ANNAMALAI VERSITY

(Accredited With'A' Grade by NAAC)

Faculty of Engineering and Technology
Department of Chemical Engineering

M.E., Chemical Engineering
(Choice Based CreditSystem)

HAND BOOK
REGULATIONS AND SYLLABUS
REGULATIONS 2023

ANNAMALAI UNIVERSITY

FACULTY OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF CHEMICAL ENGINEERING

M.E. / M. Tech (Two-Year Full Time& Three-year Part Time) DEGREE PROGRAMME (CBCS)

REGULATIONS -2023

1. Conditions for Admission

Candidates for admission to the first year of the four-semester **M.E / M.Tech Degree programme in Engineering** shall be required to have passed B.E / B.Tech degree of Annamalai University or any other authority accepted by the syndicate of this University as equivalent thereto. They shall satisfy the conditions regarding qualifying marks and physical fitness as may be prescribed by the Syndicate of the Annamalai University from time to time. The admission for M.E Part Time programme is restricted to those working or residing within a radius of **90 km** from Annamalainagar. The application should be sent through their employers.

2. Branches of Study in M.E /M.Tech

The Branch and Eligibility criteria of programmes are given in Annexure I

3. Courses of study

The courses of study along with the respective syllabi and the scheme of Examinations for each of the M.E / M. Tech programmes offered by the different Departments of study in the Faculty of Engineering and Technology are given separately.

4. Choice Based Credit System(CBCS)

The curriculum includes three components namely Program Core, Program Electives and Open Electives, Mandatory Learning Courses and Audit Courses in addition to Thesis. Each semester curriculum shall normally have a blend of theory and practical courses.

5. Assignment of Credits for Courses

Each course is normally assigned one credit per hour of lecture / tutorial per week and0.5 credit for one hour of laboratory or project or industrial training or seminar per week. The total credits for the programme will be **68**.

6. Duration of the programme

A student of M.E / M.Tech programme is normally expected to complete in four semesters for full-time / six semesters for part-time but in any case not more than four years for full-time / six years for part-time from the date of admission.

7. Registration for courses

A newly admitted student will automatically be registered for all the courses prescribed for the first semester, without any option. Every other student shall submit a completed registration form indicating the list of courses intended to be credited during the next semester. This registration will be done a week before the last working day of the current semester. Late registration with the approval of the Dean on the recommendation of the Head of the Department along with a late fee will be done up to the last working day. Registration for the Thesis Phase - I and Phase-II shall be done at the appropriate semesters.

8. Electives

8.1 Program Electives

The student has to select two electives in first semester, another two electives in the second semester and one more in the third semester from the list of Program Electives.

8.2 Open Electives

The student has to select two electives in third semester from the list of Open Electives offered by the Department and / or other departments in the Faculty of Engineering andTechnology.

8.3 MOOC (SWAYAM)Courses

Further, the student can be permitted to earn credits by studying the Massive Open Online Courses offered through the SWAYAM Portal of UGC with the approval of the Head of the Department concerned. These courses will be considered as equivalent to open elective courses. Thus the credit earned through MOOC courses can be transferred and considered for awarding Degree to the student concerned.

8.4 Value added courses (Inter Faculty Electives)

Of the two open elective courses, a student must study one value added course that is offered by other Faculties in our University either in second or third semester of the M.E programme.

9. Industrial Project

A student may be allowed to take up the one program elective and two open elective courses of third semester (Full Time program) in the first and second semester, to enable him/her to carry out Project Phase-I and Phase-II in an industry during then tire second year of study. The condition is that the student must register those courses in the first semester itself. Such students should meet the teachers offering those elective courses themselves for clarifications. No specific slots will be allotted in the time table for such courses.

10. Assessment

10.1 Theory Courses

The break-up of continuous assessment and examination marks for theory courses is as follows:

First assessment (Mid-Semester Test-I) : 10 marks Second assessment (Mid-Semester Test-II): 10 marks Third Assessment : 5marks

End SemesterExamination : 75marks

10.2 Practical Courses

The break-up of continuous assessment and examination marks for Practical courses is as follows:

First assessment(Test-I)	:	15marks
Second assessment(Test-II)	:	15marks
Maintenance of recordbook	:	10marks
End SemesterExamination	:	60marks

10.3 Thesis work

The thesis Phase I will be assessed for 40 marks by a committee consisting of the Head of the Department, the guide and a minimum of two members nominated by the Head of the Department. The Head of the Department will be the chairman. The number of reviews must be a minimum of three per semester. 60 marks are allotted for the thesis work and viva voce examination at the end of the third semester. The same procedure will be adopted for thesis Phase II in the fourth semester.

10.4 Seminar / Industrial Training

The continuous assessment marks for the seminar / industrial training will be 40 and to be assessed by a seminar committee consisting of the Seminar Coordinator and a minimum of two members nominated by the Head of the Department. The continuous assessment marks will be awarded at the end of the seminar session. 60 marks are allotted for the seminar / industrial training and viva voce examination conducted based on the seminar / industrial training report at the end of the semester.

11. Student Counselors(Mentors)

To help the students in planning their course of study and for general advice on the academic programme, the Head of the Department will attach a certain number of students to a member of the faculty who shall function as student counselor (mentor) for those students throughout their period of study. Such student counselors shall advise the students in selecting open elective courses from, give preliminary approval for the courses to be taken by the students during each semester, and obtain the final approval of the Head of the Department monitor their progress in SWAYAM courses / open elective courses.

12. Class Committee

For each of the semesters of M.E / M.Tech programmes, separate class committees will be constituted by the respective Head of the Departments. The composition of the class committees from first to fourth semesters for Full time and first to sixth semesters for Part-time will be as follows:

- Teachers of the individual courses.
- A Thesis coordinator (for Thesis Phase I and II) shall be appointed by the Head of the Department from among the Thesis supervisors.
- A thesis review committee chairman shall be appointed by the Head of the Department
- One Professor or Associate Professor, preferably not teaching the concerned class, appointed as Chairman by the Head of the Department.
- The Head of the Department may opt to be a member or the Chairman.
- All counselors of the class and the Head of the Department (if not already a member) or any staff member nominated by the Head of the Department may opt to be special invitees.

The class committee shall meet three times during the semester. The first meeting will be held within two weeks from the date of class commencement in which the type of assessment like test, assignment etc. for the third assessment and the dates of completion of the assessments will be decided.

The second meeting will be held within a week after the completion of the first assessment to review the performance and for follow-up action.

The third meeting will be held after all the assessments but before the University semester examinations are completed for all the courses, and at least one-week before the commencement of the examinations. During this meeting the assessment on a maximum of 25 marks for theory courses / 40 marks for practical courses, for Industrial Training and for Thesis work (Phase-I and Phase-II) will be finalized for every student and tabulated and submitted to the Head of the Department for approval and transmission to the Controller of Examinations.

13. Temporary Break Of Study

A student can take a one-time temporary break of study covering the current semester and / or the next semester with the approval of the Dean on the recommendation of the Head of the Department, not later than seven days after the completion of the mid- semester test. However, the student must complete the entire programme within the maximum period of **four years for Full time / six years for Part-time.**

14. Substitute Assessments

A student who has missed, for genuine reasons accepted by the Head of the Department, one or more of the assessments of a course other than the end of semester examination may take a substitute assessment for any one of the missed assessments. The substitute assessment must be completed before the date of the third meeting of the respective class committees.

A student who wishes to have a substitute assessment for a missed assessment must apply to the Head of the Department within a week from the date of the missed assessment.

15. Attendance Requirements

The students with 75% attendance and above are permitted to appear for the University examinations. However, the Vice Chancellor may give a rebate / concession not exceeding 10% in attendance for exceptional cases only on Medical Grounds.

A student who withdraws from or does not meet the minimum attendance requirement in a semester must re-register and repeat the same semester in the subsequent academic years.

16. Passing and declaration of Examination Results

All assessments of all the courses on an absolute marks basis will be considered and passed by the respective results passing boards in accordance with the rules of the University. Thereafter, the controller of examinations shall convert the marks for each course to the corresponding letter grade as follows, compute the grade point average (GPA) and cumulative grade point average (CGPA) and prepare the mark sheets.

90 to 100 marks	Grade ‘S’
80 to 89 marks	Grade ‘A’
70 to 79 marks	Grade ‘B’
60 to 69 marks	Grade ‘C’
55 to 59 marks	Grade ‘D’
50 to 54 marks	Grade ‘E’
Less than 50 marks	Grade ‘RA’
Withdrawn from the Examination	Grade ‘W’

A student who obtains less than 30 / 24 marks out of 75 / 60 in the theory / practical examinations respectively or is absent for the examination will be awarded grade RA.

A student who earns a grade of S, A, B, C, D or E for a course is declared to have successfully completed that course and earned the credits for that course. Such a course cannot be repeated by the student.

A student who obtains letter grade RA / W in the mark sheet must reappear for the examination of the courses.

The following grade points are associated with each letter grade for calculating the grade point average and cumulative grade point average.

S - 10; A - 9; B - 8; C - 7; D - 6; E - 5; RA - 0

Courses with grade RA / W are not considered for calculation of grade point average or cumulative grade point average.

A student can apply for re-totaling of one or more of his examination answer papers within a week from the date of issue of mark sheet to the student on payment of the prescribed fee per paper. The application must be made to the Controller of Examinations with the recommendation of the Head of the Department.

After the results are declared, mark sheets will be issued to the students. The mark sheet will contain the list of courses registered during the semester, the grades scored and the grade point average for the semester.

GPA is the sum of the products of the number of credits of a course with the grade point scored in that course, taken over all the courses for the semester, divided by the sum of the number of credits for all courses taken in that semester.

CGPA is similarly calculated considering all the courses taken from the time of admission.

17. Awarding Degree

After successful completion of the programme, the degree will be awarded with the following classifications based on CGPA.

For First Class with Distinction the student must earn a minimum of 68 credits within four semesters for full-time / six semesters for Part time from the time of admission, pass all the courses in the first attempt and obtain a CGPA of 8.25 or above.

For First Class, the student must earn a minimum of 68 credits within two years and six months for full-time / three years and six months for Part time from the time of admission and obtain a CGPA of 6.75 or above.

For Second class, the student must earn a minimum of 68 credits within four years for full-time / six years for Part time from the time of admission.

18. Ranking of Candidates

The candidates who are eligible to get the M.E /M.Tech degree in First Class with Distinction will be ranked on the basis of CGPA for all the courses of study from I to IV semester for M.E / M.Tech full-time / I to VI semester for M.E / M.Tech part-time.

The candidates passing with First Class and without failing in any subject from the time of admission will be ranked next to those with distinction on the basis of CGPA for all the courses of study from I to IV semester for full-time / I to VI semester for M.E / M.Tech part-time.

19. Transitory Regulations

If a candidate studying under the old regulations M.E. / M.Tech could not attend any of the courses in his/her courses, shall be permitted to attend equal number of courses, under the new regulation and will be examined on those subjects. The choice of courses will be decided by the concerned Head of the department. However he/she will be permitted to submit the thesis as per the old regulations. The results of such candidates will be passed as per old regulations.

The University shall have powers to revise or change or amend the regulations, the scheme of examinations, the courses of study and the syllabi from time to time

ANNAMALAI UNIVERSITY

FACULTY OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF CHEMICAL ENGINEERING

Program: **M.E** Specialization: **Chemical Engineering**

CURRICULUM –2023

SEMESTER I										
Course Code	**Category**	**Cou rse**	**L**	**T**	**P**	**CA**	**FE**	**Total**	**Credits**
23CHCEPC11	**PC**	Mathematical and Statistical Methods in Chemical Engineering	3	-	-	25	75	100	3
23CHCEPC12	**PC**	Advanced Separation Processes	3	-	-	25	75	100	3
23CHCEPE13	**PE**	Program Elective-I	3	-	-	25	75	100	3
23CHCEPE14	**PE**	Program Elective-II	3	-	-	25	75	100	3
23CHCEMC15	**MC**	Research Methodology and IPR	2	-	-	25	75	100	2
23CHCECP16	**CP**	Modeling & Simulation Laboratory	-	-	3	40	60	100	2
23CHCECP17	**CP**	Advanced Separation Processes Laboratory	-	-	3	40	60	100	2
23CHCEAC18	**AC**	Audit Course-I	2	-	-	-	-	-	0
							Total		**18**

SEMESTER II									
Course Code	**Category**	**Cou rse**	**L**	**T**	**P**	**CA**	**FE**	**Total**	**Credits**
23CHCEPC21	**PC**	Advanced Transport Phenomena	3	-	-	25	75	100	3
23CHCEPC22	**PC**	Advanced Reaction Engineering	3	-	-	25	75	100	3
23CHCEPE23	**PE**	Program Elective-III	3	-	-	25	75	100	3
23CHCEPE24	**PE**	Program Elective-IV	3	-	-	25	75	100	3
23CHCECP25	**CP**	Advanced Chemical Engineering Lab	-	-	3	40	60	100	2
23CHCEOE26	**OE**	Open Elective (Inter Faculty)	3	-	-	25	75	100	3
23CHCETS27	**TS**	Industrial Training and Seminar / Mini project		Tr 2	S 2	40	60	100	2
23CHCEAC28	**AC**	Audit Course-II	2	-	-	-	-	-	0
							Total		**19**

ANNAMALAI UNIVERSITY

FACULTY OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF CHEMICAL ENGINEERING

Program: **M.E** Specialization: **Chemical Engineering**

CURRICULUM –2023

SEMESTER III									
Course Code	**Category**	**Course**	**L**	**T**	**P**	**CA**	**FE**	**Total**	**Credits**
23CHCEPE31	**PE**	Program Elective-V	3	-	-	25	75	100	3
23CHCEOE32	**OE**	Open Elective (Inter Faculty)	3	-	-	25	75	100	3
23CHCEPV33	**PV-I**	Project Work & Viva-voce - Phase-I	-	Pr 2	S 2	40	60	100	10
								Total	**16**

SEMESTER IV									
Course Code	**Category**	**Cours e**	**L**	**T**	**P**	**CA**	**FE**	**Total**	**Credits**
23CHCEPV41	**PV-II**	Project Work & Viva-voce - Phase-II	-	Pr 24	S 6	40	60	100	15
							Total		**15**

LIST OF PROGRAMME ELECTIVES

1. Process Design and Synthesis
2. Chemical Reactor Analysis
3. Fluidization Engineering
4. Industrial Pollution Control
5. Application of Nanotechnology in Chemical Engineering
6. Chemoinformatics
7. Modern concepts in Catalysis and Surface Phenomenon
8. Advanced Downstream Processes
9. Computational Fluid Dynamics
10. Bioprocess Engineering
11. Process Intensification
12. Phase transitions in Process Equipment
13. Micro and Nano Fluidics
14. Process Integration
15. Transport in Porous Media
16. Micro Flow Chemistry and Process Technology
17. Process Plant Design & Flow sheeting
18. Design of Experiments and Parameter Estimation
19. Computer Aided Design
20. Cleaner Production

OPEN ELECTIVES

1. Business Analytics
2. Industrial Safety
3. Operations Research
4. Cost Management of Engineering Projects
5. Composite Materials
6. Waste to Energy

M.E (PART TIME) - DEGREE PROGRAMME Choice Based Credit System (CBCS)

REGULATION - 2023

Courses of Study and Scheme of Examination

Sl. No.	Course Code	Category	Course	L	T	P	CA	FE	Total	Credits	Equivalent Course Code in M.E. FullTime
SEMESTER – I											
1	23PCHCEPC11	**PC**	Mathematical and Statistical Methods in Chemical Engineering	3	-	-	25	75	100	3	23CHCEPC11
2	23PCHCEPC12	**PC**	Advanced Separation Processes	3	-	-	25	75	100	3	23CHCEPC12
3	23PCHCEMC13	**MC**	Research Methodology and IPR	2	-	-	25	75	100	2	23CHCEMC15
4	23PCHCECP14	**CP**	Modeling & Simulation Laboratory	-	-	3	40	60	100	2	23CHCECP16
	Total						**115**	**285**	**400**	**10**	

Sl. No.	Course Code	Category	Course	L	T	P	CA	FE	Total	Credits	Equivalent Course Code in M.E. FullTime
SEMESTER – II											
1	23PCHECPC21	**PC**	Advanced Transport Phenomena	3	-	-	25	75	100	3	23CHCEPC21
2	23PCHECPC22	**PC**	Advanced Reaction Engineering	3	-	-	25	75	100	3	23CHCEPC22
3	23PCHECOE23	**OE**	Open Elective -I (From the Dept.)	3	-	-	25	75	100	3	23CHCEOE26
4	23PCHCECP24	**CP**	Advanced Chemical Engineering Laboratory	-	-	3	40	60	100	2	23CHCECP25
	Total						**115**	**285**	**400**	**11**	

Sl. No.	Course Code	Category	Course	L	T	P	CA	FE	Total	Credits	Equivalent Course Code in M.E. FullTime
SEMESTER – III											
1	23PCHECPE31	**PE**	Program Elective-I	3	-	-	25	75	100	3	23CHCEPE13
2	23PCHECPE32	**PE**	Program Elective-II	3	-	-	25	75	100	3	23CHCEPE14
3	23PCHCECP33	**CP**	Advanced Separation Process Lab	-	-	3	40	60	100	2	23CHCECP17
	Total						**90**	**210**	**300**	**8**	

P - Part-Time, XX – Department Branch Code, YY - PG Specialization

L: Lecture ,**P:** Practical, **T**: Thesis, **CA:** Continuous Assessment; **FE:** Final Examination

Sl. No.	Course Code	Category	Course	L	T	P	CA	FE	Total	Credits	Equivalent Course Code in M.E. FullTime
S E M E S T E R – IV											
1	23PCHECPE41	PE	Program Elective-III	3	-	-	25	75	100	3	23CHCEPE23
2	23PCHECPE42	PE	Program Elective-IV	3	-	-	25	75	100	3	23CHCEPE24
3	23PCHECTS43	TS	Industrial Training and Seminar / Mini project		Tr 2	S 2	40	60	100	2	23CHCETS27
	Total						**90**	**210**	**300**	**8**	

Sl. No.	Course Code	Category	Course	L	T	P	CA	FE	Total	Credits	Equivalent Course Code in M.E. FullTime
S E M E S T E R –V											
1	23PCHECPE51	**PE**	Program Elective-V	3	-	-	25	75	100	3	23CHCEPE31
2	23PCHECOE52	**OE**	Open Elective - II (From the Dept)	3	-	-	25	75	100	3	23CHCEOE32
3	23PCHECPV53	**PV-I**	Project Work & Viva-voce Phase-I	-	Pr 16	S 4	40	60	100	10	23CHCEPV33
	Total						**90**	**210**	**300**	**16**	

Sl. No.	Course Code	Category	Course	L	T	P	CA	FE	Total	Credits	Equivalent Course Code in M.E. FullTime
S E M E S T E R –VI											
1	23PCHECPV61	**PV-II**	Project Work & Viva-voce Phase-II	-	Pr 24	S 6	40	60	100	15	23CHCEPV41
	Total						**40**	**60**	**100**	**15**	

ANNEXURE 1

S.No.	Department		Programme (Full Time & Part time)	Eligible B.E./B.TechProgramme
1	**Chemical Engineering**	i.	Chemical Engineering	B.E. / B.Tech – Chemical Engg, Petroleum Engg, Petrochemical Technology
		ii.	Food Processing Technology	B.E. / B.Tech - Chemical Engg, FoodTechnology, Biotechnology, Biochemical Engg, Agricultural Engg.
		iii.	Industrial Bio Technology	B.E. / B.Tech - Chemical Engg, FoodTechnology,Biotechnology, Leather Technology
		iv.	Industrial Safety Engineering	B.E. / B.Tech – Any Branch of Engineering
2	**Civil Engineering**	i.	Environmental Engineering	B.E. / B.Tech – Civil Engg, Civil & Structural Engg, Environmental Engg, Mechanical Engg, Industrial Engg, Chemical Engg, BioChemicalEngg, Biotechnology, Industrial Biotechnology, Chemical and Environmental Engg.
		ii.	Environmental Engineering & Management	
		iii.	Water Resources Engineering & Management	B.E. / B.Tech – Civil Engg, Civil & Structural Engg, Environmental Engg, Mechanical Engg, Agricutural and irrigation Engg, Geo informatics, Energy and EnvironmentalEngg.
3	**Civil & Structural Engineering**	i.	Structural Engineering	B.E. / B.Tech – Civil Engg, Civil & Structural Engg.
		ii.	Construction Engg. and Management	
		iii.	Geotechnical Engineering	
		iv.	Disaster Management &Engg.	
4	**Computer Science & Engineering**	i.	Computer Science & Engineering	B.E. / B.Tech - Computer Science and Engineering, Information Technology, Electronics and CommunicationEngg, Software Engineering
5	**Electrical Engineering**	i.	Embedded Systems	B.E. / B.Tech – Electrical and Electronics Engg, Control andInstrumentation Engg, Information technology, Electronics and communication Engg, Computer Science and Engg
		ii.	Smart Energy Systems	B.E. / B.Tech – Electrical and Electronics Engg, Control andInstrumentation Engg, Electronics and communication Engg,
		iii.	Power System	
6	**Electronics & Communication Engineering**	i.	Communication Systems	B.E. / B.Tech -Electronics and Communication Engg, Electronics Engg.

S.No.	Department		Programme (Full Time & Part time)	Eligible B.E./B.TechProgramme
7	**Electronics & Instrumentation Engineering**	i.	Process Control & Instrumentation	B.E. / B.Tech – Electronics and Instrumentation Engg, Electrical and ElectornicsEngg, Control and Instrumentation Engg, Instrumentation Engg, , Electronics and Communication Engg,
		ii.	Rehabilitative Instrumentation	B.E. / B.Tech – Electronics and Instrumentation Engg, Electrical and ElectornicsEngg, Electronics and Communication Engg, Control and Instrumentation Engg, Instrumentation Engg, Bio Medical Engg, Mechatronics.
		iii	Micro Electronics and MEMS	B.E. / B.Tech – B.E. / B.Tech – Electronics and Instrumentation Engg, Electrical and ElectornicsEngg, Electronics and communication Engg, Control and Instrumentation Engg, Instrumentation Engg, Bio Medical Engg, Mechatronics, Telecommunication Engg
8	**Information Technology**	i	Information Technology	B.E. / B.Tech - Computer Science and Engineering, Information Technology, Electronics and Communication Engg, SoftwareEngineering
9	**Mechanical Engineering**	iv.	Thermal Power	B.E. / B.Tech – Mechanical Engg, Automobile Engg, Mechanical Engg (Manufacturing).
		v.	Energy Engineering & Management	B.E. / B.Tech – Mechanical Engg, Automobile Engg, Mechanical (Manufacturing) Engg, Chemical Engg
10	**Manufacturing Engineering**	i.	Manufacturing Engineering	B.E. / B.Tech – Mechanical Engg, Automobile Engg, Manufacturing Engg, Production Engg, Marine Materials science Engg, Metallurgy Engg, Mechatronics Engg and IndustrialEngg.
		ii.	Welding Engineering	
		iii.	Nano Materials and Surface Engineering	B.E. / B.Tech – Mechanical Engg, Automobile Engg, Manufacturing Engg, Production Engg, Marine Materials science Engg, Metallurgy Engg, Chemical Engg

DEPARTMENT OF CHEMICAL ENGINEERING
M.E. CHEMICAL ENGINEERING

VISION

Our vision is to be a leading Chemical Engineering Department in the Nation, to create and develop technocrats, entrepreneurs and business leaders

MISSION

The department fosters chemical engineering as a profession that interfaces engineering and all aspects of basic sciences to disseminate knowledge in order to prepare the students to be successful leaders and practitioners and to meet the present and future needs of the society by highest degree of standards and ethics.

PROGRAMME EDUCATIONAL OBJECTIVES (PEO):

1. To prepare students for successful careers in Chemical Engineering and allied fields.
2. To make them professional to apply the principles of Chemical Engineering in solving practical problems
3. To develop the ability for designing chemical processes, equipments and plants with all constraints.
4. To develop the skills necessary for advanced research in Chemical Engineering through the project work.
5. To equip the students with state of art knowledge in Chemical Engineering including ethics, issues related to the global economy as well to as cultivate the skills of learning.
6. To know the latest technological advancements in computing and applied domains of engineering related to economic, environmental, social, political, ethical, and sustainability aspects.

PROGRAMME OUTCOMES (PO):

	For PG Programme
PO1	**Scholarship of Knowledge** Acquire in-depth knowledge of specific discipline or professional area, including wider and global perspective, with an ability to discriminate, evaluate, analyse and synthesise existing and new knowledge, and integration of the same for enhancement of knowledge.
PO2	**Critical Thinking** Analyse complex engineering problems critically, apply independent judgement for synthesising information to make intellectual and/or creative advances for conducting research in a wider theoretical, practical and policy context.
PO3	**Problem Solving** Think laterally and originally, conceptualise and solve engineering problems, evaluate a wide range of potential solutions for those problems and arrive at feasible, optimal solutions after considering public health and safety, cultural, societal and environmental factors in the core areas of expertise.
PO4	**Research Skill** Extract information pertinent to unfamiliar problems through literature survey and experiments, apply appropriate research methodologies, techniques and tools, design, conduct experiments, analyse and interpret data, demonstrate higher order skill and view things in a broader perspective, contribute individually/in group(s) to the development of scientific/technological knowledge in one or more domains of engineering.
PO5	**Usage of modern tools** Create, select, learn and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modelling, to complex engineering activities with an understanding of the limitations.
PO6	**Collaborative and Multidisciplinary work** Possess knowledge and understanding of group dynamics, recognise opportunities and contribute positively to collaborative-multidisciplinary scientific research, demonstrate a capacity for self-management and teamwork, decision-making based on open-mindedness, objectivity and rational analysis in order to achieve common goals and further the learning of themselves as well as others.
PO7	**Project Management and Finance** Demonstrate knowledge and understanding of engineering and management principles and apply the same to one's own work, as a member and leader in a team, manage projects efficiently in respective disciplines and multidisciplinary environments after consideration of economical and financial factors.
PO8	**Communication** Communicate with the engineering community, and with society at large, regarding complex engineering activities confidently and effectively, such as, being able to comprehend and write effective reports and design documentation by adhering to appropriate standards, make effective presentations, and give and receive clear instructions.
PO9	**Life-long Learning** Recognise the need for, and have the preparation and ability to engage in life-long learning independently, with a high level of enthusiasm and commitment to improve knowledge and competence continuously.
PO10	**Ethical Practices and Social Responsibility** Acquire professional and intellectual integrity, professional code of conduct, ethics of research and scholarship, consideration of the impact of research outcomes on professional practices and an understanding of responsibility to contribute to the community for sustainable development of society.
PO11	**Independent and Reflective Learning** Observe and examine critically the outcomes of one's actions and make corrective measures subsequently, and learn from mistakes without depending on external feedback.

PEO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
PEO1	3	2		2	2	2	1		3	2	1
PEO2	3	2	2	2	2	2	2		3	2	1
PEO3	2	2	2	3	2	2	2		3	3	2
PEO4	3	2	2	3	2	2	2		3	3	2
PEO5	3	2		3		2	2		3	2	2
PEO6	3	2		3		2	2		3		2

1–Slight,2–Moderate,3–Substantial

PROGRAM SPECIFIC OUTCOMES (PSOs)

PSO1: Develop technologies by applying ethical principles and creative knowledge for sustainable growth.

PSO2: Analyze and design solutions for the complex problems using modern software techniques.

PSO3: Apply the advanced concepts of chemical engineering in problem solving and work as a team to manage projects in multidisciplinary environments.

SEMESTER - I

23CHCEPC11	**MATHEMATICAL AND STATISTICAL METHODS IN CHEMICAL ENGINEERING**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- To give students an insight in various Chemical Engineering Processes using advanced
- Numerical and Statistical Methods.
- To provide adequate background of Mathematics to deal with Chemical Engineering
- To understand research papers on relevant topics involving advanced Mathematics.
- To study correlation and regression of multi variate data.
- To evaluate Experimental design methods and statistical quality control measures.

Equation Forms in Process Modeling, Introduction and Motivation, Linear and Nonlinear Algebraic Equation, Optimization based Formulations, ODE-IVPs and Differential Algebraic Equations, ODE-BVPs and PDEs, Abstract model forms. Fundamentals of Vector Spaces, Generalized concepts of vector space, sub-space, linear dependence, Concept of basis, dimension, norms defined on general vector spaces, Examples of norms defined on different vector spaces, Cauchy sequence and convergence, introduction to concept of completeness and Banach spaces, Inner product in a general vector space, Inner-product spaces and their examples, Cauchy-Schwartz inequality and orthogonal sets, Gram-Schmidt process and generation of orthogonal basis, well known orthogonal basis Matrixnorms.

Problem Discretization Using Approximation Theory, Transformations and unified view of problems through the concept of transformations, classification of problems in numerical analysis, Problem discretization using approximation theory, Weierstrass theorem and polynomial approximations, Taylor series approximation, Finite difference method for solving ODE-BVPs with examples, Finite difference method for solving PDEs with examples, Newton’s Method for solving nonlinear algebraic equation as an application of multivariable Taylor series, Introduction to polynomial interpolation, Polynomial and function interpolations, Orthogonal Collocations method for solving ODE-BVPs, Orthogonal Collocations method for solving ODE- BVPs with examples, Orthogonal Collocations method for solving PDEs with examples, Necessary and sufficient conditions for unconstrained multivariate optimization, Least square approximations, Formulation and derivation of weighted linear least square estimation, Geormtraic interpretation of least squares Projections and least square solution, Function approximations and normal equation in any inner product space, Model Parameter Estimation using linear least squares method, Gauss Newton Method, Method of least squares for solving ODE-BVP, Gelarkin’s method and generic equation forms arising in problem discretization, Errors in Discretization, Generaic equation forms in transformedproblems.

Solving Linear Algebraic Equations, System of linear algebraic equations, conditions forexistence of solution - geometric interpretations (row picture and column picture), review of concepts of rank and fundamental theorem of linear algebra, Classification of solution approaches as direct and iterative, review of Gaussian elimination, Introduction to methods for solving sparse linear systems: Thomas algorithm for tridiagonal and block tridiagonal matrices, Block-diagonal, triangular and block-triangular systems, solution by matrix decomposition, Iterative methods: Derivation of Jacobi, Gauss-Siedel and successive over-relaxation methods, Convergence of iterative solution schemes: analysis of asymptotic behavior of linear difference equations using Eigen values, Convergence of iterative solution schemes with examples, Convergence of iterative solution schemes, Optimization based solution of linear algebraic equations, Matrix conditioning, examples of well conditioned and ill-conditioned linearsystems.

Solving Nonlinear Algebraic Equations, Method of successive substitutions derivative free iterative solution approaches Secant method, regulafalsi method and Wegsteine iterations, Modified Newton’s method and qausi-Newton method with Broyden’s update, Optimization based formulations and Leverberg-Marquardt method, Contraction mapping principle and introduction to convergence analysis.

Solving Ordinary Differential Equations, Initial Value Problems (ODE-IVPs), Introduction, Existence of Solutions (optional topic), Analytical Solutions of Linear ODE-IVPs, Analytical Solutions of Linear ODE-IVPs (contd.), Basic concepts in numerical solutions of ODE-IVP: step size and marching, concept of implicit and explicit methods, Taylor series based and Runge- Kutta methods: derivation and examples. Runge-Kutta methods, Multi-step (predictor-corrector) approaches: derivations and examples, Multi-step (predictor-corrector) approaches: derivations and examples, Stability of ODE-IVP solvers, choice of step size and stability envelopes, Stability of ODE-IVP solvers (contd.), stiffness and variable step size implementation, Introduction to solution methods for differential algebraic equations (DAEs), Single shooting method for solving ODEBVPs.

REFERENCES:

1. Gilbert Strang, Linear Algebra and Its Applications (4th Ed.), 2009, Wellesley CambridgePress
2. Philips, G. M.,Taylor, P. J. ; Theory and Applications of Numerical Analysis (2nd Ed.), 1996, AcademicPress,
3. Gourdin, A. and M Boumhrat; Applied Numerical Methods, 2000,Prentice Hall India, NewDelhi,
4. Gupta, S. K.; Numerical Methods for Engineers. 1995, Wiley Eastern, NewDelhi,.
5. Linz, P.; Theoretical Numerical Analysis, 1979, Dover, NewYork,
6. Gilbert Strang , Introduction to Applied Mathematics, 2009, Wellesley CambridgePress

COURSE OUTCOMES:

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

1. To solve system of linear algebraicequations
2. To do numerical integrations offunctions.
3. To fit relationship between two data sets using linear, non-linearregression.
4. To calculate maxima/minimaandfunctions.
5. To apply able to methods for solving chemical engineersproblems

Mapping with PO& PSO														
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	3	3	3									2	2	2
CO2	3	3	3									2	2	2
CO3	3	3	3									2	2	2
CO4	3	3	3									3	2	3
CO5	3	3	3	2	2				3		3	3	2	3

23CHCEPC12	ADVANCED SEPARATION PROCESSES	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To familiarize students with various advanced aspects of separation processes and the selection of separation processes.
- To enable students to understand the principles and processes of adsorption, membrane separation and chromatography and to design an absorber or a membrane unit to achieve a specified separation.
- To introduce them to new trends used in the separation technologies.

Introduction: Conventional separation processes - Absorption, Adsorption, Conventional separation processes - Distillation, Drying, Conventional separation processes - Extraction,Diffusion, Conventional separation processes - Leaching, Crystalisation, Advances in separation techniques based on size, Advances in separation techniques based on surface properties, Advances in separation techniques based on ionic properties, Cross flow filtration, Electro filtration, Dual functional filter, Surface based solid-liquid separations involving a second liquid, Siroflocfilter

Bubble and Foam Fractionation: Nature of bubbles and foams, stability of foams, foam fractionation techniques, batch, continuous, single stage and multistage columns. Types and choice of membranes, Plate and frame, spiral wound membranes, Tubular and hollow fibre membrane reactors, Membrane Permeates: Dialysis, Reverse osmosis, Nanofiltration, ultrafiltration, microfiltration, Donnan dialysis, Ceramic membranes

Membrane Separation: Characteristics of organic and inorganic membranes, basis of membrane selection, osmotic pressure, partition coefficient and permeability, concentration polarization,electrolyte diffusion and facilitated transport, macro-filtration, ultra-filtration, reverse osmosis, electro-dialysis. Industrial applications.

Special Processes: Liquid membrane separation, super-critical extraction, adsorptive separation- pressure, vacuum and thermal swing, pervaporation and permeation, nano-separation.

Chromatographic Methods of Separation: Gel, solvent, ion and high performance liquid chromatography.

REFERENCES:

1. King C.J., "Separation Processes", 1982, Tata McGrawHill.
2. Nakagawal, O. V., "Membrane Science and Technology", 1992. MarcelDekker,
3. Humphrey, J and G. Keller, Separation Process Technology, 1997McGraw-Hill,
4. Khoury F.M., "Multistage Separation Processes", 3rd Ed., 2004.CRCPress.
5. Wankat P.C., "Separation Process Engineering", 2nd Ed., PrenticeHall.
6. Seader J.D. and Henley E.J., "Separation Process Principles", 2006. 2ndEd.,Wiley.
7. Basmadjian D., "Mass Transfer and Separation Processes: Principles and Applications", 2nd Ed., 2007.CRCPress.
8. Phillip C. Wankat , Separation Process Engineering (2nd Edition), 2007, PrinticeHall,
9. Rousseau, R. W., "Handbook of Separation Process Technology", 2009.John Wiley, New York,

COURSE OUTCOMES:

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

1. List situations where liquid–liquid extraction might be preferred to distillation, make a preliminary selection of a solvent using group-interaction rules, Size simple extraction equipment.
2. Differentiate between chemisorption and physical adsorption, List steps involved in adsorption of a solute, and which steps may control the rate of adsorption, Explain the concept of breakthrough in fixed-bedadsorption.
3. Explain how crystals grow, Explain the importance of supersaturation in crystallization. Describe effects of mixing on supersaturation, mass transfer, growth, and scale-up of crystallization.
4. Explain membrane processes in terms of the membrane, feed, sweep, retentate, permeate, and solute membraneinteractions.
5. Distinguish among microfiltration, ultrafiltration, nanofiltration, virus filtration, sterile filtration, filter-aid filtration, and reverse osmosis in terms of average pore size. Explain common idealized flow patterns in membranemodules.

Mapping with PO& PSO														
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	3	3							3		2	2	2	1
CO2	3	3							3			2	2	1
CO3	3	3							3			2	2	2
CO4	3								3			2	2	2
CO5	3	3							3			2	2	2

23CHCEMC15	**RESEARCH METHODOLOGY AND IPR**	**L**	**T**	**P**	**C**
		2	**0**	**0**	**2**

Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations

Effective literature studies approaches, analysis Plagiarism, Research ethics, Effective technical writing, how to write report, Paper Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee

Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting underPCT.

Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.

New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.

REFERENCES:

1. Stuart Melville and Wayne Goddard, "Research methodology: an introduction forscience&engineeringstudents'"
2. Wayne Goddard and Stuart Melville, "Research Methodology: AnIntroduction"
3. Ranjit Kumar, 2nd Edition , "Research Methodology: A Step by Step Guide for beginners"
4. Halbert, "Resisting Intellectual Property", 2007. Taylor & Francis Ltd ,
5. Mayall , "Industrial Design", 1992.McGrawHill,
6. Niebel , "Product Design", 1974. McGrawHill,
7. Asimov , "Introduction to Design", 1962.PrenticeHall,
8. Robert P. Merges, Peter S. Menell, Mark A. Lemley, " Intellectual Property inNew Technological Age",2016.
9. T. Ramappa, "Intellectual Property Rights Under WTO", 2008, S. Chand, &Co.

COURSE OUTCOMES:

At the end of this course, students will be able to

1. Understand research problemformulation.
2. Analyze research relatedinformation and follow researchethics.
3. Understand that today's world is controlled by Computer, Information Technology,but tomorrow world will be ruled by ideas, concept, andcreativity.
4. Understanding that when IPR would take such important place in growth ofindividuals & nation, it is needless to emphasis the need of information about Intellectual Property Right to be promoted among students in general & engineering inparticular.
5. Understand that IPR protection provides an incentive to inventors for further research work and investment in R & D, which leads to creation of new and better products, andin turn brings about, economic growth and socialbenefits.

Mapping with PO& PSO														
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	3	3	2	3	2				3		3	3	3	3
CO2	3	3	3	3	2				3		2	3	3	3
CO3	3		2			2	2		3	3	3	3	3	3
CO4	3	3	2	2	3	2			3	3	3	3	3	3
CO5	3	3	2	3		3	2	3	3	3	3	3	3	3

23CHCECP16	**MODELING & SIMULATION LABORATORY**	**L**	**T**	**P**	**C**
		0	**0**	**3**	**2**

COURSE OBJECTIVES:

- To learn Process Modeling and Simulation of Chemical operations andprocesses.
- To understand Dynamic Behavior ofprocesses.
- To understand Close loop control ofprocesses.
- To learn Dynamic simulation of chemical processes.
- To get acquainted with Controllability Analysis of chemicalprocesses.

List of experiments: Simulation laboratory practical
1. Thermodynamic property estimations using property estimation and property analysis in Aspen.
2. Simulate Mixer, splitter, heat exchangers, and reactive distillationcolumn.
3. Apply sensitivity, design specification and case study tools inAspen
4. Solve linear and non-linear programming problems.
5. Controller tuning by Ziegler- Nichol's & Cohen- Coonmethods
6. Stability analysis using Bode diagrams for controlsystems.
7. Simulation of Ideal Binary DistillationColumn
8. Simulation of Heat/Mass Transfer coefficient in 3 phase fluidized bedcolumn
9. Simulation studies of various unit operations usingCHEMCAD.
10. Modeling and Simulation of cycloneseparator

Note: Simulation can be done using C/C++ / MATLAB/ ASPEN PLUS/ CHEMCAD

COURSE OUTCOMES

At the end of the course, the student will be able to:
1. Carry out thermodynamic property estimations using property estimation and property analysis inAspen.
2. Simulate Mixer, splitter, heat exchangers, reactors, distillationcolumns.
3. Apply sensitivity, design specification and case study tools inAspen.
4. Solve linear and non-linear programmingproblems.
5. Able to design and simulate the chemical engineeringequipment's.

Mapping with PO& PSO														
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	3	3	3		3				3		3	1	2	2
CO2	3	3	3		3				3	2	3	1	2	2
CO3	3	3	3		3						2	3	3	3
CO4	3		3		3							3	3	3
CO5	2	3	3		3	3			3	2	3	3	3	3

23CHCECP17	**ADVANCED SEPARATION PROCESSES LABORATORY**	**L**	**T**	**P**	**C**
		0	**0**	**3**	**2**

COURSE OBJECTIVES:

- To familiarize students with various advanced aspects of separation processes and the selection of separationprocesses.
- To enable students to understand the principles and processes of adsorption, membrane separation and chromatography and to design an absorber or a membrane unit to achieve a specifiedseparation.
- To introduce them to new trends used in the separationtechnologies.

List of experiments: advanced separation processes

1) Separation of fluoride and arsenic using cellulose acetate asymmetric membraneseparation process
2) Adsorption of dyes from waste water using nanoadsorbents.
3) Supercritical extraction of the fragrance.
4) Study the effect of pressure on permeate flux and solution rejection in ROsystem.

5) Mass transfer studies and study the effect of parameters in separation system usingliquid emulsionmembrane.
6) Laboratory experiments on ion exchange membranes: effect of process parameters onflux.
7) Study the reaction with mass transfer: e.g. Synthesis of calciumcarbonate.
8) Study the reactive distillation system considering batch and continuousmode

COURSE OUTCOMES:

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

1. Gain Knowledge on mass transferoperations
2. Students should be able to know the synthesis ofmaterials
3. Students will be able to provide applicable solutions to separationprocesses.
4. Acquire Knowledge on mechanicaloperations.
5. Know the applications of materials in separation processes.

Mapping with PO& PSO														
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	3								3		2	1	2	1
CO2	3								2			2	2	1
CO3	3	3	2						3	2	2	2	2	2
CO4	3								2			2	2	2
CO5	3	2							2			2	2	2

SEMESTER II

23CHCEPC21	ADVANCED TRANSPORT PHENOMENA	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To familiarize the student with basic concepts of transport phenomena and brief review ofmathematics.
- To enable students to understand the equations of change for isothermal flow and for non-isothermalflow.
- To introduce them details of equations of change for multi componentsystems.
- To give them insight into properties of two-dimensional flows and aspects of dimensional analysis

Equations of Change for Isothermal Systems: Equation of Continuity, Equation of Motion, Equation of Mechanical Energy, Equations of Change in terms of the Substantial Derivative, Use of the Equations to solve Flow Problems, Dimensional Analysis of the Equations of Change.Velocity Distributions with more than one Independent Variable: Time Dependent Flow of Newtonian Fluids. Velocity Distributions in Turbulent Flow -Comparisons of Laminar and Turbulent Flows, Time Smoothed Equations of Change for Incompressible Fluids, Time Smoothed Velocity Profile near a wall, Empirical Expressions for the Turbulent Momentum Flux, Turbulent Flow in Ducts, Turbulent Flow inJets.

Macroscopic Balances for Isothermal Systems: The Macroscopic Mass Balance, TheMacroscopic Momentum Balance, The Macroscopic Mechanical Energy Balance, Estimation of the Viscous loss, Use of the Macroscopic Balances for Steady-State Problems, Derivation of the Macroscopic Mechanical Energy Balance.Equations of Change for Non-Isothermal Systems: The Energy Equation, Special forms of the Energy Equation, The Boussinesq Equation of Motion for Forced and Free Convection, Use of the Equations of change to Solve Steady-State Problems, Dimensional Analysis of the Equations of Change for Non-Isothermal Systems.

Temperature Distributions in Solids and in Laminar Flow: Heat Conduction with an Electrical Heat Source, Heat Conduction with a Viscous Heat Source. Temperature Distributionswith more than One Independent Variable - Unsteady Heat Conduction in Solids, Steady Heat Conduction in Laminar, Incompressible Flow. Temperature Distributions in Turbulent Flow - Time- Smoothed Equations of Change for Incompressible Non-Isothermal Flow, Time-Smoothed Temperature Profile near a Wall, Empirical Expressions for the Turbulent Heat Flux Temperature Distribution for Turbulent Flow in Tubes.

Macroscopic Balances For Non-Isothermal Systems: Macroscopic Energy Balance, Macroscopic Mechanical Energy Balance, Use Of The Macroscopic Balances To Solve Steady State Problems With Flat Velocity Profiles, Concentration Distributions in Solids and in Laminar Flow: Shell Mass Balances Boundary Conditions, Diffusion through a Stagnant Gas Film, Diffusion with a Heterogeneous Chemical Reaction. Concentration Distributions with more than One Independent Variable: Time-Dependent Diffusion, Steady-State Transport in Binary Boundary Layers, Concentration Distributions in Turbulent Flow - Concentration Fluctuations and the Time- Smoothed Concentration, Time-Smoothing of the Equation of Continuity of A, Semi-Empirical Expressions for the Turbulent Mass Flux, Enhancement of Mass Transfer by a First-Order Reaction in Turbulent Flow.

Inter phase Transport in Multi-Component Systems: Definition of Transfer Coefficients in One Phase, Analytical Expressions for Mass Transfer Coefficients, Correlation of Binary Transfer Coefficients in One Phase, Definition of Transfer Coefficients in Two Phases, Mass Transfer and Chemical Reactions. Macroscopic Balances For Multi-Component Systems: Macroscopic Mass Balances, Macroscopic Momentum, Use of the Macroscopic Balances to solve Steady-State Problems.

REFERENCES:

1. Thomson W. J., Transport Phenomena, 2001. Pearson education,Asia,
2. Geankopolis C. J., Transport Processes and Unit Operations, 4th Ed., 2004. Prentice Hall (India) Pvt. Ltd., NewDelhi.
3. Bird R. B., Stewart W. E. and Light Foot E. N., Transport Phenomena, Revised 2nd Edition, 2007.John Wiley &Sons,

COURSE OUTCOMES:

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

1. Understand the mechanism of momentum, heat and mass transport for steady and unsteady flow.
2. Perform momentum, energy and mass balances for a given system at macroscopicand microscopicscale.
3. Solve the governing equations to obtain velocity, temperature and concentrationprofiles.
4. Model the momentum, heat and mass transport under turbulentconditions.
5. Develop analogies among momentum, energy and masstransport.

Mapping with PO& PSO														
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	3	3	3		3				3		3	1	1	2
CO2	3	3	3		3				3		3	1	1	2
CO3	3	3	3		3						2	1	2	2
CO4	3	3	3		3				3		3	1	2	2
CO5	3	3	2		3				3		3	1	2	2

23CHCEPC22	**ADVANCED REACTION ENGINEERING**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

This Subject is essential for Design of Reactor especially heterogeneous reactors.

- Students will learn the energy balance, temperature and concentration profiles in different reactors, advance design aspects of multiple reactors, students will get insight of importance of population balance of particles.
- Role of Reaction Engineering in mitigation of Global warming will also addressed.

Non-elementary Kinetics Importance: Approximations for formulations of Rate laws, Formulations of Kinetic model. Effect of flow on conversions in Reactors: Semibatch Reactors : Importance and examples of applications , Material Balance on Semibatch Reactor, Multiple reaction in Semi batch Reactors, Conversion Vs Rate in Reactors, Use of POLYMATHS to solve the equations and understanding the profilesNon-Isothermal reaction modeling in CSTR & Semi-Batch reactor: Energy Balance equations for CSTR, PFR and Batch reactors, Adiabatic operations Temperature conversion profiles in PFR, CSTR, Steady state tubular reactor with heat exchange.

Need for Multi-staging CSTR with multiple stages: Exothermic and Endothermic Reaction with examples, CSTR with heat effects, Multiple reactions in CSTR and PFR with heat effects, Semi batch Reactors with heat exchange.Design of PFR and Packed Bed Tubular Reactors: Radial and Axial mixing in Tubular reactors, unsteady state in non-isothermal energy balance, CSTR, Energy balance in Batch Reactors, Volume of reactors calculations for non-isothermal reactors.Optimal Design of Reactors for Reversible exothermic reactions: Unsteady state non-isothermal reactor design, adiabatic operation in batch, Heat effects in semi batch unsteady state operation. Auto thermal Plug flow reactors and packed tubular reactors.PFR with inter stage cooling. Shift of Energy and material balance lines for reversible reactions in CSTR, Examples of optimal design of PFR and Semibatch and CSTR Exothermic Reactions.

Catalytic reactions: theory and modeling: Global rate of reaction, Types of Heterogeneous reactions Catalysis, Different steps in catalytic reactions, Theories of heterogeneous catalysis. Steady State approximation, formulations of rate law Rate laws derived from the PSSH, Rate controlling steps, Eiley-Rideal model, Reforming catalyst example :Finding mechanism consistent with experimental observations Evaluation of rate law parameters, packed beds : Transport and Reactions, Gradients in the reactors : temperature.
Porous media reactors: Mass transfer coefficients, Flow effects on spheres tube and cylinders, External Mass Transfer pore diffusion, structure and concentration gradients Internal Effectiveness Factor Catalytic wall reactor: limiting steps reactions and mass transfer limiting

Porous catalyst on tube wall reactors Design of packed bed porous catalytic reactors: Mass transfer limited reactions in Packed bed.

Fluidized bed reactor modeling: Geldart Classification of powders, Fixed bed vs fluidized bed Why fluidized bed, important parameters pressure drop in fixed bed, Class I model Arbitrary Two Region Flow Models, Class II Chemical Reactor: Plug Flow or Mixed Flow Model. Class III Modeling the Bubbling Fluidized Bed Reactor, BFB, The Kunii-Levenspiel bubbling bed model, Gas Flow Around and Within a Rising Gas Bubble in a Fine particle BFB, Reactor performance ofBFB.

Application of Population Balance Equations for reactor modeling: Particle size distribution, Distribution Functions in Particle Measuring Techniques, Particle distribution model in colloidal particle synthesis in batch reactor, Moments of Distribution, Nucleation rate based on volumetric holdup versus crystal growth rate. Reaction engineering and mitigation of Global warming: CO2 absorption in high pressure water, different techniques of mitigation of CO2, methods of separations. Recent advancements, automotive monolith catalytic converter example, removal and utilization of CO2 for thermal power plants.

REFERENCES:

1. K.G. Denbigh : Chemical Reactor Theory, 1971.Cambridge University Press, Second Edition,
2. J.M. Smith : Chemical Engineering Kinetics, 1981. Mcgraw Hill, ThirdEdition,
3. Levenspiel O., Chemical Reaction Engineering, 1998. Wiley,
4. Foggler,H.S., Elements of Chemical Reaction Engineering, 2008.Prentice Hall ofIndia,
5. Froment G.F. and Bischoff K.B., Chemical Reactor Analysis and Design, 2010. John Wiley,

COURSE OUTCOMES:

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

1. Evaluate heterogeneous reactor performance considering mass transferlimitations
2. Perform the energy balance and obtain concentration profiles in multiphasereactors.
3. Estimate the performance of multiphase reactors under non-isothermalconditions.
4. Understand modern reactor technologies for mitigation of globalwarming
5. Understand the kinetic Modeling ofreactors.

Mapping with PO& PSO														
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	3	3	3		2	3			3		3	1	2	2
CO2	3	3	3		2				3		3	2	2	2
CO3	3	3	2		2						2	2	2	2
CO4	3	3	3		3				3	3	3	2	2	2
CO5	3	3	2		3				3		3	2	2	2

23CHCEPE25	ADVANCED CHEMICAL ENGINEERING LAB	L	T	P	C
		0	0	3	2

COURSE OBJECTIVES:

- Analyze characteristics of a fluidized beddryer
- Estimate efficiency of compact heatexchangers
- Evaluate the performance of a process intensification in catalytic reactions, ultrasound assisted reactions, reactive distillation column, micro reactor and advanced flowreactor
- Design controller for a givenprocess
- Evaluate the performance of membrane separation process for waterpurification
- Characterize electrochemical phenomena such ascorrosion

List of Experiments:

1. Characteristics of a Fluidized beddryer
2. Helical Coil heatexchanger
3. Determination of Effective thermal conductivity (ETC) in granularmaterial
4. Plate Type HeatExchanger
5. Kinetics for solid catalyzed esterification reaction in a batchreactor
6. Reactive distillation in PackedColumn
7. Ultrasonic cavitation basedreactions
8. Micro-reactor
9. Advanced FlowReactor
10. Membrane Separation for waterpurification
11. Corrosion characteristics of a metal in a givenelectrolyte
12. Control of liquid level in non-interactingsystems.
13. Identification and control of a three tanksystem.
14. pH control in aprocess.

COURSE OUTCOMES:

At the end of this course, students will be able to understand

1. Performance of dryer and heatexchangers
2. Membrane separationtechniques
3. Control of level, pH in a chemicalreactor
4. Fluidized bed and packed bedreactors
5. Packed bed distillationcolumns

Mapping with PO& PSO														
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2			2				2		2	2	2	3
CO2	3								2			2	2	3
CO3	3	3	3		3				3			2	2	3
CO4	3								2			2	2	3
CO5	3								2			2	2	3

23CHCETS27	INDUSTRIAL TRAINING AND SEMINAR / MINI PROJECT	Tr	T	P	C
		2	0	2	2

COURSE OBJECTIVES:

- To train the students in the field work related to chemical engineering and to have a practical knowledge in carrying out work at chemical engineering.
- To train and develop skills in solving problems during execution of certain works related to chemical engineering.

The students individually undergo a training program in reputed concerns in the field of chemical engineering during the summer vacation (at the end of second semester for full-time/ IV semester for part time) for a minimum stipulated period of four weeks. At the end of the training, the student has to submit a detailed report on the training they had, within ten days from the commencement of third semester for full time/fifth semester for part time. The student will be evaluated by a team of staff members nominated by head of the department through a viva voce examination

COURSE OUTCOME:

At the end of this course, students will be able to

1. Interact with industrial personnel and follow engineering practices and discipline prescribed in industry.
2. Develop awareness about general workplace behavior and build interpersonal and team skills.
3. Prepare professional work reports and presentations.
4. Manage the situation arises during the execution of work related to chemical process industries.
5. Generate ideas for the startup and new business opportunities.

Mapping with PO& PSO														
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	3			1		2		1				1	1	2
CO2	3	2	2					1				2	1	2
CO3	3	2	2		3	1		2	1	2		2	1	2
CO4	3	3	3	3			1				2	2	1	2
CO5	3		1	1		1	3				1	2	3	2

THIRD SEMESTER

		L	P	S	C
23CHCEPV 33	PROJECT WORK VIVA VOCE PHASE – I	0	16	4	10

FOURTH SEMESTER

		L	P	S	C
23CHCEPV 41	PROJECT WORK VIVA VOCE PHASE – II	0	26	6	16

Dissertation Phase – I and Phase – II

Teaching Scheme Lab work: 20 and 32 hrs/week for phase I and II respectively

COURSE OBJECTIVES:

At the end of this course, students will be able to

- Ability to synthesize knowledge and skills previously gained and applied to an in-depth study and execution of new technical problem.
- Capable to select from different methodologies, methods and forms of analysis to produce a suitable research design, and justify their design.
- Ability to present the findings of their technical solution in a written report.
- Presenting the work in International/ National conference or reputed journals.

Syllabus Contents:

The dissertation / project topic should be selected / chosen to ensure the satisfaction of the urgent need to establish a direct link between education, national development and productivity and thus reduce the gap between the world of work and the world of study. The dissertation should have the following

- Relevance to social needs of society
- Relevance to value addition to existing facilities in the institute
- Relevance to industry need
- Problems of national importance
- Research and development in various domain

The student should complete the following:

- Literature survey
- Problem Definition
- Motivation for study and Objectives
- Preliminary design / feasibility / modular approaches
- Implementation and Verification
- Report and presentation

The dissertation stage II is based on a report prepared by the students on dissertation allotted to them.It may be based on:

- Experimental verification / Proof ofconcept.
- Design, fabrication, testing of Communication System.
- The viva-voce examination will be based on the above report and work.

Guidelines for Dissertation Phase – I and II

• As per the AICTE directives, the dissertation is a yearlong activity, to be carried out and evaluated in two phases i.e. Phase – I: July to December and Phase – II: January to June.

• The dissertation may be carried out preferably in-house i.e. department's laboratories and centers OR in industry allotted through department's T & P coordinator.

• After multiple interactions with guide and based on comprehensive literature survey, the student shall identify the domain and define dissertation objectives. The referred literature should preferably include Springer/Science Direct. In case of Industry sponsored projects, the relevant application notes, while papers, product catalogues should be referred and reported.

• Student is expected to detail out specifications, methodology, resources required, critical issues involved in design and implementation and phase wise work distribution, and submit the proposal within a month from the date of registration.

• Phase – I deliverables: A document report comprising of summary of literature survey, detailed objectives, project specifications, paper and/or computer aided design, proof of concept/functionality, part results, A record of continuous progress.

• Phase – I evaluation: A committee comprising of guides of respective specialization shall assess the progress/performance of the student based on report, presentation and Q & A. In case of unsatisfactory performance, committee may recommend repeating the phase-I work.

• During phase – II, student is expected to exert on design, development and testing of the proposed work as per the schedule. Accomplished results/contributions/innovations should be published in terms of research papers in reputed journals and reviewed focused conferences OR IP/Patents.

• Phase – II deliverables: A dissertation report as per the specified format, developed system in the form of hardware and/or software, A record of continuous progress.

• Phase – II evaluation: Guide along with appointed external examiner shall assess the progress/performance of the student based on report, presentation and Q & A. In case of unsatisfactory performance, committee may recommend for extension or repeating the work

COURSE OUTCOMES:

Aftercompletion ofthecourse,thestudents willbeable to

1. Comeacrossdifferentliteraturesrelevanttohisstudy
2. Reflecton,evaluate,and criticallyassessone'sownandothers'scientificresults
3. Apply the relevant knowledge and skills, which are acquired within the technical area,tosolveagiven problem
4. Presentthefindingsofthetechnical solutioninawrittenreport
5. Publishingthe noveltyofthe workin conferencesof journals

Mapping with PO& PSO														
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	3	3	3	3	2	3	2	2	3	2	3	3	2	3
CO2	3	3	3	3	2	3	2	2	3	2	3	3	2	3
CO3	3	3	3	2	2	3	2	3	3	2	3	3	2	3
CO4	3	3	3	2	2	3	2	3	3	2	3	3	2	3
CO5	3	3	3	2	1	3	2	3	3	2	3	3	2	3

PROGRAMME ELECTIVES

23CHCEPESCN	PROCESS DESIGN AND SYNTHESIS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To understand the systematic approaches for the development of conceptual chemical process designs
- To learn the advances in problem formulation and software capabilities which offer the promise of a new generation of practical process synthesis techniques based directly on structural optimization.
- Learning chemical process synthesis, analysis, and optimization principles
- Product design and development procedure and Process life cycle assessment.

Introduction

Introduction to fundamental concepts and principles of process synthesis and design and use of flow sheet simulators to assist process design. Process Flow sheet Models: An Introduction to design, Chemical process synthesis, analysis and optimization. Introduction to commercial process design software such as HYSYS, Aspen plus etc., Chemical Process (reactor, heat exchanger, distillation etc) analysis using commercial software

Product design and developments

Process engineering economics and project evaluation Life Cycle Assessments of process: From design to product development, Engineering Economic Analysis of ChemicalProcesses, Project costing and performance analysis, Environmental concerns, Green engineering, Engineering ethics, Health and safety.

Reactor Networks

Geometry of mixing and basic reactor types, The Attainable Region (AR) approach, AR in higher dimensions & for other processes, Reactive Separation processes, Fundamental behavior and problems, Separation through reactions. Reactive Residue CurveMaps

Synthesis of Separation Trains

Criteria for selection of separation methods, select ion of equipment**:** Absorption, Liquid-liquid extraction Membrane separation, adsorption, leaching, drying, crystallization, Ideal distillation - Column and sequence fundamentals, Sharp splits & sequencing Phase diagrams for 2, 3 and 4 components, Feasibility and vapor ow rates for single columns, Residue curve basics, Non-ideal Distillation **-** Azeotropic systems; detecting binary azeotropes, Residue curve maps for azeotropic systems, Topological analysis, Feasibility for single azeotropic columns, Binary VLLE and pressure swing separation, Non-ideal distillation synthesis. Equipment sequencing: VLE + VLLE, Detailed Residue Curve Maps, Residue curve maps: Interiorstructure

Heat Exchanger NetworkSynthesis

Minimum heating and cooling requirements, Minimum Energy Heat Exchanger Network, Loops and Paths, Reducing Number of Exchangers, HENS basics & graphics, The pinch point approach, Stream Splitting, Performance targets, trade-off & utilities, Heat & power integration, HENS as mathematicalprogramming

REFERENCES:

1. Douglas, J. “Conceptual Design of Chemical Processes”, 1988.New York, NY: McGraw-Hill Science/Engineering/Math, ISBN:0070177627.

2. Seider, W. D., J. D. Seader, and D. R. Lewin. “Product and Process Design Principles: Synthesis, Analysis, and Evaluation”,. 2nd ed. 2004. New York, NY: Wiley, ISBN:0471216631.
3. Richard Turton, Richard C. Bailie, Wallace B. Whiting, Joseph A. Shaeiwitz., “Analysis, Synthesis, and Design of Chemical Processes”, 2nd Edition, 2002, Prentice Hall ISBN-10: 0-13- 064792-6
4. Biegler L.T., Grossmann I.E. and Westerberg A.W., “Systematic Methods of Chemical Process Design”, 1997.PrenticeHall,

COURSE OUTCOMES:

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

1. Fundamental concepts and principles of processsynthesis
2. Flow sheet models, design software, processanalysis
3. Reactor network, separatontrains
4. Heat exchanger, network design
5. Residue curve maps for distillationcolumn

Mapping with PO& PSO														
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2							3			2	2	3
CO2	3		3		3				3		2	2	2	3
CO3	3	2	2						2			2	3	3
CO4	3	3			3				3		2	2	3	3
CO5	3				2				2			2	3	3

23CHCEPESCN	**CHEMICAL REACTOR ANALYSIS**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- To learn the heterogeneous catalyzed reactions and the models involved in reactordesign
- To study mass and heat transfer mechanisms in the differentreactors
- To appreciate the importance of both external and internal transport effects in gas-solid and liquid-solidsystems
- To design isothermal and non-isothermal reactors for heterogeneous catalyticreactions

Chemical factor affecting the choice of the reactor, fundamental mass, energy and momentum balance, Model for a semi-batch reactor, optimum operation policies and control strategies, optimal batch operation time, optimal temperature policies, stability of operation and transient behavior for mixed flow reactor. Transient CSTR analysis, Hot spot equation; Optimization using Lagrange multiplier, Poyntrgins maximumprinciple.

Fixed bed catalytic reactor: The importance and scale of fixed bed catalytic processes, factors in preliminary design, modeling of fixed bed reactor. Pseudo-homogeneous model, the multibed adiabatic reactor, auto-thermal operation, non-steady-state model with axial mixing, two dimensional pseudo-homogeneous models, heterogeneous models, global and intrinsic rates, Mechanism of catalytic reactions, Engineering properties of catalysts - BET surface area, pore volume, pore size, pore size distribution, one dimensional and two dimensional model equation.

Multiphase flow reactor: Types of multiphase flow reactors, packed columns, plate columns, empty columns, stirred vessel reactors.Development of rate equations for solid catalyzed fluid phase reactions; Estimation of kinetic parameters. External mass and heat transfer in catalyst particles. Stability and selectivity, Packed bed reactor, slurry reactor; Trickle bed reactor and fluidized bed reactor. Intra-particle heat and mass transfer - Wheelers parallel pore model, random pore model of Wakao and Smith. deactivation of catalyst, Ideal and non-ideal flow in reactors.

Design model for multiphase flow reactors, gas and liquid phase in completely mixed and plug flow, gas phase in plug flow and liquid phase in completely mixed flow, effective diffusion model, two zone model, specific design aspects, packed absorber, two-phase fixed bed reactor, plate column, spray tower, bubble reactor, stirred vessel reactor. Computer - aided reactor design.

Temperature effects in reactor: Introduction, well mixed system with steady feed, the stability and start-up of CSTR, limit cycles and oscillatory reactions, the plug flow reactors, tubular reactor, diffusion control, prorogation of reaction zone.

REFERENCES:

1. Froment G. F. and K.B.Bischoff, " Chemical Reactor Analysis and Design", John Wiley & Sons
2. Denbigh K. G. and J.C. Turner, " Chemical Reactor and Theory – an Introduction", 3rd edition Cambridge UniversityPress.
3. Bruce Nauman, " Chemical Reactor Design", John Wiley &Sons
4. Elements of Chemical Reaction Engineering by H. ScottFogler
5. Chemical Engineering Kinetics by J. M.Smith.
6. Chemical Reactor Design and Operation by K. R. Westerterp, W. P. M. Van Swaaij and A.A. C. M. Beenackers
7. Chemical Reactor Analysis and Design by G. F. Froment and K. B.Bischoff

COURSE OUTCOMES: At the end of the course, the student will be able to:
1. Evaluate heterogeneous reactor performance considering mass transferlimitations
2. Perform the energybalance
3. Estimate the performance of multiphase reactors under non-isothermalconditions
4. Obtain concentration profiles in multiphasereactors.
5. Understand the effects temperature in the reactors.

Mapping with PO& PSO														
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	3	3	2		2				3		2	2	2	2
CO2	3	2	3		2				2		2	2	2	2
CO3	3	3	3		2				3		2	2	2	2
CO4	3	2			2							2	2	2
CO5	3	2	2						2			2	2	2

23CHCEPESCN	FLUIDIZATION ENGINEERING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To study the phenomenon of fluidization with industrial processing objective
- To study the various regimes of fluidization and their mapping.
- To study the design of equipments based on fluidization technique

Introduction to fluidization and applications

Phenomenon of fluidization, behavior of fluidized bed, contacting modes, advantages and disadvantages of fluidization, fluidization quality, selection of contacting mode, Beds for Industrial applications, coal gasification, synthesis reactions, physical operations, cracking of hydrocarbons

Mapping of fluidization regimes

Characterization of particles, mechanics of flow around single particles, minimum fluidization velocity, pressure drop versus velocity diagram, The Geldart classification of solids, fluidization with carryover of particles, terminal velocity of particles, distributor types, gas entry region of bed, pressure drop requirements, design of gas distributor, power consumption

Bubbling fluidized beds

Davidson model for bubble in a fluidized bed, and its implications, the wake region and movement of solids at bubbles, coalescence and splitting of bubbles, bubble formation above a distributor, slug flow, Turbulent and fast fluidization - mechanics, flow regimes and design equations, Emulsion movement, estimation of bed properties, bubble rise velocity, scale up aspects, flow models, two phase model, K-L model

Solids movement and Gas dispersion

Vertical and horizontal movement of solids, Dispersion model, large solids in beds of smaller particles, staging of fluidized beds Gas dispersion in beds, gas interchange between bubble and emulsion, estimation of gas interchange coefficient, Heat and mass transfer in fluidized systems, Mixing in fluidized systems – measurements and models.

Fluidized bed reactors

Entrainment and elutriation, Freeboard behavior, gas outlet, entrainment from tall vessel, freeboard entrainment model, high velocity fluidization, pressure drop in turbulent and fast fluidization, Slugging, Spouted beds, Circulating Fluidized Beds.
Mathematical model of a homogeneous fluidized bed, Design of catalytic reactors, pilot plant reactors, information for design, bench scale reactors, design decisions, deactivating catalysts, Design of noncatalytic reactors, kinetic models for conversion of solids, models for shrinking particles, conversion of solids of unchanging size

REFERENCES:

1. Levenspiel O. and Kunnii D., "Fluidization Engineering", 1972 JohnWiley,
2. Liang-Shih Fan, "Gas-Liquid-Solid Fluidization Engineering", 1989 Butterworth's,

COURSE OUTCOMES:

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

1. Performing and understanding the behavior fluidization in fluidizedbed
2. Evaluate the characterization of particles and power consumption in fluidization regimes
3. Understanding the applicability of the fluidized beds in chemical industries
4. Evaluate the power consumption in fluidization regimes
5. Design the fluidized bed reactor

Mapping with PO& PSO														
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2							2			2	2	3
CO2	3	2	2						2		2	2	2	3
CO3	3	3	3		2				3		3	2	2	3
CO4	3	2	3						2		2	3	3	3
CO5	3	2			2				3			3	3	3

23CHCEPESCN	**INDUSTRIAL POLLUTION CONTROL**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- To understand the importance of industrial pollution and its abatement
- To study the underlying principles of industrial pollution control
- To acquaint the students with case studies
- Student should be able to design complete treatment system

Industries & Environment

Industrial scenario in India - Industrial activity and Environment - Uses of Water by industry - Sources and types of industrial wastewater - Industrial wastewater and environmental impacts - Regulatory requirements for treatment of industrial wastewater - Industrial waste survey – Industrial wastewater generation rates, characterization and variables - Population equivalent - Toxicity of industrial effluents and Bioassay tests.

Industrial Noise pollution

Sources of noise pollution, characterization of noise pollution prevention& control of noise pollution, Factories Act 1948 for regulatory aspects of noise pollution.

Air Pollutant Abatement

Air pollutants scales of concentration, lapse rate and stability, plume behavior, dispersion of air pollutants, atmospheric dispersion equation and its solutions, Gaussian plume models. Air pollution control methods, Source correction methods, Design concepts for pollution abatement systems for particulates and gases. Such as gravity chambers, cyclone separators, filters, electrostatic precipitators, condensation, adsorption and absorption, thermal oxidation and biological processes.

Waste water treatment processes

Design concepts for primary treatment, grid chambers and primary sedimentation basins, selection of treatment process flow diagram, elements of conceptual process design, design of thickner, biological treatment Bacterial population dynamics, kinetics of biological growth and its applications to biological treatment, process design relationships and analysis, determination of kinetic coefficients, activated sludge process. Design, trickling filter design considerations, advanced treatment processes, Study of environment pollution from process industries and their abatement: Fertilizer, paper and pulp, inorganic acids, petroleum and petrochemicals, recovery of materials from process effluents.

Solid waste and Hazardous waste management

Sources and classification, properties, public health aspects, Sanitary land fill design, Hazardous waste classification and rules, management strategies, Nuclear waste disposal Treatment methods – component separation, chemical and biological treatment, incineration, solidification and stabilization, and disposal methods, Latest Trends in solid waste management.

REFERENCES:

1. Rao C.S., "Environmental Pollution Control Engineering", 2ndedition
2. Mahajan S.P., "Pollution Control in Process Industries".
3. Nemerow N.L., "Liquid waste of industry- theories, Practices and Treatment", 1971 Addison Wesley, NewYork,
4. Weber W.J., "Physico-Chemical Processes for water quality control", 1969, Wiley IntersciencNewYork,
5. Strauss W., "Industrial Gas Cleaning", 1975, Pergamon,London,
6. Stern A.C., "Air pollution", 1968 Volumes I to VI, academic Press, NewYork,
7. Peterson and Gross .E Jr., "Hand Book of Noise Measurement", 2003, 7thEdn,.
8. Antony Milne, "Noise Pollution: Impact and Counter Measures", 2009. David &CharlesPLC,

COURSE OUTCOMES:

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

1. Know the principles of industrial pollution control
2. Recognize the causes and effects of environmental pollution
3. Analyze the mechanism of proliferation of pollution
4. Develop methods for pollution abatement and waste minimization
5. Design treatment methods for gas, liquid and solid wastes

Mapping with PO& PSO														
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	3											1	1	1
CO2	3	2	2			2			2			1	1	1
CO3	3	3	2			2			2			1	1	2
CO4	3	3	3			3			3		3	2	1	2
CO5	3	2	2			2			3		2	2	1	2

23CHCEPESCN	APPLICATION OF NANOTECHNOLOGY IN CHEMICAL ENGINEERING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To understand the fundamentals of the preparation and properties of nano materials from a chemical engineering perspective.
- To gain knowledge of structure, properties, manufacturing, and applications of various nano materials and characterization methods in nanotechnology
- To give a survey of the key processes, principles, and techniques used to build novel nanomaterials and assemblies of nanomaterials

Introduction

Introduction to nanotechnology, Feynman's Vision-There's Plenty of Room at the Bottom, Classification of nanostructures, Nanoscale architecture, Chemical interactions at nanoscale, Types of carbon basednanomaterials, Synthesisof fullerenes, Graphene, Carbon nanotubes,Functionalization of carbon nanotubes, One, two and multidimensional structures, Crystallography.

Approaches to Synthesis of Nanoscale Materials and characterization

Top down approach, Bottom up approach Bottom-up vs. top-down fabrication; Top-down: Atomization, Sol gel technique, Arc discharge, Laser ablation, RF sputtering; Bottom-up: Chemical Vapor Deposition (CVD), Metal Oxide Chemical Vapor Deposition (MOCVD), Atomic layer deposition (ALD), Molecular beam Molecular self-assembly; Ultrasound assisted, microwave assisted, Mini, micro and nanoemulsion. Wet grinding method, Spray pyrolysis, Ultrasound assisted pyrolysis, atomization techniques. Surfactant based synthesis procedures, Types of molecular modeling methods. Size, shape, crystallinity, topology, chemistry analysis usingX-ray imaging, Transmission Electron Microscopy, HRTEM, Scanning Electron Microscopy, SPM, AFM, STM, PSD, Zeta potential, DSC and TGA.

Semiconductors and Quantum dots

Intrinsic semiconductors, Extrinsic semiconductors, Review of classical mechanics, de Broglie's hypothesis, Heisenberg uncertainty principle Pauli exclusion principle Schrödinger's equation Properties of the wave function, Applications: quantum well, wire, dot, Quantum cryptography

Polymer-based and Polymer-filled Nanocomposites

Nanoscale Fillers, Nanofiber or Nanotube Fillers, Plate-like Nanofillers, Equi-axed Nanoparticle Fillers, Inorganic Filler Polymer Interfaces, Processing of Polymer Nanocomposites, Nanotube/Polymer Composites, Layered Filler Polymer Composite Processing, Nanoparticle/Polymer Composite Processing: Direct Mixing, Solution Mixing, In-Situ Polymerization, In-Situ Particle Processing, In-Situ Particle Processing Metal/Polymer Nanocomposites, Properties of nanocomposites.

Applications to Safety, Environment and Others

Chemical and Biosensors- Classification and Main Parameters of Chemical and Biosensors, Nanostructured Materials for Sensing, Waste Water Treatment, Nanobiotechnology, Drug Delivery, Nanocoatings, Self cleaning Materials, Hydrophobic Nanoparticles, Photocatalysts, Biological nanomaterials, Nanoelectronics, Nanomachines&nanodevices, Societal, Health and Environmental Impacts.

REFERENCES:

1. Louis Hornyak G., Dutta Joydeep, Tibbals Harry F. and Rao Anil K., "Introduction to Nanoscience", 2008, CRC Press of Taylor and Francis Group LLC, May, 856pp, ISBN-13: 978CN2004805
2. Ajayan P. M., SchadlerL. S., Braun P. V., "Nanocomposite Science and Technology", 2003. Edited by WILEY-VCH Verlag GmbH Co. KGaA, Weinheim ISBN:3-527-30359-6,
3. Kelsall Robert W., Hamley Ian W., GeogheganMark, "Nanoscale Science and Technology", 2006., John Wiley &Sons,Ltd,
4. KalRanganathan Sharma, "Nanostructuring Operations in Nanoscale Science and Engineering", 2010. McGraw-Hill Companies, Inc. ISBN:978-0-07-162609-5,
5. Nabok, Alexei, "Organic and inorganic nanostructures". 2005.-(Artech House MEMS series), ISBN 1-58053-818-5,

COURSE OUTCOMES:

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

1. Understanding the different top down and bottom up approaches fornanoparticles
2. Get to know the different applications of nanoparticles in chemical engineeringfield.
3. Learning the characterization techniques fornanoparticles.
4. Acquire knowledge on polymer based nano composites
5. Understand the applications of nanoparticles to safety and theenvironment.

Mapping with PO& PSO														
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	3					2			3			1		2
CO2	3	2	2						3		3	1		2
CO3	3								2			1		2
CO4	3											1		3
CO5	3					2			2			2		3

23CHCEPESCN	CHEMOINFORMATICS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To give students a concept of Chemo-informatics related to chemical structure databases and database searchmethods
- To understand the quantum methods and models involved in drug discovery and targeted drugdelivery
- To study the application of Chemical Libraries, Virtual Screening, Prediction of PharmacologicalProperties

Chemo-informatics

Introduction, scope and application, Basics of Chemo-informatics, Current Chemo-informatics resources for synthetic polymers, pigments. Primary, secondary and tertiary sources of chemical information, Databases: Chemical Structure Databases (PubChem, Binding database, Drugbank), Database search methods:chemical indexing, proximity searching, 2D and 3D structure and substructure searching. Drawing the Chemical Structure: 2D & 3D drawing tools (ACD Chemsketch) Structure optimization.

Introduction to quantum methods

Combinatorial chemistry (library design, synthesis and deconvolution), spectroscopic methods and analytical techniques, Representation of Molecules and Chemical Reactions:

Different types of Notations, SMILES Coding, Structure of Mol files and Sd files (Molecular converter, SMILESTranslator).

Analysis and use of chemical reaction information

Chemical property information, spectroscopic information, analytical chemistry information, chemical safety information, Drug Designing: Prediction of Properties of Compounds, QSAR Data Analysis, Structure-Activity Relationships, Electronic properties, Lead Identification, Molecular Descriptor Analysis.

Target Identification

Molecular Modeling and Structure Elucidation: Homology Modelling (Modeller 9v7, PROCHECK), Visualization and validation of the Molecule (Rasmol, Pymol Discovery studio), Applications of Chemoinformatics in Drug Research - Chemical Libraries, Virtual Screening, Prediction of Pharmacological Properties.

Drug Discovery

Structure based drug designing, Docking Studies (Target Selection, Active site analysis, Ligand preparation and conformational analysis, Rigid and flexible docking, Structure based design of lead compounds, Library docking), Pharmacophore - Based Drug Design, Pharmacophore Modeling (Identification of pharmacophore features, Building 2D/3D pharmacophore hypothesis), Toxicity Analysis-Pharmacological Properties (Absorption, Distribution and Toxicity), Global Properties (Oral Bioavailability and Drug-Likeness) (ADME, OSIRIS, and MOLINSPIRATION)

REFERENCES:

1. Bajorath J "Chemoinformatics: Concepts, Methods and Tools for Drug Discovery" (2004), HumanaPress
2. Leach A, Gillet V, "An Introduction to Chemoinformatics" Revised edition,Springer
3. Gasteiger J. Engel T. "A textbook of Chemoinformatics" Wiley- VCH GmbH &Co.KGaA
4. Bunin B. Siesel B. Guillermo M. "Chemoinformatics: Theory, Practice &Products",Springer
5. Lavine B. "Chemometrics and Chemoinformatics", (2005), American Chemical Society
6. Casteiger J. and Engel T "Chemoinformatics" (2003) Wiley-VCH
7. Bunin Barry A. Siesel Brian, Morales Guillermo,Bajorath Jürgen. Chemoinformatics: 2006. Theory, Practice, & Products Publisher:NewYork,Springer.
8. Leach Andrew R., Valerie J. Gillet, "An introduction to Chemoinformatics", 2003.Publisher: Kluwer academic, ISBN:1402013477
9. Gasteiger Johann, Handbook of Chemoinformatics: From Data to Knowledge (4Volumes), 2003. Publisher:Wiley-VCH.

COURSE OUTCOMES:

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

1. Prepare for professional work in chemistry must learn how to retrieve specific information from the enormous and rapidly expanding chemicalliterature.
2. Provide a broad overview of the computer technology to chemistry in all of its manifestations.
3. Expose the student to current and relevant applications inQSAR
4. Expose the student to current and relevant applications in DrugDesign.
5. Understand the concept of Chemoinformatics

Mapping with PO& PSO														
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	3	3	3		3	2			3		3	1	1	2
CO2	3	3	3		3				2		2	1	1	2
CO3	3	2	3		3				3		2	1	1	2
CO4	3	2	3		3				3		2	1		2
CO5	3	2			3				2			1	1	2

23CHCEPESCN	**MODERN CONCEPTS IN CATALYSIS AND SURFACE PHENOMENON**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- To give the students insight into advances in catalytic reactionengineering
- To understand the mechanisms involved in catalyticreactions
- To study the catalyst characterizationtechniques
- To study the advanced industrial applications incatalysis
- To understand the principles behind catalyst deactivation and study theirmodels

Introduction to Catalysis

Definition of Catalytic activity, Magnitude of Turnover Frequencies and Active Site Concentrations, Evolution of Important Concepts and Techniques in Heterogeneous Catalysis, Classification of Catalysts – Homogeneous, Heterogeneous, Biocatalysts, Dual Functional Catalysts, Enzymes, Solid Catalysts, Powder Catalysts, Pellets, Composition, Active Ingredients, Supportive materials, Catalysts Activation, Catalyst Deactivation.

Adsorption in Catalysis

Adsorption and its importance in Catalysis, Adsorption and potential energy curves, Surface Reconstruction, Adsorption Isotherms and Isobars, Dynamical Considerations, Types of Adsorption Isotherms and their Derivation from Kinetic Principles, Mobility at Surfaces, Kinetics of surface Reactions, Photochemistry on oxide and metallic surfaces, Characterization of the adsorbedmolecules

Catalyst Characterization

Catalyst Characterization Methods – Their Working Principle and Applications – XRF, XRD, IR Spectroscopy, XPS, UPS, ESR, NMR; Infrared, Raman, NMR, Mossbauer and X-Ray Absorption spectroscopy, Surface Acidity and Toxicity, Activity, Life time, Bulk density, Thermal stability Crystal Defects, Peroviskites,Spinels, Clays, Pillared Clays, Zeolites.

Significance of Pore Structure and Surface Area

Importance of Surface Area and Pore Structure, Experimental Methods for Estimating Surface Area – Volumetric, Gravimetric, Dynamic Methods, Experimental Methods for Estimating Pore Volume and Diameter – Gas Adsorption and Mercury Porosimeter Method, Models of the Pore Structure – Hysteresis Loops, Geometric Models, Wheeler's Model, Dusty Gas Model, Random Pore Model, Diffusion in Porous Catalysts – Effective Diffusivity, Knudsen Diffusion, Effect of Intraparticle Diffusion, Non-isothermal Reactions in Pores, Diffusion Control.

Industrial applications– Case Studies

Industrial processes involving heterogeneous solid catalyst: Synthesis of Methanol, Fiscer-Tropsch Catalysis, Synthesis of Ammonia, Automobile Exhaust Catalysts and Catalyst Monolith, Photocatalytic Breakdown of Water and the Harnessing of Solar Energy.

Contribution of homogeneous catalytic process in chemical industry: Oxidations of Alkenes such as production of acetaldehyde, propylene oxide etc., Polymerization such as production of polyethylene, polypropylene or polyester production

REFERENCES:

1. Emmett, P.H. - "Catalysis Vol. I and II, Reinhold Corp.", 1954 New York,
2. Smith, J.M. - "Chemical Engineering Kinetics ", 1971 McGrawHill,
3. Thomas and Thomas - "Introduction to Heterogeneous Catalysts ",1967 Academic Press, London
4. Piet W.N.M. van Leeuwen, Homogeneous catalysis: Understanding the Art, 2004,Springer,
5. Piet W.N.M. van Leeuwen, and John C. Chadwick, Homogeneous catalysis:Activity-stability –deactivation, 2011.Wiley, VCH,

COURSE OUTCOMES:

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

1. Understand the concepts of homogenous and heterogeneous catalysis, withspecific examples.
2. Study reaction mechanisms and kinetics of homogenous andheterogeneouscatalytic reactions.
3. Familiarize with the characterization ofcatalysts
4. Understand the mechanisms of several types of catalysts in chemical industry.
5. Understand the application of several types of catalysts in chemicalindustry.

Mapping with PO& PSO														
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2							3			2		2
CO2	3	2	2						3			2		2
CO3	3	3							3			2		2
CO4	3	3	3			2			3			2		2
CO5	3	3	3			2			3		3	2		2

23CHCEPESCN	**ADVANCED DOWNSTREAM PROCESSES**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- To understand the unit processes involved in downstream processing.
- To study advanced treatmen tmethods.
- To study the energy conservation in different separation processes
- To understand the underlying design principles

Introduction

Introduction to Downstream processes theory, applications in chemical separation for Gas-Liquid system, Gas-Solid system. Super critical fluids extraction in food, pharmaceutical, environmental and petroleum applications, water treatment, desalination, Bio separation, dialysis, industrial dialysis.

Downstream Processes in Petrochemical Industry

Cryogenic distillation for refinery, petrochemical off gases, natural gases, gas recovery-Olefin, Helium, Nitrogen, Desulfurization - coal, flue gases

Advanced Distillation Processes

Azeotropic& extractive distillation - residue curve maps, homogeneous azeotropic distillation, pressure swing distillation, Column sequences, heterogeneous azeotropic distillation.

Energy conservation in separation processes
Energy balance, molecular sieves - zeolights, adsorption, catalytic properties, manufacturing processes, hydrogel process, application, New trends.

Non-Ideal Mixtures and Ion Exchange
Separations process synthesis for nonazeotropic mixtures, non ideal liquid mixtures, separation synthesis algorithm, Ion exchange - manufacture of resins, physical & chemical properties, capacity, selectivity, application, regeneration, equipment, catalysis use.

REFERENCES:

1. Perry's "Chemical Engg. Handbook": McGraw Hill Pub.
2. Douglas J.M., "Conceptual Design of Chemical Processes",McGrawHill
3. Liu Y.A., "Recent Developments in Chemical Process & Plant Design", John Wiley &Sons Inc.
4. Timmerhaus K.D., "Cryogenic Process Engg.",PlenumPress
5. Othmer Kirk "Encyclopedia of Separation Technology, Vol I & II",WileyInterscience

COURSE OUTCOMES:

At the end of the course, the student will be able to:
1. Learn effective strategies of downstream processing in chemicalindustry.
2. Understand the role of downstreamprocessing.
3. Analyze reactors, upstream and downstream processes inproduction
4. Gain knowledge on energy conservation in separationprocesses
5. Understand the designprinciples.

Mapping with PO& PSO														
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	3		2			2			2			1		2
CO2	3					2			2			1		2
CO3	3	3	3		2				3		3	1		2
CO4	3	2	2						2		2	2		3
CO5	3	2	3		3				3		2	2		3

23CHCEPESCN	COMPUTATIONAL FLUID DYNAMICS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To make students understand the governing equations of fluid dynamics and their derivation from laws of conservation
- To develop a good understanding in computational skills, including discretisation, accuracy and stability.
- To acquaint the students with a process of developing a mathematical and geometrical model of flow, applying appropriate boundary conditions and solving system of equations.

Introduction to Fluid Dynamics
Concepts of Fluid Flow, Pressure distribution in fluids, Reynolds transport theorem, Integral

form of conservation equations, Differential form of conservation equations, Different Types of Flows, Euler and Navier Stokes equations, Properties of supersonic and subsonic flows, Flow characteristics over various bodies. Philosophy of CFD, Governing equations of fluid dynamics and there physical meaning, Mathematical behavior of governing equations and the impact on CFD simulations, Simple CFD techniques and CFL condition. Numerical Methods in CFD:Finite Difference, Finite Volume, and Finite Element, Upwind and downwind schemes, Simple and Simpler schemes, Higher order methods, Implicit and explicit methods, Study and transient solutions

Grid Generation

Basic theory of structured grid generation, Surface grid generation, Mono block, multi block, hierarchical multi block, Moving and sliding multiblock, Grid clustering and grid enhancement. Basic theory of unstructured grid generation, advancing front, Delaunay triangulation and various point insertion methods, Unstructured quad and hex generation, grid based methods, various elements in unstructured grids, Surface mesh generation, Surface mesh repair, Volume gridgeneration,Volumemeshimprovement,meshsmoothingalgorithms,gridclusteringandquality checks for volume mesh. Adaptive, Moving and Hybrid Grids, Need for adaptive and, moving grids, Tet, pyramid, prism, and hex grids, using various elements in combination

Turbulence and its Modelling

Transition from laminar to turbulent flow, Effect of turbulence on time-averaged Navier-Stokes equations, Characteristics of simple turbulent flows, Free turbulent flows, Flat plate boundary layer and pipe flow, Turbulence models, Mixing length model,The k-e model, Reynolds stress equation models, Algebraic stress equation models

Chemical Fluid Mixing Simulation

Stirred tank modeling using the actual impeller geometry, Rotating frame model, The MRF Model Sliding mesh model, Snapshot model, Evaluating Mixing from Flow Field Results, Industrial Examples

Post-Processing of CFD results

Contour plots, vector plots, and scatter plots, Shaded and transparent surfaces, Particle trajectories and path line trajectories, Animations and movies, Exploration and analysis of data.

REFERENCES:

1. Anderson John D., “Computational Fluid Dynamics: The Basics with Applications”, 1995, Mc GrawHill,
2. Ranade V.V., “Computational Flow Modeling for Chemical Reactor Engineering”, 2001Process Engineering Science, Volume5,
3. Knupp Patrick and Steinberg Stanly, “Fundamentals of Grid Generation”, 1994 CRCPress,
4. Wilcox D.C., “Turbulence Modelling for CFD”,1993
5. Wesseling Pieter, “An Introduction to Multigrid Methods”, 1992 John Wiley &Sons,
6. Thompson J.F., Warsi Z.U.A. and Mastin C.W., “Numerical Grid Generation:Foundations and Applications”, 1985, NorthHolland,
7. Patankar S.V., “Numerical Heat Transfer and Fluid Flow”, 1981McGraw-Hill,
8. Gatski Thomas B., Hussaini M. Yousuff and Lumley John L., “Simulation and Modellingof Turbulent Flows”, 1996, Oxford UniversityPress,
9. Laney, C. B., “Computational Gas Dynamics”, 1998. Cambridge Uni.Press,

COURSE OUTCOMES:

At the end of the course, the students will be able to:

1. Understand the basic principles of mathematics and numerical concepts of fluiddynamics.
2. Develop governing equations for a given fluid flowsystem.
3. Adapt finite difference techniques for fluid flowmodels.
4. Apply finite difference method for heat transferproblems.
5. Solve computational fluid flow problems using finite volumetechniques.

Mapping with PO& PSO														
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	3					2			2			1	1	1
CO2	3	3	3		2				3		3	1	1	1
CO3	3	3	3		3				3		3	1	2	2
CO4	3	3	3		3				3		3	2	3	3
CO5	3	3	3		3				3		3	2	3	3

23CHCEPESCN	**BIOPROCESS ENGINEERING**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- To learn the principles of bioprocessing for traditional chemical engineering in the design and development of processes involving biocatalyst.
- To study engineering principles in the development of products based on living cells or subcomponents of suchcells.
- To learn and develop quantitative models and approaches related tobio processes
- To learn mechanisitic models for enzyme catalyzed reactions for large scale production of bioproducts

Introduction

Biotechnology and bioprocessing. An overview of biological basics. Basics of enzyme and microbial kinetics. Operating considerations for bioreactors: cultivation method, modifying batch and continuous reactors, immobilized cell systems, solid state fermentations.

Advance Enzyme Kinetics

Models for complex enzyme kinetics, modeling of effect of pH and temperature, models for insoluble substrate, models for immobilized enzyme systems, diffusion limitations in immobilized enzyme system, electrostatic and steric effects.

Bioreactors

Selection, scale-up, operation and control of bioreactors: Scale-up and its difficulties, bioreactor instrumentation and control, sterilization of process fluids. Modifications of batch and continuous reactors, chemostat with recycle, multistage chemostat, fed-batch operation, perfusion system, active and passive immobilization of cells, diffusional limitations in the immobilized system, solid statefomenters.

Homogeneous and heterogeneous reactions in bioprocesses

Reaction thermodynamics, growth kinetics with Plasmid instability, The Thiele Modulus and effectiveness factor, diffusion and reaction in waste treatment lagoon. Reactors and choice of reactors.

Recovery and purification of products:
Strategies to recover and purify products, separation of insoluble products, cell disruption, separation of soluble products.

REFERENCES:
1. Bailey J.E. and Ollis D.F., "Biochemical Engineering Fundamentals",McGraw-Hill
2. Doran P.M., "Bioprocess Engineering Principles",AcademicPress
3. Shuler M.L., Kargi F., "Bioprocess Engineering", Prentice-Hall

Course Outcomes:
At the end of the course, the students will be able to:
1. Understand the principles of biotechnology and bioprocessengineering.
2. Understand the different cells and their use in biochemicalprocesses.
3. Understand the role of enzymes in kinetic analysis of biochemical reaction.
4. Analyze bioreactors, upstream and downstream processes in production ofbio-products
5. Demonstrate the fermentation process and its products for the latest industrialrevolution

Mapping with PO& PSO														
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	3					2			2			1		1
CO2	3					2			2		2	1		2
CO3	3	2		2		3			3		3	1		3
CO4	3	3	3	2		2			3		3	2		3
CO5	3	3	3		3				3		3	2		3

23CHCEPESCN	**PROCESS INTENSIFICATION**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:
- Understand the concept of ProcessIntensification.
- Know the limitations of intensification of the chemicalprocesses.
- Apply the techniques of intensification to a range of chemicalprocesses.
- Develop various process equipment used for intensifying theprocesses.
- Infer alternative solutions keeping in view point, the environmental protection, economic viability and socialacceptance.

Introduction: Techniques of Process Intensification (PI) Applications, The philosophy and opportunities of Process Intensification, Main benefits from process intensification, Process Intensifying Equipment, Process intensification toolbox, Techniques for PI application.

Process Intensification through micro reaction technology: Effect of miniaturization on unit operations and reactions, Implementation of Microreaction Technology, From basic Properties

To Technical Design Rules, Inherent Process Restrictions in Miniaturized Devices and Their

Potential Solutions, Microfabrication of Reaction and unit operation Devices - Wet and Dry Etching Processes.

Scales of mixing, Flow patterns in reactors, Mixing in stirred tanks: Scale up of mixing, Heat transfer. Mixing in intensified equipment, Chemical Processing in High-Gravity Fields Atomizer Ultrasound Atomization, Nebulizers, High intensity inline MIXERS reactors Static mixers, Ejectors, Tee mixers, Impinging jets, Rotor stator mixers, Design Principles of static Mixers Applications of static mixers, Higee reactors.

Combined chemical reactor heat exchangers and reactor separators: Principles of operation; Applications, Reactive absorption, Reactive distillation, Applications of RD Processes, Fundamentals of Process Modelling, Reactive Extraction Case Studies: Absorption of NOx Coke Gas Purification. Compact heat exchangers: Classification of compact heat exchangers, Plate heat exchangers, Spiral heat exchangers, Flow pattern, Heat transfer and pressure drop, Flat tube- and-fin heat exchangers, Microchannel heat exchangers, Phase-change heat transfer, Selection of heat exchanger technology, Feed/effluent heat exchangers, Integrated heat exchangers in separation processes, Design of compact heat exchanger - example.

Enhanced fields: Energy based intensifications, Sono-chemistry, Basics of cavitation, Cavitation Reactors, Flow over a rotating surface, Hydrodynamic cavitation applications, Cavitation reactor design, Nusselt-flow model and mass transfer, The Rotating Electrolytic Cell, Microwaves, Electrostatic fields, Sonocrystallization, Reactive separations, Superctrical fluids

REFERENCES:

1. Stankiewicz, A. and Moulijn, (Eds.), Reengineering the Chemical Process Plants, Process Intensification, 2003. MarcelDekker,
2. Reay D., Ramshaw C., Harvey A., Process Intensification, 2008.ButterworthHeinemann,
3. KameliaBoodhoo (Editor), Adam Harvey (Editor),Process Intensification Technologiesfor Green Chemistry: Engineering Solutions for Sustainable Chemical Processing,2013.Wiley,
4. Segovia-Hernández, Juan Gabriel, Bonilla-Petriciolet, Adrián (Eds.)Process Intensification in Chemical Engineering Design Optimization and Control,2016.Springer,
5. Reay, Ramshaw, Harvey, Process Intensification, Engineering for Efficiency, Sustainability and Flexibility, 2013.Butterworth-Heinemann,

COURSE OUTCOMES:

At the end of this course, students are able to:

1. Assess the values and limitations of process intensification, cleaner technologies andwaste minimizationoptions.
2. Measure and monitor the usage of raw materials and wastes generating from productionand frame the strategies for reduction, reuse andrecycle.
3. Obtain alternative solutions ensuring a more sustainable future based on environmental protection, economic viability and socialacceptance.
4. Analyze data, observe trends and relate this to othervariables.
5. Plan for research in new energy systems, materials and processintensification.

Mapping with PO& PSO														
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	3	3	3			3			3	2	2	1	1	2
CO2	3	2	3	3			2		2	2	2	1	1	2
CO3	3	3	3			3	2		3	3	3	1	1	3
CO4	3	3	3						2		3	1	2	3
CO5	3	3	2	2		2	3		3	2	2	1	2	3

23CHCEPESCN	PHASE TRANSITIONS IN PROCESS EQUIPMENT	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- Basic laws in thermodynamics.
- Basic statistical concepts and methods: heat, work, energy, temperature and the kinetic theory of matter; entropy, ensemble, partition function,etc
- Learning phase transition catalysis
- Have a good grasp of the basic thermodynamic interactions and process:adiabatic,isothermal,etc

Thermodynamic aspects of phase transitions: Concept of phase, First-order phase transition, conditions for phase coexistence lines, free energy barrier of nucleation, and crystal-melt interfacial free energy, Ehrenfest classification of phase transitions, Van der Waals equation of state, Critical point

Single phase and multiphase catalytic reactions, Acid--base catalysis, Transition metal catalysis, Phase transfer catalysis, Micellar catalysis, Microemulsion catalysis, Electron transfer catalysis, Heteropoly acid catalysis, Homogeneous polymer catalysis, Heterogenisation of homogeneous catalysts.

Applications to Multi-phase Systems Stability conditions for a homogeneous system, equilibrium between phases, phase transformations, general relations for a system with several components, general conditions for chemical equilibrium, chemical equilibrium between ideal gases, and the equilibrium constants in terms of partition functions.

Phase diagrams and transformations Phase rule- single and binary phase diagrams, lever rule, micro structural changes during cooling, Al_2O_3, Cr_2O_3, Pb-Sn, Ag-Pt and Fe-Fe_3C Systems phase diagrams, phase transformations, corrosion- theories of corrosion, control and prevention of corrosion

Energy balance - heat capacity and calculation of enthalpy changes, Enthalpy changes for phase transitions, evaporation, clausius - clapeyron equation,

REFERENCES:

1. Hegedus, L.S., Transition Metals in the Synthesis of Complex Organic Molecules, 3rd ed (2010). University ScienceBook
2. Raghavan V., Material Science and Engineering, 1996, Prentice Hall ofIndia,

3. David.M.Himmelblau, “Basic principles and calculations in chemical engineering”, 6th Edition, 1998. Prentice Hall of India Ltd.,
4. A.Hougen, K.M. Watson and K.A.Ragatz, “Chemical Process Principles”, Vol 1, 1960. JohnWiley,

COURSE OUTCOMES:

At the end of this course, students are able to:

1. Obtain considerable insight into various types of phase transitions, and how these can be described theoretically in differentways
2. Predict relationships between physical quantities using the laws and methods of thermodynamics.
3. Find probabilities and thermal quantities (free energy, entropy, etc) given the energy eigenvalues of asystem.
4. Understand phase diagrams andtransformations.
5. Solve the problems based on energybalance

Mapping with PO& PSO														
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	3	3	3						2		2	1	1	1
CO2	3	3	3						2		3	1	1	1
CO3	3	3									2	1	1	2
CO4	3	2				2			2			2	1	2
CO5	3	3	3						2		3	2	1	2

23CHCEPESCN	**MICRO AND NANO FLUIDICS**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- To introduce to the students, the various opportunities in the emerging field of micro and nano fluids.
- To the make students familiar with the important concepts applicable to small micro and nano fluidic devices, their fabrication, characterization and application.
- To get familiarize with the new concepts of real-time nano manipulation &assembly

Introduction: Fundamentals of kinetic theory-molecular models, micro and macroscopic properties, binary collisions, distribution functions, Boltzmann equation and Maxwellian distribution functions-Wall slip effects and accommodation coefficients, flow and heat transfer analysis of microscale Couette flows, Pressure driven gas micro-flows with wall slip effects, heat transfer in micro-Poiseuille flows, effects of compressibility. Pressure Driven Liquid Microflow: apparent slip effects, physics of near-wall microscale liquid flows, capillary flows, electro-kinetically driven liquid micro - flows and electric double layer (EDL) effects, concepts of electroosmosis, electrophoresis anddielectro-phoresis.

Laminar flow: Hagen-Poiseullieeqn, basic fluid ideas, Special considerations of flow in small channels, mixing, microvalves&micropumps, Approaches toward combining living cells, microfluidics and ‘the body’ on a chip, Chemotaxis, cell motility. Case Studies in Microfluidic Devices. Ionic transport: Polymer transport – microtubule transport in nanotuble channels driven by Electric Fields and by Kinesin Biomolecular Motors - Electrophoresis of individual nanotubules in microfluidic channels.

Fabrication techniques for Nanofluidic channels – Biomolecules separation using Nanochannels - Biomolecules Concentration using Nanochannels – Confinement of Biomolecules using Nanochannels. Hydrodynamics: Particle moving in flow fields – Potential Functions in Low Renoylds Number Flow – Arrays of Obstacles and how particles Move in them: Puzzles and Paradoxes in Low ReFlow.

Microfluidics and Lab-on-a-chip: Microfluidic Devices - Microchannels, Microfilters, Microvalves, Micropumps, Microneedles, Microreserviors, Micro-reaction chambers. Concepts and Advantages of Microfluidic Devices - Fluidic Transport - Stacking and Scaling – Materials for The Manufacture (Silicon, Glass, Polymers) - Fluidic Structures - Fabrication Methods – Surface Modifications - Spotting - Detection Mechanisms. Microcontact printing of Proteins Strategies printing types- methods and characterization- Cell nanostructure interactions-networks for neuronal cells. Applications in Automatic DNA sequencing, DNA and Protein microarrays.

BioMEMS (Micro-Electro-Mechanical Systems): Introduction and Overview, Biosignal Transduction Mechanisms: Electromagnetic Transducers Mechanical Transducers, Chemical Transducers, Optical Transducers – Sensing and Actuating mechanisms (for all types). Case Studies in Biomagnetic Sensors, Applications of optical and chemical transducers. Ultimate Limits of Fabrication and Measurement, Recent Developments in BioMEMS and BioNEMS - An alternative approach to traditional surgery, Specific targeting of tumors and other organs for drugdelivery,Micro-visualizationandmanipulation,Implantationofmicrosensors,microactuators and other components of a larger implanted device or external system (synthetic organs).

REFERENCES:

1. Joshua Edel “Nanofluidics” 2009. RCSpublishing,
2. PatricTabeling “Introduction to Microfluids” 2005.Oxford U. Press, NewYork
3. K. Sarit “Nano Fluids; Science and Technology”, 2007RCSPublishing,
4. M. Madou, Fundamentals of Microfabrication, 1997 CRCPress,
5. G. Kovacs, MicromachinedTransducers, 1998, McGraw-Hill,
6. Steven S Saliterman, Fundamentals of BioMEMS and Medical Microdevices,2006

COURSE OUTCOMES:

At the end of this course, students are able to:

1. Introduce students to the physicalprinciples
2. Analyze fluid flow in micro and nano-sizedevices.
3. Unifies the thermal sciences with electrostatics, electrokinetics, colloid science; electrochemistry; and molecularbiology.
4. Know the fabrication techniques for nanofludicchannels.
5. Acquire knowledge onbioMEMS

Mapping with PO& PSO														
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	3					2			2					
CO2	3	3	3						2					
CO3	3	2	2						2					2
CO4	3	3	3			2			3		2	2	2	2
CO5	3	2	2						3			2	2	2

		L	T	P	C
23CHCEPESCN	**PROCESS INTEGRATION**	**3**	**0**	**0**	**3**

COURSE OBJECTIVES:

- To introduce to the students, the various opportunities in the process integration in chemicalindustries.
- To the make students familiar with the important concepts process integration for heat recovery/minimization.
- To get familiarize with the casestudies.

Introduction to process Intensification and Process Integration (PI). Areas of application and techniques available for PI, onion diagram.

Pinch Technology-an overview: Introduction, Basic concepts, How it is different from energy auditing, Roles of thermodynamic laws, problems addressed by Pinch Technology, Key steps of Pinch Technology: Concept of _Tmin , Data Extraction, Targeting, Designing, Optimization Super targeting, Basic Elements of Pinch Technology: Grid Diagram, Composite curve, Problem Table Algorithm, Grand Composite Curve.

Heat exchanger networks analysis, Maximum Energy Recovery (MER) networks for multiple utilities and multiple, Chemical Engineering Pre-requisites: Knowledge of basic process design of process equipment. Pinches, design of heat exchanger network.

Heat integrated distillation columns, evaporators, dryers, and reactors.

Waste and waste water minimization, flue gas emission targeting, and heat and power integration. Casestudies.

REFERENCES:

1. ShenoyU.V.;"Heat Exchanger Network Synthesis", Gulf Publishingcompany.
2. Smith R.;"Chemical Process Design",McGraw-Hill.
3. Linnhoff B., Townsend D. W.,Boland D, Hewitt G. F., Thomas B.E.A., Guy A. R., and Marsland R. H.;"A User Guide on Process Integration for the Efficient Uses of Energy",Inst. of Chemical Engineers.

COURSE OUTCOMES:

At the end of this course, students are able to:

1. Understand the basics of process intensifications andintegration
2. Maximum heat recovery for a given process (both new processes, and retrofit of existing processes) identify opportunities for integration of high-efficiencyenergy.
3. Energy-intensive thermal separation operations (distillation, evaporation) at an industrial process site.
4. Evaluate the process integration measures with respect to energy efficiency, greenhouse gas emissions and economic performance.
5. Acquire knowledge on heat exchangeranalysis

Mapping with PO& PSO														
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	3								2			1		1
CO2	3	3	3				2		3		2	1		1
CO3	3	2	2						2		2	1		2
CO4	3	3	3			2	2			2	2	1		2
CO5	3								2			1		2

23CHCEPESCN	**TRANSPORT IN POROUS MEDIA**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- Introduce the physics and governing mechanisms controlling flow and transport processes in porous media.
- Learning Liquid and solute transport in porous media.

Fundamentals: Mass, momentum and energy transport, Darcy and Non-Darcy equations, equilibrium and non-equilibrium conditions, species transport, radioactive decay.

Effective medium approximation: equivalent thermal conductivity, viscosity, dispersion.

Exact solutions: Flow over a flat plate, flow past a cylinder, boundary-layers,reservoir problems.

Special topics: Field scale and stochastic modeling, Turbulent flow, compressible flow, multiphase flow, numerical techniques, hierarchical porous media, nanoscale porous media, multiscale modeling.

Engineering applications: Groundwater, waste disposal, oil and gas recovery, regenerators, energy storage systems. Experimental techniques: Flow visualization, quantitative methods, inverse parameter estimation.

REFERENCES:

1. M. Kaviany, Principles of Heat Transfer in Porous Media, (1995). Springer NewYork
2. D. R. Ingham and I. Pop,Transport Phenomena in Porous Media, Volumes I-III, (1998-2005). edited by Elsevier, NewYork
3. J. Bear, Dover Dynamics of Fluids in Porous Media,(1988).
4. J. Bear and Y. Bachmat, Introduction to Modeling of Transport Phenomena in Porous

Media, (1990). Kluwer Academic Publishers,London
5. L.W. Lake, Enhanced Oil Recovery, (1989).Gulf Publishing Co.Texas
6. R.E. Ewing, The Mathematics of Reservoir Simulation, (1983). SIAMPhiladelphia
7. Zhang, D.,Stochastic Methods for Flow in Porous Media: Coping with Uncertainties, (2002). Academic Press,California
8. Whitaker,The Method of Volume Averaging, (1999).S. Springer, NewYork

COURSE OUTCOMES:

At the end of this course, students are able to:

1. Understand the mechanisms involved in transport processes in porousmedia
2. Work with the equations that govern the fate and transport of gas, water and solutes in porousmedia.
3. Find solutions for variousproblems
4. Gain knowledge on flow visualization, quantitative methods and inverseparameters estimation.
5. Gain knowledge on engineeringapplications

Mapping with PO& PSO														
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	3	3	2			2			2			1	2	1
CO2	3	3	3		3				3		2	1	2	1
CO3	3	3	3			2			3	2	3	2	2	2
CO4	3	3	3		2				3		3	2	2	2
CO5	3	3			2	2			3	2	2	2	2	2

23CHCEPESCN	**MICRO FLOW CHEMISTRY AND PROCESS TECHNOLOGY**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- Introduce the students to micro flow chemistry and process technology.
- Learning Micromixers, Mixing Principles.
- Learning micro reactor based chemicals production

State of the Art of Microreaction Technology, Structural Hierarchy of Microreactors, Functional Classification of Microreactors, Fundamental Advantages of Microreactors, Advantages of Microreactors Due to Decrease of Physical Size, Advantages of Microreactors Due to Increase of Number of Units, Potential Benefits of Microreactors

Modern Microfabrication Techniques for Microreactors, Evaluation of Suitability of a Technique, Anisotropic Wet Etching of Silicon, Dry Etching of Silicon, LIGA Process, Injection Molding, Wet Chemical Etching of Glass, Advanced MechanicalTechniques

Micromixers, MixingPrinciples and Classes of Macroscopic Mixing Equipment,mixing Principles and Classes of Miniaturized Mixers, Mixing Tee-TypeConfiguration

Microsystems for Gas Phase Reactions, Catalyst Supply for Microreactors , Types ofas Phase Microreactors, Microchannel Catalyst Structures, H2/O2 Reaction, Selective Partial Hydrogenation of Benzene, Selective Oxidation of 1-Butene to Maleic Anhydride, Selective Oxidation of Ethylene to Ethylene Oxide, Oxidative Dehydrogenation of Alcohols, Synthesis of Methyl Isocyanate and Various Other Hazardous Gases, Synthesis of Ethylene Oxide, Oxidation of Ammonia

Microsystems for Energy Generation, Microdevices for Vaporization of Liquid Fuels, Microdevices for Conversion of Gaseous Fuels to Syngas by Means of Partial Oxidations, Hydrogen Generation by Partial Oxidations, Microdevices for Conversion of Gaseous Fuels to Syngas by Means of Steam Reforming

REFERENCES:

1. Wolfgang Ehrfeld, Volker Hessel, Holger LöweMicroreactorsNew Technology for Modern Chemistry2000.WILEY-VCH Verlag GmbH, D-69469 Weinheim (Federal Republic of Germany),
2. S.V. Luis and E. Garcia-Verdugo, Chemical Reactions and Processes under Flow Conditions, 2010 University Jaume I/CSIC, Castello´n, Spain, The Royal Society ofChemistry
3. Madhvanand N. Kashid, Albert Renken,andLioubov Kiwi-Minsker, Microstructured Devices for Chemical Processing, Wiley-VCH Verlag GmbH & Co. KGaA, Boschstr 12, 69469 Weinheim, Germany
4. Hessel, V., Renken, A., Schouten, J.C., Yoshida, Micro Process Engineering", 2009, A Comprehensive Handbook ISBN978-3-527-31550-5.

COURSE OUTCOMES: At the end of this course, students are able to:

1. Understand the role of micro flowchemistry
2. Gain the knowledge on process technology in chemicalengineering.
3. Obtain considerable insight into various types of microreactors.
4. Gain knowledge on micro systems for gas phasereactions
5. Gain knowledge on micro systems for energygenerations.

Mapping with PO& PSO														
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	3	3	2			2			2			2	2	2
CO2	3	3	3		2				3		2	2	2	2
CO3	3	3	3		3				3		3	2	2	3
CO4	3	3	2						2		3	2	2	3
CO5	3	3	2						2		3	2	2	3

23CHCEPESCN	PROCESS PLANT DESIGN & FLOW SHEETING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- Understanding of the scope, principles, norms, accountabilities and bounds of contemporary engineering practice in the specific discipline.
- Application of established engineering methods to complex engineering problem solving.
- Application of systematic engineering synthesis and design processes.

Introduction: Basic concepts: General design considerations, Process design development, Layout of plant items, Flow sheets and PI diagrams, Economic aspects and Optimum design, Practical considerations in design and engineering ethics, Degrees of freedom analysis in interconnected systems, Network analysis, PERT/CPM, Direct and Indirect costs, Optimum scheduling and crashing of activities.

Hierarchy of chemical process design; Nature of process synthesis and analysis; Developing a conceptual design and flow sheet synthesis. Synthesis of reaction-separation systems; Distillation sequencing; Energy targets. Heat integration of reactors, distillation columns, evaporators and driers; Process change for improved heat integration. Heat and mass exchange networks and network design.

Flow-sheeting: Synthesis of flow sheet: Propositional logic and semantic equations, Deduction theorem, Algorithmic flow sheet generation using P-graph theory, Sequencing of operating units, Feasibility and optimization of flow sheet using various algorithms viz, Solution Structure Generation (SSG), Maximal Structure Generation (MSG), Simplex, Branch-and-bound etc.

Analysis of Cost estimation: Factors affecting Investment and production costs, Estimation of capital investment and total product costs, Interest, Time value of money, Taxes and Fixed charges, Salvage value, Methods of calculating depreciation, Profitability, Alternative investments and replacements.

Optimum Design and Design Strategy: Break-even analysis, Optimum production rates in plant operation, Optimum batch cycle time applied to evaporator and filter press, Economic pipe diameter, Optimum insulation thickness, Optimum cooling water flow rate and optimum distillation reflux ratio.

REFERENCES:

1. Peters, M.A. and Timmerhaus, K.D., Plant Design and Economics for Chemical Engineers, (2003).McGrawHill
2. AnilKumar,ChemicalProcessSynthesisandEngineeringDesign,(1982).TataMcGrawHill
3. Ulrich, G.D., A Guide to Chemical Engineering Process Design and Economics, (1984).John Wiley &Sons
4. Perry, R.H. and Green, D., Chemical Engineer's Handbook, (1984).McGraw-Hill

COURSE OUTCOMES: At the end of this course, students are able to:
1. Analyze, synthesize and design processes for manufacturing productscommercially
2. Integrate and apply techniques and knowledge acquired in other courses such as thermodynamics, heat and mass transfer, fluid mechanics, instrumentation and control to design heat exchangers, plate and packed columns and engineering flowdiagrams
3. Use commercial flow sheeting software to simulate processes and design processequipment
4. Recognize economic, construction, safety, operability and other designconstraints
5. Estimate fixed and working capitals and operating costs for processplants

Mapping with PO& PSO														
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	3	3	3		3	2	2		3		3	2	2	3
CO2	3	3	3		3				3		3	2	2	3
CO3	3	3	3		3		3		3		3	2	2	3
CO4	3	3	3		3		3		3	3	3	2	2	3
CO5	3	3	3				3		3	3	3	2	2	3

		L	T	P	C
23CHCEPESCN	**DESIGN OF EXPERIMENTS AND PARAMETER ESTIMATION**	**3**	**0**	**0**	**3**

COURSE OBJECTIVES:

This subject provides students with the knowledge to

- Use statistics in experimentation;
- Understand the important role of experimentation in new product design, manufacturing process development, and process improvement;
- Analyze the results from such investigations to obtain conclusions; become familiar methodologies that can be used in conjunction with experimental designs for robustness and optimization.

Design of experiments. Basic concepts, Bias and confounding, controlling bias, causation, Examples. Random Variables: Introduction to discrete and continuous random variables, quantify spread and central tendencies of discrete and continuous random variables.

Exploratory Data Analysis Variable types, Displaying the distribution, mean variance and typical spread, quartiles and unusual spread, multivariate data: finding relations. Probability Definition of a random variable, expectation, percentiles, common distributions such as the binomial, Poisson and normal distributions.

Point Estimation Estimators as random variables, sample mean and the central limit theorem, normal approximations, assessing normality. Interval Estimation Confidence intervals for the mean when the variance is known, confidence interval for the mean when the variance is unknown, confidence intervals for a single proportion, sample size, Student distribution. Hypothesis Testing Hypothesis testing for a mean or proportion, testing the equality of two means assuming equal variances, testing the equality of two means with unequal variances, comparison of two proportions.

Linear Regression analysis: The linear regression model, Parameter estimation, accuracy of the coefficient estimates, checking the model, multiple linear regression, confidence and prediction intervals, potential issues, high leverage points, outliers. Matrix approach to linear regression, Variance-Covariance matrix, ANOVA in regression analysis, quantifying regression fits of experimental data, Extra sum of squares approach, confidence intervals on regression coefficients, lack of fit analysis.
Response Surface Methodology: Method of steepest ascent, first and second order models, identification of optimal process conditions

REFERENCES:

1. Hanneman, Robert A., Kposowa, Augustine J., Riddle, Mark D. Research Methods for the Social Sciences: Basic Statistics for Social Research. (2012). John Wiley & Sons.
2. Saunders, Mark, Brown, Reva Berman Dealing with Statistics: What You Need to Know. (2007). McGraw-HillEducation.
3. Cowles, Michael Statistics in Psychology: An Historical Perspective (2nd Edition). (2000). LawrenceErlb

COURSE OUTCOMES:

At the end of this course, students are able to:

1. Plan experiments for a critical comparison ofoutputs
2. Include statistical approach to propose hypothesis from experimentaldata
3. Implement factorial and randomized sampling fromexperiments
4. Estimate parameters by multi-dimensionaloptimization
5. Identify optimal processconditions

Mapping with PO& PSO														
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	3	3	3		3				3		3	2	2	2
CO2	3	3	3		3				3		3	2	3	3
CO3	3	3	3		3				3		3	2	3	3
CO4	3	3	3		3	2			3		3	3	3	3
CO5		3			3				2		3	3	3	3

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23CHCEPESCN	COMPUTER AIDED DESIGN	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To understand importance and applications of CAD in the field of chemical engineering
- To understand the basic structure and components of CAD software
- To understand the underlying thermodynamic and physical principles
- To give insight into the approaches used in the simulation of flowsheets
- To understand flow charts, computer languages and numerical methods used for writing algorithms

Introduction

Introduction to CAD, Scope and applications in chemical Engineering, Mathematical methods used in flow sheeting and simulation, Introduction to solution methods for linear and non-linear algebraic equations, solving one equation one unknown, solution methods for linear and nonlinear equations, general approach for solving sets of differential equations, solving sets of sparse non-linearequations.

Properties Estimation

Physical properties of compounds, Thermodynamic properties of gases and binary mixtures, Viscosity, Vapour pressure, Latent heat, Bubble point and drew point calculation, phase equilidria, Vapour-liquid equilibria, Liquid phase activity coefficients, K-values, Liquid phase activity coefficients, K-values, Liquid-Liquid equilidria, Gas solutions.

Equipment Design

Computer aided Design of Equipment: Design of Shell and Tube Heat exchangers; Design of Evaporators; Design of Distillation columns; Design of Reactors, Design of adsorption columns. Distillation columns (specific attention to multi components systems. Heat exchangers)

Computer Aided Flow Sheet Synthesis

Computerized physical property systems – physical property calculations, degrees of freedom in process design, degrees of freedom for a unit, degrees of freedom in a flow sheet, steady state flow sheeting and process design, approach to flow sheeting systems, introduction to sequential modular approach, simultaneous modular approach and equation solving approach, sequential modular approach to flow sheeting, examples. Tear streams, convergence of tear streams, partitioning and tearing of a flow sheet, partitioning and precedence ordering, tearing a group of units. Flow sheeting by equation solving methods based on tearing.

Dynamic Simulation

Numerical recipes in CLinear and nonlinear equations, Ordinary and partial differential equations, Dynamic simulation of stirred tanks system with heating Multi component system, Reactors, Absorption and distillation columns, Application of orthogonal collocation and weighted residuals techniques in heat and mass transfer systems, Introduction to special software for steady and dynamic simulation of Chemical engineering systems. Introduction to various commercial design software and optimizers used in field of chemical engineering.

REFERENCES:

1. Douglas James M., "Conceptual design of Chemical Processes",1988 McGraw -Hill Book Company, NewYork,
2. Remirez, W.F. - " Computational methods for Process Simulations ", Butterworths, New York,
3. Sinnott R.K. "Chemical Engineering", Volume 6, 1989, Pergamon Press, New York,
4. Westerberg A.W., et al, "Process Flow Sheeting", Cambridge UniversityPress
5. Biegler Lorenz T, et al, "Systematic method of Chemical Process Design",PrenticeHall
6. Crowe C.M., et al, "Chemical Plant Simulation-An Introduction to Computer Aided Steady State Analysis",PrenticeHall
7. Anil Kumar, "Chemical Process Synthesis and Engineering Design", 1981,TMH,

COURSE OUTCOMES:

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

1. Get the knowledge about computer Aided Flow SheetSynthesis
2. Computer aided equipment design of Evaporators; Distillation columns; Reactors, adsorptioncolumns.
3. Understand the principles of Computer aided flow sheetsynthesis
4. Understand the concept of dynamics simulation
5. Exposed to various design software.

Mapping with PO& PSO														
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	3	3	3		3				3		3	2	3	3
CO2	3	3	3		3				3		3	2	3	3
CO3	3	3			3				3		2	2	3	3
CO4	3	3			3				3		2	2	3	3
CO5	3	3			3				3		3	2	3	3

23CHCEPESCN	CLEANER PRODUCTION	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To give student an understanding about the concept of cleaner production.
- To understand in detail, the methodology involved
- Financial evaluation of cleaner production technologies
- To study the practical applications of cleaner production technologies

Introduction

Cleaner production definition: Evaluation of cleaner production, Cleaner production network, Area covered by cleaner production (what is not cleaner production?).Difference between cleaner production and other methods, End of the pipe treatment to curb pollution, prerequisites of cleanerproduction.

Cleaner production technique

Waste reduction at source, (a) Good housekeeping, (b) Process changes: change in raw material, batter process, control, equipment modification and technology changes, Recycling: on site recovery and reuse creation of useful byproducts, Product modification.

Cleaner production methodology

Methods of environmental protection -- preventive strategy, Methods of environmental protection -- preventive strategy, making team for cleaner production, Analyzing process steps, Generating C.P opportunities Selection of C.P solution, Implementing C.P solution

Concept of cleaner production

Overview of CP Assessment Steps and skills, Preparing for the site visit, Information Gathering, and process flow diagram, material balance, CP Option Generation Technical and Environmental feasibility analysis-Economic valuation of alternatives fuels, Total cost analysis-CP Financing- Establishing a program-Organizing a program preparing a programplan-Measuring progresspollution prevention and cleaner production Awareness plan -Waste audit-Environmental Statement.Energy audit related tocleaner production, Energy audit’s need and scope, Types of energy audit. Preliminary or walk through energy audit. Detailed energy audit, Methodology of energy audit, Energy balance and identifying the energy conservation opportunities.

Financial analysis of cleaner production

Gathering base line information, Determining the capital or investment cost, Establishing lifetime of equipment and annual depreciation, Determine revenue implication of the project. Estimating change in operating cost, Calculating incremental cash flow, Assessing project’s viability.

Case studies and Cleaner Production applications

Application (Industrial application of CP,LCA,EMS and Environmental Audits. C.P in chemical process industry, Practical ways & means to save material loss in loading/unloading and unit operations equipment like distillation column, drying and other equipments like heat exchanger, vacuum unit, conveying, etc. Practical ways & means for energy saving in industries. Case Studies of cleaner production.

REFERENCES:

1. "Cleaner Production Worldwide", 1993, United Nations Environment Programme, Industry and Environment, Paris,France.
2. "Cleaner Production: Training Resource Package", 1996, UNEP IE,Paris,
3. "Clean Technology for manufacture of Specialty Chemicals", Editor-W. Hoyle andM. Lancaster, Royal Society of Chemistry,U.K
4. Randall Paul M, "Engineers Guide to Cleaner ProductionTechnologies".
5. Ahluvalia V. K., "Green Chemistry: Environmentally BenignReactions".
6. Sanders R.E., "Chemical Process Safety: Learning from case Histories", Oxford Butter Worth Publication
7. "Training Manual Package" byNCPC

COURSE OUTCOMES:

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

1. Explain the concept and principles of cleaner production.
2. Suggest different unit operations in industrial production process to minimize pollutions.
3. Plan good housekeeping practices for Industry/other places with concern of safety,hygiene and waste reduction.
4. Suggest basic methods and techniques of pollution prevention during production.
5. Suggest cleaner production methods for a given situation which will also lead to cost reduction in longrun

Mapping with PO& PSO														
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	3	3							2			2	2	2
CO2	3	3	2						3		3	2	2	2
CO3	3	3	3						3	3	3	2	2	3
CO4	3	3	3						3	3	3	2	2	3
CO5	3	3	3				3		3	2	3	2	2	3

OPEN ELECTIVES

23CHCEOESCN	BUSINESS ANALYTICS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- Understand the role of business analytics within an organization.
- Analyze data using statistical and data mining techniques and understand relationships between the underlying business processes of an organization.
- To gain an understanding of how managers use business analytics to formulate and solve business problems and to support managerial decision making.
- To become familiar with processes needed to develop, report, and analyze business data.
- Use decision-making tools/Operations research techniques.
- Mange business process using analytical and management tools.

Business analytics: Overview of Business analytics, Scope of Business analytics, Business Analytics Process, Relationship of Business Analytics Process and organisation, competitive advantages of Business Analytics. Statistical Tools: Statistical Notation, Descriptive Statistical methods, Review of probability distribution and data modelling, sampling and estimation methods overview.

Trendiness and Regression Analysis: Modelling Relationships and Trends in Data, simple Linear Regression. Important Resources, Business Analytics Personnel, Data and models for Business analytics, problem solving, Visualizing and Exploring Data, Business Analytics Technology.

Organization Structures of Business analytics, Team management, Management Issues, Designing Information Policy, Outsourcing, Ensuring Data Quality, Measuring contribution of Business analytics, Managing Changes.

Descriptive Analytics, predictive analytics, predicative Modelling, Predictive analytics analysis, Data Mining, Data Mining Methodologies, Prescriptive analytics and its step in the business analytics Process, Prescriptive Modelling, nonlinear Optimization.

Forecasting Techniques: Qualitative and Judgmental Forecasting, Statistical Forecasting Models, Forecasting Models for Stationary Time Series, Forecasting Models for Time Series with a Linear Trend, Forecasting Time Series with Seasonality, Regression Forecasting with Casual Variables, Selecting Appropriate ForecastingModels.

Monte Carlo Simulation and Risk Analysis: Monte Carle Simulation Using Analytic Solver Platform, New-Product Development Model, Newsvendor Model, Overbooking Model, Cash Budget Model.

Decision Analysis: Formulating Decision Problems, Decision Strategies with the without Outcome Probabilities, Decision Trees, The Value of Information, Utility and Decision Making. Recent Trends in : Embedded and collaborative business intelligence, Visual data recovery, Data Storytelling and Data journalism.

REFERENCES:

1. Business analytics Principles, Concepts, and Applications by Marc J. Schniederjans, Dara G. Schniederjans, Christopher M. Starkey, Pearson FTPress.
2. Business Analytics by James Evans, personsEducation.

COURSE OUTCOMES:

At the end of this course, Students will
1. Demonstrate knowledge of data analytics.
2. Able to think critically in making decisions based on data and deepanalytics.
3. Able to use technical skills in predicative and prescriptive modeling to support business decision-making.
4. Demonstrate the ability to translate data into clear, actionableinsights.
5. Analyze and solve problems from different industries such as manufacturing, service, retail, software, banking and finance, sports, pharmaceutical, aerospaceetc.

Mapping with PO& PSO														
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	3	3	1	2	2	2	2		2			2	2	2
CO2	3	3	2	2	2	2	2		3		3	2	2	2
CO3	3	3	3	2	2	2	2		3	2	3	2	2	3
CO4	3	3	3	2	2	2	2		3	2	3	2	2	3
CO5	3	3	3	2	2	2	3		3	2	3	2	2	3

23CHCEOESCN	**INDUSTRIAL SAFETY**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- To know about Industrial safety programs and toxicology, Industrial laws, regulations and source models.
- To understand about fire and explosion, preventive methods, relief and its sizing methods

Industrial safety: Accident, causes, types, results and control, mechanical and electrical hazards, types, causes and preventive steps/procedure, describe salient points of factories act 1948 for health and safety, wash rooms, drinking water layouts, light, cleanliness, fire, guarding, pressure vessels, etc, Safety color codes. Fire prevention and firefighting, equipment and methods.

Fundamentals of maintenance engineering: Definition and aim of maintenance engineering, Primary and secondary functions and responsibility of maintenance department, Types of maintenance, Types and applications of tools used for maintenance, Maintenance cost & its relation with replacement economy, Service life of equipment.

Wear and Corrosion and their prevention: Wear- types, causes, effects, wear reduction methods, lubricants-types and applications, Lubrication methods, general sketch, working and applications, i. Screw down grease cup, ii. Pressure grease gun, iii. Splash lubrication, iv.Gravitylubrication, v. Wick feed lubrication vi. Side feed lubrication, vii. Ring lubrication, Definition, principle and factors affecting the corrosion. Types of corrosion, corrosion prevention methods.

Fault tracing: Fault tracing-concept and importance, decision tree concept, need and applications, sequence of fault finding activities, show as decision tree, draw decision tree for problems in machine tools, hydraulic, pneumatic, automotive, thermal and electrical equipment's like, I. Any one machine tool, ii. Pump iii. Air compressor, iv. Internal combustion engine, v. Boiler, vi. Electrical motors, Types of faults in machine tools and their general causes.

Periodic and preventive maintenance: Periodic inspection-concept and need, degreasing, cleaning and repairing schemes, overhauling of mechanical components, overhauling of electrical motor, common troubles and remedies of electric motor, repair complexities and its use, definition, need, steps and advantages of preventive maintenance. Steps/procedure for periodic and preventive maintenance of: I. Machine tools, ii. Pumps, iii. Air compressors, iv. Diesel generating (DG) sets, Program and schedule of preventive maintenance of mechanical and electrical equipment, advantages of preventive maintenance. Repair cycle concept and importance

REFERENCES:

1. Maintenance Engineering Handbook, Higgins & Morrow, Da InformationServices.
2. Maintenance Engineering, H. P. Garg, S. Chand andCompany.
3. Pump-hydraulic Compressors, Audels, Mcgrew HillPublication.
4. Foundation Engineering Handbook, Winterkorn, Hans, Chapman & HallLondon.

COURSE OUTCOMES:

On completion of the course, the student will be able to
1. Analyze the effect of release of toxicsubstances.
2. Understand the industrial laws, regulations and sourcemodels.
3. Apply the methods of prevention of fire andexplosions.
4. Understand the relief and its sizingmethods.
5. Understand the methods of preventivemaintenance.

Mapping with PO& PSO														
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	2	2	1	2		2	1		2	2		2	2	2
CO2	2	2	1	2		2	1		3	2		2	2	2
CO3	2	2	1	2		2	2		3	2		2	2	3
CO4	2	2	2	2		2	2		3	2		2	2	3
CO5	2	2	2	2		2	2		3	2		2	2	3

23CHCEOESCN	**OPERATIONS RESEARCH**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- Identify and develop operational research models from the verbal description of the real system.
- Understand the mathematical tools that are needed to solve optimization problems.
- Use mathematical software to solve the proposed models.

- Develop a report that describes the model and the solving technique, analyse the results and propose recommendations in language understandable to the decision-making processes in Management Engineering

Optimization Techniques, Model Formulation, models, General L.R Formulation, Simplex Techniques, Sensitivity Analysis, Inventory Control Models
Formulation of a LPP - Graphical solution revised simplex method - duality theory - dual simplex method - sensitivity analysis – parametricprogramming

Nonlinear programming problem - Kuhn-Tucker conditions min cost flow problem - max flow problem - CPM/PERT

Scheduling and sequencing - single server and multiple server models - deterministic inventory models - Probabilistic inventory control models - Geometric Programming.

Competitive Models,Single and Multi-channel Problems, Sequencing Models, Dynamic Programming, Flow in Networks, Elementary Graph Theory, Game Theory Simulation

REFERENCES:

1. H.A. Taha, Operations Research, An Introduction, 2008,PHI,
2. H.M. Wagner, Principles of Operations Research, 1982. PHI,Delhi,
3. J.C. Pant, Introduction to Optimisation: Operations Research, 2008 Jain Brothers,Delhi,
4. Hitler Libermann Operations Research: 2009 McGraw HillPub.
5. Pannerselvam, Operations Research2010: Prentice Hall ofIndia
6. Harvey M Wagner, Principles of Operations Research: 2010, Prentice Hall ofIndia

COURSE OUTCOMES:

At the end of the course, the student should be able to

1. Apply the dynamic programming to solve problems of discreet and continuousvariables.
2. Apply the concept of non-linearprogramming
3. Carry out sensitivityanalysis
4. Understand scheduling andsequencing
5. Model the real world problem and simulateit.

Mapping with PO& PSO														
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	3	3	2	2	2	2	2		2			2	2	2
CO2	3	3	2	2	2	2	2		2			2	2	2
CO3	3	3	3	2	2	2	2		2			2	2	3
CO4	3	3	3	2	2	2	2		2			2	2	3
CO5	3	3	3	2	2	2	2		2			2	2	3

23CHCEOESCN	COST MANAGEMENT OF ENGINEERING PROJECTS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- Prepare engineering students to analyze cost/revenue data and carry out make economic analyses in the decision making process to justify or reject alternatives/projects on an eco nomicbasis.

Introduction and Overview of the Strategic Cost Management Process Cost concepts in decision- making; Relevant cost, Differential cost, Incremental cost and Opportunity cost. Objectives of a Costing System; Inventory valuation; Creation of a Database for operational control; Provision of data for Decision-Making.

Project: meaning, Different types, why to manage, cost overruns centres, various stages of project execution : conception to commissioning. Project execution as conglomeration of technical and non technical activities. Detailed Engineering activities. Pre project execution main clearances and documents Project team : Role of each member. Importance Project site : Data required with significance. Project contracts. Types and contents. Project execution Project cost control. Bar charts and Network diagram. Project commissioning: mechanical and process Cost Behavior and Profit Planning Marginal Costing; Distinction between Marginal Costing and Absorption Costing; Break-even Analysis, Cost-Volume-Profit Analysis. Various decision- making problems. Standard Costing and Variance Analysis. Pricing strategies: Pareto Analysis. Target costing, Life Cycle Costing. Costing of service sector. Just-in-time approach, Material Requirement Planning, Enterprise Resource Planning, Total Quality Management and Theory of constraints.

Activity-Based Cost Management, Bench Marking; Balanced Score Card and Value-Chain Analysis.

Budgetary Control; Flexible Budgets; Performance budgets; Zero-based budgets. Measurement of Divisional profitability pricing decisions including transferpricing.

Quantitative techniques for cost management, Linear Programming, PERT/CPM,Transportation problems, Assignment problems, Simulation, Learning CurveTheory.

REFERENCES:

1. Cost Accounting AManagerial Emphasis, Prentice Hall of India, NewDelhi
2. Charles T. Horngren and George Foster, Advanced ManagementAccounting
3. Robert S Kaplan Anthony A. Alkinson, Management & CostAccounting
4. Ashish K. Bhattacharya, Principles & Practices of CostAccountingA. H. Wheeler publisher
5. N.D. Vohra, Quantitative Techniques in Management, Tata McGraw Hill Book Co.Ltd.

COURSE OUTCOMES:

On completion of this course, the student will be able to

1. Recognise the objectives of costing system and decisionmaking
2. Understanding various stages of project execution and role of each member in project team
3. Analyse basic project cost and time information and produce simple estimates andplans
4. Identify and managing resources usingPERT/CPM
5. Appraise project information and critique a project's likelysuccess

Mapping with PO& PSO														
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	3	3	2		2	2	3		2	2		2	2	2
CO2	3	3	2		2	2	3		3	2		2	2	2
CO3	3	3	3		2	2	3		3	2		2	2	3
CO4	3	3	3		2	2	3		3	2		2	2	3
CO5	3	3	3		2	2	3		3	2		2	2	3

23CHCEOESCN	**COMPOSITE MATERIALS**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- Students will be able to model, simulate and optimize the performance of composite structures as well as develop practical skills in one or more common manufacturing techniques.
- Students will be taught how to use and apply classical laminate theory to intelligently design laminates with tailored mechanical responses in commercial composite analysis software.
- The course will also include a design exercise for a composite component orstructure.

INTRODUCTION: Definition – Classification and characteristics of Composite materials. Advantages and application of composites. Functional requirements of reinforcement and matrix. Effect of reinforcement (size, shape, distribution, volume fraction) on overall composite performance.

REINFORCEMENTS: Preparation-layup, curing, properties and applications of glass fibers, carbon fibers, Kevlar fibers and Boron fibers. Properties and applications of whiskers, particle reinforcements. Mechanical Behavior of composites: Rule of mixtures, Inverse rule of mixtures. Isostrain and Isostress conditions.

Manufacturing of Metal Matrix Composites: Casting – Solid State diffusion technique, Cladding – Hot isostatic pressing. Properties and applications. Manufacturing of Ceramic Matrix Composites: Liquid Metal Infiltration – Liquid phase sintering. Manufacturing of Carbon – Carbon composites: Knitting, Braiding, Weaving. Properties andapplications.

Manufacturing of Polymer Matrix Composites: Preparation of Moulding compounds and prepregs – hand layup method – Autoclave method – Filament winding method – Compression moulding – Reaction injection moulding. Properties and applications.

Strength: Laminar Failure Criteria-strength ratio, maximum stress criteria, maximumstrain criteria, interacting failure criteria, hygrothermal failure. Laminate first play failure-insight strength; Laminate strength-ply discount truncated maximum strain criterion; strength design using caplet plots; stress concentrations.

REFERENCES:

1. Material Science and Technology – Vol 13 – Composites by R.W.Cahn – VCH, West Germany.
2. WD Callister, Jr., Adapted by R. Balasubramaniam, , Materials Science and Engineering, An introduction. 2007. John Wiley & Sons, NY, Indianedition,
3. K.K.Chawla.Hand Book of Composite Materials- Composite Materials,
4. Deborah D.L. Chung.Composite Materials Science and Applications.
5. Danial Gay, Suong V. Hoa, and Stephen W. Tasi.Composite Materials Design and Applications

COURSE OUTCOMES:

On completion of this course, the student will be able to

1. Identify, describe and evaluate the properties of fibre reinforcements, polymer matrix materials and commercial composites.
2. Develop competency in one or more common composite manufacturing techniques, and be able to select the appropriate technique for manufacture of fibre-reinforced composite products.
3. Analyse the elastic properties and simulate the mechanical performance of composite laminates; and understand and predict the failure behaviour of fibre-reinforced composites
4. Apply knowledge of composite mechanical performance and manufacturing methods to a composites design project
5. Critique and synthesise literature and apply the knowledge gained from the course in the design and application of fibre-reinforced composites.

Mapping with PO& PSO														
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	3	3	1	2		2			2			2	2	2
CO2	3	3	1	2		2			3			2	2	2
CO3	3	3	2	2		2			3	2		2	2	3
CO4	3	3	2	2		2			3	2		2	2	3
CO5	3	3	2	2		2			3	2		2	2	3

23CHCEOESCN	**WASTE TO ENERGY**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- To enable students to understand of the concept of Waste to Energy.
- To link legal, technical and management principles for production of energy form waste
- To learn about the best available technologies for waste to energy
- To analyze of case studies for understanding success and failures
- To facilitate the students in developing skills in the decision making process.

Introduction to Energy from Waste: Classification of waste as fuel – Agro based, Forest residue, Industrial waste - MSW – Conversion devices – Incinerators, gasifiers, digestors

Biomass Pyrolysis: Pyrolysis – Types, slow fast – Manufacture of charcoal – Methods - Yields and application – Manufacture of pyrolytic oils and gases, yields and applications.

Biomass Gasification: Gasifiers – Fixed bed system – Downdraft and updraft gasifiers – Fluidized bed gasifiers – Design, construction and operation – Gasifier burner arrangement for thermal heating – Gasifier engine arrangement and electrical power – Equilibrium and kinetic consideration in gasifier operation.

Biomass Combustion: Biomass stoves – Improved chullahs, types, some exotic designs, Fixed bed combustors, Types, inclined grate combustors, Fluidized bed combustors, Design, construction and operation - Operation of all the above biomass combustors.

Biogas: Properties of biogas (Calorific value and composition) - Biogas plant technology and status - Bio energy system - Design and constructional features - Biomass resources and their classification - Biomass conversion processes - Thermo chemical conversion - Direct combustion - biomass gasification - pyrolysis and liquefaction - biochemical conversion - anaerobic digestion - Types of biogas Plants – Applications - Alcohol production from biomass - Bio diesel production - Urban waste to energy conversion - Biomass energy programme inIndia.

REFERENCES:

1. Desai, Ashok V., Wiley Eastern Ltd., Non Conventional Energy,1990.
2. Khandelwal, K. C. and Mahdi, S. S., Biogas Technology -., 1983. A Practical Hand Book - Vol. I &II, Tata McGraw Hill Publishing Co.Ltd.
3. Challal, D. S., Food, Feed and Fuel from Biomass, 1991. IBH Publishing Co. Pvt.Ltd.,
4. C. Y. WereKo-Brobby and E. B. Hagan, Biomass Conversion and Technology, 1996. John Wiley&Sons,

COURSE OUTCOMES:

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

1. Apply the knowledge about the operations of Waste to EnergyPlants
2. Analyze the various aspects of Waste to Energy ManagementSystems
3. Carry out Techno-economic feasibility for Waste to EnergyPlants
4. Apply the knowledge in planning and operations of Waste to Energyplants
5. Design waste to energy plants and contribute to the society with social responsibility

Mapping with PO& PSO														
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	2	2	2	3		2			2	2		2	2	2
CO2	2	2	2	3		2			3	2		2	2	2
CO3	2	2	2	3		2			3	2		2	2	3
CO4	2	2	2	3		2			3	2		2	2	3
CO5	2	2	2	3		2			3	2		2	2	3