L1/L2	Exam/Assignment/Seminar/Quiz / lab
CO2	Develop transient models for chemical processes using material and/or energy balance equations by incorporating constitutive relationships	Apply	PO 2	L3	Exam/Assignment/Seminar/Quiz /Lab/Project
CO3	Represent a process system using model and estimate parameters in simulation model.	Analyze /	PO 3	L4	Exam/Assignment/Seminar/Quiz /Lab/Project
CO4	Construct a process and instrumentation diagram to a process system.	Investigate / Modern Tools	PO 2	L5	Mini Project/Assignment/Quiz/Lab/Exam
CO5	Analyze the systems of lumped and distributed systems.	Design / Modern Tools	PO 4	L6	Assignment/Lab /Exam/Seminar
CO6	Develop a empirical modeling population and parameters in stochastic modelling	Evaluate / Modern Tools	PO 5	L6	Lab/Project

Course Level Assessment Questions

19UCH707 Process Design and Simulation Laboratory	L	T	P	C
	0	0	3	1.5

AIM

To apply the knowledge of differential equations and Formulation of a mathematical model for various chemical Engineering system

OBJECTIVES

To train the students to an understand and apply the mass/ heat and chemical reaction engineering fundamental principles and law of modelling in various chemical engineering systems to develop mathematical model.

TOPICS

LIST OF EXPERIMENTS

1. Composition of vapor and liquid streams in a flash distillation still using VLE data
2. Computation of ideal number of places using optimal reflux ratio.
3. Material balance/enthalpy balance in the plate columns.
4. Multicomponent distillation with reboiler and condenser
5. Study of absorption, reaction and diffusion processes in a contact reactor/bubble absorber/packed tower/plate column through a two film model.
6. Design and optimization of single effect evaporator.
7. Design and optimization of multiple effect evaporator.
8. Design of a shell and tube heat exchanger
9. Simulation of developing flow in a pipe
10. Simulation of cumene production process
11. Simulation of ammonia synthesis
12. Manufacture of vinyl chloride monomer and hydrodealkylation.

	Total Hours	**30**

COURSE OUTCOMES

CO1	Students are able to model every Chemical Engineering system assigned to them.
CO2	Analyze the model and the equation to get output results and analyzed the performance of the system
CO3	Calculate the parameter of by simulation using Process Simulator
CO4	Analyse and estimate the physical properties of data bank and non data bank components

OPEN ELECTIVE

19UCH951	CORROSION SCIENCE & ENGINEERING	L	T	P	C
		3	0	0	3

AIM

To have an insight into all aspects of corrosion and testing methods.

OBJECTIVE:

To gain knowledge in different types of corrosion and its testing methods, various methods of protection, corrosion in specific environment and the corrosion protection management and testing methods.

MODULE	TOPICS	L Hrs
I	**BASIC ASPECTS OF CORROSION** Introduction, classification, economics, emf series, Galvanic series. Corrosion theories: derivation of potential – current relationships of activation controlled and diffusion controlled corrosion processes. Potential – pH diagrams Fe-H2O system, application and limitations. Passivation-definition, anodic passivation theory of Passivation.	9
II	**CORROSION PREVENTION METHODS:** Corrosion inhibitors, Electroplated coatings, Conversion coatings, Anodizing, Hot dipping, Spray metal coatings, Zinc coating by alloying, Electrophoteric coatings and electro painting, Powder coating. Corrosion minimization by material selection. Cathodic and Anodic protections	9
III	**CORROSION IN SPECIFIC ENVIRONMENTS:** Corrosion by organic acids and alkalies. Seawater and Fresh water corrosion on concrete structures, Corrosion in automobiles, Biological corrosion, Halogen corrosion of metals, Corrosion in Petroleum industry, Corrosion in aerospace. Corrosion damage to concrete in industrial and marine environments environmental degradation of materials, corrosion and inspection managements in chemical processing and petrochemical industries.	9
IV	**CORROSION CONTROL METHODS** Forms of corrosion - Definition, factors and control methods of various forms of corrosion such as pitting, inter granular, crevice, dezincification, stress corrosion, corrosion fatigue, fretting corrosion, hydrogen embitterment, corrosion processes and control methods in fertilizers, petrochemical, chemical building industries	9

V	**CORROSION TEST & IMPACTS ON ECONOMY** Corrosion testing, Electrochemical methods of corrosion rate measurements by DC and AC methods, corrosion monitoring methods, chemical and electrochemical removal of corrosion products, newer techniques to study corrosion processes, inspection methods by NDT. Surface analytical techniques such as AES, ESCA, SEM. Corrosion protection management – Process maintenance procedures under corrosion Environments.	**9**
	Total Hours	**45**

Text Books

1. Fontana M.G., ―Corrosion Engineering‖, Tata McGraw Hill, 2005.
2. Roberge P. R., Corrosion Engineering, McGraw Hill, New York, 2008

Reference Books

1. Jones D.A., ―Principal and Protection of Corrosion‖, Prentice-Hall, 1996.
2. Sastri V.S., Ghali E. And Elboujdaini M., ―Corrosion Prevention and Protection: Practical Solutions‖, John Wiley and Sons, 2007.
3. Banarjee.S.N., An introduction to corrosion and corrosion inhibitors, Oxonian Press Ltd., New Delhi, 1985.

COURSE OUTCOMES

The students have the

CO1	Ability to classify the different types of corrosion and theories in a specific environment.
CO2	Ability to apply the principles of corrosion inhibition and corrosion control methods.
CO3	Ability to examine the factors involved in corrosion and control methods of various industries
CO4	Ability to defend the suitable corrosion control methods in different type of industries.
CO5	Ability to construct a corrosion free environment by selecting proper monitoring and inspection tests.

Course Outcome Assessment Questions

Course Outcome 1 (CO1)

1. Distinguish chemical and electrochemical corrosion.
2. Discuss briefly the different types of corrosion.
3. Examine the pH diagram for Fe-H_2O systems.
4. Differentiate Galvanic cell & Electrolytic cell.
5. Report an example for galvanic corrosion.

Course Outcome 2 (CO2)

1. Discuss the different types of protective coatings.
2. How can we minimize the corrosion by material selection?
3. Examine the electroplating method of corrosion protection.
4. What is spray metal coating?
5. Design a suitable method for corrosion prevention in a process industry.

Course Outcome 3 (CO3)

1. Demonstrate briefly about the corrosion inhibition and protection in marine environment.
2. Explain in detail about the corrosion and protection in concrete structures.
3. What is biological corrosion and explain with suitable examples?
4. Examine the corrosion happening areas in a petrochemical industry.
5. Distinguish biological and halogen corrosion

Course Outcome 4 (CO4)

1. Sketch a corrosion fatigue diagram and explain it briefly.

2. Discuss briefly about corrosion protection and management in a process industry.
3. What are the different types of forms of corrosion explain briefly.
4. Examine the corrosion control method in a fertilizer industry.
5. Discuss briefly about hydrogen embrittlement.

Course Outcome 5 (CO5)

1. Discuss briefly about electrochemical removal of corrosion.
2. Differentiate DC & AC methods of measurement of corrosion.
3. Explain in detail the process maintenance procedures under corrosion environments.
4. What is NDT method explains briefly.
5. How corrosion affects the nation's economy?

Course Outcomes	**Skill**	**PO**	**Blooms**	**Assessing tools**
Ability to classify the different types of corrosion and theories in a specific environment.	Remember/Understand	PO10	L1/L2	Assignment/Exam/ Quiz/ Seminar
Ability to apply the principles of corrosion inhibition and corrosion control methods.	Apply	PO1	L3	Assignment/ Exam/ Quiz
Ability to examine the factors involved in corrosion and control methods of various industries	Analyse	PO3, PO4, PO7	L4	Assignment/ Exam/ Quiz
Ability to defend the suitable corrosion control methods in different type of industries.	Investigation	PO3, PO4, PO7	L5	Exam/ Quiz/Assignment/Seminar
Ability to construct a corrosion free environment by selecting proper monitoring and inspection tests.	Design	PO11,	L6	Assignment/Exam/Seminar/ Project

19UCH952	ENERGY STORAGE SYSTEM	L	T	P	C
OBJECTIVES The course is aimed to To facilitate integral research, development, implementation and integration of energy-storage technologies to optimise the energy efficiency of all kinds of energy system.		**2**	**1**	**0**	**3**

MODULE		TOPICS	L Hrs
I	**A**	**INTRODUCTION** Necessity of energy storage, different types of energy storage, mechanical, chemical, electrical, electrochemical, biological, magnetic, electromagnetic, thermal, comparison of energy storage technologies.	**9**
II	**A**	**ENERGY STORAGE SYSTEMS** Thermal Energy storage, sensible and latent heat, phase change materials, Energy analysis of thermal energy storage, Electrical Energy storage-super-capacitors, Magnetic Energy storage-Superconducting systems, Mechanical-Pumped hydro, flywheels and pressurized air energy storage, Chemical-Hydrogen production and storage, Principle of direct energy conversion using fuel cells, thermodynamics of fuel cells, Types of fuel cells,Microbial fuel cell, Fuel cell performance, Electrochemical Energy Storage- Battery, primary, secondary and flow batteries.	**9**
III	**A**	**Design and Applications of Energy Storage** Renewable energy storage-Battery sizing and stand-alone applications, stationary (Power Grid application), Small scale application-Portable storage systems and medical devices, Mobile storage Applications- Electric vehicles (EVs), types of EVs, batteries and fuel cells, future technologies, hybrid systems for energy storage.	**9**
IV	**A**	**ENERGY BALANCE** Energy Balance & MIS First law of efficiency and Second law of efficiency, Facility as an Energy system, Methods for preparing process flow, Materials and Energy Balance diagram, Identification of losses, Improvements. Energy Balance sheet and Management Information System (MIS) ,Energy Modeling and Optimization.	**9**
V	**A**	**ENERGY AUDIT** Energy Audit Instruments,Instruments for Audit and Monitoring Energy and Energy Savings, Types of instruments and Accuracy.	**9**
		Total Hours	**45**

Text Books

1. Energy Storage - Technologies and Applications by Ahmed Faheem Zobaa, InTech.

2. Fundamentals of Energy Storage by J. Jensen and B. Sorenson, Wiley-Interscience, New York,

3. Handbook of battery materials by C. Daniel, J. O. Besenhard,Wiley VCH Verlag GmbH & Co. KgaA

4. Electric & Hybrid Vehicles by G. Pistoia, Elsevier B. V.

5. Thermal energy storage: Systems and Applications by Dincer I. and Rosen M. A., Wiley pub

Reference Books

1. Energy Storage: Fundmentals, Materials and Applications, by Huggins R. A., Springer
2. Fuel cell Fundamentals by R. O'Hayre, S. Cha, W. Colella and F. B. Prinz, Wiley Pub.
3. Chemical and Electrochemical Energy System by R. Narayan and B. Viswanathan, University Press.
4. Battery Systems Engineering by C. D. Rahn and C. Wang, Wiley Pub.
5. Electrochemical Energy Storage for Renewable sources and grid balancing by P. T. Moseley and J. Garche, Elsevier Science.
6. Compressed air energy storage by F. P. Miller, A. F. Vandome, M. B. John, VDM publishing

COURSE OUTCOMES

The students have the

CO1	Ability to understand need of energy storage systems.
CO2	Ability to evaluate the acquire knowledge pertaining to various ways to store energy, its and use.
CO3	Ability to ascertain and analyze focus develop hydrogen storage fuel cell systems though research.
CO4	Ability to choose design obtain knowledge about energy policy, regulations & business practices.
CO5	Ability to select & investigate obtain knowledge on the energy balance sheets & management information system.
CO6	Ability to conduct experiments using modern tools.

Course Outcomes Mapping with Bloom's Taxonomy and Programme Outcomes

Course Outcome		Skill	PO	Bloom's Taxonomy	Assessment Tools to measure CO
CO1	Ability to understand need of energy storage systems.	Remember/ Understand	-	L1/L2	Exam/Assignment/Seminar/Quiz
CO2	Ability to evaluate the acquire knowledge pertaining to various ways to store energy, its and use.	Evaluate	PO4	L5	Exam/Assignment/Seminar/Quiz/Lab/Project
CO3	Ability to ascertain and analyze focus develop hydrogen storage fuel cell systems though research.	Analyze	PO2	L4	Exam/Assignment/Seminar/Quiz/Lab/Project
CO4	Ability to choose design obtain knowledge about energy policy, regulations & business practices.	Design	PO3	L6	Mini Project/Assignment/Quiz/Lab/Exam
CO5	Ability to select & investigate obtain	Investigate	PO4	L5	Assignment/Lab

	knowledge on the energy balance sheets & management information system.				/Exam/Seminar
CO6	Ability to conduct experiments using modern tools.	Modern Tools	PO5	L3	Lab/Project

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Write a note on importance of Energy Storage?
2. Explain the principle of Necessity of energy storage.
3. With a neat sketch,explain the different types of energy storage.
4. Distinguish between the importance of energy storage technologies.

Course Outcome 2 (CO2):

1. Evaluate the Energy analysis of thermal energy storage.
2. Derive an expression of most efficient way to store energy?
3. Explain how will you find out the Electrical Energy storage.
4. Discuss in detail about the Magnetic Energy storage-Superconducting systems.

Course Outcome 3 (CO3):

1. Analyze the hybrid systems for energy storage.
2. Find out the types of electrical energy storage system.
3. Illustrate the measure of batteries and fuel cells.
4. Explain in detail about the principle of Mobile storage Applications.

Course Outcome 4 (CO4):

1. Design a Materials and Energy Balance diagram.
2. Elaborate a Principles of Energy Balance sheet and Management Information System.
3. Discuss about the different types of Energy Balance Sheets?
4. With a neat sketch explain about the Energy Modeling and Optimization.

Course Outcome 5 (CO5):

1. Find out the Instruments for Audit at Energy Storage System.
2. How to obtain the Monitoring Energy storage system.
3. Explain in detail about the Types of instruments using Energy Storage System.
4. Discuss in detail about the Energy Savings.

19UCH953	Industrial Waste Management	L	T	P	C
		3	0	0	3

Objective:

To impart knowledge on sources and characteristics of various industrial wastes and strategies for its prevention and control

MODULE	TOPICS	L (Hrs)
I	INTRODUCTION Types of industries and industrial pollution, Characteristics of industrial wastes, Population equivalent, Bioassay studies, effects of industrial effluents on streams, sewer, land, sewage treatment plants and human health ,Environmental legislations related to prevention and control of industrial effluents and hazardous wastes	9
II	CLEANER PRODUCTION Waste management Approach, Waste Audit, Volume and strength reduction, Material and process modifications, Recycle, reuse and product recovery, Applications.	9
III	POLLUTION FROM MAJOR INDUSTRIES Sources, Characteristics, waste treatment flow sheets for selected industries such as Textiles, Tanneries, Pharmaceuticals, Electroplating industries, Dairy, Sugar, Paper, distilleries, Steel plants, Refineries, fertilizer, thermal power plants – Wastewater reclamation concepts	9
IV	TREATMENT TECHNOLOGIES Equalisation, Neutralisation, Removal of suspended and dissolved organic solids, Chemical oxidation, Adsorption, Removal of dissolved inorganics, Combined treatment of industrial and municipal wastes, Residue, management, Dewatering, Disposal	9
V	HAZARDOUS WASTE MANAGEMENT Hazardous wastes, Physico chemical treatment, solidification, incineration, Secure land fills	9
VI	Case Studies and Industrial Visits	
	Total Hours	**45**

Text Books

1. M.N.Rao & A.K.Dutta, "Wastewater Treatment", Oxford – IBH Publication, 1995.
2. W .W. Eckenfelder Jr., "Industrial Water Pollution Control", McGraw-Hill Book Company, New Delhi, 2000.
3. Patwardhan. A.D., Industrial Wastewater Treatment", Prentice Hall of India, New Delhi 2010.

Reference Books:

1. T.T.Shen, "Industrial Pollution Prevention", Springer, 1999.
2. R.L.Stephenson and J.B.Blackburn, Jr., "Industrial Wastewater Systems Hand book", Lewis Publisher, New Yark, 1998
3. H.M.Freeman, "Industrial Pollution Prevention Hand Book", McGraw-Hill Inc., New Delhi, 1995.
4. Bishop, P.L., "Pollution Prevention: Fundamental & Practice", McGraw Hill, 2000.
5. Pandey, "Environmental Management" Vikas Publications, 2010.
6. Industrial Wastewater Management, Treatment and Disposal",(WEF – MOP – FD3) McGraw Hill, 2008.

COURSE OUTCOMES

The students will have the	
CO1	Ability to understand the basic concepts and sources of industrial wastes and the need for industrial waste management
CO2	Ability to identify and classify waste in industries
CO3	Ability to investigate and analyse the waste and its prevention techniques
CO4	Ability to apply different methodologies to predict and assess the impacts of project on various aspects of industrial wastes.
CO5	Ability to apply the knowledge in investigating developments in waste management

Course Outcomes Mapping with Bloom's Taxonomy and Programme Outcomes

Course Outcome		**Skill**	**PO**	**Bloom's Taxonomy**	**Assessment Tools to measure CO**
CO1	Ability to understand the basic concepts and sources of industrial wastes and the need for industrial waste management	Remember/ Understand	PO1, PO6, PO7	L1/L2	Exam/Assignment /Seminar/Quiz
CO2	Ability to identify and classify waste in industries	Apply	PO1, PO5, PO6	L3	Exam/Assignment /Seminar/Quiz/Lab/Project
CO3	Ability to investigate and analyse the waste and its prevention techniques	Analyze	PO1, PO2, PO3	L4	Exam/Assignment /Seminar/Quiz/Lab/Project
CO4	Ability to apply different methodologies to predict and assess the impacts of project on various aspects of industrial wastes.	Investigate	PO2, PO3, PO7,	L5	Mini Project/Assignment/Quiz/Lab/Exam
CO5	Ability to apply the knowledge in investigating developments in waste management	Investigate	PO2, PO3, PO4, PO9	L5	Assignment/Exam /Seminar
CO6	Ability to devising safety policy and procedures to be adopted to implement total safety in a plant	Design	PO5, PO7	L6	Seminar/Mini Project/ Lab

19UCH954 WASTE TO ENERGY CONVERSION	L	T	P	C
	3	0	3	3

AIM

To provide an understanding of the various aspects of Waste to Energy.

OBJECTIVES

The objective of the course is to provide insights into waste management options by reducing the waste destined for disposal and encouraging the use of waste as a resource for alternate energy production

MODULE	TOPICS	L Hrs
I	**INTRODUCTION** Introduction to energy from waste: characterisation and classification of waste as fuel –agro based, forest residues, industrial waste, Municipal solid waste. The Principles of Waste Management and Waste Utilization.	9
II	**WASTE SOURCES & CHARACTERIZATION** Waste production in different sectors such as domestic, industrial, agriculture, postconsumer, waste etc. Classification of waste – agro based, forest residues, domestic waste, industrial waste (hazardous and non-hazardous). Characterization of waste for energy utilization. Waste Selection criteria.	9
III	**TECHNOLOGIES FOR WASTE TO ENERGY** Biochemical Conversion – Energy production from organic waste through anaerobic digestion and fermentation. Thermo-chemical Conversion – Combustion, Incineration and heat recovery, Pyrolysis, Gasification; Plasma Arc Technology and other newer technologies.	9
IV	**WASTE TO ENERGY OPTIONS** Landfill gas, collection and recovery. Refuse Derived Fuel (RDF) – fluff, briquettes, pellets. Alternate Fuel Resource (AFR) – production and use in Cement plants, Thermal power plants and Industrial boilers. Conversion of wastes to fuel resources for other useful energy applications	9
V	**WASTE TO ENERGY & ENVIRONMENTAL IMPLICATIONS** Environmental standards for Waste to Energy Plant operations and gas clean-up. Savings on non-renewable fuel resources. Carbon Credits: Carbon foot calculations and carbon credits transfer mechanisms	9
	Total Hours	45

Course Outcomes		Bloom's Level
CO1	Ability to understand the conversion factor and basic concept of Waste to Energy.	Remember/Understand
CO2	Apply the knowledge about the operations of Waste to Energy Plants	Apply
CO3	Analyse the various aspects of Waste to Energy Management Systems	Analyse
CO4	Carry out Techno-economic feasibility for Waste to Energy Plants.	Evaluate
CO5	Create a plant for planning and operations of Waste to Energy	Create
CO6	Ability to design the plant for consumption of energy.	Modern Tools

Text Books

1. Waste-to-Energy in Austria – White Book – Figures, Data Facts, 2nd edition , May 2010

2. M.M. EL-Halwagi, Biogas Technology- Transfer and diffusion, Elsevier Applied science Publisher, New York, 1984..

Reference Books

1. D.O Hall and R.P. Overeed, Biomass – regenerable energy, John Willy and Sons Ltd. New York. 1987
2. Wealth from Waste: Trends and Technologies by Banwari Lal and Patwardhan, TERI Press..

Course Outcomes	**Skill**	**PO**	**Blooms**	**Assessing tools**
CO1 - Ability to understand the conversion factor and basic concept of Waste to Energy.	Remember/Understand	--	L1/L2	Assignment/Exam/ Quiz/ Seminar
CO2 - Apply the knowledge about the operations of Waste to Energy Plants	Apply	PO1	L3	Assignment/ Exam/ Quiz
CO3 - Analyse the various aspects of Waste to Energy Management Systems	Analyse	PO2	L4	Assignment/ Exam/ Quiz
CO4 - Carry out Techno-economic feasibility for Waste to Energy Plants.	Evaluate	PO3	L5	Exam/ Quiz/ Assignment/Seminar
CO5 - Create a plant for planning and operations of Waste to Energy	Create	PO4	L6	Assignment/Exam/ Seminar
CO6 - Ability to design the plant for consumption of energy.	Modern Tools	PO5	L3	Lab/Project

PROFESSIONAL ELECTIVE

19UCH901	PETROLEUM REFINERY ENGINEERING	L	T	P	C
		2	1	0	3

MODULE		TOPICS	L Hrs
I	A	**Petroleum** Exploration Practices - Reservoir Rock Properties - Reservoir types - Reservoir Estimation Origin – Composition - Classification and constituents of petroleum - Dehydration of crude oil Transportation of crude oil - Classification of petroleum	9
	B	**Evaluation of crude oil properties** and testing methods Specific gravity - Vapor pressure – Viscosity - red wood viscometer - Flash point - Fire point - Pour point - Smoke point - Aniline point - Diesel index - Octane number - Performance number - Cetane number - Properties of greases - Drop point of grease. and	
II	A	**Design of crude oil distillation column** Components of crude oil distillation - various crude oil distillation systems - uses of petroleum products	9
	B	Treatment Techniques Desalting of crudes, dehydration and fractionation methods; Thermal and catalytic cracking processes. Necessity of cracking - Types of cracking - advantages and disadvantages of catalytic cracking over thermal cracking - Houdrys fixed bed processes - Moving bed processes - Fluid bed catalytic cracking processes	
III	A	**Reforming** Thermal and catalytic Reforming; Polymerization; Alkylation; Isomerization, finishing and purification processes.	9
	B	Upgrading Processes Solvent extraction; hydro treatment processes, Sweetening processes types – Merox – HDS; Dewaxing; Deasphalt; Lube oil treatment	
IV	A	**Knocking** Reasons for knocking - Additives in petrol - Aviation gasoline - Aviation turbine fuel (ATF) - Storage and handling of liquid fuels.	9
	B	**Feedstock and product handling** Storage, Blending, Loading, Unloading **Auxiliary facilities** Boilers , Waste water treatment ,Hydrogen production ,Sulfur recovery plant, Cooling towers , Blow down system, Compressor engines	
V	A	Material and Energy balances calculation; controlling hydrocarbon losses in refinery.	9
	B	**Environmental issues and New Trends in petroleum refinery operations.** Ecological consideration in petroleum refinery, Waste water treatment, control of air pollution, New trends in refinery, Alternative energy sources, Biodiesel, Hydrogen energy from biomass.	

	Total Hours	**45**

Text Books

1. Gary, J.H.; Handwerk, G.E. 2001. Petroleum refining: Technology and economics. 4th ed. Marcel Dekker, Inc.
2. Fahim, M.A.; AlSahhaf, T.A.; Elkilani, A. 2010. Fundamentals of petroleum refining. Elsevier.
3. Myers, R.A. 2004. Handbook of petroleum refining processes. 3rd ed. McGraw-Hill.
4. Seader, J.D.; Henley, E.J.; Roper, D.K. 2011. Separation process principles: Chemical and biochemical operations. 3rd ed., John Wiley & Sons, Inc.

Reference Books

1. Seader, J.D.; Henley, E.J.; Roper, D.K. 2011. Separation process principles: Chemical and biochemical operations. 3rd ed., John Wiley & Sons, Inc.
2. BhaskaraRao B.K., "Modern Petroleum Refining Processes", 5th Edition, Oxford and IBH Publishing Company, New Delhi, 2008.
3. Nelson W.L., ―Petroleum Refinery Engineering‖, 4th Edition, McGraw Hill Publishing Company Limited, 1958.
4. Hobson G. D., ―Modern Petroleum Technology", Part 1&2, 5th Edition, Wiley Publishers, 1984.

COURSE OUTCOMES

The students have the

CO1	Ability to Explain the crude oil and its products properties, along with its characterization methods
CO2	Ability to Discuss the conversion and treatment and upgrading processes used in refining crude oil
CO3	Ability to Implement the chemical engineering principles to the analysis of safe and efficient refinery operations
CO4	Ability to Identify the specifications required for good quality petroleum product
CO5	Ability to design a various separation and treatment column based on product specifications
CO6	Ability to Interpret the relationship safety and environment in Petroleum Refining Industries.

Course Outcomes Mapping with Bloom's Taxonomy and Programme Outcomes

Course Outcome		Skill	PO	Bloom's Taxonomy	Assessment Tools to measure CO
CO1	Ability to Explain the crude oil and its products properties, along with its characterization methods.	Remember/ Understand	-	L1/L2	Exam/Assignment/Seminar/Quiz
CO2	Ability to Discuss the conversion and treatment and upgrading processes used in refining crude oil	Apply	PO2	L3	Exam/Assignment/Seminar/Quiz/Lab/Project
CO3	Ability to Implement the chemical engineering principles to the analysis of safe and efficient refinery operations	Analyze	PO2	L4	Exam/Assignment/Seminar/Quiz/Lab/Project
CO4	Ability to Identify the specifications required for good quality petroleum product	Investigate	PO4	L5	Mini Project/Assignment/Quiz/Lab/Exam

CO5	Ability to design a various separation and treatment column based on product specifications	Design	PO3	L6	Assignment/Lab /Exam/Seminar
CO6	Ability to Interpret the relationship safety and environment in Petroleum Refining Industries	Investigate	PO4	L5	Case studies/Project

19UCH902	POLYMER TECHNOLOGY	L	T	P	C
		3	0	3	3

AIM

To study the basics principles and types of polymers.

OBJECTIVES

To enable the students to compute molecular weight averages from the molecular weight distribution, Condensation polymerization and transition in polymers.

MODULE	TOPICS	L Hrs
I	**INTRODUCTION TO POLYMERIZATION** Monomer; functionality and degree of polymerizations; polymers and their classification; Types of polymerization and mechanisms: addition; condensation and copolymerization, bulk, solution, emulsion and suspension polymerizations.	9
II	**STRUCTURE AND PROPERTIES OF POLYMERS** Structure of polymers: linear, branched and cross linked; Characterization of polymers: molecular weight, crystallinity, glass transition and mechanical propertiesUltrasonic waves; Photodegradation, High energy radiation, Oxidative and hydrolytic	9
III	**PLASTICS AND METHODS** Introduction to plastics: Anti-oxidants and stabilizers, polymer additives; fillers, plasticizers; colorants. Moulding methods: Injection; compression transfer and Blow moulding, Processing techniques: Calendaring; casting; extrusion; thermoforming; foaming.	9
IV	**CHARACTERIZATION TECHNIQUES** Chemical analysis of polymer; X-ray diffraction, Microscopic technique: Light scattering, SEM; Spectroscopic methods: IR, NMR. Thermal analysis: DSC, DTA and TGA.	9
V	**PREPARATION, PROPERTIES AND INDUSTRIAL USES OF POLYMERS** Polyethylene; poly propylene; polystyrene, polymethylmethacrylate; polyvinyl chloride; polytetrafluoroethylene; polyacrylate; nylon 6, nylon 6,6 and polyesters; Phenol formaldehyde, urea formaldehyde, and melamine formaldehyde; epoxy; urethanes and silicones, ion exchange polymers.	9
	Total Hours	**45**

Course Outcomes		Bloom's Level
CO1	Understand the principles and types of polymerization processes	Remember/Understand
CO2	Gain insight into the structure and properties of polymers	Apply
CO3	Grasp the methods of preparation and molding of plastics	Analyse
CO4	Develop the knowledge to characterize the plastics by using different instruments	Evaluate
CO5	Comprehend the properties and manufacturing processes of polymers.	Create

Text Books

1. Gowarikar V.R., Viswanathan N.V., and Jayadev Sreedhar, ―Polymer Science‖, 9th Reprint, New Age International Pvt. Ltd., India, 1996.
2. Rodriguez. F., Cohen, C., Ober, C, Archer, L.A., ―Principles of Polymer Systems‖, 5th Edition, Taylor and Francis, Great Britain, London, 2003

Reference Books

1. Williams D.J., ―Polymer Science and Engineering‖, Prentice Hall, New York, 1971.
2. Arora M.G. and Singh M., ―Polymer Chemistry‖, Anmol Publications Pvt. Limited, 2003..

Course Outcomes	**Skill**	**PO**	**Blooms**	**Assessing tools**
Understand the principles and types of polymerization processes	Remember/Understand		L1/L2	Assignment/Exam/ Quiz/ Seminar
Gain insight into the structure and properties of polymers	Apply		L3	Assignment/ Exam/ Quiz
Grasp the methods of preparation and molding of plastics	Analyse		L4	Assignment/ Exam/ Quiz
Develop the knowledge to characterize the plastics by using different instruments	Evaluate		L5	Exam/ Quiz/ Assignment/Seminar
Comprehend the properties and manufacturing processes of polymers.	Create		L6	Assignment/Exam/ Seminar

19UCH903	FERTILIZER TECHNOLOGY	L	T	P	C
		3	0	0	3

COURSE OBJECTIVE:

To enable the students to learn the fertilizer manufacturing process including new or modified fertilizer products and new techniques.

MODULE	TOPICS	L Hrs
I	**INTRODUCTION** Chemical Fertilizers and Organic Manures - Types of chemical Fertilizers. Secondary nutrients, micro nutrients.	9
II	**NITROGEN FERTILIZERS** Nitrogenous Fertilizers - Methods of production of Ammonia and Urea. Nitric acid, Ammonium sulphate, Ammonium Nitrate, Calcium Ammonium Nitrate, Ammonium Chloride - Their methods of production, characteristics, storage and handling specifications.	9
III	**PHOSPHATIC FERTILIZERS** Raw materials, phosphate rock, Sulphur pyrites -Process for the production of Sulphuric and Phosphoric acids. Ground phosphate rock, bone meal. Single Super Phosphate, Triple Super phosphate -Methods of production, characteristics and specifications.	9
IV	**POTASSIC FERTILIZERS** Potassium chloride, Potassium sulphate, Potassium schoenite - Methods of production, specification, characteristics. Complex Fertilizers, NPK Fertilizers, Mono ammonium phosphate, Diammonium phosphate, Nitro phosphate Methods of production.	9
V	**FERTILIZERS IMPACTS AND STANDARDS** Fluid fertilizers. Controlled Release of fertilizers. Solid, Liquid and Gaseous pollution from ammonia urea and NPK fertilizer industries and standards laid down for them. Fertilizer production in India.	9
	Total Hours	**45**

TEXT BOOKS

1. Gopala Rao M., Marshall Sittig, Dryden's Outlines of Chemical Technology, Third Edition, WEP East-West Press, New Delhi, 2010.
2. George T. Austin., Shreve's Chemical Process Industries, Fifth Edition, McGraw Hill Professional, 2012
3. Vincent Sauchelli., The Chemistry and Technology of Fertilizers, Reinhold Pub. Corp., 1960.

REFERENCES:

1. Sauchelli, V.; "The Chemistry and Technology of Fertilizers", ACS MONOGRAPH No. 148,
2. Reinhold Publishing Cor. New York, 1980.
3. Fertiliser Manual, "United Nations Industrial Development Organisation", United Nations, New York, 1967.
4. Slack, A.V.; Chemistry and Technology of Fertilisers, Interscience, New York, 1966.

COURSE OUTCOMES

The students have the ability to understand

CO1	Ability to define and classify chemical, organic fertilizers and nutrients

CO2	Ability to demonstrate the flow chart for the manufacture of various types of fertilizers.
CO3	Ability to compare the manufacturing process of different types of fertilizers.
CO4	Ability to investigate the quality and pollution standards permissible in fertilizer industry.
CO5	Ability to design various equipments in a fertilizer industry.

Course Outcomes	**Skill**	**PO**	**Blooms**	**Assessing tools**
Ability to define and classify chemical, organic fertilizers and nutrients	Remember/Understand	PO7	L1/L2	Assignment/Exam/ Quiz/ Seminar
Ability to demonstrate the flow chart for the manufacture of various types of fertilizers.	Apply	PO1, PO3	L3	Assignment/ Exam/ Quiz
Ability to compare the manufacturing process of different types of fertilizers.	Analyse	PO11	L4	Assignment/ Exam/ Quiz
Ability to investigate the quality and pollution standards permissible in fertilizer industry.	Investigation	PO6, PO7, PO9	L5	Exam/ Quiz/Assignment/Seminar
Ability to design various equipments in a fertilizer industry.	Design	PO3,	L6	Assignment/Exam/Seminar/ Project

19UCH904 FOOD SCIENCE AND TECHNOLOGY	L	T	P	C
	3	0	3	3

AIM

To study the basics principles and the calculation techniques used in the chemical industry.

OBJECTIVES

To enable the students to learn to design processing equipments for Food Industries.

MODULE	TOPICS	L Hrs
I	**CONSTITUENTS OF FOOD** Carbohydrates – proteins, Lipids, Vitamins, Additives, Preservatives, Solvents, Flavors, Agents, Food Engineering Operations, Food Sorting, Cleaning, Grading – Harvesting –Drying storage –Prime processing.	9
II	**FOOD PROCESS ENGINEERING OPERATIONS** Materials and Energy Balances – Fluid flow applications, Heat transfer applications, Drying, Evaporation, Equilibrium stage process, leaching and Extractions, Applications, Application of Mechanical separations and Mixing, in Diary, Meat Industry, Oil and Flat Industry, Cereal processing.	9
III	**PRESERVATION OPERATIONS AND PLANT HYGIENE** Preservation methods & strategies, Thermal Methods, Nabla Factor Sterilization, Pasteurization, Dehydro freezing, Irradiation, Dosimetry, Transport of food & Preservation Strategies.Plant Hygiene: Plant Hygiene, Design of sterilization Process, Water Quality Upkeep, waste disposal, Material handling, Packaging, Packing of solid Liquid foods, Food storage, Special case Studies.	9
IV	**DEVELOPMENTS IN FOOD PROCESSING** Food Constituents and processing, Food emulsions, Food Rheology, Advances in thermal Operation, Extrusion, cooking Spray dryer design, Energy expenditure & Saving Food for developing countries, Food Detoxification, Production of Sweeteners, Starch, Microbial Polysaccharides, Amino acid, Rice bran Tocopherols.	9
V	**FOOD SAFETY AND QUALITY CONTROL** Quality Control in Food Industry, Dose Response Relationship, Health Problem, Chemical and Micro biological aspects, Food analysis, Instruments & Enzymatic Analysis, Food Safety. Food laws and standards PFA, FPO, ISI/BIS and AGMARK. GMP's, SSOP's HACCP and ISO9000 programs.	9
	Total Hours	**45**

Course Outcomes		Bloom's Level
CO1	Understand the constituents of food, food preservation, development and food safety	Remember/Understand
CO2	Comprehend the food process engineering operations with preservation and development.	Apply
CO3	Familiarize with preservation operations, food safety and quality control.	Analyse
CO4	Acquaint with plant hygiene in food processing industries	Evaluate
CO5	Acquire the knowledge in safety and quality control in food processing industries	Create

Text Books

1. Jowitt R., ―Hygienic Design and Operation of Food Plant‖, AVI Pvt. Co., West Port, 1980.
2. Head man D.R. and Singh R.P., ―Food Processing Technology‖, AVI Pvt. Co., West Port, 1981

Reference Books

1. Brennan J., Butters G.J.R., Cowell, N.D. and AEV Lilly, ―Food Engineering Operations‖, 3rd Edition, Applied Scientific Publishers, London, 1990
2. Ronald H. Schmidt and Gary E. Rodrick, ―Food Safety Handbook‖, John Wiley and Sons, New Jersey, 2005.

19UCH906	OIL & NATURAL GAS ENGINEERING	L	T	P	C
		3	0	0	3

MODULE		TOPICS	L Hrs
Course Objective			
Students will be able to understand the Natural gas processing, Gas Compression, Gas Gathering and Transport Installation, Operation and trouble shooting of natural gas pipelines.			
I	**A**	**NATURAL GAS** Natural gas technology and earth science: Branches of petroleum Industry. Sources of Information for natural gas engineering and its applications. Geology and earth sciences: Earth sciences-Historical geology, Sedimentation process, Petroleum reservoirs, Origin of petroleum. Earth temperatures & pressure, Earth temperatures, Earth pressure. Petroleum: Natural gas, LP gas, Condensate, & Crude oil.	**9**
	B	**COMPOSITION OF NATURAL GAS** Properties of Natural Gases: typical compositions. Equations of state: general cubic equations, specific high accuracy equations. Use of equation of state to find residual energy properties,	
II	**A**	**Pumps & Compressors** Gas Compression: Positive displacement and centrifugal compressors; fans. Calculation of poser requirements. Compressible Flow in Pipes: Fundamental equations of flow: continuity, momentum, elegy equations.	**9**
	B	**Natural Gas Offshore Drilling, Production & Handling** Directional Drilling and Horizontal Drilling-Drilling Deepwater Reservoir – Deepwater production systems – Mooring Systems – Gas Terminals-Sucker Rod pumping – Separation , Storage, Transportation of Natural Gas	
III	**A**	**Well testing** Non-dimensional forms of the equation; derivation of coefficients relation dimensionless to real variables. Infinite reservoir solution: Pseudo-steady-state solution. Gas Well Deliverability Tests: Flow-after-flow tests: prediction of IPR curve and AOF for the well. Isochronal tests. Draw down tests: need for data at two flow rates.	**9**
	B	**Natural Gas estimation in reservoir:** Isothermal flow in pipes: the Weymouth equation. Static and flowing bottom-hole pressures in wells. Fundamentals of Gas flow in porous media: Steady state flow equations. Definition of pseudo-pressure function. Gas flow in cylindrical reservoirs: general equation for radial flow of gases in symmetrical homogeneous reservoirs.	
IV	**A**	**Natural Gas Treatment & Process** Dehydration – Desulphurization processes Acid Gas Removal – Low temperature processes	**9**
	B	**NATURAL GAS AND NGL RECOVERY** NGL, LPG, C3, C2 Fraction Recovery from Natural Gas- Refrigeration process – Lean oil absorption process – Solid bed adsorption and membrane separation process – NGL fractionation.	
V	**A**	**Economics of Natural Gas** Current status in India – Trade & Selection of port location – Economics of Gas Processing	**9**

	B	**Contemporary issues and Trends in Oil & Natural Gas process.** Ecological consideration in Natural gas ,Waste water treatment, control of air pollution, trends in process of natural gas, Alternative energy	
		Total Hours	**45**

Text Books

1Katz D.L.et al., Natural Gas Engineering (Production & storage), McGraw-Hill, Singapore. 1968

2. Lyons, W.C., "Standard Handbook of Petroleum and Natural Gas Engineering", Vol. 2, Gulf Professional Publishing, Elsevier Inc., 2006.

Reference Books

1. Katz, D. L. and Lee, R.L., "Natural Gas Engineering", McGraw Hill, 1990.

2. Dring, M.M., "The Natural Gas Industry – A Review of World Resources and Industrial Applications", Butterworth, 1974.

3. Saied Mokhatab, William A. Poe, and James G. Speight, "Handbook of Natural Gas Transmission and Processing", Gulf Professional Publishing, Elsevier Inc., 2006. 4. Hobson G. D., —Modern Petroleum Technology", Part 1&2, 5th Edition, Wiley Publishers, 1984.

COURSE OUTCOMES

The students have the

CO1	Ability to Emphasize fundamentals of mathematics and integrates them in application to traditional Natural Gas Engineering to improve further needs
CO2	Ability to Select, locate and orient systems for offshore problems
CO3	Ability to Implement revamp and retrofit a system, process to meet desired needs within realistic constraints such as environmental, health, safety, manufacturability and sustainability in the field of Natural Gas
CO4	Ability to Apply natural Gas Refining principles and practices for optimizing resource development and management
CO5	Ability to Recognize the purification mechanism to estimate, design equipment's for processing, storage And transport
CO6	Ability to Inspect project economics and resource valuation methods for design and decision making under conditions of risk and uncertainty environment in NG Production ans process.

Course Outcomes Mapping with Bloom's Taxonomy and Programme Outcomes

Course Outcome		**Skill**	**PO**	**Bloom's Taxonomy**	**Assessment Tools to measure CO**
CO1	Ability to Emphasize fundamentals of mathematics and integrates them in application to traditional Natural Gas Engineering to improve further needs	Analyze	PO2	L4	Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test
CO2	Ability to Select, locate and orient systems for offshore problems	Apply	PO2	L3	Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test
CO3	Ability to Implement revamp and retrofit a system, process to meet desired needs within realistic constraints such as environmental, health, safety, manufacturability and sustainability in the field of Natural Gas	Analyze	PO2	L4	Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test

CO4	Ability to Apply natural Gas Refining principles and practices for optimizing resource development and management	Apply	PO2	L3	Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test
CO5	Ability to Recognize the purification mechanism to estimate, design equipment's for processing, storage And transport	Investigate	PO4	L5	Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test
CO6	Ability to Inspect project economics and resource valuation methods for design and decision making under conditions of risk and uncertainty environment in NG Production and process.	Investigate	PO4	L5	Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test

19UCH907	COMPUTATIONALFLUID DYNAMICS	L	T	P	C
		3	0	0	3

OBJECTIVES

- To introduce Governing Equations of viscous fluid flows
- To introduce numerical modeling and its role in the field of fluid flow and heat transfer
- To enable the students to understand the various discretization methods, solution procedures and turbulence modeling
- To create confidence to solve complex problems in the field of fluid flow and heat transfer by using high speed computers

MODULE		TOPICS	L Hrs
I	A	**GOVERNING EQUATIONS AND BOUNDARY CONDITIONS** Basics of computational fluid dynamics – Governing equations of fluid dynamics – Continuity, Momentum and Energy equations – Chemical species transport – Physical boundary conditions – Time-averaged equations for Turbulent Flow – Turbulent–Kinetic Energy Equations – Mathematical behaviour of PDEs on CFD – Elliptic, Parabolic and Hyperbolic equations.	9
II	A	**FINITE DIFFERENCE AND FINITE VOLUME METHODS FOR DIFFUSION** Derivation of finite difference equations – Simple Methods – General Methods for first and second order accuracy – Finite volume formulation for steady state One, Two and Three -dimensional diffusion problems – Parabolic equations – Explicit and Implicit schemes – Example problems on elliptic and parabolic equations – Use of Finite Difference and Finite Volume methods.	9
III	A	**FINITE VOLUME METHOD FOR CONVECTION DIFFUSION** Steady one-dimensional convection and diffusion – Central, upwind differencing schemes properties of discretization schemes – Conservativeness, Boundedness, Transportiveness, Hybrid, Power-law, QUICK Schemes.	9
IV	A	**FLOW FIELD ANALYSIS** Finite volume methods -Representation of the pressure gradient term and continuity equation – Staggered grid – Momentum equations – Pressure and Velocity corrections – Pressure Correction equation, SIMPLE algorithm and its variants – PISO Algorithms.	9
V	A	**TURBULENCE MODELS AND MESH GENERATION** Turbulence models, mixing length model, Two equation models – High and low Reynolds number models – Structured Grid generation – Unstructured Grid generation – Mesh refinement – Adaptive mesh – Software tools.	9
		Total Hours	**45**

Text Books

1. Versteeg, H.K., and Malalasekera, W., "An Introduction to Computational Fluid Dynamics: The finite volume Method", Pearson Education Ltd.Second Edition, 2007.
2. Ghoshdastidar, P.S., "Computer Simulation of flow and heat transfer", Tata McGraw Hill Publishing Company Ltd., 1998.

Reference Books

1. Patankar, S.V. "Numerical Heat Transfer and Fluid Flow", Hemisphere Publishing Corporation, 2004.
2. Chung, T.J. "Computational Fluid Dynamics", Cambridge University, Press, 2002.
Ghoshdastidar P.S., "Heat Transfer", Oxford University Press, 2005

3. Muralidhar, K., and Sundararajan, T., "Computational Fluid Flow and Heat Transfer", Narosa Publishing House, New Delhi, 1995.
4. ProdipNiyogi, Chakrabarty, S.K., Laha, M.K. "Introduction to Computational Fluid Dynamics", Pearson Education, 2005.
Anil W. Date "Introduction to Computational Fluid Dynamics" Cambridge University Press, 2005.

COURSE OUTCOMES

The students have the

CO1	Ability to understand basic principles of turbulence, mixing, fast reactions, multiphase flows in CFD
CO2	Ability to use the various discretization methods, solution procedures and turbulence modeling to solve flow and heat transfer problems
CO3	Ability to analyze limitations with the models used in CFD and select appropriate models for these systems
CO4	Ability to investigate the problems related to the systems by selecting suitable models and numerical methods and critically evaluate simulation results
CO5	Ability to create numerical modeling and its role in the field of fluid flow and heat transfer
CO6	Ability to conduct experiments using modern software tools

Course Outcomes Mapping with Bloom's Taxonomy and Programme Outcomes

Course Outcome		Skill	PO	Bloom's Taxonomy	Assessment Tools to measure CO
CO1	Ability to understand basic principles of turbulence, mixing, fast reactions, multiphase flows in CFD	Remember/ Understand	-	L1/L2	Exam/Assignment/Seminar/Quiz
CO2	Ability to use the various discretization methods, solution procedures and turbulence modeling to solve flow and heat transfer problems	Apply	PO1	L3	Exam/Assignment/Seminar/Quiz/Lab/Project
CO3	Ability to analyze limitations with the models used in CFD and select appropriate models for these systems	Analyze	PO2	L4	Exam/Assignment/Seminar/Quiz/Lab/Project
CO4	Ability to investigate the problems related to the systems by selecting suitable models and numerical methods and critically evaluate simulation results	Investigate	PO4	L5	Mini Project/Assignment/Quiz/Lab/Exam
CO5	Ability to create numerical modeling and its role in the field of fluid flow and heat transfer	Design	PO3	L6	Assignment/Lab/Exam/Seminar
CO6	Ability to conduct experiments using modern software tools	Modern Tools	PO5	L3	Lab/Project

19UCH908	CHEMICAL PROCESS PLANT SAFETY	L	T	P	C
		3	0	0	3

Objective:

The course is aimed to educate the students about the fundamentals of plant safety and execution of safety measures, risk analysis and assessment, hazard identification in chemical industries.

MODULE		TOPICS	L (Hrs)
I	A	**Safety Fundamentals and Principles:** Need for Development of Safety Consciousness in Chemical Industries, Safety programs, components and realization, training & education, psychological attitude towards safety.	9
	B	**Potential Hazards in Chemical Process Industries** Risk, Hazard, Chemical Hazard Symbols, Toxic Substances, Classes of Toxicity, Entry Points for Toxic Agents, Effects of Toxic Substance, Relationship of Doses and Responses, Threshold Limiting Values, Exposure Thresholds	
II	A	**Safety in Operations and Processes**: Incompatible chemicals, Safe Handling and Operation of materials and Machinery; Periodic inspection and replacement. MSDS and Storage of Chemicals. Safety in operations and processes, Decomposition & Runaway reactions, unstable products, Initiating factors, Reactive Chemical Hazard, Pressurized Heavy Water Reactor	9
	B	Fuel Arrangement in FBR, Safety Criteria, Liquid Metal Fast Breeder Reactor Safety Features, Passive Shutdown System, Potential Failure Events, Severe Accident Scenarios Sodium Reactivity with Water: Micro, Small, Intermediate, Large Leak, Leak Detection System, Strong Signal Detection, Rate of Rise Detection, Plant Operator Action Plan Sodium Fire Protection.	
III	A	**Fire and Explosion** Types of Fire, Fire triangle, Effective Ignition Source, Static Electricity, Explosion: BLEVE, VCE, Detonation and Deflagration, Flammability Limits, LOC, Flash point, Flammability Diagram, Flammable and Combustible Liquids.	9
	B	**Industrial Accidents:** Industrial accidents –types, nature/effects, causes, costs, prevention, investigation and analysis, accident proneness, case studies.	
IV	A	**Hazard Identification & Risk Assessment** Process of Risk Management Hazard Identification, Evaluation (Risk Assessment, Risk Matrix), Quantitative, Qualitative Safety Review, Process /System Checklists, Risk Control Implementation, Action and Recommendation**.**	9
	B	**Safety Studies** – HAZOPS, HAZANS, Fault tree, Event tree and risk analysis. **Assessing Reaction Hazard**: Tools for evaluating thermal explosion, Steps to Reduce Reactive Hazards. Process Plant Design: Flow Diagrams	
V	A	**Legal Aspects:** Factories Act, ESI act and Workmen‘s compensation act, Role of Government, safety organizations, management and trade unions in promoting industrial safety. Emergency response systems for hazardous goods basic rules and requirements which govern the chemical industries.	9
	B	Case Studies and Industrial Visits	
		Total Hours	45

Text Books

1. Ridley Safety at Work, VII Edition, Butterworth Heinman 2007.
2. William Handley, Industrial Safety Hand Book McGraw-Hill Book Company 2nd Edition, 1977.
3. Fawatt, H.H. and Wood, W.S.Safety and Accident Prevention in Chemical Operation, Interscience, 1965

Reference Books:

1. Heinrich, H.W. Dan Peterson, P.E. and Nester Rood. Industrial Accident Prevention, McGraw-Hill Book Co., 1980
2. Blake, R.P., Industrial Safety, Prentice Hall Inc., New Jersy – 3rd Edn. 1963.

COURSE OUTCOMES

The students will have the

CO1	Ability to understand the basic concepts related to chemical plant safety
CO2	Ability to identify and classify hazards in chemical industries
CO3	Ability to investigate and analyse the accident causes and prevention techniques
CO4	Ability to analyse qualitative and quantitative risk assessment
CO5	Ability to apply the knowledge in handling hazards
CO6	Ability to devise safety policies and procedures in implementing total safety in a plant

Course Outcomes Mapping with Bloom's Taxonomy and Programme Outcomes

Course Outcome		**Skill**	**PO**	**Bloom's Taxonomy**	**Assessment Tools to measure CO**
CO1	Ability to understand the basic concepts related to chemical plant safety	Remember/ Understand	PO1, PO4, PO5	L1/L2	Exam/Assignment/Seminar/Quiz
CO2	Ability to identify and classify hazards in chemical industries	Apply	PO2, PO4, PO5	L3	Exam/Assignment/Seminar/Quiz/ Lab/Project
CO3	Ability to investigate and analyse the accident causes and prevention techniques	Analyze	PO2, PO5, PO6, PO7, PO8	L4	Exam/Assignment/Seminar/Quiz/ Lab/Project
CO4	Ability to analyse qualitative and quantitative risk assessment	Investigate	PO2, PO3,	L5	Mini Project/Assignment/Quiz/Lab/Exam
CO5	Ability to apply the knowledge in handling hazards	Investigate	PO1, PO6, PO7	L5	Assignment/Exam/Seminar
CO6	Ability to devise safety policies and procedures in implementing total safety in a plant	Design	PO6, PO9, PO10	L6	Seminar/Mini Project/ Lab

19UCH909 AIR POLLUTION & CONTROL			L	T	P	C
OBJECTIVE: On successful completion of the course the student should able to study the Air pollution and control.			**2**	**1**	**0**	**3**
MODULE		**TOPICS**			**L Hrs**	
I	**A**	**INTRODUCTION** Definition, Sources, classification and characterization of air pollutants. Effects of air pollution on health, vegetation & materials. Types of inversion, photochemical smog.			**9**	
II	**A**	**METEOROLOGY** Temperature lapse rate & stability, wind velocity & turbulence, plume behavior, measurement of meteorological variables, wind rose diagrams, Plume Rise, estimation of effective stack height and mixing depths. Development of air quality models-Gaussian dispersion model			**9**	
III	**A**	**SAMPLING** Sampling of particulate and gaseous pollutants (Stack, Ambient & indoor air pollution), Monitoring and analysis of air pollutants (PM2.5, PM10, SOX, NOX, CO, NH3).			**9**	
IV	**A**	**CONTROL TECHNIQUES** Particulate matter and gaseous pollutants- settling chambers, cyclone separators, scrubbers, filters & ESP.			**9**	
V	**A**	**AIR POLLUTION DUE TO AUTOMOBILES** Air pollution due to automobiles, standards and control methods. Noise pollution causes, effects and control,noise standards. Environmental issues, global episodes, laws, acts, protocols.			**9**	
		Total Hours			**45**	

Text Books

1. M. N. Rao and H V N Rao, “Air pollution”, Tata Mc-G raw Hill Publication.

2. H. C. Perkins, “Air pollution”. Tata McGraw Hill Publication

3. Mackenzie Davis and David Cornwell, “Introduction t o Environmental Engineering” McGraw-Hill Co.

Reference Books

1. Noel De Nevers, “Air Pollution Control Engineering” , Waveland Pr Inc.

2. Anjaneyulu Y, “Text book of Air Pollution and Contr ol Technologies”, Allied Publishers.

COURSE OUTCOMES

The students have the

CO1	Ability to identify the major sources of air pollution and understand their effects on health and environment.
CO2	Ability to evaluate the dispersion of air pollutants in the atmosphere and to develop air quality models.
CO3	Ability to ascertain and analyze sampling techniques for atmospheric and stack pollutants.
CO4	Ability to choose and design control techniques for particulate and gaseous emissions.
CO5	Ability to select & investigate Air pollution due to automobiles forming at a Air pollution and control.
CO6	Ability to conduct experiments using modern tools.

Course Outcomes Mapping with Bloom's Taxonomy and Programme Outcomes

Course Outcome		Skill	PO	Bloom's Taxonomy	Assessment Tools to measure CO
CO1	Ability to identify the major sources of air pollution and understand their effects on health and environment.	Remember/Understand	-	L1/L2	Exam/Assignment/Seminar/Quiz
CO2	Ability to evaluate the dispersion of air pollutants in the atmosphere and to develop air quality models.	Evaluate	PO4	L5	Exam/Assignment/Seminar/Quiz/Lab/Project
CO3	Ability to ascertain and analyze sampling techniques for atmospheric and stack pollutants.	Analyze	PO2	L4	Exam/Assignment/Seminar/Quiz/Lab/Project
CO4	Ability to choose and design control techniques for particulate and gaseous emissions.	Design	PO3	L6	Mini Project/Assignment/Quiz/Lab/Exam
CO5	Ability to select & investigate Air pollution due to automobiles forming at a Air pollution and control.	Investigate	PO4	L5	Assignment/Lab/Exam/Seminar
CO6	Ability to conduct experiments using modern tools.	Modern Tools	PO5	L3	Lab/Project

Course Level Assessment Questions
Course Outcome 1 (CO1): 1.Write a note on major sources of air pollution? 2. Explain the principle of main health effects of air pollution? 3. With a neat sketch, explain the working principle of Five major causes of air pollution? 4. Distinguish between the impacts of air pollution?
Course Outcome 2 (CO2): 1.Derive an methods of pollution dispersion in the atmosphere? 2.Evaluate the dispersion of air pollutant? 3.Explain how will you find out the favorable condition for the dispersion of pollutants in the atmosphere? 4. Discuss in detail about the difference between primary and secondary air pollutants?
Course Outcome 3 (CO3): 1.Analyze the basic principles of ambient air sampling and stack sampling. 2.Find out the atmospheric air sampling. 3.Explain in detail about the technique is used to collect and sample particulate matter. 4.Discuss in detail about the use of impinges in stack monitoring.
Course Outcome 4 (CO4): 1.Design the control of particulate matter emissions. 2.Explain in detail about the most effective method for control of particulate matter. 3.Discuss in detail about the dangerous is particulate matter. 4.With a neat sketch about the primary and secondary pollutants.
Course Outcome 5 (CO5): 1.Find out the three main air pollution from the automobile and explain how it is formed. 2. Identify the air pollution to be controlled from automobiles. 3. Discuss in detail about the following factors affected by air pollution. 4. Explain in detail about the causes of air pollution.

19UCH910 WASTE WATER TREATMENT AND RECYCLING	L	T	P	C
	3	0	0	3

Objective:

- The course is aimed to educate the students about the source identification, treatment techniques, recycling of waste water and apply the same for field application.

MODULE	TOPICS	L (Hrs)
I	**Waste Water an Overview:** Terminology –Sources and Types of Waste water- Point and Non point sources, Waste water characteristics- Pollutants in waste water inorganic – Organic and metallic constituents. **Waste water management:** Concept of Treatment and Recycling - Regulations – Health and Environment Concerns in waste water management – Issues and Challenges- Wastewater Reclamation and reuse - ZLD Concept.	9
II	**Physical and Chemical Treatment:** Role of unit processes in waste water treatment, Screening- Equalization- Neutralization- Sedimentation- Flocculation- Floatation and Aeration Systems-Chemical coagulation – Chemical Oxidation- Chemical precipitation for improved plant performance chemical oxidation.	9
III	**Biological Treatment:** Overview of biological treatment – Microbial metabolism- Bacterial growth and its kinetics – Aerobic biological oxidation – Activated Sludge process- Trickling filters– Rotating biological contactors – Combined aerobic processes. **Anaerobic treatment:** suspended growth, attached growth, fluidized bed and sludge blanket systems; nitrification, denitrification- Phosphorus removal	9
IV	**Advanced Treatment:** Technologies used in advanced treatment – Removal of Colloids and suspended particles – Nutrient Removal – Membrane processes – Adsorption and Ion Exchange – Advanced oxidation process – Disinfection and Chemical Treatments. **Alternate Waste water Treatment Systems:** SBR and SBBR- MBR and MBBR	9
V	**Sludge Management:** Introduction to Waste water sludge – Quantity and Characteristics. **Sludge Processing and Treatment:** Sludge Thickening- Sludge stabilization and Conditioning – Dewatering Hygienisation and Disposal/Reuse	9
VI	**Process Analysis and Selection:** Components of waste water flows – Analysis of Data – Reactors used in waste water treatment – Mass Balance Analysis – Modeling of ideal and non ideal flow in Reactors – Process Selection.	9
VII	**Waste Water Reuse and Recycling:** Challenges and Risks -Decision making in Waste water Reuse and Recycling- Global Practices and Case Studies.	
	Total Hours	**45**

Text Books

1. Metcalf, Eddy and Tchobanoglous G., ―Waste Water Engineering Treatment and Reuse‖, 2nd Edition, Tata McGraw Hill Company, NewYork, 2002.
2. Industrial Waste Water Management, Treatment and Disposal-MOP FD-3‖, 3rd Edition, Tata McGraw Hill Professional Publishing Company, New York, 2008.

Reference Books

1. Mackenzie L Davis, Water and Wastewater Engineering", Prentice Hall of India, New Delhi, 2010.
2. David A Cornwell and Mackenzie L Davis., "Introduction to Environmental Engineering", Volume I, 4th Edition, Asian Books Pvt. Ltd., 1985.
3. Eckenfelder W.W., ―Industrial Water Pollution Control‖, 2nd Edition, McGraw-Hill, 1999.
4. Arceivala S.J., ―Wastewater Treatment for Pollution Control‖, 3rd Edition, McGraw-Hill,

2006.

COURSE OUTCOMES

The students will have the

CO1	Ability to understand the sources, components and need for treatment of waste water
CO2	Ability to identify and classify various water treatment processes
CO3	Ability to analyze the principles involved in waste water treatment techniques
CO4	Ability to investigate recent developments in the treatment technologies
CO5	Ability to design water treatment systems
CO6	Ability to carry out modeling of reactors used for waste water treatment

Course Outcomes Mapping with Bloom's Taxonomy and Programme Outcomes

Course Outcome		**Skill**	**PO**	**Bloom's Taxonomy**	**Assessment Tools to measure CO**
CO1	Ability to understand the sources, components and the need for treatment of waste water	Remember/Understand	PO1, PO6, PO7	L1/L2	Exam/Assignment/Seminar/Quiz
CO2	Ability to identify and classify various physicochemical treatment processes	Apply	PO2, PO3, PO4, PO7	L3	Exam/Assignment/Seminar/Quiz/Lab/Project
CO3	Ability to analyze the principles involved in waste water treatment techniques	Analyze	PO2, PO3, PO4,	L4	Exam/Assignment/Seminar/Quiz/Lab/Project
CO4	Ability to investigate suitable advanced treatment techniques	Investigate	PO2, PO3, PO4,	L5	Mini Project/Assignment/Quiz/Lab/Exam
CO5	Ability to design systems for water treatment	Design	PO2, PO3, PO4, PO9	L5	Assignment/Exam/Seminar, Project work
CO6	Ability to carry out modeling of reactors	Create	PO5	L5	Assignment/Exam/Seminar

Course Outcomes	**Questions**

CO1	1. How are the characteristics of industrial waste water expressed? What is the importance of dissolved oxygen which is present in water? How does it help for the treatment of waste water? How the dissolved oxygen level is maintained in the stream, explain with the help of oxygen Sag curve. 2. Describe the anaerobic process of decomposition.
CO2	1. i) State the function and importance of two stage anaerobic sludge digestion (High rate process) for production of Biogas. ii) Discuss the phenomenon of discrete sitting of particles in primary treatment process. iii) Discuss the working principle of Trickling filter which acts as attached growth biological reactor. 2. Draw a standard flow chart for waste water treatment operation. 3. Enlist various treatment operation for facilitating reuse of waste water
CO3	1. The data on oxygen utilisation are given below in BOD tests of waste water. Obtain the rate constant (k) and initial organic matter concentration (LO) using the established B.O.D. equation. 2. Between BOD and COD, which one usually assumes higher value for a food plant. Justify your answer.
CO4	1. A waste treatment plant is required to digest a sludge in such a way that the moisture content is reduced to 90% from the initial value of 95%. The inflow of sludge initially contains 60% volatile matter in the solid portion and during digestion only 60% of the volatile matter is destroyed. The volatile matter has a specific gravity of 2.5 and fixed solid has a value of 1.0. Calculate the volume of sludge before and after digestion if the inflow contains 1000 lb dry solid. 2. List and differentiate different types of Aerobic Attached Growth Bioreactors and discuss when and under what conditions each of these bioreactors are preferred?
CO5	1. i) Discuss the relative merits and demerits of Batch and continuous processes for treatment of waste water. ii) How will you proceed to formulate the design criteria for a sedimentation tank. 2. Write note on the design guidelines for a reactor to be used for the treatment of municipal sewage.
CO6	1. From the kinetic consideration establish the Mathematical Model for the BOD curve which is equivalent to destruction of organic matter by biological oxidation.

19UCH911	SOLID WASTE MANGEMENT	L	T	P	C
		3	0	0	3

Objective:

The course is aimed to provide comprehensive overview of solid and hazardous wastes and impart knowledge on solid waste management aspects.

MODULE		TOPICS	L (Hrs)
I	A	Legal and Organizational foundation: Definition of solid waste - waste generation in a technological society - sources and types of solid waste – legislations on management and handling of municipal solid wastes, hazardous wastes, biomedical wastes, batteries waste, E - waste and plastics, monitoring responsibilities.	9
II	A	Collection of Solid Waste: Type of waste collection systems, analysis of collection system - Alternative techniques for collection system. Separation and Processing and Transformation of Solid Waste: unit operations used for separation and processing, Materials Recovery facilities, Waste transformation through combustion and anerobic composting, anaerobic methods for materials recovery and treatment - Energy recovery - Inc incerators. Transfer and Transport: need for transfer operation, transport means and methods, transfer station types and design requirements. Landfills: Site selection, design and operation, drainage and leachate collection systems - requirements and technical solutions, designated waste landfill remediation - Integrated waste management facilities.	9
III	A	Definition and identification of hazardous wastes - sources and characteristics - hazardous wastes in Municipal Waste - Hazardous waste regulations - minimization of Hazardous Waste - compatibility, handling and storage of hazardous waste - collection and transport.	9
IV	A	Hazardous waste treatment technologies - Design and operation of facilities for physical, chemical and thermal treatment of hazardous waste - Solidification, chemical fixation and encapsulation, incineration. Hazardous waste landfills: Site selection, design and operation - remediation of hazardous waste disposal sites.	9
V	A	Sampling and characterization of Solid Wastes; TCLP tests and leachate studies	9
		Total Hours	**45**

Reference Books

1. Techobanoglous G, Integrated Solid Waste Management, McGraw - Hill Publication, 1993.
2. Wentz C A, Hazardous Waste Management, McGraw - Hill Publication, 1995.
3. Michael D. LaGrega, Philip L Buckingham, Jeffrey C. E vans and Environmental
4. Resources Management, Hazardous waste Management, Mc - Graw Hill International edition, New York, 2001.
5. CPHEEO, "Manual on Municipal Solid waste management, Central Public Health and Environmental Engineering Organisation , Government of India, New Delhi, 2000.
6. Vesilind P.A., Worrell W and Reinhart, Solid waste Engineering, Thomson Learning Inc., Singapore, 2002.

COURSE OUTCOMES

The students will have the

CO1	Ability to understand solid wastes and its sources
CO2	Ability to identify and classify solid and hazardous wastes

CO3	Ability to investigate and analyse the solid waste remedial measures its importance
CO4	Ability to understand the legislations pertaining to solid waste management
CO5	Ability to apply the knowledge and undertake projects related to solid waste management

Course Outcomes Mapping with Bloom's Taxonomy and Programme Outcomes

Course Outcome		**Skill**	**PO**	**Bloom's Taxonomy**	**Assessment Tools to measure CO**
CO1	Ability to understand solid wastes and its sources.	Remember/ Understand	PO1, PO4, PO5	L1/L2	Exam/Assignment/Seminar/Quiz
CO2	Ability to identify and classify solid and hazardous wastes	Apply	PO1, PO5, PO6	L3	Exam/Assignment/Seminar/Quiz/Lab/Project
CO3	Ability to investigate and analyse the solid waste remedial measures its importance.	Analyze	PO2, PO3, PO6, PO7	L4	Exam/Assignment/Seminar/Quiz/Lab/Project
CO4	Ability to understand the legislations pertaining to solid waste management.	Investigate	PO6, PO9, PO10	L5	Mini Project/Assignment/Quiz/Lab/Exam
CO5	Ability to apply the knowledge and undertake projects related to solid waste management	Investigate	PO5, PO6, PO7, PO8, PO9, PO10	L5	Assignment/Exam/Seminar, Project work

19UCH911 ALTERNATIVE ENERGY TECHNOLOGY .	L	T	P	C
OBJECTIVES The course is aimed to Impart knowledge can be seen as a way to reduce carbon emissions, to promote industrial development, to decrease fossil fuel imports and meet other policy goals. Each of these goals leads to a different set of programs and technologies.	**2**	**1**	**0**	**3**

MODULE		TOPICS	L Hrs
I	**A**	**SOLAR ENERGY** Solar Radiation, Measurements of Solar Radiation, Flat Plate And Concentrating Collectors, Solar Direct Thermal Applications, Solar Thermal Power Generation, Fundamentals of Solar Photo Voltaic Conversion, Solar Cells, Solar PV Power Generation, Solar PV Applications.	**9**
II	**A**	**WIND ENERGY** Wind Energy Estimation, Types of Wind Energy Systems, Performance, Site Selection, Details of Wind Turbine Generator.	**9**
III	**A**	**OCEAN ENERGY** Ocean Thermal Energy Conversion (OTEC), Principle of operation, development of OTEC plants, Tidal and wave energy, Potential and conversion techniques, mini-hydel power plants.	**9**
IV	**A**	**BIO-MASS** Principles of Bio-Conversion, Anaerobic/aerobic digestion, types of Bio-gas digesters, gas yield, combustion characteristics of bio-gas, utilization for cooking.	**9**
V	**A**	**GEOTHERMAL ENERGY** Introduction of Geothermal Energy Resources, types of wells, methods of harnessing the energy, scope in India.	**9**
		Total Hours	**45**

Text Books

1. Reneweble energy resources: Tiwari and ghosal, Narosa publication.

2. Non conventional Energy Sources,Khanna Publication.

Reference Books

1. Renewable Energy Sources:Twidell& Weir, CRC Press.
2. Solar Energy/ S.P. Sukhatme, Tata McGraw-Hill.
3.Non Conventional Energy Systems: K M. Mittal, A H WheelerPublishing Co Ltd.
4. Renewable Energy Technologies: Ramesh & Kumar, Narosa publication.
5. Biomass Energy, Oxford &IBH Publication Co.

COURSE OUTCOMES

The students have the

CO1	Ability to Understand the Need, importance and scope of non conventional and alternate energy resources.
CO2	Ability to evaluate role significance of wind energy.
CO3	Ability to analyze importance of ocean Energy.
CO4	Ability to design the role of bio-gas conversion.
CO5	Ability to investigate geothermal energy.
CO6	Ability to conduct experiments using modern tools.

Course Outcomes Mapping with Bloom's Taxonomy and Programme Outcomes

Course Outcome		Skill	PO	Bloom's Taxonomy	Assessment Tools to measure CO
CO1	Ability to Understand the Need, importance and scope of non conventional and alternate energy resources.	Remember/ Understand	-	L1/L2	Exam/Assignment/Seminar/Quiz
CO2	Ability to evaluate role significance of wind energy.	Evaluate	PO4	L5	Exam/Assignment/Seminar/Quiz/Lab/Project
CO3	Ability to analyze importance of ocean Energy.	Analyze	PO2	L4	Exam/Assignment/Seminar/Quiz/Lab/Project
CO4	Ability to design the role of bio-gas conversion.	Design	PO3	L6	Mini Project/Assignment/Quiz/Lab/Exam
CO5	Ability to investigate geothermal energy.	Investigate	PO4	L5	Assignment/Lab/Exam/Seminar
CO6	Ability to conduct experiments using modern tools.	Modern Tools	PO5	L3	Lab/Project

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Write a note on importance of non-conventional sources of energy?
2. Explain the principle of alternative sources.
3. With a neat sketch,explain the conventional and non-conventional sources of energy?
4. Distinguish between the importance of non-renewable resources?

Course Outcome 2 (CO2):

5. Evaluate the significance of wind energy?
6. Derive an expression of Wind Energy Estimation.
7. Explain how will you find out the Types of Wind Energy Systems.
8. Discuss in detail about the importance of wind energy.

Course Outcome 3 (CO3):

5. Analyze the development of OTEC plants.
6. Find out the Tidal and wave energy.

7. Illustrate the measure of ocean as an energy resource benefit society?
8. Explain in detail about the Principle of operation at ocean energy.

Course Outcome 4 (CO4):

5. Design a combustion characteristics of bio-gas.
6. Elaborate a Principles of Bio-Conversion.
7. Discuss about the types of Bio-gas digesters.
8. With a neat sketch explain about the Anaerobic/aerobic digestion.

Course Outcome 5 (CO5):

1. Find out the geothermal energy utilized?
2. How to obtain the geothermal energy resources?
3. Explain in detail about the methods of harnessing the energy.
4. Discuss in detail about the largest producer of geothermal energy?

19UCH913 ENVIRONMENTAL IMPACT ASSESSMENT	L	T	P	C
	3	0	0	3

Objective:

To identify the need to assess major principles and evaluate the impact on environment. To impart knowledge in overall environmental management.

MODULE	TOPICS	L (Hrs)
I	Impact of development projects, Sustainable development, Need for Environmental Impact Assessment (EIA), Environmental Impact Statement (EIS), EIA capability and limitations, Legal provisions on EIA, EIA regulations in India	5
II	Stages of EIA, Types of EIA Methods of EIA, Check lists, Matrices, Networks, Cost-benefit analysis, EMP,.	9
III	Assessment of Impact on land, water, air, social economic, cultural and biological activities - Mathematical models- Public participation	9
IV	Environmental Audit & Environmental legislation objectives of Environmental Audit, Types of environmental Audit, Audit protocol, stages of Environmental Audit, onsite activities, evaluation of Audit data and preparation of Audit report, Post Audit activities.	9
V	Description of the Baseline Environment: Purposes for defining the Environmental Setting, Selection of parameters, Monitoring of physical environmental parameters, Collection and interpretation of baseline data for various environmental attributes.	9
VI	Case Studies: EIA for Chemical Industry	4
	Total Hours	45

Text Books

1. A Chadwick, *Introduction to Environmental Impact Assessment*, Taylor & Francis , 2007
2. Larry W. Canter, *Environmental Impact Assessment*, McGraw Hill Inc. Singapore , 1996
3. Canter, R.L., "Environmental Impact Assessment", McGraw Hill Inc., New Delhi, 1996.
4. Shukla, S.K. and Srivastava, P.R., "Concepts in Environmental Impact Analysis", Common Wealth Publishers, New Delhi, 1992.

Reference Books:

1. R.Therirvel, E. Wilson, S. Hompson, D. Heaney, D.Pritchard, *Strategic Environmental Assessment*, Earthscan, London , 1992
2. Paul, A Erickson, *A Practical Guide to Environmental Impact Assessment*, Academic Press , 1994
3. John G. Rau and David C Hooten "Environmental Impact Analysis Handbook", McGraw Hill Book Company, 1990.
4. Judith Petts, "Handbook of Environmental Impact Assessment Vol. I & II", Blackwell Science, 1999.

COURSE OUTCOMES	
The students will have the	
CO1	Ability to understand the concept of sustainable development and environmental impact assessment.

CO2	Ability to identify environmental attributes to be considered for the EIA study.
CO3	Ability to apply suitable methodology to prepare EIA and incorporate mitigation measures.
CO4	Ability to evaluate environmental impact assessment reports and assess the risks posing threats to the environment.
CO5	Ability to apply different methodologies to predict and assess the impacts of project on various aspects of environment.

Course Outcomes Mapping with Bloom's Taxonomy and Programme Outcomes

Course Outcome		**Skill**	**PO**	**Bloom's Taxonomy**	**Assessment Tools to measure CO**
CO1	Ability to understand the concept of sustainable development and environmental impact assessment.	Remember/ Understand	PO1, PO6, PO7	L1/L2	Exam/Assignment/ Seminar/Quiz
CO2	Ability to identify environmental attributes to be considered for the EIA study.	Understand	PO3, PO4, PO7	L3	Exam/Assignment/ Seminar/Quiz/Lab/ Project
CO3	Ability to apply suitable methodology to prepare EIA and incorporate mitigation measures.	Apply	PO2, PO3, PO4,	L4	Exam/Assignment/ Seminar/Quiz/Lab/ Project
CO4	Ability to evaluate environmental impact assessment reports and assess the risks posing threats to the environment.	Analyze	PO2, PO3, PO8,	L5	Mini Project/Assignment/Quiz/Lab/Exam
CO5	Ability to apply different methodologies to predict and assess the impacts of project on various aspects of environment.	Create	PO2, PO3, PO5, PO9	L5	Assignment/Exam/ Seminar

19UCH914	BIOPROCESS TECHNOLOGY	L	T	P	C
		3	0	0	3

COURSE OBJECTIVE

- To provide the students with the basics of bioprocess and bioreactor engineering.
- To develop bioengineering skills for the production of biochemical product using integrated biochemical processes.
- To impart knowledge on scale up of reactors and to develop bioreactor models

MODULE		TOPICS	L Hrs
I	A	**HISTORICAL DEVELOPMENT OF BIOPROCESS TECHNOLOGY** Bioprocess principles and operations, generalized process flow sheets. General material balance equation for steady state bioprocess operation, outline of a bioprocess and the various unit operations - upstream and downstream bioprocesses	9
II	A	**MEDIA DESIGN AND STERILIZATION** Media requirements for bioprocesses, medium formulation for optimal growth and product formation, design of various commercial media for industrial bioprocess, medium optimization methods, sterilization kinetics, design of batch and continuous thermal sterilization, sterilization of air and filter design, radiation and chemical sterilization	9
III	A	**BIOPROCESS STOICHIOMETRY** Stoichiometry of microbial growth and product formation, elemental balances, degree of reduction, yield coefficients for biomass and product formation, maintenance coefficient, energetic analysis, oxygen consumption and heat of evolution in aerobic culture, thermodynamic efficiency of growth	9
IV	A	**OPERATIONAL MODES OF BIOREACTOR** Choosing the cultivation method, modifying batch and continuous bioreactors, immobilized cell systems, solid-state fermentations and its applications, chemostat with recycle and fed batch culture, simple structured models, rheology of fermentation fluids, mass transfer in bioreactors	9
V	A	**BIOREACTOR SCALE UP** Overview of methods for online and offline monitoring of bioreactors, bioprocess control methodologies, various approaches to scale-up including regime analysis and scale-down, scale-up methods by constant P/V and k_La, analysis of alternate bioreactor configurations including cell-recycle, airlift and immobilized-cell bioreactors, problems on scale-up methods	9
		Total Hours	45

Text Books

1. Shuler, Michael L. and Fikret Kargi, Bioprocess Engineering , Prentice Hall, 1992.
2. Doran, Pauline of Bioprocess Engineering Principles . Elsevier, 1995

Reference Books

1. Anton Moser, Bioprocess Technology, Kinetics and Reactors, , Springer Verlag.
2. Bailey, James E. and David F. Ollis, Biochemical Engineering Fundamentals, IInd Edition. McGraw Hill , 1986.
3. Peter F. Stanbury, Stephen J. Hall and A. Whitaker, Principles of Fermentation Technology,

Science and Technology Books.

4. Harvey W. Blanch, Douglas S. Clark, Biochemical Engineering, Marcel Dekker, Inc.

COURSE OUTCOMES

The students have the ability to

CO1	Understand the basics of bioprocess principles and learn about bioreactor operations
CO2	Apply engineering principles to systems containing biological catalysts to meet the needs of the society
CO3	Analyze and select appropriate bioreactor configurations and operation modes based upon the nature of bioproducts
CO4	Investigate and select bioreactor equipment for various industrial applications
CO5	Design the bioprocess and scale up the bioreactor system
CO6	Conduct experiments using modern tools

Course Outcomes Mapping with Bloom's Taxonomy and Programme Outcomes

Course Outcome		Skill	PO	Bloom's Taxonomy	Assessment Tools to measure CO
CO1	Ability to understand the basics of bioprocess principles and learn about bioreactor operations	Remember/ Understand	-	L1/L2	Exam/Assignment/Seminar/Quiz
CO2	Ability to apply engineering principles to systems containing biological catalysts to meet the needs of the society	Apply	PO1	L3	Exam/Assignment/Seminar/Quiz/Lab/Project
CO3	Ability to analyze and select appropriate bioreactor configurations and operation modes based upon the nature of bioproducts	Analyze	PO2	L4	Exam/Assignment/Seminar/Quiz/Lab/Project
CO4	Ability to investigate and select bioreactor equipment for various industrial applications	Investigate	PO4	L5	Mini Project/Assignment/Quiz/Lab/Exam
CO5	Ability to design the bioprocess and scale up the bioreactor system	Design	PO3	L6	Assignment/Lab/Exam/Seminar
CO6	Ability to conduct experiments using modern tools.	Modern Tools	PO5	L3	Lab/Project

19UCH915 FERMENTATION TECHNOLOGY	L	T	P	C
AIM: The process of knowledge required for fermentation and the industrial applications and recent technological advances in fermentation technology.	**2**	**1**	**0**	**3**

MODULE		TOPICS	L Hrs
I	**A**	**INTRODUCTION TO FERMENTATION PROCESSES** Microbial biomass –Microbial Enzymes – Microbial metabolites – Recombinant products – Transformation Process –Microbial growth – Isolation and preservation and improvement of industrially important micro organism.	**9**
II	**A**	**INSTRUMENTATION AND CONTROL** Measurement of process variables – Temperature and its control – Flow measurement and control –Gases and Liquids – Pressure measurement and control –Cenline analysis –Control System –Combination of Control Systems– Computer application in termentation technology.	**9**
III	**A**	**RECOVERY AND PURIFICATION OF FERMENTATION PRODUCTS** Removal of Microbial cells – Foam Separation – Precipitation Filtration – Different Filtration process –Centifugation – Different centrifuge cell description– Different methods – Solvent recovery – Superfluid extraction – Chromatography – Membrane processes – Drying – Crystallization – Whole growth processing.	**9**
IV	**A**	**EFFLUENT TREATMENT** Strength of fermentation effluent – Treatment and disposal – Treatment Processes – Physical, chemical and biological –Aerobic process – Anareobic treatment.	**9**
V	**A**	**FERMENTATION ECONOMICS** Introduction – Isolation of micro organisms of industrial interest – Strain improvement – Market potential – Plant and equipment – Media – Air sterilization –Heating and cooling –Recovery costs.	**9**
		Total Hours	**45**

Text Books

1. Principles of fermentation Technology P.Stanbury Buttuworth Hanman – 1999.

2. Fermentation and Biochemical Engineering Handbook – C.C Haber. William Andrew II Edition 2007.

Reference Books

1. Bioprocess Engineering Hydersen B.K Nancy A.dela K.L.Nelsen Wiley Interscience,1994.

COURSE OUTCOMES

The students have the

CO1	Ability to the various reactors used in Industries.
CO2	Ability to apply the selection of media for microbial growth.
CO3	Ability to identify the strain improvement and preservation of cultures.
CO4	Ability to analyze the Upstream as well as processing involved in fermentation industries.
CO5	Ability to the downstream apply as well as processing involved in fermentation industries.
CO6	Ability to conduct experiments using modern tools.

Course Outcomes Mapping with Bloom's Taxonomy and Programme Outcomes

Course Outcome		Skill	PO	Bloom's Taxonomy	Assessment Tools to measure CO
CO1	Ability to the various reactors used in Industries.	Remember/Understand	-	L1/L2	Exam/Assignment/Seminar/Quiz
CO2	Ability to apply the selection of media for microbial growth.	Apply	PO 1	L3	Exam/Assignment/Seminar/Quiz/Lab/Project
CO3	Ability to identify the strain improvement and preservation of cultures.	Apply	PO 1	L3	Exam/Assignment/Seminar/Quiz/Lab/Project
CO4	Ability to analyze the Upstream as well as processing involved in fermentation industries.	Analyze	PO 2	L4	Mini Project/Assignment/Quiz/Lab/Exam
CO5	Ability to the downstream apply as well as processing involved in fermentation industries.	Apply	PO 1	L3	Assignment/Lab/Exam/Seminar
CO6	Ability to conduct experiments using modern tools.	Modern Tools	PO 5	L3	Lab/Project

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Write a note on Microbial metabolites?
2. Explain the principle of Microbial growth?
3. With a neat sketch, explain the types of Microbial biomass ?
4. Distinguish between Isolation and improvement of industrially important micro organism?

Course Outcome 2 (CO2):

1. Derive an method used for a selective media in microbiology.
2. Explain how will you find out the selective media can be used to identify microorganisms?
3. Find out the use of solid media contribute to the study of microorganisms.
4. Discuss in detail about the purpose of peptone in the media.

Course Outcome 3 (CO3):

1.Enumerate the methods of strain improvement?
2. Find out the methods used for preservation of microbial cultures.
3. Explain in detail about the technique is used to different methods of maintaining cultures.
4. Discuss in detail about the preserve fungal culture.

Course Outcome 4 (CO4):

1.Analyze the mean by upstream processing using fermentation products.
2.Identify the following is included in upstream processing?
3.How will you find out the process is also called product recovery?
4.Explain in detail about the upstream manufacturing using fermentation effluent.

Course Outcome 5 (CO5):

1.Expain in detail about the downstream processing in fermentation?
2.Discuss in detail about the major processes are involved in downstream processing?
3.Derive an bioprocessing processing involved in fermentation industries.
4.Discuss in detail about the material used in Isolation of micro organisms

19UCH916 PROCESS OPTIMIZATION	L	T	P	C
	3	0	0	3

AIM

To study various models to optimize chemical processes

OBJECTIVES

- To provide an overview of state-of-the-art optimization algorithms, the theoretical principles that underpin them, and to provide students with the modeling skills.
- To describe and formulate optimization problems and their use for solving several types of practically relevant optimization problems arising in process systems engineering.

MODULE	TOPICS	L Hrs
I	**FORMULATION OF OPTIMIZATION PROBLEMS** Mathematical concepts of optimization. Taylor expansion, Gradient, Hessian etc. Quadratic functions. Convex functions and sets. Gaussian elimination method.	6
II	**MODELS FOR OPTIMIZATION** Selection of function, degrees of freedom, factorial experimental design, constraints in model	5
III	**LINEAR AND NONLINEAR LEAST SQUARE PROBLEMS** One-dimensional search - Methods requiring derivatives (Newton-Raphson, Secant etc) Region elimination methods (Interval halving, Golden section) Polynomial approximations (quadratic & Cubic)	6
IV	**MULTIVARIABLE OPTIMIZATION-I** Unconstrained multivariable optimization - Graphical visualization (contour plots, 3D plots) - Gradient based methods (Steepest descent, conjugate direction, and Newton methods)	6
V	**MULTIVARIABLE OPTIMIZATION-II** Linear programming (LP) - Graphical solution - Simplex Method - Sensitivity analysis - Concept of duality - Introduction to interior-point method.	6
VI	**NONLINEAR PROGRAMMING** Nonlinear programming (NLP) with constraints - Lagrange multipliers - Graphical illustration of NLP problems - KKT necessary and sufficient conditions - Quadratic programming - Successive linear and quadratic programming. Integer and mixed integer programming. (IP and MIP) - Graphical solution - Branch and bound methods.	8
VII	**DYNAMIC PROGRAMMING** Dynamic programming - Minimum cost routing problems - Solution of separable nonlinear programming problems. Global optimization problems. - Introduction to multi objective optimization problems- Pareto optimal solutions (graphical illustration)	8
	Total Hours	**45**

Course Outcomes		Bloom's Level
CO1	Identify different types of optimization problems	Understand
CO2	Solve various multivariable optimization problems	Apply
CO3	Test different types of Hypotheses	Analyze
CO4	Solve problems by using least square analysis.	Apply
CO5	organize Correlation and Regression	create
CO6	Solve optimization using software tools.	Apply

Text Books

1. T. F. Edger, D. M. Himmelblau, and L. S. Lasdon, Optimization of chemical processes by McGraw-Hill, Second edition, 2015.

Reference Books

1. Singiresu S Rao, 'Engineering Optimization: Theory and Practice, 4th Edition, John Wiley & Sons Ltd., 2009

2. F. S. Hillier, and G. J. Lieberman, Introduction to operations research by McGraw-Hill, Seventh edition 2001.
3. Mohan C. Joshi and Kannan M. Moudgalya , 'Optimization: Theory and Practice', Alpha Science International Limited, 2004

19UCH917 QUALITY MANAGEMENT FOR CHEMICAL ENGINEERS	L	T	P	C
OBJECTIVES The course is aimed to When a quality management system is to ensure every time a process is performed, the same information, methods, skills and controls are used and applied in a consistent manner. If there are process issues or opportunities, this is then fed into the quality management system to ensure continuous improvement.	**2**	**1**	**0**	**3**

MODULE		TOPICS	L Hrs
I	**A**	**INTRODUCTION TO QUALITY MANAGEMENT** Definitions - TOM framework, benefits, awareness and obstacles – Quality - vision, mission and policy statements - Customer Focus - customer perception of quality, Translating needs into requirements, customer retention. Dimensions of product and service quality. Cost of quality	**9**
II	**A**	**PRINCIPLES AND PHILOSOPHIES OF QUALITY MANAGEMENT** Overview of the contributions - Strategic quality planning, Quality Councils – Employee involvement -Motivation, Empowerment, Team and Teamwork, Quality circles Recognition and Reward, Performance appraisal - Continuous process improvement - PDCA cycle, 5S, Kaizen - Supplier partnership - Partnering,Supplier selection, Supplier Rating.	**9**
III	**A**	**STATISTICAL PROCESS CONTROL AND PROCESS CAPABILITY** Meaning and significance of statistical process control (SPC) - construction of control charts for variables and attributed - Process capability - meaning, significance and measurement - Six sigma concepts of process capability - Reliability concepts - definitions, reliability in series and parallel, product life characteristics curve - Business process re-engineering (BPR) - principles, applications, reengineering process, benefits and limitations	**9**
IV	**A**	**TOOLS AND TECHNIQUES FOR QUALITY MANAGEMENT** Quality functions development (QFD) - Benefits, Voice of customer, information organization, House of quality (HOQ), building a HOQ, QFD process. Failure mode effect analysis (FMEA) - requirements of reliability, failure rate, FMEA stages, design, process and documentation.	**9**
V	**A**	**QUALITY SYSTEMS** Need for ISO 9000 - ISO 9001-2008 Quality System - Elements, Documentation, Quality Auditing - QS 9000 - ISO 14000 - Concepts, Requirements and Benefits - TQM Implementation in manufacturing and service.	**9**
		Total Hours	**45**

Text Books

1. Dale H. Besterfiled, et at., “Total quality Management”, Pearson Education Asia, Third Edition, Indian Reprint,(2006).

Reference Books

1. James R. Evans and William M. Lindsay, "The Management and Control of Quality", 8th Edition, First Indian Edition, Cengage Learning, 2012.
2.Suganthi.L and Anand Samuel, "Total Quality Management", Prentice Hall (India) Pvt. Ltd., 2006.
3.Janakiraman. B and Gopal .R.K., "Total Quality Management – Text and Cases", Prentice Hall (India) Pvt. Ltd., 2006.

COURSE OUTCOMES

The students have the

CO1	Ability to identify frameworks quality management for chemical engineers.
CO2	Ability to evaluate the evolution of quality management for chemical engineers.
CO3	Ability to ascertain and analyze identify the features of quality management for chemical engineer and philosophy.
CO4	Ability to choose and design derive tools for identity at a solving quality problem.
CO5	Ability to select & investigate the knowledge of quality management in their field of use.
CO6	Ability to conduct experiments using modern tools.

Course Outcomes Mapping with Bloom's Taxonomy and Programme Outcomes

Course Outcome		Skill	PO	Bloom's Taxonomy	Assessment Tools to measure CO
CO1	Ability to identify frameworks quality management for chemical engineers.	Remember/Understand	-	L1/L2	Exam/Assignment/Seminar/Quiz
CO2	Ability to evaluate the evolution of quality management for chemical engineers.	Evaluate	Po 4	L5	Exam/Assignment/Seminar/Quiz/Lab/ Project
CO3	Ability to ascertain and analyze identify the features of quality management for chemical engineer and philosophy.	Analyze	Po 2	L4	Exam/Assignment/Seminar/Quiz/Lab/ Project
CO4	Ability to choose and design derive tools for identity at a solving quality problem.	Design	Po 3	L6	Mini Project/Assignment/Quiz/Lab/Exam
CO5	Ability to select & investigate the knowledge of quality management in their field of use.	Investigate	Po 4	L5	Assignment/Lab/Exam/Seminar
CO6	Ability to conduct experiments using modern tools.	Modern Tools	Po 5	L3	Lab/Project

Course Level Assessment Questions

Course Outcome 1 (CO1):

5. Write a note on importance of Quality management & its importance.
6. Explain the principle of Four stages of quality management.
7. With a neat sketch,explain about the three levels of quality management.
8. Distinguish between the importance role of quality management.

Course Outcome 2 (CO2):

9. Evaluate the principles of quality evolution at management.
10. Derive an expression of Elements of Quality management.
11. Explain how will you find out the PDCA cycle.
12. Discuss in detail about the four stages of quality management.

Course Outcome 3 (CO3):

9. Analyze the construction of control charts for variables.
10. Find out the Six sigma concepts of process capability.
11. Illustrate the measure of significance of statistical process control.
12. Explain in detail about the principle of product life characteristics curve.

Course Outcome 4 (CO4):

9. Design a tools and techniques for quality improvement?
10. Elaborate a Principles of Quality functions development.
11. Discuss about the different types of Failure mode effect analysis.
12. With a neat sketch explain about the following quality tools to identify quality problem.

Course Outcome 5 (CO5):

5. Find out the Elements of quality systems.
6. How to obtain the Implementation of quality systems.
7. Explain in detail about the use of quality systems.
8. Discuss in detail about the Requirements of quality systems.

19UCH918	PILOT PLANT AND SCALEUP STUDIES	L	T	P	C
		3	0	0	3

Course Objectives:

To understand the importance of process equipment geometry and to provide concepts, methods and analysis to translate various chemical processes from laboratory scale to plant scale.

MODULE	TOPICS	L Hrs
I	**Fundamentals of Scale up and Dimensional Analysis:** Principles of Similarity, Pilot Plants and Models, Introduction to Scale-up Methods, Dimensional Analysis, Regime Concept, Similarity Criterion and Scale up Methods used in Chemical Engineering.	9
II	**Fluid-fluid Reactors:** Scale-up considerations in packed bed absorbers and bubble columns, Applicability of models to scale-up. Major scale-up issues, Prediction of performance in large equipment, Practical commercial experience, Problem areas.	9
III	**Mixing Processes:** Scale-up relationships, Scale-up of polymerization units, Continuous stages gas-liquid slurry processes, Liquid-liquid emulsions. Typical Problems in Scale-up of Heat Transfer Equipment.	9
IV	**Solid-Liquid Separation Processes**: Fundamental considerations, Small scale studies for equipment design and selection, Scale-up techniques, Uncertainties. **Continuous Mass Transfer Process**: Fundamental considerations scale-up procedure for distillation, Absorption, Stripping and extraction units.	9
V	**Reaction Vessels**: Scale-up Techniques available for Tubular Reactor, CSTR and Catalytic Reactors. Pseudo-homogeneous and heterogeneous models, Two-dimensional models, Scale up considerations.	9
	Total Hours	45

Text Books:

1. M. Zlokarnik, Scale-up in Chemical Engineering, Wiley-VCH (2006).
2. R.E. Johnstone and M.W. Thring, Pilot Plants, Models and Scale-up Methods in Chemical Engineering, McGraw-Hill (1957).

Reference Books:

1. C. Divall, and S. Johnston, Scaling up: the Institution of Chemical Engineers and the Rise of a New Profession, Springer (2000).
2. A. Bisio, and R.L. Kabel, Scale-up of Chemical Processes, John Wiley (1985).

COURSE OUTCOMES

The students have the

CO1	Ability to understand about the basic pilot plants, models, similarity and scale up methods
CO2	Ability to implement scaling up models for liquid and solid systems.
CO3	Ability to compare the methods and techniques of scaling for various unit operations
CO4	Ability to select suitable scaling technique for mixing operations.
CO5	Ability to develop a model to scale up fluid- fluid catalytic reactors.

Course Outcomes	**Skill**	**PO**	**Blooms**	**Assessing tools**
Ability to understand about the basic pilot plants, models, similarity and scale up methods	Remember/Understand	PO 11	L1/L2	Assignment/Exam/ Quiz/ Seminar
Ability to implement scaling up models for liquid and solid systems.	Apply	PO1	L3	Assignment/ Exam/ Project
Ability to compare the methods and techniques of scaling for various unit operations	Analyse	PO2, PO7, PO11	L4	Assignment/ Exam/ Quiz
Ability to select suitable scaling technique for mixing operations.	Investigation	PO2, PO4,	L5	Exam/ Quiz/Assignment/Seminar
Ability to develop a model to scale up fluid- fluid catalytic reactors.	Design	PO3,	L6	Model / Project

19UCH920 FLUIDIZATION TECHNOLOGY	L	T	P	C
	3	0	0	3

AIM

To study the fluidization phenomena, fluidized bed regimes and models.

OBJECTIVES

- To teach the concept of fluidization, application and characterization of fluidization and analyze the hydrodynamic aspects of fluidization process.

MODULE	TOPICS	L Hrs
I	**INTRODUCTION TO FLUIDIZATION** Concept of Fluidization - Special Features of Fluidization - Comparison with other Contacting Methods - Advantages and Disadvantages of Fluidized Beds - Industrial Applications of Fluidized Beds - Historical Highlights - Physical Operation - Chemical Operations.	7
II	**CHARACTERIZATION OF FLUIDIZATION I** Gross Behavior of Fluidized Beds – Minimum and Terminal Velocities in Fluidized Beds	6
III	**CHARACTERIZATION OF FLUIDIZATION II** Geldart Classifications of Particles – Mapping of Fluidization Regions – Design of Distributors – Power Consumption	6
IV	**BUBBLE MECHANICS IN FLUIDIZED BEDS** Bubbles in Dense Beds - Single Rising Bubble - Coalescence and Splitting of Bubbles – Bubble Formation above a Distributor. Bubbling Fluidized Beds - Experimental Findings - Estimation of Bed Properties - Bubbling Bed Model	7
V	**ENTRAINMENT AND ELUTRIATION** Free Board Behavior - Entertainment from Tall and Short Vessels. Constant Approach. Flow Pattern of Gases through Fluidized Beds - Solid Movement - Mixing, Segregation and Staging	6
VI	**HEAT TRANSFER IN FLUIDIZED BEDS** Heat Transfer between Fluid and Solid - Determination and Interpretation of Heat Transfer. Heat Transfer between Fluidized Beds and Surface - Experimental Findings and Theoretical Studies.	**8**
VII	**MISCELLANEOUS SYSTEMS** Conical fluidized bed, Inverse fluidized bed, Draft tube systems; Semi fluidized bed systems, Annular systems and typical applications.	**5**
	Total Hours	**45**

Course Outcomes		Bloom's Level
CO1	Explain the basics of fluidization	Understand
CO2	Identify the various industrial applications of fluidization.	Apply
CO3	Analyze the various fluidization regimes, classification of particles.	Analyze
CO4	Construct the K-L bubbling model.	create
CO5	Test the staging of fluidized beds, and calculation of the exchange coefficient.	Apply
CO6	Construct flow pattern of gases through fluidized bed	create

19UCH921	EXTRACTIVE METALLURGY	L	T	P	C
		3	0	0	3

COURSE OBJECTIVE:

Student will be in a position to ascertain the method of extraction of a particular metal and also understands the importance of recovery of byproducts during extraction

MODULE	TOPICS	L Hrs
I	**INTRODUCTION** Classification of ores, basics of pyrometallurgy, hydrometallurgy, electrometallurgy calcination, roasting, and type of roasting, thermodynamics of extraction, Ion exchange.	9
II	**UNIT PROCESSES IN PYRO METALLURGY:** Calcination and roasting, sintering, smelting, converting, reduction, smelting-reduction, Metallothermic and hydrogen reduction; distillation and other physical and chemical refining methods: Fire refining, Liquation and Cupellation. Small problems related to pyro metallurgy.	9
III	**UNIT PROCESSES IN HYDROMETALLURGY:** Leaching practice: In situ leaching, Dump and heap leaching, Percolation leaching, Agitation leaching, Purification of leach liquor, Kinetics of Leaching; Bioleaching: Precipitation and Cementation process. Recovery of Au from leach liquors, recovery of Nickel and Cobalt. Small problems relate to hydrometallurgy	9
IV	**UNIT PROCESS IN ELECTROMETALLURGY**: Faraday's Laws of Electrolysis, concept of overvoltage, limiting current density, total cell voltage, series and parallel electrical circuits in refining, aqueous and fused salt electrolysis, electro refining of common metals like Cu, Zn, Au, Ni, Al, Mg etc. Electroplating. Small related problems to Electrometallurgy	9
V	**PRODUCTION METHODS:** Simplified flow sheets for the extraction of Nickel, Magnesium, Tin, Gold, Silver, Uranium and Titanium. Non-ferrous metal industry in India.	9
	Total Hours	45

Text books:¬

1. Principles of Extractive Metallurgy, Terkel Rosenqvist, McGraw-Hill Book Company
2. Principles of Extractive Metallurgy, H. S. Ray and A. Ghosh, WEL Publishing

REFERENCES:

1. Extractive Metallurgy of Copper, W.G. Davenport, A.K. Biswas, PERGAMON publishing company
2. Handbook of Extractive Metallurgy: Fathi Habashi; Wiley-VCH New York, 1967.

COURSE OUTCOMES

The students have the ability to understand

CO1	Ability to understand and classify various techniques, unit process and operations used in

	metal extraction and refining.
CO2	Ability to apply the fundamental knowledge in design of an extraction methodology and process flow sheets.
CO3	Ability to differentiate the different types of metallurgical process..
CO4	Ability to select the correct process routes, extraction method and be able to optimize and control them.
CO5	Ability to develop computational and mathematical abilities to be applied for process design and control.

Course Outcomes	**Skill**	**PO**	**Blooms**	**Assessing tools**
Ability to understand and classify various techniques, unit process and operations used in metal extraction and refining.	Remember/Understand	PO6	L1/L2	Assignment/Exam/ Quiz/ Seminar
Ability to apply the fundamental knowledge in design of an extraction methodology and process flow sheets.	Apply	PO1, PO2, PO3	L3	Assignment/ Exam/ Quiz
Ability to differentiate the different types of metallurgical process.	Analyse	PO3	L4	Assignment/ Exam/ Quiz
Ability to to select the correct process routes, extraction method and be able to optimize and control them.	Investigation	PO2, PO4,	L5	Exam/ Quiz/Assignment/Seminar
Ability to develop computational and mathematical abilities to be applied for process design and control.	Design	PO5, PO9	L6	Assignment/Exam/Seminar/ Project

19UCH921 INSTRUMENTAL METHOD OF ANALYSIS			L	T	P	C
AIM This course provides basic knowledge on various analytical instruments and methods for accurate chemical analysis.			**2**	**1**	**0**	**3**
MODULE		**TOPICS**			**L Hrs**	
I	**A**	**UV SPECTROSCOPY AND NMR SPECTROSCOPY** Characteristics of electromagnetic radiations - Definition-wave length, wave number, frequency, energy. The absorption laws -Theory of electronic spectroscopy –Double beam spectrophotometer. Chromospheres - Auxochrome - Types of absorption bands – Absorption and intensity shifts - Applications. Theory - number of signals - Instrumentation – Chemical shift - Factors influencing chemical shift - Spin - Spin coupling - Applications.			**9**	
II	**A**	**IR SPECTROSCOPY AND MASS SPECTROSCOPY IR SPECTROS COPY** Theory - Vibrational frequency - Number of fundamental vibrations - Hook's law Scanning of IR spectrum– Applications.Basic principles - Theory - Instrumentation - Nitrogen rule - Molecular ion - McLafferty rearrangement – Applications.			**9**	
III	**A**	**SEPARATION METHODS** Principles of solvent extraction - Extraction techniques - Analytical applications. Principles of chromatography - Different types - Thin layer, column and gas chromatography. Radio chemical methods - Activation analysis - Isotopic dilution methods.			**9**	
IV	**A**	**THERMAL METHODS AND ELECTROCHEMICAL METHOD** Thermogravimetry - Factors influencing the thermogram - TGA instrument - Applications of TGA – DTA- Definition – Instrumentation. Thermal analysis of calcium oxalate monohydrate and calcium acetate monohydrate - Applications of DTA. FLUORIMETRIC METHOD - Fluorescence - Phosphorescence –Theory – Fluorimeter.			**9**	
V	**A**	**ELECTROCHEMICAL METHOD** Principles of polarography - Half wave potential - Factors affecting the limiting current –Applications of polarography.			**9**	
		Total Hours			**45**	

Text Books

1. Sharma B.K., Instrumental methods of chemical analysis, Eighteenth Edition, GOEL publishing House. 2002.

2.Ewing G.W., Instrumental methods of Chemical Analysis, Fifth Edition, McGraw Hill,New York, 1992.

3.Chatwal, Anand, Instrumental Methods of Chemical Analysis, Seventh Edition, Himalaya Publishing House. 2005.

4. Vogel's textbook of Quantitative Chemical Analysis, Fifth Edition. ELBS Publications, 2007.

Reference Books

1.Skoog D.A., - Pinciples of Instrumental Analysis, Sixth Edition, Saunders College Publication, 2007.

2.Williard H.H., Meritt L.C and Dean J.H., - Instrumental Methods of Analysis, Sixth Edition, 1990.

COURSE OUTCOMES

The students have the

CO1	Ability to identify the structure of the organic compound from the spectroscopic studies, no. of Hydrogen atoms and the position of hydrogen atoms in a molecule.
CO2	Ability to evaluate types of precipitants, their advantages and disadvantages; theories of precipitation; general rules for precipitation and types of crucibles.
CO3	Ability to analyze the thermal stability from TGA, exothermic & endothermic reactions of the sample from DTA. .
CO4	Ability to analyze the concentration of the solutes in a mixture using solvent extraction, chromatography methods and polarographic studies.
CO5	Ability to predict the nature of the organic compounds and the functional groups from the various spectroscopic techniques.
CO6	Ability to conduct experiments using modern tools.

Course Outcomes Mapping with Bloom's Taxonomy and Programme Outcomes

Course Outcome		Skill	PO	Bloom's Taxonomy	Assessment Tools to measure CO
CO1	Ability to identify the structure of the organic compound from the spectroscopic studies, no. of Hydrogen atoms and the position of hydrogen atoms in a molecule.	Remember/ Understand	-	L1/L2	Exam/Assignment/Seminar/Quiz
CO2	Ability to evaluate types of precipitants, their advantages and disadvantages; theories of precipitation; general rules for precipitation and types of crucibles.	Evaluate	PO4	L5	Exam/Assignment/Seminar/Quiz/Lab/Project
CO3	Ability to analyze the thermal stability from TGA, exothermic & endothermic reactions of the sample from DTA.	Analyze	PO2	L4	Exam/Assignment/Seminar/Quiz/Lab/Project
CO4	Ability to analyze the concentration of	Analyze	PO2	L4	Mini

	the solutes in a mixture using solvent extraction, chromatography methods and polarographic studies.				Project/Assignment/Quiz/Lab/Exam
CO5	Ability to predict the nature of the organic compounds and the functional groups from the various spectroscopic techniques.	Investigate	PO4	L5	Assignment/Lab/Exam/Seminar
CO6	Ability to conduct experiments using modern tools.	Modern Tools	PO5	L3	Lab/Project

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Write a note on spectroscopy used to determine the structure of an unknown compound.
2. Explain the principle of basic principle behind organic spectroscopy.
3. With a neat sketch, explain about the spectrometer.
4. Distinguish between the components of spectrometer.

Course Outcome 2 (CO2):

1. Evaluate the different types of gravimetric methods.
2. Derive an expression of Hook's law Scanning of IR spectrum.
3. Explain how will you find out the Vibrational frequency.
4. Discuss in detail about the Mass Spectroscopy.

Course Outcome 3 (CO3):

1. Analyze the Principles of chromatography.
2. Find out the thermal stability using Radio chemical methods.
3. Illustrate the measure thermal stability of Isotopic dilution methods.
4. Explain in detail about the Principles of solvent extraction.

Course Outcome 4 (CO4):

1. Elaborate in detail about the Factors influencing the thermogram.
2. How do you find out the concentration of a calibration curve.
3. With graphical representation find out the Factors influencing thermogram.
4. Analyze the description of Fluorescence and Phosphorescence.

Course Outcome 5 (CO5):

1. Identify the detector is used in polarographic method.
2. Find out the Factors affecting the limiting current.
3. Explain in detail about the Principles of polarography.
4. Discuss in detail about the polarographic analysis.

19UCH922	NANO TECHNOLOGY	L	T	P	C
		3	0	3	3

AIM

To provide an understanding of the various aspects of Waste to Energy.

OBJECTIVES

The objective of the course is to provide insights into waste management options by reducing the waste destined for disposal and encouraging the use of waste as a resource for alternate energy production

MODULE	TOPICS	L Hrs
I	**INTRODUCTION TO NANOMATERIALS** Properties of materials & nanomaterials, role of size in nanomaterials, nanoparticles, semiconducting nanoparticles, nanowires, nanoclusters, quantum wells, conductivity and enhanced catalytic activity compared to the same materials in the macroscopic state	9
II	**CONFINEMENT AND TRANSPORT IN NANOSTRUCTURE** Current, Reservoirs and Electron channels, Conductance formula for nanostructures, Quantized conductance. Local density of states. Ballistic transport, Coulomb blockade, Diffusive transport, Fock space.	9
III	**ELECTRONIC PROPERTIES:** Free electron theory of metals, Band theory of solids, Bloch theorem, Kroning-Penne model, Metals and Insulators, Semiconductors: Classification, Transport properties, Size and Dimensionality effects, Band structures, Brillouin zones, Mobility, Resistivity, Relaxation time, Recombination centers, Hall effects.	9
IV	**FABRICATION OF NANOMATERIALS BY PHYSICAL METHODS** Inert gas condensation, Arc discharge, Plasma arc technique, RF plasma, MW plasma, Ion sputtering, Laser ablation, Laser pyrolysis, Ball Milling, Molecular beam epitaxy, Chemical vapour deposition method and Electro deposition.	9
V	**NANOCOMPOSITES** An Introduction: Types of Nanocomposite (i.e. metal oxide, ceramic, glass and polymer based); Core-Shell structured nanocomposites Superhard Nanocomposite: Synthesis, applications and milestones	9
	Total Hours	**45**

Course Outcomes		Bloom's Level
CO1	Learn a broad foundational knowledge of the Concept of vector and scalar fields.	Remember/Understand
CO2	Apply the students the essential role of Nanoscience	Apply
CO3	Acquire an understanding the Nanoscience and Applications	Analyse
CO4	Evaluate the nanostructure materials.	Evaluate
CO5	Create the Nanoparticle based Drug Delivery.	Create

Text Books

1. Nanochemistry: A chemical approach to nanomaterials by G. A. Ozin, A. C. Aresnault, L. Cadematriri, RSC
Publishing
2. A Chemical Approach to Nanomaterials – Royal Society of Chemistry, Cambridge UK 2005...

Reference Books

1. Principles of Quantum Mechanics 2nd ed. - R. Shankar
2. Quantum wells, Wires & Dots,: Theoretical & Computational Physics of Semiconductors Nanostuructures,
Paul Harrison.

Course Outcomes	**Skill**	**PO**	**Blooms**	**Assessing tools**
Learn a broad foundational knowledge of the Concept of vector and scalar fields.	Remember/Understand	--	L1/L2	Assignment/Exam/ Quiz/ Seminar
Apply the students the essential role of Nanoscience	Apply	PO1	L3	Assignment/ Exam/ Quiz
Acquire an understanding the Nanoscience and Applications	Analyse	PO2	L4	Assignment/ Exam/ Quiz
Evaluate the nanostructure materials.	Evaluate	PO3	L5	Exam/ Quiz/ Assignment/Seminar
Create the Nanoparticle based Drug Delivery.	Create	PO4	L6	Assignment/Exam/ Seminar

19UCH924	MODERN SEPARATION PROCESS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVE:

To enable the students to learn the principle and technical concept of advanced separation processes.

MODULE	TOPICS	L Hrs
I	**Fundamentals of Separation process & Filtration** Review of conventional processes, Recent advances in separation techniques based on size and surface properties. Characteristics and Mechanism of Separation, Feasibility of Separation Processes. Theory and Selection of Equipment for Filtration Process - Cross Flow, Electro, Dual Functional Filters.	9
II	**Membrane process:** Theory of Membranes Process, Types and Choice of Membranes, Types and Relative Merits of Membrane Modules.	9
III	**Application of Membrane process:** Principle and Applications of Micro filtration, Ultra filtration, Nano Filtration and Reverse Osmosis; Dialysis and Electro Dialysis; Pervaporation, lyophilsation Ceramic- Hybrid process and Biological Membranes.	9
IV	**Other separation process:** Principle and Applications of Ion Exchange, Chromatography, Affinity Chromatography and Immuno Chromatography, Ion Exchange Chromatography and Eletrodialysis, Electrophoresis, Dielectrophoresis,	9
V	**Current Trends:** Principles and Applications of Supercritical Fluid Extraction, Zone melting, Reversible Chemical Complexation, Foam Separation, Thermal Diffusion, Cryoseperations.	9
	Total Hours	45

Text Books

1. Seader, J.D., Ernest J.Henley, Keith Roper D., ―Separation Process Principles, 3rd Edition, Wiley,. 2010
2. Kaushik Nath, Membrane separation processes, First Edition, Prentice Hall publishers, 2008.

Reference Books

1. Schoen H.M., ―New Chemical Engineering Separation Techniques‖, Interscience Publishers, 1972.
2. Coulson, J.M. and Richardson, J.F., "Chemical Engineering" Vol. I and II, 4th Edition, Asian Books Pvt. Ltd., India, 1998.
3. King, C. J., "Separation Processes", Tata McGraw Hill, 1982.

COURSE OUTCOMES

The students have the

CO1	Ability to classify the separation processes for new and innovative applications and the novel techniques of filtration
CO2	Ability to apply the latest concepts like super critical fluid extraction, per evaporation and

	lyophilisation in chemical process industries.
CO3	Ability to compare different membrane separation processes and its application in process industries
CO4	Ability to select the suitable separation technique for solid and liquid systems.
CO5	Ability to exhibit the skill to develop membrane process, adsorption techniques and inorganic separations.

Course Outcomes	**Skill**	**PO**	**Blooms**	**Assessing tools**
Ability to classify the separation processes for new and innovative applications and the novel techniques of filtration	Remember/Understand	PO 11	L1/L2	Assignment/Exam/ Quiz/ Seminar
Ability to apply the latest concepts like super critical fluid extraction, per evaporation and lyophilisation in chemical process industries.	Apply	PO1, PO5	L3	Assignment/ Exam/ Project
Ability to compare different membrane separation processes and its application in process industries	Analyse	PO7	L4	Assignment/ Exam/ Quiz
Ability to select the suitable separation technique for solid and liquid systems.	Investigation	PO2, PO3,	L5	Exam/ Quiz/Assignment/Seminar
Ability to exhibit the skill to develop membrane process, adsorption techniques and inorganic separations.	Design	PO6 PO9,	L6	Model / Project

19UCH924 NUCLEAR SCIENCE & TECHNOLOGY			L	T	P	C
OBJECTIVES The course is aimed to It will Promoting the exchange of ideas and research within the nuclear/atomic science community. Responding to global energy and environmental needs and objectives through the study of nuclear science, technology and resources.			**2**	**1**	**0**	**3**
MODULE		**TOPICS**			**L Hrs**	
I	**A**	**INTRODUCTION** basic properties of the nucleus and nuclear radiations.two nucleon problem, quadrupole & magnetic moments of deuteron, existence of non-central forces. deuteron bound state wave function & energy.			**9**	
II	**A**	**NUCLEAR FORCES** scattering cross-section, ortho & para hydrogen states,Nuclear forces, spin dependence, scattering, Existence of repulsive core inside a nucleon. Binding energy and nuclear stability.			**9**	
III	**A**	**NUCLEAR REACTIONS** Kinematics, Direct and Compound Nucleus Reactions, Energetic and general cross section behavior in nuclear reactions.			**9**	
IV	**A**	**RADIOACTIVE DECAYS** Fermi's theory of beta decay, determination of mass of neutrino, Radiation processing of food and allied products, applications of radio isotopes in Industry and Agriculture, Industrial radiotracer applications in Ground water exploration, Desalination.			**9**	
V	**A**	**NUCLEAR MODEL** Liquid drop Model, Nuclear Fission, Shell Model, Spin-Orbit interaction. Application of Shell Model.			**9**	
		Total Hours			**45**	

Text Books

1. Kenneth S. Krane, Introductory Nuclear Physics. Hoboken: John Wiley & Sons, Inc.
2. Walter E. Meyerhof, Elements of Nuclear Physics. New York: McGraw-Hill.
3. R.R. Roy & B.P. Nigam, Nuclear Physics.

Reference Books

1. Bernard L. Cohen, Concepts of Nuclear Physics. New York: McGraw-Hill.

COURSE OUTCOMES

The students have the

CO 1	Ability to identify basic nuclear properties and outline their theoretical descriptions.
CO 2	Ability to evaluate the different models of nuclear structure.
CO 3	Ability to ascertain and analyze explain the different nuclear reactions their cross sections.
CO 4	Ability to choose and design different decay processes then prominent decay chains.
CO 5	Ability to select & investigate Nuclear science then able to involve in active research.
CO 6	Ability to conduct experiments using modern tools.

Course Outcomes Mapping with Bloom's Taxonomy and Programme Outcomes

Course Outcome		Skill	PO	Bloom's Taxonomy	Assessment Tools to measure CO
CO1	Ability to identify basic nuclear properties and outline their theoretical descriptions.	Remember/Understand	-	L1/L2	Exam/Assignment/Seminar/Quiz
CO2	Ability to evaluate the different models of nuclear structure.	Evaluate	PO 4	L5	Exam/Assignment/Seminar/Quiz/Lab/Project
CO3	Ability to ascertain and analyze explain the different nuclear reactions their cross sections.	Analyze	PO 2	L4	Exam/Assignment/Seminar/Quiz/Lab/Project
CO4	Ability to choose and design different decay processes then prominent decay chains.	Design	PO 3	L6	Mini Project/Assignment/Quiz/Lab/Exam
CO5	Ability to select & investigate Nuclear science then able to involve in active research.	Investigate	PO 4	L5	Assignment/Lab/Exam/Seminar

CO6	Ability to conduct experiments using modern tools.	Modern Tools	PO 5	L3	Lab/Project

Course Level Assessment Questions

Course Outcome 1 (CO1):

9. Write a note on importance of basic properties of the nucleus and nuclear radiations.
10. Explain the principle of deuteron bound state wave function & energy.
11. With a neat sketch,explain about the types of nucleus.
12. Distinguish between the importance of two nucleon problem.

Course Outcome 2 (CO2):

13. Evaluate the Existence of repulsive core inside a nucleon.
14. Derive an expression of structure of nucleus.
15. Explain how will you find out the nuclear stability.
16. Discuss in detail about the Binding energy of nucleus.

Course Outcome 3 (CO3):

13. Analyze the Direct and Compound Nucleus Reactions.
14. Find out the different types of Nucleus Reactions.
15. Illustrate the measure of Kinematics energy of Nucleus Reactions.
16. Explain in detail about the principle of Energetic and general cross section behavior in nuclear reactions.

Course Outcome 4 (CO4):

13. Design a Radiation processing of food and allied products.
14. Elaborate a Principles at determination of mass of neutrino.
15. Discuss about the different types of Fermi's theory of beta decay,
16. With a neat sketch explain about the Industrial radiotracer applications in Ground water exploration.

Course Outcome 5 (CO5):

9. Find out the Spin-Orbit interaction.
10. How to obtain the Liquid drop Model.
11. Explain in detail about the nuclear model.
12. Discuss in detail about the Application of Shell Model.

19UCH925	ELECTROCHEMICAL ENGINEERING	L	T	P	C
		2	1	0	3

MODULE		TOPICS	L Hrs
I	A	Review basics of electrochemistry: Faraday's law - Nernst potential – Galvanic cells – Polarography, The electrical double layer: 94It's role in electrochemical processes –Electrocapillary curve – Helmoltz layer – Guoy –Steven's layer – fields at the interface.	9
II	A	Mass transfer in electrochemical systems: diffusion controlled electrochemical reaction – the importance of convention and the concept of limiting current. over potential, primary-secondary current distribution – rotating disc electrode.	9
III	A	Introduction to corrosion, series, corrosion theories derivation of potential-current relations of activities controlled and diffusion controlled corrosion process. Potential-pH diagram, Forms of corrosion- definition, factors and control methods of various forms of corrosion-corrosion control measures-industrial boiler water corrosion control – protective coatings –Vapor phase inhibitors – cathodic protection, sacrificial anodes – Paint removers.	9
IV	A	Electro deposition – electro refining – electroforming – electro polishing – anodizing – Selective solar coatings, Primary and secondary batteries – types of batteries, Fuel cells.	9
V	A	Electrodes used in different electrochemical industries: Metals-Graphite – Lead dioxide – Titanium substrate insoluble electrodes – Iron oxide – semi conducting type etc. Metal finishing-cell design. types of electrochemical reactors, batch cell, fluidized bed electrochemical reactor, filter press cell, Swiss roll cell, plug flow cell, design equation, figures of merits of different type of electrochemical reactors.	9
		Total Hours	**45**

Text Books

1. Picket, " Electrochemical Engineering ", Prentice Hall. 1977.
2. Newman, J. S., " Electrochemical systems ", Prentice Hall, 1973.

Reference Books

1. Barak, M. and Stevenge, U. K., " Electrochemical Power Sources - Primary and Secondary Batteries" 1980
2. Mantell, C.," Electrochemical Engineering ", McGraw Hill, 1972.R.Subramanian , "Professional Ethics ",Oxford University Press ,Reprint ,2015.

COURSE OUTCOMES

The students have the

CO1	Understanding on aspects of electrochemistry -

CO2	Understanding on the electrochemical kinetics,
CO3	Understanding on electrochemical reaction, concept of limiting current. Over potential
CO4	Understanding the causes of and the mechanisms of various types of corrosion,
CO5	Apply the concepts involved in electro process and design of batteries, fuel cell and electrochemical reactors
CO6	Understanding on the mechanism of corrosion.

Course Outcomes Mapping with Bloom's Taxonomy and Programme Outcomes

Course Outcome		Skill	PO	Bloom's Taxonomy	Assessment Tools to measure CO
CO1	Understanding on aspects of electrochemistry	Remember/ Understand	-	L1/L2	Exam/Assignment/Seminar/Quiz
CO2	Understanding on the electrochemical kinetics	Remember/ Understand	-	L1/L2	Exam/Assignment/Seminar/Quiz/Lab/Project
CO3	Understanding on electrochemical reaction, concept of limiting current. Over potential	Remember/ Understand	-	L1/L2	Exam/Assignment/Seminar/Quiz/Lab/Project
CO4	Understanding the causes of and the mechanisms of various types of corrosion	Remember/ Understand	-	L1/L2	Mini Project/Assignment/Quiz/Lab/Exam
CO5	Apply the concepts involved in electro process and design of batteries, fuel cell and electrochemical reactors	Apply	PO 2	L3	Assignment/Lab/Exam/Seminar
CO6	Understanding on the mechanism of corrosion.	Remember/ Understand		L1/L2	Assignment/Lab/Exam/Seminar

19UCH861 MATLAB FOR CHEMICAL ENGINEERING L T P C
0 0 2 1

OBJECTIVES

- To explain basics of numerical methods calculations involved in chemical process systems.
- To know in depth of mathematical modeling of a given physical or chemical systems with the simulation.

Course Contents

1. Basics of MATLAB,
2. Data Types in MATLAB
3. Random Numbers
4. Variables and Variable Names
5. Suppressing Output
6. Built-in Functions in MATLAB – Go through the Function list
7. Vectors and Arrays
8. Plotting in MATLAB 9. Loops in MATLAB
10. Data Transfer in MATLAB
11. Solution of System of Linear Algebraic Equations using MATLAB
12. Solution of Single Non-linear Algebraic Equation using MATLAB
13. Solving Single Ordinary Differential Equations (ODEs) in MATLAB
14. Solving Simultaneous ODEs in MATLAB
15. Solving Mixed Differential and Algebraic Equations in MATLAB
16. Development of Graphical User Interfaces (GUI) in MATLAB

TOTAL: 30 PERIODS

OUTCOMES

Upon completion of the course students will,

- Understand the importance and use mathematical modeling and numerical calculations in chemical or physical systems.
- Able to construct models using MATLAB simulation software.
- Understand and use methods for model simplification.

TEXT BOOK:

1. Mathematical modeling in Chemical Engineering by Anders Rasmuson, Bengt Andersson, Louise Olsson, Ronnie Andersson, Cambridge University Press 2014, New York.

REFERENCE BOOK:

1. Numerical Methods Applied to Chemical Engineering by Frederick bernardin, MIT Open CourseWare, Fall 2006.

19UCH862 SIMULATION ON PROCESS FUNDAMENTALS L T P C

0 0 2 1

Course Objective:

This course is designed to provide knowledge on Industrial operations and training in the operation of major equipment deployed in process industry. It includes classroom instructions, as well as hands-on training with a PC based, full scope Simulator. The classroom instructions cover all major unit operations and their controls. Simulator training includes startup from cold condition to full load, load maneuvering, and shutdown from full load to cold condition, major malfunctions, and efficient operations of various equipment.

List of Experiments

1) Introduction to process control, Control objectives and benefits, Distributed control and DCS operation, Hands-on training on Simulator.

2) Automatic Control Systems (PID Control, On-Off, Flow, Level, Pressure, Temperature Controls), Advanced Control Systems (Cascade, Split Range and Feed Forward & Feed Back Controls and 3-element boiler level control)
3) Hands-on training on Simulator

4) Heat exchangers - Heat transfer calculation, Exercise on simulator

5) Pumps - Flow in a pump, head, characteristic curve, NPSH, Exercise on simulator

6) Compressor - Gas compression, discharge temperature, power, Performance, characteristic, Surge curve, Exercise on simulator

7) Distillation - Principles of distillation , Configuration of distillation column, Operating parameters, Dynamics, Malfunctions, Distillation startup

8) Furnace operation - Combustion principle , Operating parameters , Dynamics, Exercise on simulator, Start-up , Shutdown

9) Boiler - Operating parameters , Dynamics , Exercise on simulator , Start-up

10) Reactors - CSTR, PFR & Fixed bed reactor - Theory , Exercise on simulator, Start-up , Shutdown

TOTAL: 30 PERIODS

OUTCOMES:

After completion of the course students will able to

Understand the fundamental knowledge on process control and instrumentation, operations of major unit operations in a process plant.

Understand the trouble shooting, emergency handling, startup and shutdown operations of the unit operations.

19UCH863 SUGARCANE PROCESSING AND ITS PRODUCTS L T P C
2 0 0 1

AIM:

- To attain a broad comprehension of sugarcane processing and its products

OBJECTIVES:

- To explain various sources of sugar.
- To know in depth of its principles, types, methods of production, protection of environment, environmental impact of the unit.

UNIT I **8**

Introduction, classification of sugar, composition of raw materials; Different types of raw materials used, various methods are available for manufacturing of sugar; Details of the process, advantages and disadvantages of the various processes used; Equipments and machineries are used in the process.

UNIT II **7**

Quality of sugar, Sugar analysis, Refining, crystallization, packing, storing, shipping, Sugar derivatives, starch, uses of sugar, by products from sugar processing, solis, water and air pollution control applicable in the process, Quality of product

TOTAL: 15 PERIODS

OUTCOMES:

After the completion of course,

- Students are able to understand the various process of sugar manufacturing operations in details.
- Students are able to understand in depth of its principles, types, methods of production, protection of environment, environmental impact of the Sugar processing unit.

TEXT BOOKS:

1. Chemical Process Indusries by R.N. Shreve and T. Austin, McGraw Hill Book company, 5th Edition, Singapore.
2. Outline of Chemical Technology by C.E. Dryden, Affiliated East West press, New Delhi,

REFERENCE BOOKS:

1. Encyclopedia of Chemical Technology by Kirk & Othmer, Wiley & Sons, New York.
2. Hand Book of Sugar Manufacture by Newis Lanrence. N.J., Oxford University Press.

19UCH864 DRY CEMENTS MANUFACTURING PROCESS L T P C
2 0 0 1

AIM:

- To attain a broad comprehension of cement manufacturing processing and its products.

OBJECTIVES:

- To explain various sources of cement
- To know in depth of its principles, types, methods of production, protection of environment, environmental impact of the cement manufacturing unit.

UNIT I **7**

Introduction, Classification of cements, compositions of raw materials, various methods for manufacturing of cement, advantages and disadvantages of the various processes used; different types of raw materials used; Equipments and machineries are used in the process; solids and air pollution control applications in the process.

UNIT II **9**

Clinker chemistry, clinker formation, raw materials proportions, Hydration, cement paste structure and concrete properties, unit operations, chemical conversions, energy requirements, compounds in cements, setting and hardening of cement, special cements, Quality of cement, Cement Analysis, packing, storing, shipping, by products from cement processing, water, land and air pollution control applicable in the process, Quality of the product.

TOTAL: 15 PERIODS

OUTCOMES:

After the completion of the course,

- Students are able to understand the various process of cement manufacturing operations in details.
- Students are able to understand of its principles, types, methods of production, protection of environment, environmental impact of the cement manufacturing unit

TEXT BOOKS:

1. Chemical Process Indusries by R.N. Shreve and T. Austin, McGraw Hill Book company, 5th Edition, Singapore.
2. Outline of Chemical Technology by C.E. Dryden, Affiliated East West press, New Delhi,

REFERENCE BOOKS:

1. Encyclopedia of Chemical Technology by Kirk & Othmer, Wiley & Sons, New York.
2. Hand Book of Cement Manufacture by Alexander. K. I. Tata McGraw Hill Publishing Company.

19UCH865 RECLAMATION OF WASTE LUBRICATING OILS AND ITS PRODUCTS

L T P C
2 0 0 1

AIM:

- To attain a broad comprehension of Reclamation of Waste Lubricating Oils and its products.

OBJECTIVES:

- To explain basics of reclamation process systems.
- To know in depth of its types, process and design of reclamation of waste lubricating oils.

UNIT I **9**

Introduction to engine oil grade and uses, analysis of oils, physico chemical properties of oils, carbon residue in oil and viscosity characteristics. Basic analysis parameters like acid number, iodine number, base number, etc., Sludge analysis and analysis of waste engine oils, use of chemicals for reclamation.

UNIT II **6**

Various methods for reclamation waste lube oils process, economics of the process and its products

TOTAL: 15 PERIODS

OUTCOMES:

- Understand the basics of reclamation processes
- Understand in depth of its types and design of various pyrotechnics products and its composition.

REFERENCE BOOK:

1. Hand book of Waste Oil Reclamation by Walter Wanes. D.J.M.M, McGraw Hill Publishing co., Singapore.

19UCH866 POLLUTION CONTROL ENGINEERING L T P C
2 0 0 1

AIM:

- To attain a broad comprehension of pollution control engineering to the environment

OBJECTIVES:

To enable students to learn about Air, Water pollution, effects of air, water pollution, Global effects, Sampling of pollutants, Meteorology and air and water pollution, Atmospheric stability, Plume rise and dispersion and Prediction of air and water quality

UNIT I INTRODUCTION, PROCESS ANALYSIS AND SELECTION 8

Air pollution regulatory framework history – Regulatory system – Laws and Regulations – Clean air act – Provisions for recent developments.

Terminology, regulations, health and environment concerns in waste management, constituents, Components of flue gases and waste water flows – Analysis of data – Reactors used in waste water and flue gases treatment – Mass Balance Analysis – Process Selection.

UNIT II POLLUTION PREVENTION 7

Mass exchange network synthesis for pollution control and minimization implications of environmental constraints for process design, policies for regulation of environmental impacts.

Concepts of common effluent treatment; Environmental Legislations, Role of Government and Industries.

TOTAL: 15 PERIODS

OUTCOMES:

Upon completion of the course,

- Students would have knowledge on physical/chemical/biological characteristics and the evaluation technique for pollutants

TEXTBOOKS:

1. Air Pollution Control Equipment by Louis Theodore, Burley intuscence 2008.
2. Air Pollution Control by C.D. Cooper and F.C. Alley Wairland Press III Edition 2002.
3. Industrial Waste Water Management Treatment and Disposal of Waste water, McGraw Hill III edition, 2008.

REFERENCE BOOK:

1. Kirk and Othmer, Chemical Technology Hand Books, IV Edn, (1994)

19UCH867 ENZYMES FOR ENVIRONMENTAL APPLICATIONS L T P C
2 0 0 1

AIM:

- To attain a broad comprehension of Enzymes used in environmental applications

OBJECTIVES:

- To explain basics of enzymes for environmental applications
- To know in depth of its principles, treatment methods for various types of waste water effluents

UNIT I **7**

Nature, Enzyme: Characteristics, Substrate Binding, Reactors, Immobilization, Sensors: Types of Pollutants, Quality Product After Treatment, Treating, Aromatic Pollutants

UNIT II **8**

Treating methods for pesticide residues, heavy metals, solid wastes, surfactants in effluents, food process industry wastes, water treatment

TOTAL: 15 PERIODS

OUTCOMES:

- Understand the various types of enzymes for environmental applications process
- Understand in knowledge for application of enzymes in industrial waste water effluents.

REFERENCE BOOKS:

1. Enzyme Immobilization: Advances in Industry, Agriculture, Medicine and the Environment by Alka Dwevedi, Springer International Publishing, Switzerland 2016.s
2. Enzymes in the Environment: Activity, Ecology, and Applications by Richard G. Burns, Richard P. Dick, CRC Press, 2002, Marcel Dekker, Inc., New York, Basel.

19UCH868 RECLAMATION OF PRESS MUD WAX L T P C
2 0 0 1

AIM:

- To attain a broad comprehension of reclamation processes for press mud wax

OBJECTIVES:

- To explain basics of reclamation process press mud wax
- To know in depth of its types, process and design of reclamation of press mud wax

UNIT I **9**

Introduction to press mud wax and uses, analysis of press mud, physic chemical properties of press mud, characteristics of press mud. Basic analysis parameters, sludge analysis and analysis of press mud, use of chemicals for reclamation, processing of press mud.

UNIT II **6**

Various methods for reclamation press mud wax process, economics of the process and its products

TOTAL: 15 PERIODS

OUTCOMES:

- Understand the basics of reclamation processes of press mud
- Understand in depth of its types and design of various methods and products and its composition of press mud

REFERENCE BOOK:

1. Hand Book of press mud reclamation by John. Fridrick. J.L., Koes Hudny. I. L., McGraw Hill Publishing Co.

19UCH869 SENSORS FOR AIR POLLUTION L T P C
2 0 0 1

AIM:

- To attain the basics of Air Pollution Sensors

OBJECTIVES:

- To explain basics of Air Pollution Control Sensor Systems
- To know in depth of its principles, types, materials, process and design of water purification
- To enable the students to learn about sensors for air pollution effects, sampling of pollutants, plume rise and dispersion and prediction of air quality

UNIT I **7**

Introduction, quality of air, effect of air pollutants, types of air sensors, Sensors for air pollution, basics of quality of air, types of air sensors

UNIT II **8**

Description of personal exposure monitoring, types of pollutants to characterize sensors, environmental condition for air pollution and health implications, parameters used to design sensors, economics in the design

TOTAL: 15 PERIODS

OUTCOMES:

Upon completion of the course the students,

- Would have the knowledge of ambient sensors for air pollution, its sources and design
- Able to understand the basics of air pollution sensors
- Able to understand in depth of air pollution, effect of air pollution, characteristics and monitoring and design of sensors for air pollution.

TEXT BOOKS:

1. Air Pollution Control Equipment by Louis Theodore, Burley intuscence 2008.
2. Air Pollution Control by C.D. Cooper and F.C. Alley Wairland Press III Edition 2002.
3. Air pollution control engineering by Noel de Nevey – McGraw Hill, co.
4. Air pollution controlengineering by de Nevey, N., – McGraw Hill, Inc., 2000
5. Air pollution control : A design approach by Cooper, C.D. and Alley, F.C. Waveland Press, 2002.

REFERENCE BOOKS:

1. Chemical Technology Hand Book by Kirk and Othmer, IV edn 1994
2. Fundamentals of air pollution by Vallero, A., Daniel A., (Electronic resources) Amsterdam.

19UCH870 WASTE RECYCLING FROM PULP AND TEXTILE MILLS L T P C
2 0 0 1

AIM:

- To attain a broad comprehension of water recycling from pulp and textile mills systems

OBJECTIVES:

- To explain various water recycling from pulp and textile mills systems
- To know in depth of its principles, various methods of processing of waste water from Pulp and Textile mills

UNIT I **9**

Characterization of waste water from pulp and textile mills, composition of waste water, various treatment methods of waste water, products and by products, quality of water, sludge disposal, Evaluation, classifications and characterization of waste water, Treatment types o waste water: Preliminary, Primary, Secondary and Tertiary methods, Advantages and Disadvantages of the methods

UNIT II **6**

Theory and practice of aeration in waste water treatment, Sludge treatment: Sludge disposal, activated sludge process, other methods and products and by products.

TOTAL: 15 PERIODS

OUTCOMES:

After completion of the course, Students are

- Able to understand the various water recycling from pulp and textile mills mehods
- Able to understand in depth of its principles, various methods of processing of waste water from pulp and textile mills.

TEXTBOOKS:

1. Introduction to waste water treatment processes by R.S. Ramlho, Academic press, New York.
2. Chemical Process Industries by R.N. Shreves and T. Austin, McGraw Hill Book Company, 5th Edition, Singapore.
3. Outline of Chemical Technology by C.E. Dryden, Affiliated East West Press, New Delhi

REFERENCE BOOKS:

1. Encyclopedia of Chemical Technology by Kirk and Othmer, Wiley & Sons, New York.
2. Industrial Pollution Control Hand Book by Lund J.E., McGraw Hill Publishers 1971.
3. American Public Health Association Inc., Standard methods for the examination of water & Waste Water- New York.

19UCH871 MEMBRANE TECHNOLOGY L T P C
2 0 0 1

AIM:

- To attain a broad comprehension of Membrane technology for water purification process.

OBJECTIVES:

- To explain basics of membrane technology process systems
- To know in depth of its principles, types, materials, process and design of Membranes for water purification

UNIT I **5**

Introduction, principles, theory -Membrane transport theory, membranes and modules, various types

UNIT II **10**

Advanced processes, membrane reactors and application Reverse Osmosis, Ultra filtration and micro filtration, gas serration and per evaporation, ion exchange membranes, advance dialysis.

TOTAL: 15 PERIODS

OUTCOMES:

- Understand the basics of membrane technology
- Understand in depth of its types, principles, materials used, advanced methods, applications of membrane technology.

TEXTBOOKS:

1. Marcel Mulder, Basic Principles of Membrane Technology, Kluwer Academic Publications.
2. Coulson and Richardson's Chemical Engineering , Volume 2, Elesvier.
3. S.P. Nunes and K.V. peinemann, Membrane Technology in the Chemical industry, Wiley – VCH.
4. R. Rautanbach and R. Albrecht, Membrane Process, John Wiley & Sons.

REFERENCE BOOKS:

1. R.Y.M. Huang, Perevaporation Membrane Separation Processes, Elsevier.
2. J.G. Crespo, K.W. Boddekes, Membrane Processes in Separation and Purification, Kluwer Academic Publications
3. Larry Ricci and the staff of Chemical Engineering Separation Techniques, McGraw Hill Publications
4. Richard W. Baker, Membrane technology and Applications, John Wiley & Sons, Ltd.

19UCH872 PYROTECHNICS L T P C
2 0 0 1

AIM:

- To attain a broad comprehension of Pyrotechnology systems used for various applications.

OBJECTIVES:

- To explain basics of pyrotechnology systems
- To know in depth of its types and design of pyrotechnics systems

UNIT I **7**

Classification of energetic materials and its compositions, basic chemistry, uses of ire, how to control fire, Environmental effects and concerns

UNIT II **8**

Pyrotechnic oxidizers, fuels, binders, other ingredients, important properties, ignition and propagation of reaction; characterization of pyrotechnics, pyrotechnics applications: heat generation, color/light generation, smoke generation, sound generation.

TOTAL: 15 PERIODS

OUTCOMES:

- Understand the basics of pyrotechnics
- Understand in depth of its types and design of various pyrotechnics products and its composition.

REFERENCE BOOKS:

1. Hand Book of Pyrotechnics by john Wales. F.R., McGraw Hill Publishing Co., Singapore.
2. Pyrotechnics by George Weingart, 2 Edm, 1992, Oxford University Press.
3. Principles of Pyrotechnics by A.A. Shidlovskiy: ISBN-13:978-0929931135.