ANNAMALAI UNIVERSITY

FACULTY OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF CHEMICAL ENGINEERING

M.E.

CHEMICAL ENGINEERING

HAND BOOK
2017

DEPARTMENT OF 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):

1. Work as an engineering professional as individual or as a team member/leader.
2. Apply knowledge of mathematics, science, engineering fundamentals and core engineering subjects to define and apply them with proper improvisation to solve the chemical engineering problems.
3. Able to survey appropriate literatures, identify, formulate, and analyze broadly-defined Chemical engineering and allied problems.
4. Ability to select and handle analytical instruments
5. Understand and commit to professional ethics and responsibilities and norms of engineering technology and practice.

6. Capability to handle research and design problems and engage in further research activities
7. Commitment towards environmentally benign design and engineering.
8. To provide suitable environment and motivation for research activity.

Mapping PO with PEO								
PEO s/PO s	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
PEO1	√		√	√				
PEO2	√	√	√			√		
PEO3	√	√	√			√	√	
PEO4	√	√	√	√		√	√	
PEO5	√		√		√	√	√	√
PEO6	√		√		√		√	√

ANNAMALAI UNIVERSITY
FACULTY OF ENGINEERING AND TECHNOLOGY

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

CHOICE BASED CREDIT SYSTEM (CBCS)

REGULATIONS

1. **Condition 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 condition regarding qualifying marks and physical fitness as may be prescribed by the syndicate of the Annamalai University from time to time. The admission for 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 1**
3. **Courses of study**
   The courses of study and the respective syllabi for each of the M.E / M. Tech programmes offered by the different Departments of study are given separately.
4. **Scheme of Examinations**
   The scheme of Examinations is given separately.
5. **Choice Based Credit System (CBCS)**
   The curriculum includes three components namely Professional Core, Professional Electives and Open Electives in addition to Thesis. Each semester curriculum shall normally have a blend of theory and practical courses.
6. **Assignment of Credits for Courses**
   Each course is normally assigned one credit per hour of lecture / tutorial per week and one credit for two hours or part thereof for laboratory or practical per week. The total credits for the programme will be 65.
7. **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.
8. **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 II shall be done at the appropriate semesters.

9. Electives

The student has to select two electives in first semester and another two electives in the second semester from the list of Professional Electives. The student has to select two electives in third semester from the list of Open Electives offered by the department/ allied department. A student may be allowed to take up the open elective courses of third semester (Full Time program) in the first and second semester, one course in each of the semesters to enable them to carry out thesis in an industry during the entire second year of study provided they should 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.

Further, the two open elective courses to be studied in III semester (Full Time programme) may also be credited through the SWAYAM portal of UGC with the approval of Head of the Department concerned. In such a case, the courses must be credited before the end of III Semester.

10. Assessment

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	:	5 marks
End Semester Examination	:	75 marks

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

First assessment (Test-I)	:	15 marks
Second assessment (Test-II)	:	15 marks
Maintenance of record book	:	10 marks
End Semester Examination	:	60 marks

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.

11. Student Counsellors (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 counsellor for those students throughout their period of study. Such student counsellors shall advise the students, give preliminary approval for the courses to be taken by the students during each semester, monitor their progress in SWAYAM courses / open elective courses and obtain the final approval of the Head of the Department.

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 / 40 marks for practical and project work 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 65 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 65 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 65 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.

S.No.	Department		Programme (Full Time & Part time)	Eligible B.E./B.Tech Programme *
1	**Civil Engineering**	i.	Environmental Engineering	B.E. / B.Tech – Civil Engg, Civil & Structural Engg, Environmental Engg, Mechanical Engg, Industrial Engg, Chemical Engg, BioChemical Engg, 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 anf irrigation Engg, Geo informatics, Energy and Environmental Engg.
2	**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.	
3	**Mechanical Engineering**	i.	Thermal Power	B.E. / B.Tech – Mechanical Engg, Automobile Engg, Mechanical Engg (Manufacturing).
		ii.	Energy Engineering & Management	B.E. / B.Tech – Mechanical Engg, Automobile Engg, Mechanical (Manufacturing) Engg, Chemical Engg
4	**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, Industrial Engg.
		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
5	**Electrical Engineering**	i.	Embedded Systems	B.E. / B.Tech – Electrical and Electronics Engg, Control and Instrumentation Engg, Information technology, Electronics and communication Engg, Computer Science and Engg
		ii.	Smart Energy Systems	B.E. / B.Tech – Electrical and Electronics Engg, Control and Instrumentation Engg, Electronics and communication Engg,
		iii.	Power System	
		i.	Process Control & Instrumentation	B.E. / B.Tech – Electronics and Instrumentation Engg, Electrical and Electorics Engg, Control and Instrumentation Engg,

6	**Electronics & Instrumentation Engineering**			Instrumentation Engg
		ii.	Rehabilitative Instrumentation	B.E. / B.Tech – Electronics and Instrumentation Engg, Electrical and Electornics Engg, 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 Electornics Engg, Electronics and communication Engg, Control and Instrumentation Engg, Instrumentation Engg, Bio Medical Engg, Mechatronics, Telecommunication Engg
7	**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, Food Technology, Biotechnology, Biochemical Engg, Agricultural Engg.
		iii.	Industrial Bio Technology	B.E. / B.Tech - Chemical Engg, Food Technology, Biotechnology, Leather Technology
		iv.	Industrial Safety Engineering	B.E. / B.Tech – Any Branch of Engineering
8	**Computer Science & Engineering**	i.	Computer Science & Engineering	B.E. / B.Tech - Computer Science and Engineering, Information Technology, Electronics and Communication Engg, Software Engineering
9	**Information Technology**	i	Information Technology	B.E. / B.Tech - Computer Science and Engineering, Information Technology, Electronics and Communication Engg, Software Engineering
10	**Electronics & Communication Engineering**	i.	Communication Systems	B.E. / B.Tech - Electronics and Communication Engg, Electronics Engg.

*** AMIE in the relevant discipline is considered equivalent to B.E**

COURSES OF STUDY AND SCHEME OF EXAMINATIONS

Full-Time

Sl. No.	Category	Course Code	Course	L	P	T	CA	FE	Total	Credits
Semester – I										
1	PC-I	CHEC101	Applied Mathematics	4	-	-	25	75	100	3
2	PC-II	CHEC102	Advanced Process Control Systems	4	-	-	25	75	100	3
3	PC-III	CHEC103	Advanced Thermodynamics	4	-	-	25	75	100	3
4	PC-IV	CHEC104	Transport Phenomena	4	-	-	25	75	100	3
5	PE-I	CHEE 105	Professional Elective – I	4	-	-	25	75	100	3
6	PE-II	CHEE 106	Professional Elective – II	4	-	-	25	75	100	3
7	PC Lab-I	CHEP 107	Advanced Chemical Engineering Laboratory – I	-	3	-	40	60	100	2
			Total	**24**	**3**	**-**	**190**	**510**	**700**	**20**

Sl. No.	Category	Course Code	Course	L	P	T	CA	FE	Total	Credits
Semester – II										
1	PC-V	CHEC 201	System Optimization and Management Techniques	4	-	-	25	75	100	3
2	PC-VI	CHEC 202	Heterogeneous Reactor Design	4	-	-	25	75	100	3
3	PC-VII	CHEC 203	Advanced Heat Transfer	4	-	-	25	75	100	3
4	PC-VIII	CHEC 204	Petroleum Refinery Engg.	4	-	-	25	75	100	3
5	PE-III	CHEE 205	Professional Elective – III	4	-	-	25	75	100	3
6	PE-IV	CHEE 206	Professional Elective – IV	4	-	-	25	75	100	3
7	PC Lab-II	CHEP 207	Advanced Chemical Engineering Laboratory – II	-	3	-	40	60	100	2
8	Seminar	CHES 208	Seminar	-	2	-	100	-	100	1
			Total	**24**	**5**	**-**	**290**	**510**	**800**	**21**

Sl. No.	Category	Course Code	Course	L	P	T	CA	FE	Total	Credits
Semester – III										
1	OE-I	CHEE 301	Open Elective – I	4	-	-	25	75	100	3
2	OE-II	CHEE 302	Open Elective – II	4	-	-	25	75	100	3
3	Thesis	CHET 303	Thesis Phase-I	-	-	4	40	60	100	4
4	Ind Training	CHEI 304	Industrial Training		*	-	100	-	100	2
			Total	**8**	**-**	**4**	**90**	**210**	**300**	**12**

Note: * - Four weeks during the summer vacation at the end of IInd Semester.

Sl. No.	Category	Course Code	Course	L	P	T	CA	FE	Total	Credits
Semester – IV										
1	Thesis	CHET 401	Thesis Phase-II	-	-	8	40	60	100	13
			Total	**-**	**-**	**8**	**40**	**60**	**100**	**13**

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

Part Time

Sl. No.	Category	Course Code	Course	L	P	T	CA	FE	Total	Credits	Equivalent Course Code in M. E. Full Time
Semester – I											
1	PC-I	PCHEC 101	Applied Mathematics	4	-	-	25	75	100	3	CHEC 101
2	PC-II	PCHEC 102	Advanced Process Control Systems	4	-	-	25	75	100	3	CHEC 102
3	PC-III	PCHEC 103	Advanced Thermodynamics	4	-	-	25	75	100	3	CHEC 103
			Total	**12**	**-**	**-**	**75**	**225**	**300**	**9**	

Sl. No.	Category	Course Code	Course	L	P	T	CA	FE	Total	Credits	Equivalent Course Code in M. E. Full Time
Semester – II											
1	PC-IV	PCHEC 201	System Optimization and Management Techniques	4	-	-	25	75	100	3	CHEC 201
2	PC-V	PCHEC 202	Heterogeneous Reactor Design	4	-	-	25	75	100	3	CHEC 202
3	PC-VI	PCHEC 203	Advanced Heat Transfer	4	-	-	25	75	100	3	CHEC 203
			Total	**12**	**-**	**-**	**75**	**225**	**300**	**9**	

Sl. No.	Category	Course Code	Course	L	P	T	CA	FE	Total	Credits	Equivalent Course Code in M. Tech. Full Time
Semester – III											
1	PC-VII	PCHEC 301	Transport Phenomena	4	-	-	25	75	100	3	CHEC 104
2	PE-I	PCHEE 302	Professional Elective – I	4	-	-	25	75	100	3	CHEC 105
3	PE-II	PCHEE 303	Professional Elective – II	4	-	-	25	75	100	3	CHEC 106
4	PC Lab-I	PCHEP 304	Advanced Chemical Engineering Laboratory – I	-	3	-	40	60	100	2	CHEC 107
			Total	**12**	**3**	**-**	**115**	**285**	**400**	**11**	

S.No	Category	Course Code	Course	L	P	T	CA	FE	Total	Credits	Equivalent Course Code in M. E. Full Time
Semester – IV											
1	PC-VIII	PCHEC 401	Petroleum Refinery Engg.	4	-	-	25	75	100	3	CHEP 204
2	PE-III	PCHEE 402	Elective – III	4	-	-	25	75	100	3	CHEE 205
3	PE-IV	PCHEE 403	Elective – IV	4	-	-	25	75	100	3	CHEE 206
4	PC Lab-II	PCHEP 404	Advanced Chemical Engineering Laboratory – II	-	3	-	40	60	100	2	CHEP 207
8	Seminar	PCHES 405	Seminar	-	2	-	100	-	100	1	CHES 208
			Total	**12**	**5**	**-**	**215**	**285**	**500**	**12**	

Sl. No.	Category	Course Code	Course	L	P	T	CA	FE	Total	Credits	Equivalent Course Code in M. E. Full Time
Semester – V											
1	OE-I	PCHEE 501	Open Elective – I	4	-	-	25	75	100	3	CHEE 301
2	OE-II	PCHEE 502	Open Elective – II	4	-	-	25	75	100	3	CHEE 302
3	Thesis	PCHET 503	Thesis Phase-I	-	-	4	40	60	100	4	CHET 303
4	Ind Training	PCHEI 305	Industrial Training		*	-	100	-	100	2	CHEI 304
			Total	**8**	**-**	**4**	**90**	**210**	**300**	**12**	

Note: * - Four weeks during the summer vacation at the end of IVth Semester.

Sl. No.	Category	Course Code	Course	L	T	P	CA	FE	Total	Credits	Equivalent Course Code in M.E. Full Time
Semester – VI											
1	Thesis	PCHET 601	Thesis Phase-II	-	-	8	40	60	100	13	CHET 401
			Total	**-**	**-**	**8**	**40**	**60**	**100**	**13**	

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

LIST OF PROFESSIONAL ELECTIVES

S.No	Subject
1	Bio Technology
2	Electrochemical Engineering
3	Polymer Engineering
4	Biochemical Engineering
5	Mixing - Theory and Practice
6	Distillation
7	Industrial Drying
8	Advanced Separation Processes
9	Advanced Fluidization Engineering
10	Safety in Chemical Process Industries
11	Computer Aided Process Plant Design
12	Advanced Wastewater Treatment
13	Applications of Nanotechnology in Chemical Engineering

LIST OF OPEN ELECTIVES

S.No	Subject
1	Membrane Technology
2	Energy Conservation Technology
3	Air Pollution Control
4	Mathematical Modeling
5	Total Quality Management
6	Computational Fluid Dynamics

CHEC 101	APPLIED MATHEMATICS	L	T	P
		4	0	0

COURSE OBJECTIVES:

To acquaint the student with the concepts in

- Vector analysis
- Solving second order differential equation with variable coefficient
- Gamma and Beta functions
- Bessels and Legendre polynomials
- Multiple fourier series and their applications

Vector Analysis: Orthogonal curvilinear coordinates - cylindrical and spherical polar co-ordinates - expressions for gradients of a scalar point function. divergence and curve of a vector point function in orthogonal curvilinear co-ordinates.

Solving second order differential equation with variable coefficient: Complete solution when one integral of the complementary function is known - Reduction to normal form by the removal of the first derivative - Changing the independent variables - variation of parameters.

Special functions: Gamma, Beta functions - Solution of differential equations in series - Bessels function - Legendres poynominals and their properties.

Multiple Fourier series: Fourier series expansion of function of two and three variables - double Fourier sine series - Double Fourier cosine series - Triple fouierr cosine series.

Partial differential equations and Boundary value problems: Two dimensional wave equation in rectangular, cartesian and cylindrical polar co-ordinate systems-transverse and vibration of rectangular and circular membrance-two dimensional heat flow - transient state both in rectangular and circular plates. Three dimensional heat flow in transient spherical polar co- ordinate systems, steady state temperature distribution in solid spheres in spherical shells.

REFERENCES:

1. Mickeley, Sherwood and Reed: Applied Mathematics in Chemical Engineering, Tata McGraw Hill. New Delhi.
2. Pipes.L.A: Applied Mathematics for Engineering and science, Hartill McGraw Hill.
3. Venkataraman.M.K: Higher Mathematics for Engineering and Science, National Pub.Co., Madras-1.

COURSE OUTCOMES:

1. This course equips students to have knowledge and understanding in orthogonal curve linear coordinates and solving second order differential equation with variable coefficients
2. Students will be able to solve problems related to multiple fourier series and boundary value problems

Mapping with Programme outcomes								
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO1		√	√			√		
CO2		√				√		

CHEC 102	ADVANCED PROCESS CONTROL SYSTEMS	L	T	P
		4	0	0

COURSE OBJECTIVES:

- To impart advanced knowledge on the concepts of chemical process control
- To give an idea on indepth analysis of various processes and to get the input/output data
- To study the effect of time domain analysis and frequency domain analysis of a process
- To apply various computer architecture for the study of inputs to various complex systems and to get their output
- To study about multivariable processes, Z-transform and stability analysis and an indepth idea of identification of processes

Introduction: Some important Simulation Results, General Concepts and terminology, Laws, Languages and Levels of process control. Time Domain Dynamics: Classification and definition, linearization and perturbation variables, responses to simple linear systems, solutions using MATLAB.

Laplace - Domain Dynamics, Laplace - Domain Analysis of conventional feed back control systems Laplace-Domain analysis of advanced control systems. Frequency-domain Dynamics and Control: Frequency-Domain Dynamics, Frequency-Domain analysis of closed loop systems.

Conventional control systems and Hardware: Control Instrumentation performance of feedback controllers , controller tuning. Advanced control systems: Ratio control, cascade control, override control, computed variable control, nonlinear and adaptive control, valve position control, feed forward control aspects, control design concepts.

Interaction between steady state design and dynamic control lability qualitative examples, simple quantitative example, impact of controllability on capital investment and yield, general trade-off between controllability and thermodynamic reversibility, dynamic controllability, plant wide control.

Multivariable processes: Matrix representation and analysis, Design of Controllers for multivariable processes, sampling, Z_Transform and stability, stability analysis. Process identification: Fundamental concepts, direct methods, pulse testing, relay feedback identification, Least-square methods, use of MATLAB identification Toolbox.

REFERENCES:

1. Luyben.M.L, W. L.Luyben, Essentials of process control, McGraw Hill International Edn., 1997.

COURSE OUTCOMES:

On completion of this course, the students are able to

1. Understand the importance of control of a process
2. Analyze a process by giving various inputs
3. Concentrate on various complex systems and their behaviour
4. Analyze the stability of different processes and to identify a process by different techniques

Mapping with Programme outcomes								
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO1		√	√		√			
CO2		√	√			√		
CO3		√				√		
CO4		√						

CHEC 103	ADVANCED THERMODYNAMICS	L	T	P
		4	0	0

COURSE OBJECTIVES:

- This course will help to interpret, correlate, and predict thermodynamic properties used in mixture-related phase-equilibrium calculations.
- Basic statistical mechanical principles and intermolecular forces will be discussed, and applied to the correlation and prediction of thermodynamic properties and phase equilibria.
- Concepts of statistical thermodynamics along with classical thermodynamics, molecular physics, and physical chemistry will be applied to solve real-world problems.

Review of Basic Postulates, Maxwell's relations, Legendre Transformation, Pure Component properties, Theory of corresponding states, real fluids Equilibrium, Phase Rule, Single component phase diagrams.

Introduction to Multicomponent Multiphase equilibrium, introduction to Classical Mechanics, quantum Mechanics, Canonical Ensemble, Microcanonical Ensemble, Grand Canonical Ensemble, Boltzmann, Fermi-dirac and Bose Einstein Statistics, Fluctuations, Monoatomic and Diatomic Gases,

Introduction to Classical Statistical Mechanics, phase space, liouville equation, Crystals, Intermolecular forces and potential energy functions, imperfect Monoatomic Gases, Molecular theory of corresponding states,

introduction to Molecular Simulations, Mixtures, partial molar properties, Gibbs Duhems equations, fugacity and activity coefficients, Ideal and Non-ideal solutions, Molecular theories of activity coefficients, lattice models,

Multiphase multicomponent phase equilibrium, VLE/SLE/LLE/VLLE, Chemical Equilibrium and Combined phase and reaction equilibria.

REFERENCES:

1. McQuarrie D.A, Statistical Mechanics, Viva Books Private Limited, 2003.
2. Hill Terrel, An Introduction to Statistical Thermodynamics, Dover, 1960.
3. Allen MP, Tildesley DJ, Computer simulation of liquids, Oxford, 1989.
4. Callen, HB. Thermodynamics and an Introduction to Thermodstatics, 2nd Edition, John Wiley and Sons, 1985.
5. Prausnitz, J.M., Lichtenthaler R.M. and Azevedo, E.G., Molecularthermodynamics of fluid-phase Equilibria (3rd edition), Prentice Hall Inc., New Jersey,1996.
6. J.M. Smith. H.C.Van Ness and M.M.Abott. "Introduction to ChemicalEngineering Thermodynamics:. McGraw Hill International edition (5th ed.). 1996

COURSE OUTCOMES:

By the end of the course, a student should be able to:
1. Apply chemical engineering thermodynamics to phase and reaction equilibrium.
2. Use theoretical concepts to describe and interpret solution properties.
3. Apply statistical thermodynamics and molecular simulation to chemical engineering reaction systems.

Mapping with Programme outcomes								
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO1		√	√			√		
CO2		√	√					
CO3		√				√		

CHEC 104	**TRANSPORT PHENOMENA**	**L**	**T**	**P**
		4	**0**	**0**

COURSE OBJECTIVES:

- To give an overview of mass, momentum and energy transport, present the fundamental equations and illustrate how to use them to solve problems.
- To describe mass, momentum and energy transport at molecular, microscopic and macroscopic level, to determine velocity, temperature and concentration profiles.

Phenomenological Equations and Transport properties, Rheological behaviour of fluids, Balance Equations – Differential and Integral equations.

Applications in laminar and turbulent transport in compressible and incompressible fluids.Boundary layer theory

Macroscopic balance for isothermal and nonisothermal systems and their applications in Momentum, Heat and Mass transport problems.

Friction factor, Fluid –Fluid systems, Flow patterns in vertical and horizontal pipes, Formulation of bubbles and drops and their size distribution, Solid – fluid systems, Forces acting on stagnant and moving solids, Flow through porous medium, capillary tube model and its applications.

Heat Transfer coefficient, Forced convection in tubes, around submerged objects, Heat Transfer by free convection, film type and dropwise condensation and equations for heat transfer, Heat transfer in boiling liquids. Mass Transfer co-efficient in single and multiple phases at low and high mass transfer rates, Film theory, Penetration theory, Boundary layer theory, Macroscopic balance to solve steady and Unsteady state problems.

REFERENCES:

1. Bird R.B., Stewart, W. E. and Lightfoot, E. N., "Transport Phenomena", 2nd Edn.John Wiley and Sons, 2002.
2. Welty, J.R., Wicks, C. E. and Wilson, R. E., "Fundamentals of Momentum, Heat Mass Transfer", 5th Edn., John Wiley and Sons, 2007.
3. Brodkey, R. S. and Hershey, H. C., "Transport Phenomena – A Unified Approach", Brodkey Publishing, 2003.

COURSE OUTCOMES:

1. An understanding of molecular transport of momentum, heat, and mass.
2. Ability to set up and solve shell momentum, heat, and mass balances for one dimensional steady state problems.
3. An appreciation and some facility for dimensional analysis and knowledge of the dimensional numbers that are important in momentum, heat, and mass transfer applications.
4. An appreciation and some facility for solving inter phase transport problems which involve friction factors, drag coefficients, heat and mass transfer coefficients.

Mapping with Programme outcomes								
Cos	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO1		√				√		
CO2		√	√					
CO3	√	√						
CO4		√						

CHEP 107	**ADVANCED CHEMICAL ENGINEERING LABORATORY - I**	**L**	**T**	**P**
		0	**0**	**3**

COURSE OBJECTIVES:

- To understand basic principles of various chemical processes and working of the equipments
- To impart practical knowledge and have on experience on various techniques.

LIST OF EXPERIMENTS

1. Packed bed absorption column
2. Excess property determination
3. Liquid liquid extraction
4. Adiabatic reactor
5. Multiple reactor
6. UV-Visible spectrophotometer
7. Gas chromatography
8. High performance liquid chromatography
9. Atomic absorption spectrophotometer.

COURSE OUTCOMES:

1. To understand the basic principles of various chemical engineering operations
2. To develop a sound working knowledge on different chemical engineering operation
3. Better understanding of industrial operations by performing the experiments

Mapping with Programme outcomes								
Cos	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO1		√				√		
CO2		√	√					
CO3		√						

CHEC 201	SYSTEM OPTIMIZATION AND MANAGEMENT TECHNIQUES	L	T	P
		4	0	0

COURSE OBJECTIVES:

- The primary goal of this course is to provide an overview of state-of-the-art optimization algorithms, the theoretical principles that underpin them, and
- To provide students with the modelling skills necessary to describe and formulate optimization problems and their use for solving several types of practically relevant optimization problems arising in process systems engineering.

The Synthesis of Plausible Alternatives - Structure of systems, Economic Design Criteria and Cost Estimation.

Optimization: The search for optimum conditions- Linear programming – The Sub-optimization of systems with acylic structure – Macro Optimization System – strategies - Multilevel Attack on Very Large Problems.

Process Design Information - Accommodating for Future Development- Accounting For Uncertainty In Data, Failure Tolerance - Engineering Around Variations And Simulation

Programming Evaluation and Review Technique (PERT) - PERT Network and Time Estimates- Reduction Of Data- Commutation.

Critical Path Method (CPM) - Cost Analysis- Updating The Network Management And Network Analysis.

REFERENCES:

1. Rudd, F., C. Watson, Strategy of Process Engineering, John Wiley,1968.
2. PERT and CPM Principles and Applicstions, L.S.Srinath, 3rd Ed, Affiliated East-west press PVT, LTD. NEW DELHI
3. Optimization of Chemical Process Thomas F. Edgar, David. M. Himmelblau, McGraw-Hill Higher Education; 2 edition, 2001.
4. Engineering Optimization: Theory and Practice, Singaresu S. Rao, 4th Edition, John Wiley & Sons, 2009.

COURSE OUTCOMES:

After learning the course the students should be able to

1. Identify different types of optimization problems and understanding of different optimization technique

2. Apply the knowledge of optimization to formulate the problems and analyze the optimization criterion for solving problems
3. Apply simplex method for linear optimization problems and ability to solve various multivariable optimization problems
4. Ability to solve optimization using software tools and Identify different types of test of Hypotheses.
5. Understand how optimization can be used to solve the industrial problems of relevance to the chemical industry.

Mapping with Programme outcomes								
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO1		√	√			√		
CO2		√	√					
CO3		√						
CO4		√						
CO5		√				√		

CHEC 202	**HETEROGENEOUS REACTOR DESIGN**	**L**	**T**	**P**
		4	**0**	**0**

COURSE OBJECTIVES:

- To impart knowledge on catalytic reactions and catalyst preparation
- To develop the Knowledge of the impact of Mass and heat transfer effects on heterogeneous reactions.
- To understand Multiphase reactors (gas-liquid and fluid-solid reactions) concept in heterogeneous reactor
- To analysis and design of different heterogeneous reactor

Catalyst and characterization: Introduction catalysts and Reactions – catalyst preparation – characterization of catalyst – characterization of support, Catalyst Deactivation: Deactivation by sintering – Coking or fouling – poisoning – Moving bed reactor.

Catalytic reactions, rate controlling steps, Langmuir-Hinshelwood model, Rideal-Eiley mechanism, Non-catalytic fluid-solid reactions, single particle kinetics, shrinking and unreacted core model.

External diffusion effects in heterogeneous reactions- Mass and heat transfer coefficients in packed beds, quantitative treatment of external transport effects, modeling diffusion with and without reaction-Internal transport process-porous catalyst- Interpellet mass and heat transfer, evaluation of effectiveness factor, mass and heat transfer with reaction.

Fluid-Fluid Reactors- Rate equations – Kinetic regimes

Analysis and design of Heterogeneous Reactors- Packed bed reactors -Two-phase fluidized bed model- slurry reactor model- trickle bed reactor model-Experimental determination and evaluation of reaction kinetics for heterogeneous systems-Application to Design Reactors with particles of single size - mixture of particles of different sizes under plug flow and mixed flow conditions

REFERENCES:

1. Octave Levenspiel, Chemical Reaction Engineering, 3rd Edition, John Wiley & Sons, 1997
2. J.M. Smith, Chemical Kinetics, 3rd Edition, McGraw Hill., 1984.
3. Froment, G. F. and Bischoff, K. B., "Chemical Reactor Design and Analysis", 2nd Edition, John Wiley & Sons, New York, 1997.
4. Sharma, M.M. and Doraiswamy, L.K., "Heterogeneous reactions: Analysis, Examples and Reactor Design". Vols. I & II, John Wiley and Sons, NY, 1984.

COURSE OUTCOMES:

After learning the course the students should be able to

1. Understand the fundamentals of catalyst preparation and characterization.
2. Understand the effect of mass transport on observed rates in catalytic reactions.
3. Understand the importance of rate controlling steps in heterogeneous reaction system.
4. Understand the principles of heterogeneous reactor designs.

Mapping with Programme outcomes								
Cos	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO1		√				√		
CO2		√	√					
CO3		√						
CO4		√				√		

CHEC 203	ADVANCED HEAT TRANSFER	L	T	P
		4	0	0

COURSE OBJECTIVES:

- Apply scientific and engineering principles to analyze thermofluid aspects of engineering systems
- Use appropriate analytical and computational tools to investigate the steady state and unsteady state heat transfer phenomena
- To understand the heat transfer mechanisms in fluids and their applications in various heat transfer equipment in process industries.
- Recognize the broad technological context of heat transfer, especially related to energy technology

Transient heat conduction. Extended surfaces and fins. Numerical solutions for one-dimensional and two-dimensional steady state heat conduction problems. Unsteady state conduction: unidimensional and multidimensional systems-Use of transient heat conduction charts.

Convective heat transfer: theories and practice-energy equation for thermal boundary layer over a flat plate. Momentum and heat exchange in turbulent fluid flow- empirical equations for forced and free convection based on experimental results.

Heat transfer with change of phase: Phenomena of boiling and condensation- Regimes of pool boiling-heat transfer during boiling-dropwise and filmwise condensation-effects of turbulence and high vapour velocity on filmwise condensation.

Compact heat exchangers: plate and spiral type heat exchangers-finned tube heat exchangers- heat pipes-regenerators and recuperators.

Special topics in heat transfer: Heat transfer in magneto fluidynamic systems-transpiration cooling-ablation-heat transfer in liquid metals-heat transfer in fluidized beds- heat transfer processes in nuclear reactors

REFERENCES:

1. Knudsen.J.G., D.L.Katz, Fluid Dynamics and Heat Transfer, McGraw-Hill, New York, 1958.
2. Jacob.M., Heat Transfer, John Wiley, New York, 1962.
3. Mc Adams, Heat transmission, McGraw Hill, New York, 1954.
4. Holman.J.P., Heat Transfer, McGraw Hill, New York, 7th Edn..

COURSE OUTCOMES:

After the completion of this course, the students able to

1. Understand and solve steady state and unsteady state problems
2. Analyze the empirical equations in heat transfer
3. Design and analyze compact heat exchangers and
4. Analyze heat transfer in special cases

Mapping with Programme outcomes								
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO1		√				√		
CO2		√						
CO3		√	√					
CO4		√				√		

CHEC 204	PETROLEUM REFINERY ENGINEERING	L	T	P
		4	0	0

COURSE OBJECTIVES:

This course will present an overview of

- the modern, integrated petroleum refinery, its feedstocks and products
- the processes employed to convert crude oil and intermediate streams into finished products.
- hydrocarbon chemistry, crude oil properties and fuel product quality
- primary and secondary processes like atmospheric distillation, vacuum distillation, cracking, hydrocracking, catalytic reforming, processes for LOBS, coking and visbreaking, in a typical refinery.

Introduction: Composition of petroleum, laboratory tests, refinery feedstocks and products - evaluation of crude oil properties and Design of crude oil distillation column.

Thermal and Catalytic cracking: Coking and Thermal process, Delayed coking - Catalytic cracking, Cracking reactions, Zeolite Catalysts - Cracking Feedstocks and reactors, Effect of process variables - FCC Cracking, Catalyst coking and regeneration, Design concepts, New Designs for Fluidized-Bed Catalytic Cracking Units.

Catalytic Reforming: Objective and application of catalytic reforming process reforming catalysts – Reformer feed reforming reactor design continuous and semi regenerative process.

Hydrotreating and Hydrocracking: Objectives & Hydrocracking reactions, Hydrocracking feedstocks, Modes of Hydrocracking, Effects of process variables. - Hydro treating process and catalysts Resid hydro processing, Effects of process variables, Reactor design concepts.

Isomerization, Alkylation and Polymerization: Isomerization process, Reactions, Effects of process variables - Alkylation process, Feedstocks, reactions, products, catalysts and effect of process variables - Polymerization: Objectives, process, Reactions, catalysts and effect of process variables.

Lube Oil Manufacturing: Lube oil processing: propane deasphalting Solvent extraction, dewaxing, Additives production from refinery feedstocks.

Environmental issues and New Trends in petroleum refinery operations: Ecological consideration in petroleum refinery,Waste water treatment,control of air pollution, New trends in refinery, Alternative energy sources, Biodiesel, Hydrogen energy from biomass.

REFERENCES:

1. W.L..Nelson " Petroleum Refining Engineering " Mc Graw- Hill.
2. R.N.Watkins, " Petroleum Refinery distillation " Gulf Publishing Co.
3. Robert A Mayers " Hand book of petroleum refining process ".
4. James G Speight " The chemistry and technology of petroleum ".
5. J.H. Gary and G.E. Handwerk " Petrolem Refinery Technologies and economics ".
6. J.B.Maxwell, Data Book of Hydrocarbons.
7. W.C.Edmister, Applied Hydrocarbon Thermodynamics Vol I & II Gulf Publishing.
8. Joseph Hilyard , International petroleum encyclopedia 2008 (Vol.3).
9. American Petroleum Institute , Technical Data Book.

COURSE OUTCOMES:

After taking the course the students should have a clear comprehension of

1. Characterization of crude petroleum and petroleum refinery
2. Fractionation crude petroleum into useful fractions
3. Measurement of important physical properties of petroleum products
4. Application refinery processes to maximize desired petro products
5. Use of treatment techniques to purify petro products

Mapping with Programme outcomes								
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO1		√						
CO2		√						
CO3		√		√		√		
CO4		√					√	√

CHEP 207	ADVANCED CHEMICAL ENGINEERING LABORATORY - II	L	T	P
		0	0	3

COURSE OBJECTIVES:

- To understand basic principles of various processes
- To impart practical knowledge and have on experience on various techniques.

LIST OFEXPERIMENTS:

1. Estimation of COD
2. Estimation of BOD
3. Design of controller using MATLAB
4. Pneumatic & motorized control valves
5. Various inputs to process models
6. Computerized control of level of flow
7. Computerized control of level of temperature and pressure
8. Various software's used for control
9. Process identification methods

COURSE OUTCOMES:

1. To understand the basic principles of various chemical engineering and it allied field
2. To develop a sound working knowledge on different chemical engineering and its allied field operation
3. Better understanding of industrial operations by performing the experiments

Mapping with Programme outcomes								
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO1		√				√		
CO2		√	√					
CO3		√						

CHET 303	THESIS PHASE – I	L	T	P
		0	4	0

COURSE OBJECTIVES:

- To learn the ability to take data through literature survey
- To observe and assess the various Chemical Engineering operations in an industrial environment
- To document and present one's own work, for a given target group, with strict requirements on structure, format, and language usage

A thesis work on a specialized topic in Chemical Engineering should be taken at the beginning of the Third Semester in consultation with the Head of the Department. A report must be submitted at the end of the Third semester and there will be a Viva Voce examination on the thesis.

COURSE OUTCOMES:

After learning the course, the students should be able to

1. Come across different literatures relevant to his study

2. Reflect on, evaluate, and critically assess one's own and others' scientific results
3. Apply the relevant chemical engineering knowledge and skills, which are acquired within the technical area, to solve a given problem

Mapping with Programme outcomes								
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO1		√	√			√		
CO2		√	√					√
CO3		√	√	√		√	√	√

CHEI 304	**INDUSTRIAL TRAINING**	**L**	**T**	**P**
		0	**0**	**2**

COURSEOBJECTIVES

- To train the students in the field work related the Chemical Engineering and to have a practical knowledge in carrying out Chemical field related works.
- 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 / fourth 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 the third semester for Full-time / fifth semester for part-time. The students will be evaluated by a team of staff members nominated by head of the department through a viva-voce examination.

COURSE OUTCOMES

1. The students can face the challenges in the practice with confidence.
2. The student will be benefited by the training with managing the situation arises during the execution of works related to Chemical Engineering.

FPTT401	**THESIS PHASE – II**	**L**	**T**	**P**
		0	**8**	**0**

COURSE OBJECTIVES:

- To learn the ability to take data through literature survey
- To observe and assess the various chemical engineering operations in an industrial environment
- To document and present one's own work, for a given target group, with strict requirements on structure, format, and language usage
- To identify one's need for further knowledge and continuously develop one's own competencies

The thesis work on a specialized topic in Chemical Engineering already selected in the Third Semester will be continued in the fourth semester. A report must be submitted at the end of the Fourth semester and there will be a Viva Voce examination on the thesis.

COURSE OUTCOMES:

After learning the course, the students should be able to

1. Manage the selection and initiation of individual projects
2. Conduct project planning activities that accurately forecast the process scenarios
3. Reflect on, evaluate, and critically assess one's own and others' scientific results
4. Apply the relevant knowledge and skills, which are acquired within the technical area, to solve a given problem

Mapping with Programme outcomes								
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO1		√	√			√		
CO2		√	√			√		√
CO3		√	√					√
CO4		√	√	√		√	√	√

PROFESSIONAL ELECTIVES

CHEE XXX	BIOTECHNOLOGY	L	T	P
		4	0	0

COURSE OBJECTIVES:

- To create general understanding amongst the students in the subject of Biotechnology through in-depth lectures.
- To understand them a general overview, concepts and basic principles in the subject of Biotechnology with emphasis on how to apply the knowledge in bio processing engineering.
- To familiarize the student with enzymes, their kinetics, purification and applications in different fields.

Important classes of microbes, Characteristics of biological materials, Types of micro organisms, Shape and size of microbial cells, Isolation of microorganisms: Methods and media used, Identification, Classification and Nutrition of microorganisms. Chemicals of life: Sugars and Polysaccharides, Amino acids and Proteins.

Enzyme immobilization - Physical and chemical techniques for enzyme immobilization – Adsorption, matrix entrapment, encapsulation, cross-linking, covalent binding and suitable examples – Advantages and disadvantages – Medical and analytical applications of immobilized enzymes - Analysis of intraparticle diffusion and reaction - Enzymes-denaturation and renaturation, lock and key model.

Biotechnology of food and beverage products: Production of baker's yeast - Modern brewing technology, traditional fermented soybean foods, cheese technology and fermented dairy products. Biotechnology of pharmaceutical and industrial chemicals: Production of citric acid, lactic acid, acetone and butanol; antibiotics, vitamin B12, products from recombinant DNA technology.

Biotechnology applied to mineral processing: Biosorption and Bio-accumulation of heavy metals, microbial enhanced oil recovery, bio-pulping, and bio-bleaching. Biotechnology of waste management and pollution control: Biodegradation - Aerobic and anaerobic degradation, Activated sludge processes - oxidation ditches - aerated lagoons - waste stabilization ponds, land fills for the treatment of solid wastes.

Downstream Processing: Introduction, Removal of microbial cells and solid matter, Foam separation, Precipitation, Filtration, Centrifugation, Cell disruptions. Separation of soluble products, Liquid-liquid extraction, Aqueous two-phase extraction, Adsorption, Dialysis, Reverse osmosis, Ultra filtration, Chromatography, Electrophoresis, Electro dialysis, Crystallization and drying.

REFERENCES:

1. Bailey, J.E. and Ollis, D.F., Biochemical Engineering Fundamentals, McGraw-Hill, New York, 1986.
2. Rao, D.G., Introduction to Biochemical Engineering, Tata McGraw-Hill Publishing Company Limited, New Delhi, 2005.

3. Jogdand, S.N., 1995, Environmental Biotechnology, Himalaya Publishing House, Mumbai.
4. Rev. Fr Dr. Ignacimuthu, S.J., 1999, Basic Biotechnology, Tata McGraw Hill Publishing Company Ltd, New Delhi.
5. Comprehensive Biotechnology: Principles, Applications and Regulations of Biotechnology in Industry, Agriculture and Medicine, Murray - Moo-young, Pergamon Press Ltd. 1985.
6. Aiba, S., Humphrey, A.E. and Milli, N.R., Biochemical Engineering, 2nd edn, Academic Press, 1973.
7. Web, F.C., Biochemical Engineering, Van Nostrand, 1964.
8. Sanuelcate Prescott and Cecil Gordon Dunn, Industrial Microbiology, McGraw-Hill Book Company, Inc.

COURSE OUTCOMES:

At the end of the semester, it is expected that students

1. Understood the basic principles of engineering knowledge to solve a critical problem
2. Will be more confident to use the knowledge in pursuing Bioprocess knowledge in industrial biotechnological application.

Mapping with Programme outcomes								
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO1		√	√			√	√	
CO2		√				√		

CHEE XXX	**ELECTROCHEMICAL ENGINEERING**	**L**	**T**	**P**
		4	**0**	**0**

COURSE OBJECTIVES:

- To develop an understanding of electrochemical engineering
- Gain basic understanding of the fundamental concepts of electrochemical science and engineering such as electrolyte solution, electrochemical cell, electric conductivity, equilibrium electrochemistry, electrochemical kinetics, and current-potential relationship.

Review basics of electrochemistry: Faraday's law -Nernst potential –Galvanic cells –Polarography, The electrical double layer: It's role in electrochemical processes –Electro capillary curve –Helmoltz layer –Guoy –Steven's layer –fields at the interface.

Mass transfer in electrochemical systems: diffusion controlled electrochemical reaction –the importance of convention and the concept of limiting current. over potential, primarysecondary current distribution –rotating disc electrode.

Introduction to corrosion, series, corrosion theories derivation of potential-current relations of activities controlled and diffusion controlled corrosion process. Potential-pH diagram, Forms of corrosion- definition, factors and control methods of various forms of corrosion-

corrosioncontrol measures- industrial boiler water corrosion control –protective coatings – Vapor phase inhibitors –cathodic protection, sacrificial anodes –Paint removers.

Electro deposition –electro refining –electroforming –electro polishing –anodizing – Selective solar coatings, Primary and secondary batteries –types of batteries, Fuel cells.

Electrodes used in different electrochemical industries: Metals-Graphite –Lead dioxide – Titanium substrate insoluble electrodes –Iron oxide –semi conducting type etc. Metal finishing- cell design. types of electrochemical reactors, batch cell, fluidized bed electrochemical reactor, filter press cell, Swiss roll cell, plug flow cell, design equation, figures of merits of different type of electrochemical reactors.

REFERENCES:

1. Picket, “ Electrochemical Engineering “, Prentice Hall. 1977.
2. Newman, J. S., “ Electrochemical systems “, Prentice Hall, 1973.
3. Barak, M. and Stevenge, U. K., “ Electrochemical Power Sources - Primary and Secondary Batteries” 1980
4. Mantell, C., ” Electrochemical Engineering “, McGraw Hill, 1972.

COURSE OUTCOMES:

After learning the course the students should be able to

1. Understand the fundamentals of electrochemical principles
2. Expected to provide an in-depth analysis of electrochemical device operation, including a thermodynamic assessment of efficiencies
3. Use of appropriate modeling in quantitative characterization of kinetic, as well as comparative evaluation of different electrochemical cell.

Mapping with Programme outcomes								
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO1	√	√	√			√		
CO2		√	√	√		√		
CO3		√				√		√

		L	T	P
CHEE XXX	**POLYMER ENGINEERING**	**4**	**0**	**0**

COURSE OBJECTIVES:

- To impart knowledge on polymer engineering and its industrial applications
- To teach various method in manufacture of polymers
- To impart knowledge in design of reactors used to manufacture polymers

Classification of polymers, characterization of polymers -Thermal analysis, Morphological characterization, Physical testing.

Kinetics of polymerisation - Condensation, free radical, cationic, anionic, stereo regular polymerisation - polymerisation reaction engineering, Emulsion polymerisation - Smith and Ewart model. dispersion polymerisation - Fitch model.pearl and bead polymerisation, Solution polymerisation.

Polymerisation reactor design - Principles of reactor design, batch reactor, CSTR, plug flow reactor, design equations.

Rheology - Definitions, Simple shear flow, measurement of viscosity with various flow geometries like capillary viscometer, cone and plate viscometer, cup and bob viscometer.

Viscoelasticity - Mechanical models, Maxwell model, Voight model, response of models in creep, Streep, Stress relaxation dynamic experiments. Temperature dependency of viscosity. William Landel Ferry equation.

Processing operations - Description of various process operations such as extrusion calendering, moulding, block moulding, thermoforming, compounding and mixing of polymers.

REFERENCES:

1. Anil Kumar and S.K.Gupta, Fundamentals of polymer Science and Engineering, Tata-McGraw Hill Publications. 1981.
2. Crawford.R.J., Plastic Engineering, 2^{th} Edn., Pergamon Press, 1989.

COURSE OUTCOMES:

1. Students will develop knowledge in polymerisation techniques
2. Knowledge in chemical kinetics of polymwer products
3. Knowledge on properties uses and structures of polymers
4. Knowledge in rheological instruments and reactors for polymers

Mapping with Programme outcomes								
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1		√						
CO2		√	√					
CO3		√						
CO4		√		√		√	√	√

CHEE XXX	BIOCHEMICAL ENGINEERING	L	T	P
		4	0	0

COURSE OBJECTIVES:

- To develop an understanding of Enzymatic activity, Enzyme kinetics and Application of Enzymes.
- To understand transport in microbial systems
- To understand the concept of design and analysis of Ideal bioreactors
- To study Downstream processing

Introduction and characteristics of biological materials: the enzyme-substrate complex and enzyme action - simple enzyme kinetics with one and two substrates - other patterns of substrate concentration dependence - modulation and regulation of enzymatic activity - enzyme deactivation - application of enzymes - immobilized enzyme technology - immobilized enzyme kinetics.

Kinetics of substrate utilization, product formation and biomass production in cell cultures: Ideal reactor for kinetics measurements -kinetics of balanced growth - Transient growth kinetics - product formation kinetics - thermal death kinetics of cells and spores.

Transport in Microbial Systems: Gas-liquid mass transfer in cellular systems - mass transfer freely rising or falling bodies - forced convective mass transfer - overall Kla'. Estimates and power requirements for sparged and agitated vessels - mass transfer across free surfaces - other factors affecting Kla' - Non-Newtonian fluids - scaling of mass transfer equipment - Heat transfer - Heat transfer correlations.

Design and Analysis of Biological Reactors: Ideal bioreactors - Reactor Dynamics - Reactors with nonideal mixing - Sterilization Reactors - Immobilized Biocatalyst - Multiphase Bioreactors - fermentation Technology - Animal and plant cell reactor technology.

Downstream processing and Effluent treatment: Recovery of cells and solid particles - Product Isolation - chromatography and fixed-bed Adsorption - Membrane Separations - Product recovery trains, Biosensors, Biological Wastewater Treatment Systems.

REFERENCES:

1. J.E.Bailey and D.F.Oills, Biochemical Engineering Fundamentals, McGraw-Hill, New York, 1986.
2. S.Aiba, A.E. Humphrey and N.R. Milli, Biochemical Engineering, 2nd

Edition, Academic press, 1973.
3. F.C. Web, Biochemical Engineering, Van Nostrand, 1964.

COURSE OUTCOMES:

After learning the course the students should be able to
1. Understand the fundamentals of Enzymatic activity and kinetics.
2. Able to apply the Kinetics of substrate utilization, product formation and biomass production.
3. Understand Design and analysis of biological reactors.
4. Use appropriate Downstream processing and Effluent treatmentns.

Mapping with Programme outcomes								
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO1		√				√		
CO2		√	√					
CO3		√						
CO4		√				√		√

CHEE XXX	**MIXING – THEROY AND PRACTICE**	**L**	**T**	**P**
		4	**0**	**0**

COURSE OBJECTIVES:
- To impart knowledge on liquid mixing in Chemical Engineering
- To study about the equipments used in mixing and scale up of mixing equipments
- To study about the design and power requirement of mixing stirred tanks

Theory and Practice of mixing - Mixing in stirred tanks –

Power requirements in liquid mixing- Scale up of liquid mixing systems

Heat Transfer in Stirred Tanks, Liquid- Liquid Extraction in Stirred Tanks

Agitation of non-Newtonian liquids in Stirred Tank Reactors.

Design of auxiliary equipments and materials of constructions for Stirred tanks

REFERENCES:

1. Uhl and Gray, Mixing theory and practice, Vol.1 and II, Academic Press, New York and London 1967
2. Holland and Chapman - Liquid Mixing and processing in Stirred Tanks, Reinhold Publishing Co-operation, New York and London, 1966.
3. Shinji Nagata, Mixing Principles and Applications, Holted Press, Tokyo, 1975
4. S.D Dawande , Process design of equipments, Vol 1.Central techno publications, III edition 2003.

COURSE OUTCOMES:
1. Students attain knowledge in mixing of liquids in stirred tanks and its chemical engineering applications
2. Heat and mass transfers studies in stirred tanks
3. Design of auxiliary equipments used in mixing

Mapping with Programme outcomes								
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO1		√				√		
CO2		√	√					
CO3		√	√			√		

CHEEXXX	**DISTILLATION**	**L**	**T**	**P**
		4	**0**	**0**

COURSE OBJECTIVES:

- To understand the various principles, practices Vapour Liquid separation process
- To learn the various methods of distillation.
- To apply a design of distillation coloumn using different graphical methods and analytical methods .
- To learn the various problems associated with distillation column.

Thermodynamics of equilibrium vapour liquid equilibria of ideal and non ideal solutions-Binary and Multi component systems. Correlation and prediction of VLE data (Brief outlines only).

Principles of differential distillation and steam distillation. Equilibrium Flash vaporisation. Hydrocarbon water mixtures.

Binary distillation Determination of minimum and total reflux calculations for the number of equilibrium stages- Analytical and graphical methods-problems with open steam side streams.

Multiple feeds-batch columns multicomponent distillation: Preliminary calculations - selection of key components- Rigorouis calculations - Methods of Sorel. Lewis-sorel, Thiele-Geddes and Short cut methods.

Azeotropic and extractive Distillation :Separation of azeotrops selection of solvents and entrainers, column design by pseudo ternary and pseudo binary methods. Solvent recovery. Design of distillation equipment, plate and packed columns.

REFERENCES:

1. Van Winkle.M., Distillation, Chemical Engineering Series, McGraw Hill, NewYork, 1967.
2. Henry Kister., Distillation Operation, McGraw Hill Professional, 1990.
2. Treybal, R. E., “ Mass-Transfer Operations”, 3rd Eddition, McGraw-Hill, 1981

COURSE OUTCOMES:

1. The student would be able to understand the vapour liquid equilibrium and separation process
2. Effective process design of distillation coloumn using various methods.

Mapping with Programme outcomes								
Cos	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO1		√				√		
CO2		√	√			√		

CHEE XXX	INDUSTRIAL DRYING	L	T	P
		4	0	0

COURSE OBJECTIVES:

- To give an overview of drying, absorption, heat transfer, mass transport and the drying characteristics of solids to solve the drying problems.
- To describe the mass transport from solids in microscopic and macroscopic level, to determine the rate of drying and its profiles.
- To study various types of industrial important and commercial dryers.

Fundamentals of drying. Psychometric, absorption, transport phenomena in porous media. Heat transfer to particles, beds and surfaces evaporation form drops and surfaces, simultaneous heat and mass transfer drying characteristics for batch and continuous drying.

Types, Classification and selection of Industrial dryers-Tray dryers-Through-circulation dryer-Rotary dryer-Pneumatic dryer- fluid bed dryer-spray dryer-Indirect agitated dryer-Infrared, Freeze and Dielectric dryers-drying of gases. Industrial drying, applications to such areas as drying of paper, pharmaceuticals, food products and fine chemicals.

REFERENCE:

1. Industrial Drying, A.W.Gardner,Leonard Hill,London,1971.

COURSE OUTCOMES:

1. Gain knowledge about the basics of drying phenomena
2. Aware of the characteristics of drying and its nature.
3. Types of dryers used in the industries and commercially available dryers are well known.

Mapping with Programme outcomes								
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1		√				√		
CO2		√	√					
CO3		√	√					

CHEE XXX	ADVANCED SEPARATION PROCESSES	L	T	P
		4	0	0

COURSE OBJECTIVES:

- To impart knowledge of recent advancement in research and development in novel separation processes.
- 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.

Introduction to Separation Processes

Review of conventional processes, recent advances in separation techniques based on size, surface properties, ionic properties and other special characteristics of substances, Process concept, Theory and equipment used in cross flow filtration, cross flow electro filtration, dual functional filter, Surface based solid - liquid separations involving a second liquid, Sirofloc filter.

Membrane Separations

Types and choice of membranes, Plate and frame, tubular, spiral wound and hollow fibre membrane reactors and their relative merits, Commercial, pilot plant and laboratory membranes permeators involving dialysis, reverse osmosis, Design aspects of Nanofiltration, Ultrafiltration, Microfiltration and Donnan dialysis, Ceramic Membranes. Liquid membranes and its applications.

Pervaporation

Theory of PV – parameter study Classification of PV, Osmotic distillation, thermo-pervaporation Advantages and disadvantages of PV Application of PV Working principle and applications, Design aspects of Pervaporation and Permeation techniques for liquids and gases.

Separation by Adsorption Techniques

Mechanism, Types and choice of adsorbents, adsorption techniques, HPLC, GPC, HPTLC techniques of analytical separation, Recent Advances and Process Economics of Analytical Separation., Reactive absorption for removal of hazardous gases like H2S, SOx etc.

Ionic Separations

Controlling factors, Applications, Types of equipment employed for electrophoresis, Dielectrophoresis, Ion exchange chromatography and electro dialysis, Commercial Processes.

Other Techniques

Reactive separation processes - Reactive extraction and distillation , Separations involving lyophilisation, Industrial viability and Examples, Zone melting, Adductive crystallization, Supercritical fluid extraction, Ultrasound and Microwave assisted extraction, Oil spill Management, Foam Separation technique.

REFERENCES:

1. Lacey, R.E. and Loaeb S. - “Industrial Processing with Membranes", Wiley –Inter Science, New York, 1972.
2. King, C.J. " Separation Processes ", Tata McGraw - Hill Publishing Co., Ltd., 1982.
3. Schoew, H.M. - “New Chemical Engineering Separation Techniques", Interscience Publishers, 1972.
4. Roussel Ronald W. - “Handbook of Separation Process Technology", John Wiley, New York, 1987.
5. Kestory, R.E. - “Synthetic Polymeric Membranes ", Wiley, New York, 1987.
6. Osadar, Varid Nakagawa I - “Membrane Science and Technology ", Marcel Dekker 1992.

COURSE OUTCOMES:

After learning the course the students should be able to

1. Learn fundamentals of membrane separation processes and current market scenario
2. Classify and characterize membrane separation processes
3. Thorough in the Principles and methodologies of separation and transport of molecules through membrane
4. Learn latest development in both theory and applications
5. Complete process design of separation through assignment / group task

Mapping with Programme outcomes								
Cos	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO1		√						
CO2		√	√					
CO3		√				√		
CO4		√	√			√		
CO5		√				√		

CHEE XXX	**ADVANCED FLUIDIZATION ENGINEERING**	**L**	**T**	**P**
		4	**0**	**0**

COURSE OBJECTIVES:

- To learn the fluidization phenomena, industrial applications of fluidized beds and
- To acquire knowledge on their operational and design aspects.

The phenomenon of Fluidization - Liquid like behavior of a Fluidized Bed – Comparison with Other contacting Methods – Advantages and Disadvantages of Fluidization in Industrial Applications - Types of Fluidization Operations. Applications of fluidized bed: Physical Operations – Synthesis Reactions – Cracking and Reforming of Hydrocarbons – Carbonization and Gasification – Calcining and Clinkering – Gas Solid Reactions

Minimum Fluidizing Velocity, Terminal Velocity and Pressure Drop in Fluidized Beds – Types of Fluidization, bubble formation and importance of the distributors – Voidage in Fluidized Beds – Transport Disengaging Height, TDH – Variation in Size Distribution with height – Viscosity and Fluidity of Fluidized Beds – Power Consumption

Single Rising Bubbles – Stream of Bubbles from a Single Source – Bubbles in Ordinary Bubbling Beds – The Bubbling Bed Model for the Bubble Phase Movement of Individual Particles – Turnover of Individual Particles – Residence Time Distribution of solids – The Diffusion Model for Movement of Solids – The Bubbling model for the Emulsion Phase – Interpretation of Solids Mixing Data in terms of the Bubbling Bed Model

The Bubbling Bed Model for Gas Interchange – Interpretation of Gas Mixing Data in Terms of the Bubbling Bed Model. Experimental Findings of Mass Transfer – Mass Transfer Rate from the Bubbling Bed model – Experimental Findings on Heat Transfer – Heat Transfer Rate from the Bubbling Bed Model - Two Region Models – Catalytic Conversion from the Bubbling Bed Model

Experimental Findings – Theories for Bed Wall Heat Transfer – Comparison of Theories – Evaluation – A Model for Entrainment from a Dense Fluidized Bed. Particles of Unchanging Size – Particles of Changing Size – Finding required Circulation Rates for Solids – Flow of High Bulk Density Mixtures – Flow of Low Bulk Density Mixtures – Assemble of a Circuit

Batch operations – Continuous Operations – Pilot Plant Reactors – Pilot plant and Commercial Plant Design Decisions – Design Calculations for a Reactor without Circulation of Solids – Deactivating Catalysts – Design Calculation for a Reactor – Regenerator System with Circulating Catalyst

Kinetic Models for the Conversion of Solids – Conversion of Solids of Uniform Size – Conversion of Solids of Uniform Size – Conversion of Both Gas and Solids – Conversion of Solids of Non-uniform Size – Solids of Changing Size – Non catalytic Gas Phase Reactions

REFERENCES:

1. Daizo Kunii, Octave Levenspiel, Fluidization Engineering, John Wiley & Sons, inc., New York, 1985.
2. Davidson.J.F., Cliff.R., Harrison.D., Fluidization, II Edition, Academic press, London, 1985.

COURSE OUTCOMES:

1. Understanding of fluidization behaviour
2. Ability to estimate pressure drop, bubble size, TDH, voidage, heat and mass transfer rates for the fluidized beds
3. Ability to write model equations for fluidized beds
4. Ability to design gas-solid fluidized bed reactors

Mapping with Programme outcomes								
Cos	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO1		√						
CO2		√	√					
CO3		√				√		√
CO4		√				√		√

CHEE XXX	**SAFETY IN CHEMICAL INDUSTRIES**	**L**	**T**	**P**
		4	**0**	**0**

COURSE OBJECTIVES:

- To develop and evaluate appropriate strategies designed to mitigate risk;
- To take all reasonably practicable measures to prevent accidents in nuclear installations and to mitigate their consequences.
- To identify the hazards in erection, commissioning, storage, habndling, etc, of chemical industries

Safety in the design process of chemical plants- safety in erection and commissioning of chemical plants- safety in material handling – Pressure and leak testing.

Safety in operational and maintenance – Exposure of personnel, Operational activities and hazards – Work permit systems entry into confined space where toxic contaminants are present.

Safety in storage and Handling of chemical and gases – Hazards during transportation – pipeline transport – safety in chemical laboratories.

Toxic release and control methodologies – toxic effects- threshold limit values – Awareness and preparedness for energy at local level Specific safety consideration for Cement, paper, pharmaceutical, petroleum, petrochemical, rubber, fertilizer and distilleries.

Safety in nuclear plants - Objectives and concepts , technical requirements, safety functions , accident prevention and plant safety characteristics , radiation protection,

Safety analysis, safety requirements for reactor core and associated features , reactor coolant system, containment system ,Waste treatment and control systems, fuel handling and storage systems.

REFERENCES:

1. Lees, F.P., Loss Prevention in Process Industries, Butterworths, NewDelhi, 1986
2. Accident Prevention Manual for Industrial Operations, NSC, Chicago, 1982.

COURSE OUTCOMES:

After learning the course the students will be able to

1. Recommend safety parameters required for the design process of equipment
2. Develop safety precautions to be followed in the erection and commissioning of plants
3. Develop emergency preparedness plans for various industries at toxic release scenario

Mapping with Programme outcomes							
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**
CO1		√				√	
CO2							√
CO3							√

CHEE XXX	**COMPUTER AIDED PROCESS PLANT DESIGN**	**L**	**T**	**P**
		4	**0**	**0**

COURSE OBJECTIVES:

- To introduce the analysis of software tools and their Principles.
- To analysis the static and dynamic behavior of chemical processing system and models employed through the use of computer aided process
- To develop block diagram using mathematical systems and stability analysis

- Emphasis on Frequency Response Analysis and its application in feedback of software solution

MATLAB: Introduction to MATLAB - MATLAB Environment-Functions-Matrix Computations-Symbolic Mathematics-Numerical Techniques

Physical properties evaluation: viscosity, thermal conductivity, diffusivity and vapor pressure, Bubble point and Dew point- - Vapor liquid equilibrium data for ideal and non ideal mixtures - Development of methods of calculations and MATLAB programming for the above problems

Flash distillation and Multistage distillation systems calculations. Development of design procedure and MATLAB programming for the above systems.

Heat Exchangers: Double pipe and Shell and Tube Heat Exchangers - Evaporators: Single Effect and Multiple Effect Evaporators. Development of design procedure and MATLAB programming for the above equipments.

Design development and MATLAB programming for Absorbers, Strippers and Dryers

REFERENCES:

1. Computer aided Process Plant Design, M. E. Leesley, Gulf publishing CC, Houstan, 1982
2. Fundamentals and Modelling of separation processes, C. D. Holland, Printice Hall,1975
3. Introduction to MATLAB 6, Delores M. Etter, David C. Kuncicky and Doug Hull, Pearson Education Pte Ltd, Delhi, 2004

COURSE OUTCOMES:

On completion of course the students are expected to

1. Critically analyze and create models for Chemical Engineering Processes.
2. Use principles of engineering model to develop models and its constraints
3. Know about applications of modeling and important of simulation industrial processes.

Mapping with Programme outcomes								
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO1		√				√		
CO2		√	√			√		
CO3		√				√		√

CHEE XXX	**ADVANCED WASTEWATER TREATMENT**	**L**	**T**	**P**
		4	**0**	**0**

COURSE OBJECTIVES:

- To learn about the sources, characteristics of wastewater
- To learn about advanced wastewater pollution control methods

Wastewater Treatment: The role of the Engineer - Wastewater Treatment - objectives and Regulation - Classification of waste water treatment methods - Application of treatment methods - Selection of treatment process flow diagram - Implementation of wastewater management programs.

Wastewater flowrates from water supply data - Physico - chemical and biological characteristics of waste water and their studies. Impact of flowrate an mass loading factors on design - Evaluation and selection of design flowrates - Evaluation and selection of mass loadings - elements of conceptual design - Analysis of Gas transfer - Evaluation of Oxygen transfer coefficients - Factors affecting Oxygen transfer - Mass transfer rates of VOCS - Mass transfer of VOCS from surface and diffused air aeration process.

Design of preliminary treatment operations - odor control and control of VOCS Released from wastewater management facilities - Activated sludge process design - Aerobic lagoons, Trickling Filters, Rotating Biological contractors - combined Aerobic Treatment Process.

Need for advanced wastewater treatment. Treatment technologies for advanced wastewater treatment - Removal of residual suspended solids by Granular medium filtration - Removal of residual suspended solids by micro screening control of Nutrients - Conversion of Ammonia by Biological Nitrification / Denitrification - Removal of phosphorus by Biological methods combined removal of Nitrogen and phosphorus by Biological methods.

Removal of Nitrogen by physical and chemical process - Removal of phosphorus by chemical addition - Removal of Toxic compound and refractory Organics - Removal of dissolved in Organic substances.

REFERENCES:

1. Wastewater Engineering, Treatment, Dispose and Reuse - METCALF & EDDY, Inc.

COURSE OUTCOMES:

1. Understanding of air/water pollution regulations and their scientific basis
2. Apply knowledge for the protection and improvement of the environment
3. Ability to monitor and design the air and water pollution control systems
4. Ability to select and use suitable waste treatment technique

Mapping with Programme outcomes								
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO1		√						
CO2		√	√					
CO3		√				√		
CO4		√				√		√

CHEE XXX	APPLICATION OF NANOTECHNOLOGY IN CHEMICAL ENGINEERING	L	T	P
		4	0	0

COURSE OBJECTIVES:

- To understand the fundamentals of the preparation and properties of nanomaterials from a chemical engineering perspective.

- To gain knowledge of structure, properties, manufacturing, and applications of various nanomaterials 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 based nanomaterials, Synthesis of fullerenes, Graphene, Carbon nanotubes, Functionalization of carbon nanotubes, One, two and multidimensional structures, Crystallography.

Approaches to Synthesis of Nanoscale Materials

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.

Characterization of Nanoscale Structures and Surfaces

Size, shape, crystallinity, topology, chemistry analysis using X-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", (CRC Press of Taylor and Francis Group LLC), May 2008, 856pp, ISBN-13: 978142004805

2. Ajayan P. M., Schadler L. S., Braun P. V., "Nanocomposite Science and Technology", Edited by WILEY-VCH Verlag GmbH Co. KGaA, Weinheim ISBN: 3-527-30359-6, 2003.
3. Kelsall Robert W., Hamley Ian W., Geoghegan Mark, "Nanoscale Science and Technology", John Wiley & Sons, Ltd, 2006.
4. Kal Ranganathan Sharma, "Nanostructuring Operations in Nanoscale Science and Engineering", McGraw-Hill Companies, Inc. ISBN: 978-0-07-162609-5, 2010.
5. "Organic and inorganic nanostructures".-(Artech House MEMS series), Nabok, Alexei, ISBN 1-58053-818-5, 2005

COURSE OUTCOMES:
Upon completion of the course students are expected to:
1. Comprehend the state of the arts in nanotechnology and its broad range of applications
2. Synthesize and charecterize the nanoparticles

Mapping with Programme outcomes								
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO1		√	√			√		
CO2		√	√			V		

OPEN ELECTIVES

CHEE XXX	MEMBRANE TECHNOLOGY	L	T	P
		4	0	0

COURSE OBJECTIVES:
- To give the students the technical background on membrane technology
- To provide wide level of understanding that will allow them to design, using appropriate combinations of unit processes and water treatment plant
- The practical component will provide the students with a range of laboratory skills together with an understanding of the need for rigorous experimental design of membrane modules for water treatment plant

Synthetic Membranes - configuration, morphology, principles of permeation and separation, membrane materials.

Processing: Phase-inversion process, anisotropic membranes, isotropic porous membranes. Polymer blends and alloys, dynamic membranes, liquid membranes, biomimetic membranes ion exchange membranes, electro dialysis, bipolar membranes, mosaic membranes.

Separation processes: Electro dialysis, micro filtration, ultra filtration, reverse osmosis, hemodialysis, hem filtration.

Membrane systems: Plate and frame, spiral-wound module, hollow fiber modules.

Membrane Applications: Wastewater treatment, bioseparation, biomedical.

REFERENCES:

1. R.B.Kesting., Synthetic Polymeric Membranes, Second Edn., Wiley-Interscience, New York, 1985.

COURSE OUTCOMES:

1. Knowledge and understanding of depth and breadth of knowledge that is at the frontier of their disciplines
2. Ability to evaluate critically current diverse approaches for solving critical problems in research and to creating new knowledge judged by international standards
3. Evaluate methodologies and develop critiques of them.
4. Carry out research in an area of water treatment.

Mapping with Programme outcomes								
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO1		√						
CO2		√	√			√		
CO3		√						
CO4		√				√		√

CHEE XXX	ENERGY CONSERVATION TECHNOLOGY	L	T	P
		4	0	0

COURSE OBJECTIVES:

- To study the various energy conservation technologies

Principle of energy conservation - Energy auditing - Energy management. Energy conservation equipment: Waste heat recovery - Boilers, Recuperators, Regenerators, Heat pipes - Heat pumps - Multiple effect evaporators - Steam traps.

Efficient use of steam: Insulation

Energy conservation techniques in Process Industries: Petroleum and petrochemical industries, sugar and alcohol industries, pulp and paper industries, fertilizer industries, cement plants, Steel plants.

Adoption of new technologies: Co-generation fluidized bed combustion, Magneto Hydrodynamic(MHD) power generation, adoption of solar energy devices.

REFERENCES:

1. Reay.D.A., Industrial Energy Conservation, 1st Edn., Pergamon Press, 1977.
2. Chiogiogi.M.H., Marcel Dekker, Industrial Energy Conservation, New York.
3. Huo,S.D., Hand book of Industrial Energy Conservation, Van Nostrand Rainhold Publishers, New York, 1983.

COURSE OUTCOMES:

1. Able to understand the basics of energy conservation and eneegy management
2. Able to know the various energy conservation technologies applied in industries
3. Ably to apply modern technologies

Mapping with Programme outcomes								
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO1		√						
CO2		√	√					
CO3		√						

CHEE XXX	AIR POLLUTION CONTROL	L	T	P
		4	0	0

COURSE OBJECTIVES:

- To impart knowledge on air pollutants and measurement.
- To understand the control of gas and particulate contaminants by using control equipments.
- To develop the knowledge of automobile emissions, indoor air pollution and odour control.
- To analysis the industrial applications and its control measures.

Scope-nature of air pollutants-air pollution measurement- principles underlying the design of pollution control equipment. Pollutant distributions and collection efficiencies: properties and collection of particles-particle distributions-collection offences-multiple collectors

Design of industrial ventilation systems; Control of particulate contaminants: Settling chambers-Intertial separators-Cyclones-Filters-Scrubbers or wet collectors-Electrostatic Precipitators and collection efficiency.

Control of gaseous contaminants: Methods of control and designs- absorption, Adsorption, condensation, Incineration; Design of biological systems-Bio filters, Biotrickling filter, Bio scrubbers; Odours and their control

Types and control of automobile emissions- Exhaust emissions, evaporative emissions, crank-case emissions; Indoor air pollution

Control Measures for Industrial Applications**:** Mineral products – asphaltic concrete, glass manufacturing, asbestos processing; Cement Industry-Thermal Power plants-Petroleum refining and storage plants, Fertilizers, Pharmaceuticals and wood processing industry

REFERENCES:

1. Martin Crawford, Air Pollution Control Theory 2nd Edn.,Tata McGraw-Hill Publications
2. Noel de Nevers, Air Pollution control Engineering, McGraw Hill, New York, 1995.
3. M.N. Rao et al, “Air Pollution” Tata McGraw Hill, 1989.
4. Pollution Prevention and Abatement Handbook, 1998: Toward Cleaner Production,”World Bank group” 1999

COURSE OUTCOMES:

After learning the course the students should be able to

1. Understand the effect of air pollution and fundamentals.
2. Understand the selection of control measures for air and particulate pollutions.
3. Understand the impact of air pollution on automobile emission, Odours and indoor emission

4. Understand the importance of control measures on industrial

Mapping with Programme outcomes								
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO1		√				√		
CO2		√	√				√	
CO3		√		√		√	√	
CO4		√					√	

CHEE XXX	MATHEMATICAL MODELING	L	T	P
		4	0	0

COURSE OBJECTIVES:

- The course is aimed at developing the skills of engineering students in Chemical data interpolation.
- The learners will be enabled to appreciate the important role of mathematical concepts in engineering and industrial application.

Models: definition, classification, fundamental, empirical, analogy, limitations of models; necessity for modeling, stages in modeling examples.

Construction of models: modeling logic, constitutive equations, model development.

Modeling Reactors: conservation of mass - chemical, biological and autocatalytic systems, batch and continuous reactors.

Modeling Reactors: conservation energy - linear and nonlinear models, order reduction, transient behaviour, sensitivity, stability, multiplicity, examples.

Scaling: simplification of models, non-dimensionalization, heat equation, scaling the heat equation, transport of mass, momentum and energy.

Model analysis: linearization, nonlinearization, nonhomogeneous systems, eigenvalues and eigenvectors, modal control, slightly non-linear processes, discretization, method of weighted residuals, continuous approximation. Case studies.

REFERENCES:

1. Process Modeling, Morton M.Denn, Longman Scientific & Technical, Essex, England.
2. S. Pushpavanam, Mathematical methods in chemical engineering, PHI Learning Pvt. Ltd. 2008.
3. N. W. Loney, Applied Mathematical Methods for Chemical Engineers, 2nd edn, CRC Press, 2006.
4. R. G. Rice, D. D. Do, Applied Mathematics and Modeling For Chemical Engineers, John Wiley & Sons, 2012.

COURSE OUTCOMES:

After successfully completing the course the student should be able to

1. Present data in appropriate form,
2. Estimate the error component in data,
3. Design/development of models for chemical processes.
4. Analyze data by statistical methods and solve linear algebraic, ordinary differential and partial differential equations by analytical methods.

Mapping with Programme outcomes								
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO1		√						
CO2		√	√					
CO3		√				√		
CO4		√						

CHEE XXX	**TOTAL QUALITY MANAGEMENT**	**L**	**T**	**P**
		4	**0**	**0**

COURSE OBJECTIVES:

- The Deming Quality philosophy,understanding variability of processes through statistical thinking
- The role of management and leadership in a TQM organisation
- The role of quality improvement teams and how to organise them and the "seven simple tools"
- Data collection through surveys and experimental design and basic statistical methods;
- More advanced statistical techniques such as control charts, statistical process control and experimental design;
- Quality standards, complementary quality techniques such as benchmarking

Concepts of TQM - Deming, Crosby and Juran's Philosophies - Quality system - ISO 9000 Quality costs, Seven tools for Quality Control, Seven tools for Quality management, Quality Function Development (QFD).

Statical Process Control: Control charts for attributes and count of defects - p chart, np-chart, c chart, u chart and stabilized p chart.

Control charts for variables - X chart, M chart R chart, chart - process capabilities studies (Cp and Cpk) - Modified control charts.

Special control charts - Group control chart, sloping control chart, moving averages and moving ranges control charts, coefficient of variation control chart and cumulative sum control chart.

Acceptance sampling plans for attributes: Concepts - OC curves - single, double, multiple and sequential sampling plans - Acceptance Rectification plan - ATI and ASN concepts - LTPD sampling plan, switching rules for normal, tightened and reduced inspection - IS 2500 part I - Acceptance sampling plans for variables - Different criteria - IS 2500 part II - Continuous sampling plan.

Reliability engineering: Failure data analysis and life testing - Reliability parameters - Reliability evaluation methods-Weibull analysis - System reliability with components in series, parallel and mixed configuration - Active, partial and stand by redundancy - Availability and Maintainability concepts. Reliability centered maintains - FTA, FMECA.

REFERENCES:
1. Introduction to Statistical Quality Control, Montgomery D.C., John Wiley, 1994.
2. Statistical Quality Control, Gupta R.C., Khanna Pub., 1998.
3. Total Quality Control, Faigenbaum A.V., Me Graw-Hill., 1996.
4. Statistical Quality Control, Grant EX., Me Graw-Hill., 1998.
5. The Assurance Sciences, Halpern Siegmund, PHI, 1978.
6. Concepts in Reliability Engg., Srinath L.S., Eastwest Press Ltd., 1991.
7. IS 397 Part I, II and III, IS 2500 Part I and II.

COURSE OUTCOMES:

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

1. Understand the fundamental principles of Total Quality Management
2. Choose appropriate statistical techniques for improving processes
3. Write reports to management describing processes and recommending ways to improve them
4. Develop research skills that will allow them to keep abreast of changes in the field of Total Quality Management

Mapping with Programme outcomes								
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO1	√	√						
CO2		√						
CO3		√						
CO4		√						

CHEE XXX	COMPUTATIONAL FLUID DYNAMICS	L	T	P
		4	0	0

COURSE OBJECTIVES:

- Formulate problems that can be solved and Hands - on experience with a commercial CFD program
- Develop skills to use CFD in industrial settings and get a solid foundation in both fluid mechanics and numerical analysis.
- Able to critically analyze different mathematical models and computational methods for flow simulations

Philosophy of computational fluid dynamics: CFD as a research tool, CFD as a design tool, applications. Governing equations, their derivation, physical meaning and presentation of forms suitable to CFD.

Models of flow, continuity, momentum and energy equations, Navier-Stokes equation, Euler equation, physical boundary conditions.

Mathematical behavior of partial differential equations, discrimination, finite differences, explicit and implicit approaches.
Grids with appropriate transformation: transformation of equations, stretched grids, adaptive grids, mesh generation.

Simple CFD techniques: the Lax-Wendroff Technique, MacCormack's technique, relaxation technique, the alternating direction implicit technique, pressure correction method.

Some applications: numerical solution of Quasi one-dimensional nozzle flows, incompressible coutte flow.

REFERENCES:

1. Sengupta T. K., "Fundamentals of Computational Fluid Dynamics", University Press. 2013
2. Anderson Jr J. D., "Computational Fluid Dynamics: The Basics with Applications", McGraw Hill. 1995
3. H. K. Versteeg and W. Malalasekera, An introduction to computational fluid dynamics: the finite volume method, Longman scientific & technical publishers, 2007
4. Muralidhar K. and Sundararajan T., "Computational Fluid Flow and Heat Transfer", Narosa Publishing House. 2003
5. Vivek V. Ranade, Computational flow modeling for chemical reactor engineering Academic Press, San Diego, 2002

COURSE OUTCOMES:

After completion of this course the student should be:

1. Familiar with the differential equations for flow phenomena and numerical methods for their solution
2. Able to use and develop flow simulation software for the most important classes of flows in engineering and science.
3. Able to critically analyze different mathematical models and computational methods for flow simulations
4. Able undertake flow computations using current best practice for model and method selection, and assessment of the quality of results obtained.

Mapping with Programme outcomes								
Cos	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO1		√						
CO2		√	√			√		
CO3		√						
CO4		√				√		