KONGU ENGINEERING COLLEGE

(Autonomous Institution Affiliated to Anna University, Chennai)

PERUNDURAI ERODE – 638 060

TAMILNADU INDIA

Estd : 1984

REGULATIONS, CURRICULUM & SYLLABI - 2020

(CHOICE BASED CREDIT SYSTEM AND OUTCOME BASED EDUCATION)

(For the students admitted during 2020 - 2021 and onwards)

MASTER OF TECHNOLOGY DEGREE IN CHEMICAL ENGINEERING

DEPARTMENT OF CHEMICAL ENGINEERING

KONGU

Assuring the Best

INDEX

KONGU ENGINEERING COLLEGE
PERUNDURAI ERODE – 638 060
(Autonomous)

INSTITUTE VISION

To be a centre of excellence for development and dissemination of knowledge in Applied Sciences, Technology, Engineering and Management for the Nation and beyond.

INSTITUTE MISSION

We are committed to value based Education, Research and Consultancy in Engineering and Management and to bring out technically competent, ethically strong and quality professionals to keep our Nation ahead in the competitive knowledge intensive world.

QUALITY POLICY

We are committed to

- Provide value based quality education for the development of students as competent and responsible citizens.
- Contribute to the nation and beyond through research and development
- Continuously improve our services

DEPARTMENT OF CHEMICAL ENGINEERING

VISION

To be a centre of excellence for development and dissemination of knowledge in Chemical Engineering for the Nation and beyond.

MISSION

Department of Chemical Engineering is committed to:

MS1:	Impart knowledge to students at all levels through a vibrant, dynamic and state of the art intellectual delivery to ensure the creation of a complete Chemical Engineer with a high sense of social responsibility and professional ethics
MS2:	Synergize the efforts of the students and faculty to evolve innovative engineering practices and teaching methodologies
MS3:	Generate an environment of continuous learning and research

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

Graduates of Chemical Engineering will

PEO1:	Exhibit professional competency in design and development of chemical products, Processes and equipment in chemical and allied industries.
PEO2:	Perform research and development work by utilizing the experimental skills. Mathematical tools and applied software and simulation practices.
PEO3:	Demonstrate interpersonal skills and leadership qualities and contribute to solve multidisciplinary problems in national and global level

MAPPING OF MISSION STATEMENTS (MS) WITH PEOs

MS\PEO	PEO1	PEO2	PEO3
MS1	2	3	3
MS2	3	2	2
MS3	3	3	2

1 – Slight, 2 – Moderate, 3 – Substantial

PROGRAM OUTCOMES (POs)

Graduates of Chemical Engineering will**:**

PO1 An ability to independently carry out research /investigation and development work to solve practical problems

PO2 An ability to write and present a substantial technical report/document

PO3 Understand the requirement of the industry and perform effectively with the managerial skills

PO4 Design and develop advanced chemical processes, products and equipments for the benefit of society through research and continuous learning efforts

PO5 Improvise and apply their knowledge in various frontiers of chemical engineering and evolve as a successful leader/ teacher / technocrat and scientist

MAPPING OF PEOs WITH POs AND PSOs

PEO\PO	PO1	PO2	PO3	PO4	PO5
PEO1	3	2	2	3	3
PEO2	1	2	3	3	3
PEO3	2	3	3	2	2

1 – Slight, 2 – Moderate, 3 – Substantial

KONGU ENGINEERING COLLEGE, PERUNDURAI, ERODE – 638060

(An Autonomous Institution Affiliated to Anna University)

REGULATIONS 2020

CHOICE BASED CREDIT SYSTEM AND OUTCOME BASED EDUCATION

MASTER OF ENGINEERING (ME) / MASTER OF TECHNOLOGY (MTech) DEGREE PROGRAMMES

These regulations are applicable to all candidates admitted into ME/MTech Degree programmes from the academic year 2020 – 2021 onwards.

1. DEFINITIONS AND NOMENCLATURE

In these Regulations, unless otherwise specified:

i. “University” means ANNA UNIVERSITY, Chennai.

ii. “College” means KONGU ENGINEERING COLLEGE.

iii. “Programme” means Master of Engineering (ME) / Master of Technology (MTech) Degree programme

iv. “Branch” means specialization or discipline of ME/MTech Degree programme, like Construction Engineering and Management, Information Technology, etc.

v. “Course” means a Theory / Theory cum Practical / Practical course that is normally studied in a semester like Engineering Design Methodology, Machine Learning Techniques, etc.

vi. “Credit” means a numerical value allocated to each course to describe the candidate’s workload required per week.

vii. “Grade” means the letter grade assigned to each course based on the marks range specified.

viii. “Grade point” means a numerical value (0 to 10) allocated based on the grade assigned to each course.

ix. “Principal” means Chairman, Academic Council of the College.

x. “Controller of Examinations” means authorized person who is responsible for all examination related activities of the College.

xi. "Head of the Department" means Head of the Department concerned of the College.

2. PROGRAMMES AND BRANCHES OF STUDY

The following programmes and branches of study approved by Anna University, Chennai and All India Council for Technical Education, New Delhi are offered by the College.

Programme	Branch
ME	Construction Engineering and Management
	Structural Engineering
	Engineering Design
	Mechatronics Engineering
	VLSI Design
	Embedded Systems
	Power Electronics and Drives
	Control and Instrumentation Engineering
	Computer Science and Engineering
MTech	Information Technology
	Chemical Engineering
	Food Technology

3. ADMISSION REQUIREMENTS

Candidates seeking admission to the first semester of the ME/MTech Degree programme shall be required to have passed an appropriate qualifying Degree Examination of Anna University or any examination of any other University or authority accepted by the Anna University, Chennai as equivalent thereto, subject to amendments as may be made by the Anna University, Chennai from time to time. The candidates shall also be required to satisfy all other conditions of admission prescribed by the Anna University, Chennai and Directorate of Technical Education, Chennai from time to time.

4. STRUCTURE OF PROGRAMMES

4.1 Categorisation of Courses

The ME / MTech programme shall have a curriculum with syllabi comprising of theory, theory cum practical, practical courses in each semester and project work, internship,etc that have been approved by the respective Board of Studies and Academic Council of the College. All the programmes have well defined Programme Outcomes (PO) and Programme Educational Objectives (PEOs) as per Outcome Based Education (OBE). The content of each course is designed based on the Course Outcomes (CO). The courses shall be categorized as follows:

i. Foundation Courses (FC)

ii. Professional Core (PC) Courses

iii. Professional Elective (PE) Courses

iv. Open Elective (OE) Courses

v. Employability Enhancement Courses (EC) like Innovative Project, Internship cum Project work in Industry or elsewhere, Project Work

4.2 Credit Assignment

Each course is assigned certain number of credits as follows:

Contact period per week	Credits
1 Lecture / Tutorial Period	1
2 Practical Periods	1
2 Project Work Periods	1
40 Training /Internship Periods	1

The minimum number of credits to complete the ME/MTech programme is 72.

4.3 Employability Enhancement Courses

A candidate shall be offered with the employability enhancement courses like innovative project, internship cum project work and project work during the programme to gain/exhibit the knowledge/skills.

4.3.1 Innovative Project

A candidate shall earn two credits by successfully completing the project by using his/her innovations in second semester during his/her programme.

4.3.2 Internship cum Project Work

The curriculum enables a candidate to go for full time internship during the third semester and can earn credits through it for his/her academics vide clause 7.6 and clause 7.12. Such candidate shall earn the minimum number of credits as mentioned in the third semester of the curriculum other than internship by either fast track mode or through approved courses in online mode or by self study mode. Such candidate can earn the number of credits for the internship same as that of Project Work in the third semester. Assessment procedure is to be followed as specified in the guidelines approved by the Academic Council.

4.3.4 Project Work

A candidate shall earn nine credits by successfully completing the project work in fourth semester during the programme inside the campus or in industries.

4.4 Value Added Courses / Online Courses / Self Study Courses

The candidates may optionally undergo Value Added Courses / Online Courses / Self Study Courses as elective courses.

4.4.1 **Value Added Courses:** Value Added courses each with One / Two credits shall be offered by the college with the prior approval from respective Board of Studies. A candidate can earn a maximum of three credits through value added courses during the entire duration of the programme.

4.4.2 **Online Courses:** Candidates may be permitted to earn credits for online courses, offered by NPTEL / SWAYAM / a University / Other Agencies, approved by respective Board of Studies.

4.4.3 **Self Study Courses:** The Department may offer an elective course as a self study course. The syllabus of the course shall be approved by the respective Board of Studies. However, mode of assessment for a self study course will be the same as that used for other courses. The candidates shall study such courses on their own under the guidance of member of the faculty. Self study course is limited to one per semester.

4.4.4 The elective courses in the final year may be exempted if a candidate earns the required credits vide clause 4.4.1, 4.4.2 and 4.4.3 by registering the required number of courses in advance (up to second semester).

4.4.5 A candidate can earn a maximum of 15 credits through all value added courses, online courses and self study courses.

4.5 Flexibility to Add or Drop Courses

4.5.1 A candidate has to earn the total number of credits specified in the curriculum of the respective programme of study in order to be eligible to obtain the degree. However, if the candidate wishes, then the candidate is permitted to earn more than the total number of credits prescribed in the curriculum of the candidate's programme.

4.5.2 From the second to fourth semesters the candidates have the option of registering for additional elective/Honors courses or dropping of already registered additional elective/Honors courses within two weeks from the start of the semester. Add / Drop is only an option given to the candidates. Total number of credits of such courses during the entire programme of study cannot exceed six.

4.6 Maximum number of credits the candidate can enroll in a particular semester cannot exceed 30 credits.

4.7 The blend of different courses shall be so designed that the candidate at the end of the programme would have been trained not only in his / her relevant professional field but also would have developed to become a socially conscious human being.

4.8 The medium of instruction, examinations and project report shall be English.

5. DURATION OF THE PROGRAMME

5.1 A candidate is normally expected to complete the ME / MTech Degree programme in 4 consecutive semesters (2 Years), but in any case not more than 8 semesters (4 Years).

5.2 Each semester shall consist of a minimum of 90 working days including continuous assessment test period. The Head of the Department shall ensure that every teacher imparts instruction as per the number of periods specified in the syllabus for the course being taught.

5.3 The total duration for completion of the programme reckoned from the commencement of the first semester to which the candidate was admitted shall not exceed the maximum duration specified in clause 5.1 irrespective of the period of break of study (vide clause 11) or prevention (vide clause 9) in order that the candidate may be eligible for the award of the degree (vide clause 16). Extension beyond the prescribed period shall not be permitted.

6. COURSE REGISTRATION FOR THE EXAMINATION

6.1 Registration for the end semester examination is mandatory for courses in the current semester as well as for the arrear courses failing which the candidate will not be permitted to move on to the higher semester. This will not be applicable for the courses which do not have an end semester examination.

6.2 The candidates who need to reappear for the courses which have only continuous assessment shall enroll for the same in the subsequent semester, when offered next, and repeat the course. In this case, the candidate shall attend the classes, satisfy the attendance requirements (vide clause 8), earn continuous assessment marks. This will be considered as an attempt for the purpose of classification.

6.3 If a candidate is prevented from writing end semester examination of a course due to lack of attendance, the candidate has to attend the classes, when offered next, and fulfill the attendance requirements as per clause 8 and earn continuous assessment marks. If the course, in which the candidate has a lack of attendance, is an elective, the candidate may register for the same or any other elective course in the subsequent semesters and that will be considered as an attempt for the purpose of classification.

7. ASSESSMENT AND EXAMINATION PROCEDURE FOR AWARDING MARKS

7.1 The ME/MTech programmes consist of Theory Courses, Theory cum Practical courses, Practical courses, Innovative Project, Internship cum Project work and Project Work. Performance in each course of study shall be evaluated based on (i) Continuous Assessments (CA) throughout the semester and (ii) End Semester Examination (ESE) at the end of the semester except for the courses which are evaluated based on continuous assessment only. Each course shall be evaluated for a maximum of 100 marks as shown below:

Sl. No.	Category of Course	Continuous Assessment Marks	End Semester Examination
1.	Theory / Practical	50	50
2.	Theory cum Practical	The distribution of marks shall be decided based on the credit weightage assigned to theory and practical components respectively.	
3.	Innovative Project/ Project Work / Internship cum Project Work	50	50
4.	Value Added Course	The distribution of marks shall be decided based on the credit the credit weightage assigned	---
5.	All other Courses		

7.2 Examiners for setting end semester examination question papers for theory courses, theory cum practical courses and practical courses and evaluating end semester examination answer scripts, project works, innovative project and internships shall be appointed by the Controller of Examinations after obtaining approval from the Principal.

7.3 Theory Courses

For all theory courses out of 100 marks, the continuous assessment shall be 50 marks and the end semester examination shall be for 50 marks. However, the end semester examinations shall be conducted for 100 marks and the marks obtained shall be reduced to 50. The continuous assessment tests shall be conducted as per the schedule laid down in the academic schedule. Three tests shall be conducted for 50 marks each and reduced to 30 marks each. The total of the continuous assessment marks and the end semester examination marks shall be rounded off to the nearest integer.

7.3.1 The assessment pattern for awarding continuous assessment marks shall be as follows:

Sl. No.	Type	Max. Marks	Remarks
1.	Test – I	30	Average o f best two
	Test – II	30	
	Test - III	30	
2.	Tutorial	15	Should be of Open Book/Objective Type. Average of best 4 (or more, depending on the nature of the course, as may be approved by Principal)

3.	Assignment / Paper Presentation in Conference / Seminar / Comprehension / Activity based learning / Class notes	05	To be assessed by the Course Teacher based on any one type.
Total		50	Rounded off to the one decimal place

However, the assessment pattern for awarding the continuous assessment marks may be changed based on the nature of the course and is to be approved by the Principal.

7.3.2 A reassessment test or tutorial covering the respective test or tutorial portions may be conducted for those candidates who were absent with valid reasons (Sports or any other reason approved by the Principal).

7.3.3 The end semester examination for theory courses shall be for duration of three hours.

7.4 Theory cum Practical Courses

For courses involving theory and practical components, the evaluation pattern as per the clause 7.1 shall be followed. Depending on the nature of the course, the end semester examination shall be conducted for theory and the practical components. The apportionment of continuous assessment and end semester examination marks shall be decided based on the credit weightage assigned to theory and practical components approved by Principal.

7.5 Practical Courses

For all practical courses out of 100 marks, the continuous assessment shall be for 50 marks and the end semester examination shall be for 50 marks. Every exercise / experiment shall be evaluated based on the candidate’s performance during the practical class and the candidate's records shall be maintained.

7.5.1 The assessment pattern for awarding continuous assessment marks for each course shall be decided by the course coordinator based on rubrics of that particular course, and shall be based on rubrics for each experiment.

7.6 Project Work

7.6.1 Project work shall becarried out individually. Candidates can opt for full time internship (vide clause 7.8) in lieu of project work in third semester. The project work is mandatory for all the candidates.

7.6.2 The Head of the Department shall constitute review committee for project work. There shall be three assessments by the review committee during the semester. The candidate shall make presentation on the progress made by him/her before the committee.

7.6.3 The continuous assessment and end semester examination marks for Project Work and the Viva-Voce Examination shall be distributed as below.

Continuous Assessment (Max. 50 Marks)						End Semester Examination (Max. 50 Marks)			
Review I (Max..10 Marks)		Review II (Max.. 20 Marks)		Review III (Max. 20 Marks)		Report Evaluation (Max. 20 Marks)	Viva - Voce (Max. 30 Marks)		
Rv. Com	Guide	Review Committee (excluding guide)	Guide	Review Committee (excluding guide)	Guide	Ext. Exr.	Guide	Exr.1	Exr.2
5	5	10	10	10	10	20	10	10	10

7.6.4 The Project Report prepared according to approved guidelines and duly signed by the Guide and Project Co-ordinator shall be submitted to Head of the Department. A candidate must submit the project report within the specified date as per the academic schedule of the semester. If the project report is not submitted within the specified date then the candidate is deemed to have failed in the Project Work and redo it in the subsequent semester. This applies to both Internship cum Project work and Project work.

7.6.5 If a candidate fails to secure 50% of the continuous assessment marks in the project work, he / she shall not be permitted to submit the report for that particular semester and shall have to redo it in the subsequent semester and satisfy attendance requirements.

7.6.6 Every candidate shall, based on his/her project work, publish a paper in a reputed journal or reputed conference in which full papers are published after usual review. A copy of the full paper accepted and proof for that shall be produced at the time of evaluation.

7.6.7 The project work shall be evaluated based on the project report submitted by the candidate in the respective semester and viva-voce examination by a committee consisting of two examiners and guide of the project work.

7.6.8 If a candidate fails to secure 50 % of the end semester examination marks in the project work, he / she shall be required to resubmit the project report within 30 days from the date of declaration of the results and a fresh viva-voce examination shall be conducted as per clause 7.6.7.

7.6.9 A copy of the approved project report after the successful completion of viva-voce examination shall be kept in the department library.

7.7 Innovative Project

The evaluation method shall be same as that of the Project Work as per clause 7.6 excluding clause 7.6.6.

7.8 Internship cum Project Work

Each candidate shall submit a brief report about the internship undergone and a certificate issued from the organization concerned at the time of Viva-voce examination to the review committee. The evaluation method shall be same as that of the Project Work as per clause 7.6 excluding 7.6.6.

7.9 Value Added Course

Two assessments shall be conducted during the value added course duration by the offering department concerned.

7.10 Online Course

The Board of Studies will provide methodology for the evaluation of the online courses. The Board can decide whether to evaluate the online courses through continuous assessment and end semester examination or through end semester examination only. In case of credits earned through online mode from NPTEL / SWAYAM / a University / Other Agencies approved by Chairman, Academic Council, the credits may be transferred and grades shall be assigned accordingly.

7.11 Self Study Course

The member of faculty approved by the Head of the Department shall be responsible for periodic monitoring and evaluation of the course. The course shall be evaluated through continuous assessment and end semester examination. The evaluation methodology shall be the same as that of a theory course.

7.12 Audit Course

A candidate may be permitted to register for specific course not listed in his/her programme curriculum and without undergoing the rigors of getting a 'good' grade, as an Audit course, subject to the following conditions.

The candidate can register only one Audit course in a semester starting from second semester subject to a maximum of two courses during the entire programme of study. Such courses shall be indicated as 'Audit' during the time of Registration itself. Only courses currently offered for credit to the candidates of other branches can be audited.

A course appearing in the curriculum of a candidate cannot be considered as an audit course. However, if a candidate has already met the Professional Elective and Open Elective credit requirements as stipulated in the curriculum, then, a Professional Elective or an Open Elective course listed in the curriculum and not taken by the candidate for credit can be considered as an audit course.

Candidates registering for an audit course shall meet all the assessment and examination requirements (vide clause 7.3) applicable for a credit candidate of that course. Only if the candidate obtains a performance grade, the course will be listed in the semester Grade Sheet and in the Consolidated Grade Sheet along with the grade SF (Satisfactory). Performance grade will not be shown for the audit course.

Since an audit course has no grade points assigned, it will not be counted for the purpose of GPA and CGPA calculations.

8. REQUIREMENTS FOR COMPLETION OF A SEMESTER

8.1 A candidate who has fulfilled the following conditions shall be deemed to have satisfied the requirements for completion of a semester and permitted to appear for the examinations of that semester.

8.1.1 Ideally, every candidate is expected to attend all classes and secure 100 % attendance. However, a candidate shall secure not less than 80 % (after rounding off to the nearest integer) of the overall attendance taking into account the total number of working days in a semester.

8.1.2 A candidate who could not satisfy the attendance requirements as per clause 8.1.1 due to medical reasons (hospitalization / accident / specific illness) but has secured not less than 70 % in the current semester may be permitted to appear for the current semester examinations with the approval of the Principal on payment of a condonation fee as may be fixed by the authorities from time to time. The medical certificate needs to be submitted along with the leave application. A candidate can avail this provision only twice during the entire duration of the degree programme.

8.1.3 In addition to clause 8.1.1 or 8.1.2, a candidate shall secure not less than 60 % attendance in each course.

8.1.4 A candidate shall be deemed to have completed the requirements of study of any semester only if he/she has satisfied the attendance requirements (vide clause 8.1.1 to 8.1.3) and has registered for examination by paying the prescribed fee.

8.1.5 Candidate's progress is satisfactory.

8.1.6 Candidate's conduct is satisfactory and he/she was not involved in any indisciplined activities in the current semester.

8.2. The candidates who do not complete the semester as per clauses from 8.1.1 to 8.1.6 except 8.1.3 shall not be permitted to appear for the examinations at the end of the semester and not be permitted to go to the next semester. They have to repeat the incomplete semester in next academic year.

8.3 The candidates who satisfy the clause 8.1.1 or 8.1.2 but do not complete the course as per clause 8.1.3 shall not be permitted to appear for the end semester examination of that course alone. They have to repeat the incomplete course in the subsequent semester when it is offered next.

9. REQUIREMENTS FOR APPEARING FOR END SEMESTER EXAMINATION

9.1 A candidate shall normally be permitted to appear for end semester examination of the current semester if he/she has satisfied the semester completion requirements as per clause 8, and has registered for examination in all courses of that semester. Registration is mandatory for current semester examinations as well as for arrear examinations failing which the candidate shall not be permitted to move on to the higher semester.

9.2 When a candidate is deputed for a National / International Sports event during End Semester examination period, supplementary examination shall be conducted for such a candidate on return after participating in the event within a reasonable period of time. Such appearance shall be considered as first appearance.

9.3 A candidate who has already appeared for a course in a semester and passed the examination is not entitled to reappear in the same course for improvement of letter grades / marks.

10. PROVISION FOR WITHDRAWAL FROM EXAMINATIONS

10.1 A candidate may, for valid reasons, be granted permission to withdraw from appearing for the examination in any regular course or all regular courses registered in a particular semester. Application for withdrawal is permitted only once during the entire duration of the degree programme.

10.2 The withdrawal application shall be valid only if the candidate is otherwise eligible to write the examination (vide clause 9) and has applied to the Principal for permission prior to the last examination of that semester after duly recommended by the Head of the Department.

10.3 The withdrawal shall not be considered as an appearance for deciding the eligibility of a candidate for First Class with Distinction/First Class.

10.4 If a candidate withdraws a course or courses from writing end semester examinations, he/she shall register the same in the subsequent semester and write the end semester examinations. A final semester candidate who has withdrawn shall be permitted to appear for supplementary examination to be conducted within reasonable time as per clause 14.

10.5 The final semester candidate who has withdrawn from appearing for project viva-voce for genuine reasons shall be permitted to appear for supplementary viva-voce examination within reasonable time with proper application to Controller of Examinations and on payment of prescribed fee.

11. PROVISION FOR BREAK OF STUDY

11.1 A candidate is normally permitted to avail the authorised break of study under valid reasons (such as accident or hospitalization due to prolonged ill health or any other valid reasons) and to rejoin the programme in a later semester. He/She shall apply in advance to the Principal, through the Head of the Department, stating the reasons therefore, in any case, not later than the last date for registering for that semester examination. A candidate is permitted to avail the authorised break of study only once during the entire period of study for a maximum period of one year. However, in extraordinary situation the candidate may apply for additional break of study not exceeding another one year by paying prescribed fee for the break of study.

11.2 The candidates permitted to rejoin the programme after break of study / prevention due to lack of attendance shall be governed by the rules and regulations in force at the time of rejoining.

11.3 The candidates rejoining in new Regulations shall apply to the Principal in the prescribed format through Head of the Department at the beginning of the readmitted semester itself for prescribing additional/equivalent courses, if any, from any semester of the regulations in-force, so as to bridge the curriculum in-force and the old curriculum.

11.4 The total period of completion of the programme reckoned from the commencement of the semester to which the candidate was admitted shall not exceed the maximum period specified in clause 5 irrespective of the period of break of study in order to qualify for the award of the degree.

11.5 If any candidate is prevented for want of required attendance, the period of prevention shall not be considered as authorized break of study.

11.6 If a candidate has not reported to the college for a period of two consecutive semesters without any intimation, the name of the candidate shall be deleted permanently from the college enrollment. Such candidates are not entitled to seek readmission under any circumstances.

12. PASSING REQUIREMENTS

12.1 A candidate who secures not less than 50 % of total marks (continuous assessment and end semester examination put together) prescribed for the course with a minimum of 50 % of the marks prescribed for the end semester examination in all category of courses vide clause 7.1 except for the courses which are evaluated based on continuous assessment only shall be declared to have successfully passed the course in the examination.

12.2 A candidate who secures not less than 50 % in continuous assessment marks prescribed for the courses which are evaluated based on continuous assessment only shall be declared to have successfully passed the course. If a candidate secures less than 50% in the continuous assessment marks, he / she shall have to re-enroll for the same in the subsequent semester and satisfy the attendance requirements.

12.3 For a candidate who does not satisfy the clause 12.1, the continuous assessment marks secured by the candidate in the first attempt shall be retained and considered valid for subsequent attempts. However, from the fourth attempt onwards the marks scored in the end semester examinations alone shall be considered, in which case the candidate shall secure minimum 50 % marks in the end semester examinations to satisfy the passing requirements, but the grade awarded shall be only the lowest passing grade irrespective of the marks secured.

13. REVALUATION OF ANSWER SCRIPTS

A candidate shall apply for a photocopy of his / her semester examination answer script within a reasonable time from the declaration of results, on payment of a prescribed fee by submitting the proper application to the Controller of Examinations. The answer script shall be pursued and justified jointly by a faculty member who has handled the course and the course coordinator and recommended for revaluation. Based on the recommendation, the candidate can register for revaluation through proper application to the Controller of Examinations. The Controller of Examinations will arrange for revaluation and the results will be intimated to the candidate concerned. Revaluation is permitted only for Theory courses and Theory cum Practical courses where end semester examination is involved.

14. SUPPLEMENTARY EXAMINATION

If a candidate fails to clear all courses in the final semester after the announcement of final end semester examination results, he/she shall be allowed to take up supplementary examinations to be conducted within a reasonable time for the courses of final semester alone, so that he/she gets a chance to complete the programme.

15. AWARD OF LETTER GRADES

Range of % of Total Marks	Letter Grade	Grade Point
91 to 100	O (Outstanding)	10
81 to 90	A+ (Excellent)	9
71 to 80	A (Very Good)	8
61 to 70	B+ (Good)	7
50 to 60	B (Average)	6
Less than 50	RA (Reappear)	0
Satisfactory	SF	0
Withdrawal	W	-
Absent	AB	-
Shortage of Attendance in a course	SA	-

The Grade Point Average (GPA) is calculated using the formula:

$$GPA = \frac{\sum[(\text{course credits})\times(\text{grade points})] \text{ for all courses in the specific semester}}{\sum(\text{course credits}) \text{ for all courses in the specific semester}}$$

The Cumulative Grade Point Average (CGPA) is calculated from first semester (third semester for lateral entry candidates) to final semester using the formula

$$CGPA = \frac{\sum[(\text{course credits})\times(\text{grade points})] \text{ for all courses in all the semesters so far}}{\sum(\text{course credits}) \text{ for all courses in all the semesters so far}}$$

The GPA and CGPA are computed only for the candidates with a pass in all the courses.

The GPA and CGPA indicate the academic performance of a candidate at the end of a semester and at the end of successive semesters respectively.

A grade sheet for each semester shall be issued containing Grade obtained in each course, GPA and CGPA.

A duplicate copy, if required can be obtained on payment of a prescribed fee and satisfying other procedure requirements.

Withholding of Grades: The grades of a candidate may be withheld if he/she has not cleared his/her dues or if there is a disciplinary case pending against him/her or for any other reason.

16. ELIGIBILITY FOR THE AWARD OF DEGREE

A candidate shall be declared to be eligible for the award of the ME / MTech Degree provided the candidate has

i. Successfully completed all the courses under the different categories, as specified in the regulations.

ii. Successfully gained the required number of total credits as specified in the curriculum corresponding to the candidate's programme within the stipulated time (vide clause 5).

iii. Successfully passed any additional courses prescribed by the respective Board of Studies whenever readmitted under regulations other than R-2020 (vide clause 11.3)

iv. No disciplinary action pending against him / her.

17. CLASSIFICATION OF THE DEGREE AWARDED

17.1 First Class with Distinction:

17.1.1 A candidate who qualifies for the award of the degree (vide clause 16) and who satisfies the following conditions shall be declared to have passed the examination in First class with Distinction:

- Should have passed the examination in all the courses of all the four semesters in the **First Appearance** within four consecutive semesters excluding the authorized break of study (vide clause 11) after the commencement of his / her study.
- Withdrawal from examination (vide clause 10) shall not be considered as an appearance.
- Should have secured a CGPA of not less than 8.50

(OR)

17.1.2 A candidate who joins from other institutions on transfer or a candidate who gets readmitted and has to move from one regulation to another regulation and who qualifies for the award of the degree (vide clause 16) and satisfies the following conditions shall be declared to have passed the examination in First class with Distinction:

- Should have passed the examination in all the courses of all the four semesters in the **First Appearance** within four consecutive semesters excluding the authorized break of study (vide clause 11) after the commencement of his / her study.
- Submission of equivalent course list approved by the respective Board of studies.
- Withdrawal from examination (vide clause 10) shall not be considered as an appearance.
- Should have secured a CGPA of not less than 9.00

17.2 First Class:

A candidate who qualifies for the award of the degree (vide clause 16) and who satisfies the following conditions shall be declared to have passed the examination in First class:

- Should have passed the examination in all the courses of all four semesters within six consecutive semesters excluding authorized break of study (vide clause 11) after the commencement of his / her study.
- Withdrawal from the examination (vide clause 10) shall not be considered as an appearance.
- Should have secured a CGPA of not less than 7.00

17.3 Second Class:

All other candidates (not covered in clauses 17.1 and 17.2) who qualify for the award of the degree (vide clause 16) shall be declared to have passed the examination in Second Class.

17.4 A candidate who is absent for end semester examination in a course / project work after having registered for the same shall be considered to have appeared for that examination for the purpose of classification.

18. MALPRACTICES IN TESTS AND EXAMINATIONS

If a candidate indulges in malpractice in any of the tests or end semester examinations, he/she shall be liable for punitive action as per the examination rules prescribed by the college from time to time.

19. AMENDMENTS

Notwithstanding anything contained in this manual, the Kongu Engineering College through the Academic council of the Kongu Engineering College, reserves the right to modify/amend without notice, the Regulations, Curricula, Syllabi, Scheme of Examinations, procedures, requirements, and rules pertaining to its ME / MTech programme.

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CURRICULUM BREAKDOWN STRUCTURE						
Summary of Credit Distribution						
Category	**Semester**				**Total number of credits**	**Curriculum Content (% of total number of credits of the program)**
	I	**II**	**III**	**IV**		
FC	**7**	**-**	**-**	**-**	**7**	**9.72**
PC	**12**	**15**	**-**	**-**	**27**	**37.50**
PE	**3**	**6**	**3**	**6**	**18**	**25.00**
EC		**2**	**9**	**9**	**20**	**27.78**
Semester wise Total	**22**	**23**	**12**	**15**	**72**	**100.00**

Category	**Abbreviation**
Lecture hours per week	**L**
Tutorial hours per week	**T**
Practical, Project work, Internship, Professional Skill Training, Industrial Training hours per week	**P**
Credits	**C**

CATEGORISATION OF COURSES

FOUNDATION COURSES (FC)

S. No.	**Course Code**	**Course Name**	**L**	**T**	**P**	**C**	**Sem**
1.	20AMT16	Advanced Calculus and Numerical Analysis	3	1	0	4	I
2.	20GET11	Introduction to Research	2	1	0	3	I
Total Credits to be earned						**7**	

PROFESSIONAL CORE (PC)

S. No.	**Course Code**	**Course Name**	**L**	**T**	**P**	**C**	**Sem**	**Domain/ Stream**
1.	20MHT11	Momentum Heat and Mass Transfer	3	1	0	4	I	T.O
2.	20MHT12	Chemical Reaction Engineering and Reactor Dynamics	3	0	0	3	I	PSS&RE
3.	20MHT13	Modeling in Chemical Engineering	3	0	0	3	I	T.O
4.	20MHL11	Technical Analysis Laboratory	0	0	2	1	I	PSS&RE
5.	20MHL12	Chemical Engineering Laboratory I	0	0	2	1	I	PSS&RE

6.	20MHT21	Chemical Equipment Design	3	1	0	4	II	DMPC&E
7.	20MHT22	Advanced Chemical Engineering Thermodynamics	3	1	0	4	II	TM&TD
8.	20MHT23	Computer Control of Process	3	0	0	3	II	DMPC&E
9.	20MHT24	Industrial Wastewater Treatment	3	0	0	3	II	E&EM
10.	20MHL21	Chemical Engineering Laboratory II	0	0	2	1	II	DMPC&E
Total Credits to be earned						**27**		

		PROFESSIONAL ELECTIVE (PE)						
S. No.	**Course Code**	**Course Name**	**L**	**T**	**P**	**C**	**Sem**	**Domain/ Stream**
		Elective – I						
1.	20MHE01	Advanced Fluidization Engineering	3	0	0	3	I	T.O
2.	20MHE02	Energy Management in Chemical Industries	3	0	0	3	I	E&EM
3.	20MHE03	Environmental Impact Assessment	3	0	0	3	I	E&EM
		Elective – II						
4.	20MHE04	Advanced Separation Techniques	3	0	0	3	II	S.T
5.	20MHE05	Computational Fluid Dynamics	3	0	0	3	II	T.O
6.	20MHE06	Mixing Technology	3	0	0	3	II	T.O
7.	20MHE07	Process Instrumentation and Automation	3	0	0	3	II	DMPC&E
8.	20MHE08	Process Intensification	3	0	0	3	II	DMPC&E
9.	20MHE09	Risk Analysis	3	0	0	3	II	PSS&RE
		Elective - III						
10.	20MHE10	Chemical Product Design	3	0	0	3	III	DMPC&RE
11.	20MHE11	Process Optimization Techniques	3	0	0	3	III	DMPC&RE
12.	20MHE12	Bio-Process Engineering	3	0	0	3	III	S.T
		Elective – IV						
13.	20MHE13	Multiphase Flow	3	0	0	3	IV	T.O
14.	20MHE14	Piping Flow sheeting Process and Instrumentation Diagrams	3	0	0	3	IV	DMPC&RE
15.	20MHE15	Chemical Process Design	3	0	0	3	IV	DMPC&RE
16.	20MHE16	Advanced Materials for Chemical Engineers	3	0	0	3	IV	S.T
17.	20MHE17	Industrial Drying	3	0	0	3	IV	S.T
18	20MHE18	Design and Analysis of Experiments	3	0	0	3	IV	DMPC

19.	GE	Innovation Entrepreneurship and Venture development	3	0	0	3	IV	DMPC&RE
Total Credits to be earned						**18**		

*TO-Transport Operations, E&EM-Environment & Energy Management, RE- Reaction Engineering, DMP- Design, Modeling, Process Control & Economics, ST- Separation Techniques

EMPLOYABILITY ENHANCEMENT COURSES (EC)							
1.	20MHP21	Innovative Project	0	0	4	2	II
2.	20MHP31	Internship cum Project work	---	---	27	9	III
3.	20MHP41	Project Work			27	9	IV
Total Credits to be earned						**20**	

KEC R2020: SCHEDULING OF COURSES – M.Tech. (Chemical Engineering) Total Credits : 72

Sem.	Course1	Course2	Course3	Course4	Course5	Course6	Course7	Course8	Course9	Course10	C
I	20AMT16 Advanced Calculus and Numerical Analysis (3-1-0-4)	20GET11 Introduction to Research (2-1-0-3)	20MHT11 Momentum Heat and Mass Transfer (3-1-0-4)	20MHT12 Chemical Reaction Engineering and Reactor Dynamics (3-0-0-3)	20MHT13 Modeling in Chemical Engineering (3-0-0-3)	Professional Elective I (3-0-0-3)	20MHL11 Technical Analysis Laboratory (0-0-2-1)	20MHL12 Chemical Engineering Laboratory I (0-0-2-1)			22
II	20MHT21 Chemical Equipment Design (3-1-0-4)	20MHT22 Advanced Chemical Engineering Thermodynamics (3-1-0-4)	20MHT23 Computer Control of Process (3-0-0-3)	20MHT24 Industrial Wastewater Treatment (3-0-0-3)	Professional Elective II (3-0-0-3)	Professional Elective III (3-0-0-3)	20MHL21 Chemical Engineering Laboratory II (0-0-2-1)	20MHP21 Innovative Project (0-0-4-2)			23
III	Professional Elective IV (3-0-0-3)	20MHP31 Internship cum Project work (0-0-27-9)									12
IV	Professional Elective V (3-0-0-3)	Professional Elective VI (3-0-0-3)	20MHP41 Project Work (0-0-27-9)								15

MAPPING OF COURSES WITH PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

Sem.	Course Code	Course Title	PO1	PO2	PO3	PO4	PO5
1	20AMT16	Advanced Calculus and Numerical Analysis	✓				
1	20GET11	Introduction to Research	✓	✓	✓		
1	20MHT11	Momentum Heat and Mass Transfer	✓			✓	✓
1	20MHT12	Chemical Reaction Engineering and Reactor Dynamics					
1	20MHT13	Modeling in Chemical Engineering	✓			✓	✓
1	20MHL11	Technical Analysis Laboratory	✓	✓		✓	✓
1	20MHL12	Chemical Engineering Laboratory I	✓			✓	✓
2	20MHT21	Chemical Equipment Design	✓			✓	
2	20MHT22	Advanced Chemical Engineering Thermodynamics	✓	✓	✓	✓	✓
2	20MHT23	Computer Control of Process	✓			✓	✓
2	20MHT24	Industrial Wastewater Treatment					
2	20MHL21	Chemical Engineering Laboratory II	✓	✓	✓	✓	
2	20MHP21	Innovative Project	✓	✓	✓	✓	✓
3	20MHP31	Internship cum Project work	✓	✓	✓	✓	✓
4	20MHP41	Project Work	✓	✓	✓	✓	✓
1	20MHE01	Advanced Fluidization Engineering	✓	✓	✓	✓	✓
1	20MHE02	Energy Management in Chemical Industries	✓	✓	✓	✓	✓
1	20MHE03	Environmental Impact Assessment	✓	✓	✓		
2	20MHE04	Advanced Separation Techniques	✓		✓	✓	✓
2	20MHE05	Computational Fluid Dynamics	✓			✓	✓
2	20MHE06	Mixing Technology	✓			✓	✓
2	20MHE07	Process Instrumentation and Automation	✓		✓	✓	

Sem.	Course Code	Course Title	PO1	PO2	PO3	PO4	PO5
2	20MHE08	Process Intensification	✓		✓	✓	✓
2	20MHE09	Risk Analysis	✓	✓	✓		
3	20MHE10	Chemical Product Design	✓	✓	✓	✓	✓
3	20MHE11	Process Optimization Techniques	✓		✓	✓	✓
3	20MHE12	Bio-Process Engineering	✓	✓		✓	✓
4	20MHE13	Multiphase Flow	✓	✓	✓	✓	✓
4	20MHE14	Piping Flow sheeting Process and Instrumentation Diagrams			✓	✓	
4	20MHE15	Chemical Process Design	✓	✓	✓	✓	✓
4	20MHE16	Advanced Materials for Chemical Engineers	✓	✓	✓	✓	✓
4	20MHE17	Industrial Drying	✓	✓	✓	✓	✓
4	20MHE18	Design and Analysis of Experiments	✓		✓	✓	✓

M.Tech. CHEMICAL ENGINEERING CURRICULUM – R2020

SEMESTER – I

Course Code	Course Title	Hours / Week			Credit	Maximum Marks			Category
		L	T	P		CA	ESE	Total	
Theory/Theory with Practical									
20AMT16	Advanced Calculus and Numerical Analysis	3	1	0	4	50	50	100	FC
20GET11	Introduction to Research	2	1	0	3	50	50	100	FC
20MHT11	Momentum Heat and Mass Transfer	3	1	0	4	50	50	100	PC
20MHT12	Chemical Reaction Engineering and Reactor Dynamics	3	0	0	3	50	50	100	PC
20MHT13	Modeling in Chemical Engineering	3	0	0	3	50	50	100	PC
	Professional Elective I	3	0	0	3	50	50	100	PE
Practical / Employability Enhancement									
20MHL11	Technical Analysis Laboratory	0	0	2	1	50	50	100	PC
20MHL12	Chemical Engineering Laboratory I	0	0	2	1	50	50	100	PC
Total Credits to be earned					22				

SEMESTER – II

Course Code	Course Title	Hours / Week			Credit	Maximum Marks			Category
		L	T	P		CA	ESE	Total	
Theory/Theory with Practical									
20MHT21	Chemical Equipment Design	3	1	0	4	50	50	100	PC
20MHT22	Advanced Chemical Engineering Thermodynamics	3	1	0	4	50	50	100	PC
20MHT23	Computer Control of Processes	3	0	0	3	50	50	100	PC
20MHT24	Industrial Wastewater Treatment	3	0	0	3	50	50	100	PC
	Professional Elective II	3	0	0	3	50	50	100	PE
	Professional Elective III	3	0	0	3	50	50	100	PE
Practical / Employability Enhancement									
20MHL21	Chemical Engineering Laboratory II	0	0	2	1	50	50	100	PC
20MHP21	Innovative Project	0	0	4	2	50	50	100	EC
Total Credits to be earned					23				

SEMESTER – III									
Course Code	**Course Title**	**Hours / Week**			**Credit**	**Maximum Marks**			**Category**
		L	**T**	**P**		**CA**	**ESE**	**Total**	
Theory/Theory with Practical									
	Professional Elective IV	3	0	0	3	50	50	100	PE
20MHP31	Internship cum Project work	---	---	27	9	50	50	100	EC
Total Credits to be earned					12				

SEMESTER – IV									
Course Code	**Course Title**	**Hours / Week**			**Credit**	**Maximum Marks**			**Category**
		L	**T**	**P**		**CA**	**ESE**	**Total**	
Theory/Theory with Practical									
	Professional Elective V	3	0	0	3	50	50	100	PE
	Professional Elective VI	3	0	0	3	50	50	100	PE
Practical / Employability Enhancement									
20MHP41	Project Work			27	9	50	50	100	EC
Total Credits to be earned					15				

20AMT16 - ADVANCED CALCULUS AND NUMERICAL ANALYSIS

Programme & Branch	**M.TECH. Chemical Engineering**	**Sem.**	**Category**	**L**	**T**	**P**	**Credit**
Prerequisites	**Nil**	**1**	**FC**	**3**	**1**	**0**	**4**

Preamble	This course is designed to enrich the knowledge in tensor calculus and calculus of variations. Also the course will develop problem solving skills in numerical methods aided by technology to apply finite difference methods for solving the boundary value problems in differential equations.	
Unit - I	**Tensor Calculus**	**9+3**
Spaces of N-dimensions – Coordinate transformations – Covariant, Contravariant and mixed tensors – Fundamental operation with tensors – Symmetric and Skew-symmetric tensors – Riemannian Metric: Metric tensor – Associated tensors – Conjugate tensor – Christoffel symbols – Covariant derivative.		
Unit - II	**Calculus of Variations**:	**9+3**
Concept of variation and its properties – Euler's equation – Functional dependant on first and higher order derivatives – Functionalsdependant on functions of several independent variables – Variational problems with moving boundaries – Isoperimetric problems - Direct methods : Ritz and Kantorovich methods.		
Unit - III	**Numerical solution of Ordinary differential equations**	**9+3**
Runge - Kutta methods for system of IVPs – Numerical stability of Runge - Kutta method – Adams - Bashforth multistep method – Shooting method –Solution of BVP : Finite difference method – Collocation method and orthogonal collocation method.		
Unit - IV	**Finite difference method for time dependent partial differential equations**	**9+3**
Parabolic equations: Explicit and implicit finite difference methods – Weighted average approximation - Dirichlet's and Neumann conditions – Two dimensional parabolic equations – ADI method: First order hyperbolic equations – Method of numerical integration along characteristics – Wave equation: Explicit scheme – Stability.		
Unit - V	**Finite Difference Methods For Elliptic Equations**	**9+3**
Laplace and Poisson's equations in a rectangular region: Five point finite difference schemes, Leibmann's iterative methods, Dirichlet's and Neumann conditions – Laplace equation in polar coordinates: Finite difference schemes – Approximation of derivatives near a curved boundary while using a square mesh.		

Lecture:45, Tutorial:15, Total:60

REFERENCES:

1	Prasun Kumar Nayak, "REFERENCES, of Tensor Calculus and Differential Geometry", PHI Learning Pvt. Ltd New Delhi, 2012.
2	Gupta,A.S., "Calculus of Variations with applications", PHI Learning Pvt. Ltd., 1996.
3.	Burden, R.L., and Faires, J.D., "Numerical Analysis – Theory and Applications", 9th Edition, Cengage Learning, New Delhi, 2016.
4.	SaumyenGuha and Rajesh Srivastava, "Numerical methods for Engineering and Science", Oxford Higher Education, New Delhi, 2010.
5.	Smith, G. D., "Numerical Solutions of Partial Differential Equations: Finite Difference Methods", Clarendon Press, 1985.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	identify various tensors that occur in chemical engineering problems.	Applying (K3)
CO2	solve problems involving the functional that occur in various branches of engineering disciplines.	Applying (K3)
CO3	solve ordinary differential equations using finite difference and finite element methods.	Applying (K3)
CO4	solve time dependent partial differential equations by using finite difference approach.	Applying (K3)
CO5	solve elliptic PDE by using finite difference methods.	Applying (K3)

Mapping of COs with POs and PSOs					
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1	1				
CO2	2				
CO3	3				
CO4	3				
CO5	3				
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy					

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	10	20	70	-	-	-	100
CAT2	10	20	70	-	-	-	100
CAT3	10	20	70	-	-	-	100
ESE	10	20	70	-	-	-	100

*** ±3% may be varied**

20GET11 INTRODUCTION TO RESEARCH

(Common to Engineering and Technology Branches)

Programme & Branch	M.TECH. Chemical Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	1	FC	2	1	0	3

Preamble	Preamble: This course will familiarize the fundamental concepts/techniques adopted in research, problem formulation and patenting. Also will disseminate the process involved in collection, consolidation of published literature and rewriting them in a presentable form using latest tools.	
Unit - I	**Concept of Research**	**6**
Meaning and Significance of Research: Skills, Habits and Attitudes for Research - Time Management - Status of Research in India. Why, How and What a Research is? - Types and Process of Research - Outcome of Research - Sources of Research Problem - Characteristics of a Good Research Problem - Errors in Selecting a Research Problem - Importance of Keywords - Literature Collection – Analysis - Citation Study - Gap Analysis - Problem Formulation Techniques.		
Unit - II	**Research Methods and Journals**	**6**
Interdisciplinary Research - Need for Experimental Investigations - Data Collection Methods - Appropriate Choice of Algorithms / Methodologies / Methods - Measurement and Result Analysis - Investigation of Solutions for Research Problem - Interpretation - Research Limitations. Journals in Science/Engineering - Indexing and Impact factor of Journals - Citations - h Index - i10 Index - Journal Policies - How to Read a Published Paper - Ethical issues Related to Publishing - Plagiarism and Self-Plagiarism.		
Unit - III	**Paper Writing and Research Tools**	**6**
Types of Research Papers - Original Article/Review Paper/Short Communication/Case Study - When and Where to Publish? - Journal Selection Methods. Layout of a Research Paper - Guidelines for Submitting the Research Paper - Review Process - Addressing Reviewer Comments. Use of tools / Techniques for Research - Hands on Training related to Reference Management Software - EndNote, Software for Paper Formatting like LaTeX/MS Office. Introduction to Origin, SPSS, ANOVA etc., Software for detection of Plagiarism.		
Unit - IV	**Effective Technical Thesis Writing/Presentation**	**6**
How to Write a Report - Language and Style - Format of Project Report - Use of Quotations - Method of Transcription Special Elements: Title Page - Abstract - Table of Contents - Headings and Sub-Headings - Footnotes - Tables and Figures - Appendix - Bibliography etc. - Different Reference Formats. Presentation using PPTs.		
Unit - V	**Nature of Intellectual Property**	**6**
Patents - Designs - Trade and Copyright. Process of Patenting and Development: Technological research - innovation - patenting - development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents.		

Lecture: 30, Tutorial:15, Total:45

REFERENCES:

1	DePoy, Elizabeth, and Laura N. Gitlin, “Introduction to Research-E-Book: Understanding and Applying Multiple Strategies”, Elsevier Health Sciences, 2015.
2	Walliman, Nicholas, “Research Methods: The basics”,Routledge, 2017.
3.	Bettig Ronald V., “Copyrighting culture: The political economy of intellectual property”,Routledge, 2018.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	list the various stages in research and categorize the quality of journals.	Analyzing (K4)
CO2	formulate a research problem from published literature/journal papers	Evaluating (K5)
CO3	write, present a journal paper/ project report in proper format	Creating (K6)
CO4	select suitable journal and submit a research paper.	Applying (K3)
CO5	compile a research report and the presentation	Applying (K3)

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	3	2	1		
CO2	3	2	3		
CO3	3	3	1		
CO4	3	2	1		
CO5	3	2	1		

1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy

ASSESSMENT PATTERN - THEORY

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT1		30	40	30			100
CAT2		30	40	30			100
CAT3			30	40	30		100
ESE		30	40	30			100

*** ±3% may be varied**

20MHT11 MOMENTUM, HEAT AND MASS TRANSFER

Programme& Branch	M.TECH. - Chemical Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	**1**	**PC**	**3**	**1**	**0**	**4**

Preamble	This course provides the student with a vast knowledge about the transport of momentum mass and energy	
Unit - I	**Introduction to Units and Dimensions**	**9+3**
Phenomenological equations and transport properties, Rheological behavior of fluids, Balance Equations - Differential and Integral equations, shell balance approach to transfer problems; Momentum flux and velocity distribution for flow of Newtonian and Non-Newtonian fluids in pipes, planes, slits and annulus		
Unit - II	**Energy and mass transfer in laminar flow**	**9+3**
Heat flux and temperature distribution for heat sources such as electrical, nuclear, viscous and chemical, forced and free convection, Mass flux and concentration profile for diffusion in stagnant gas,systems involving reactions.		
Unit - III	**Applications of equations of change**	**9+3**
Development of equations of change and solutions to momentum, mass and heat transfer problems discussed under shell balance by applications of equation of change		
Unit - IV	**Turbulent flow**	**9+3**
Comparison of laminar and turbulent flows, Time-smoothedequations of change for incompressible fluids, time smoothed velocity, temperature profile near a wall, Semi-Empirical Expressions for turbulent momentum, heat and mass flux		
Unit - V	**Macroscopic balance for steady state system**	**9+3**
Macroscopic momentum and mass balance, Overall energy and mechanical balance, Pressure rise and friction losses in sudden enlargement, Performance of a liquid-liquid ejector, Isothermal flow of a liquid through an orifice		

Lecture:45; Tutorial : 15; Total: 60

REFERENCES:

1.	Bird R.B., Stewart W.E. and Lightfoot E.N., "Transport Phenomena”, Revised 2nd Edition, John Wiley & Sons, 2007.
2.	WeltyJ.R., Wicks C.E.and Wilson R.E.,“Fundamentals of Momentum, Heat and MassTransfer”,5th Edition,John Wiley and Sons,2007.
3.	Mark W.V., and Bhatia S.C, "Chemical Process Industries", 2nd Edition, CBS Publishers and Distributors, New Delhi, 2007.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	understand the phenomena behind the transport of momentum, mass and energy from a first principles perspective and apply the shell balance approach to solve momentum transport problems	Applying (K3)
CO2	apply the shell balance approach to solve energy and masstransport problems	Applying (K3)
CO3	utilize equations of change to solve the transport problems	Applying (K3)
CO4	apply the concept of Turbulent flow	Applying (K3)
CO5	develop macroscopic balance for steady state system	Applying (K3)

Mapping of COs with POs and PSOs					
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1	3			3	2
CO2	3			3	2
CO3	3			3	2
CO4	3			3	2
CO5	3			3	2
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy					

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	10	30	60				100
CAT2	10	30	60				100
CAT3	10	30	60				100
ESE	10	30	60				100

*** ±3% may be varied**

20MHT12 CHEMICAL REACTION ENGINEERING AND REACTOR DYNAMICS

Programme& Branch	**M.TECH. Chemical Engineering**	**Sem.**	**Category**	**L**	**T**	**P**	**Credit**
Prerequisites	Nil	**1**	**PC**	**3**	**0**	**0**	**3**

Preamble	This course provides an overview about the exploitation of chemical reactions in commercial scale and gives vast understanding about the design and operations of chemical reactors	
Unit – I	**Industrial catalysis**	**9**
Classification of Catalysis -Homogeneous, Heterogeneous, Biocatalysts, Typical industrial catalytic processes. Preparation of catalysis -Laboratory Techniques, characterization of catalysts, Catalysts deactivation -Poisons, Sintering of catalysts, Pore mouth plugging and uniform poisoning models, Kinetics of deactivation, Catalyst regeneration. Inhibition.		
Unit - II	**Theories of catalysts**	**9**
Adsorption isotherms -Langmuir model, Tempkin model, Freundich model, Elovich equation, LangmiurHinshel - wood model, Rideal -Eely mechanism, Reversible -irreversible mono and bimolecular reactions with and without inerts. Determination ofratecontrollingsteps		
Unit - III	**External diffusion effects in heterogeneous reactions**	**9**
Fixed bed Reactors: Mass and heat Transfer coefficients in packed beds, Quantitative treatment of external transport effects, Effect of external transport processes on selectivity. Modeling diffusion with and without reaction. Construction and operation: Fixed bed Reactors		
Unit - IV	**Fluidized Bed Reactors**	**9**
Fluidized Bed Reactors: Mass and Heat Transfer Correlations .Slurry bedReactors: Mass Transfer Correlations, Effect of mass transfer on Observed rate. Calculation of Global rate. Construction and operation: Fluidized bed Reactors, Surry reactors and Trickle bedreactor		
Unit - V	**Gas-solid non-catalytic reactors**	**9**
Models for explaining the kinetics; volume and surface models; controlling resistances and rate controlling steps; time for complete conversion for single and mixed sizes.		

Total: 45

REFERENCES:

1.	Smith J.M., "Chemical Engineering Kinetics", 3rd Edition, McGraw-Hill, New York, 1981
2.	Fogler H.S, "Elements of Chemical Reaction Engineering", 4th Edition, Prentice Hall of India, New Delhi, 2008.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	demonstrate the preparation of different types of catalysts	Applying (K3)
CO2	explain the isotherm concepts and analyze the rate controlling mechanism	Analyzing (K4)
CO3	analyze various models used for heterogeneous reactors	Analyzing (K4)
CO4	compare the different rate controlling mechanisms in reactor design	Analyzing (K5)
CO5	design catalytic and multi-phase reactors	Applying (K3)

Mapping of COs with POs and PSOs					
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1	2	2	1		1
CO2	2	1	2		
CO3	2	1		1	
CO4	1			3	1
CO5	2			3	1
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy					

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	15	25	30	30	-	-	100
CAT2	15	25	30	30	-	-	100
CAT3	15	25	30	30	-	-	100
ESE	15	25	30	30	-	-	100

*** ±3% may be varied**

20MHT13 MODELING IN CHEMICAL ENGINEERING

Programme& Branch	M.TECH. Chemical Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	1	PC	3	0	0	3

Preamble	This course makes the students knowledgeable in different aspects of modeling chemical process systems & familiarizes with the numerical simulation of models in fluid flow operations, separation processes and reactors. They will also acquire knowledge on the fundamental concepts of recent techniques in process simulation	
Unit - I	**Introduction to fundamentals of process modeling**	**9**
Introduction, Physical modeling, mathematical modeling and its classification, chemical systems modeling, Principles of formulation, Representation of a model, Model building, Boundary conditions, Black box principles, Fundamental laws used in modeling: Continuity equations, Energy equation, Equation of Motion, Transport equations, Equations of state, Equilibrium relations, Chemical kinetics.		
Unit - II	**Models in Fluid Flow Operations**	**9**
The process and the model aspects of : Mixed vessel, laminar flow in pipe, Gravity flow tank, Cone shaped tank, Mixing tank, Stirred tank heater, Two stirred tank heaters, Interacting stirred tank heaters, Interacting and Non-interacting tanks, Agitated tank for solid dissolution		
Unit - III	**Mathematical Modeling of Reactors**	**9**
The Process and the model aspects of Batch reactor, Tubular reactor, Jacketed tubular reactor, CSTR, CSTR with cooling jacket, Two CSTRs, Series of CSTR – three CSTRs, constant and variable holdup, CSTR – isothermal and non-isothermal, Continuous stirred tank bioreactor.		
Unit - IV	**Models in Separation Processes**	**9**
Mathematical model aspects of Multi component flash drum, Single component vaporizer, Refinery debutanizer column, Ideal binary distillation column, Binary continuous distillation column, Gas liquid bubble reactor, Solvent extraction – steady state single stage and two stage, Absorption column, Triple effect evaporator – Forward and backward feed, Double pipe heat exchanger		
Unit - V	**Process Simulation**	**9**
Process Simulation – Scope, Formulation of a problem, Steps in Steady state simulation, Simulation approach for steady state process, Process Simulator- Organization and structure. HYSYS: Integrated simulation environment, products, intuitive and interactive process modeling, open and extensible HYSYS architecture; ASPEN PLUS: Unit operation models, selection of EOS; Introduction to Artificial Neural Network – training, modes & applications		

Total: 45

REFERENCES:

1.	Babu B.V., "Process Plant Simulation", Oxford University Press, New Delhi, 2004.
2.	Luyben W.L., "Process Modeling, Simulation and Control for Chemical Engineers", 2nd Edition, McGraw Hill Book Company, New York, 1990.
3.	Amiya K. Jana, "Chemical Process Modeling and Computer Simulation", Prentice Hall of India, 2017.
4.	Gaikwad R.W. and Dhirendra, "Process Modeling and Simulation", 2nd Edition, Denett and Company, Nagpur, 2010.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	apply the concepts of various mathematical models and fundamentals laws	Applying (K3)
CO2	develop mathematical models for various fluid flow systems	Analyzing (K4)
CO3	develop mathematical models for various types of reactors	Analyzing (K4)
CO4	build up mathematical models for distillation and separation columns	Applying (K3)
CO5	apply the concepts of simulations and novel techniques to simulate chemical systems	Analyzing (K4)

Mapping of COs with POs and PSOs					
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1	3			3	2
CO2	3			3	2
CO3	3			3	2
CO4	3			3	2
CO5	3			3	2
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy					

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	20	20	60	-	-	-	100
CAT2	-	10	50	40	-	-	100
CAT3	-	20	50	30	-	-	100
ESE	10	20	40	30	-	-	100

*** ±3% may be varied**

20MHL11 TECHNICAL ANALYSIS LABORATORY

Programme & Branch	M.TECH. - Chemical Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	1	PC	0	0	2	1
Preamble	This course covers a variety of methods of analysis in chemical instrumentation used to determine experimentally the various properties of the Waste water, Polymers, chemicals etc						

List of Exercises / Experiments :

1.	UV Spectro photometer: Analysis of Iron, Cobalt, etc, in the given sample.
2.	Determination of BOD, COD for the given Industrial wastewater.
3.	Analysis of water: pH, Conductivity, Hardness, Chlorides and Sulphate.
4.	Flame Photometer: Determination of Sodium and Potassium.
5.	Nephelometer: Determination of Turbidity.
6.	Conductometric Titrations.
7.	Potentiometric Titrations
8.	Oswald Viscometer: Viscosity Measurement for Polymer solutions.
9.	Thermodynamic Parameters for first order Kinetics.
10.	Determination of Melting and Boiling points of solid and liquid samples.
11.	Atomic Absorption Spectroscopic Analysis of heavy metals in Industrial Wastewater.
12.	Infrared (IR) spectroscopic analysis of Organic compounds.

Practical : 30,Total: 30

REFERENCES/MANUAL/SOFTWARE:

1.	Lab Manual

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	understand the principles of instrumental analysis and determine physical, chemical and biological properties of waste water	Applying (K3), Imitation (S1)
CO2	estimate the physical and chemical properties of organic compoundsusing various instrumental analyses	Evaluating (K5), Manipulation (S2)
CO3	examine the kinetics and mechanism of chemical reactions	Analyzing (K4), Imitation (S1)

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	2	2		2	1
CO2	2	2		2	1
CO3	3	2		2	1
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy					

20MHL12 CHEMICAL ENGINEERING LABORATORY I

Programme & Branch	M.TECH. - Chemical Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	1	PC	0	0	2	1
Preamble	This course covers a variety of methods of performance analysis of various unit operations and processes						

List of Exercises / Experiments :

1.	Determination of Rheological Behavior of a non-Newtonian fluid
2.	Performance evaluation of a Centrifugal Pump
3.	Residence Time Distribution studies in a Packed Bed Reactor
4.	Surface Area analysis using BET Adsorption Isotherm
5.	Analysis of Ratio Control System
6.	Analysis of Feed Forward Control System
7.	Determination of Optimum Controller settings by Tuning and Stability Analysis
8.	Comparison of P, PI and PID modes for flow, level and pressure control systems
9.	Simulation of Shell and Tube/ Double Pipe Heat Exchanger using Aspen Plus and HTRI
10.	Simulation of Distillation Operation using Aspen Plus
11.	Sensitivity Analysis of an Flash Separation using Aspen Plus
12.	Simulation of a simple Process Flow Diagram using Aspen Plus

Practical : 30,Total: 30

REFERENCES/MANUAL/SOFTWARE:

1.	Lab Manual

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	Analyze physical phenomena and efficiency of transfer processes using various equipment used in process industries	Applying (K3), Imitation (S1)
CO2	Evaluate the working of various control configurations/modes and advanced control systems used in process industries	Evaluating (K5), Manipulation (S2)
CO3	Simulation and sensitivity analysis of process equipment using Aspen Plus	Analyzing (K4), Imitation (S1)

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	3			2	2
CO2	3			2	2
CO3	3			2	2
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy					

20MHT21 CHEMICAL EQUIPMENT DESIGN

Programme& Branch	M.TECH. Chemical Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	1	PC	3	1	0	4

Preamble	This course provides a basic understanding of design parameter, complete knowledge of design procedures for commonly used process equipment like pressure vessel, heat exchangers, distillation column, absorption column, extractor, crystallizer, cooling tower and dryers. The concepts and skills learnt in process calculations, thermodynamics, momentum transfer, mass transfer and heat transfer will be utilized.	
Unit - I	**Design of pressure vessel**	**9+3**
Introduction- pressure vessel codes and standards- Fundamental principles and equations, Failure mode in pressure vessel. Design of pressure vessels under combined loading and high pressure. Design of storage vessel.		
Unit - II	**Design of heat transfer equipment**	**9+3**
Process design of Shell and tube heat exchanger, double pipe heat exchanger – estimation of individual and overall heat transfer coefficient, estimation of pressure drop. Design of single effect evaporator – calculation of steam requirement and heat transfer area.		
Unit - III	**Design of mass transfer equipment**	**9+3**
Design of distillation column- Determination of number of stages, column diameter and height – McCabe Thiele and Ponchon Savarit method. Design of absorption column – Calculation of diameter and height, Absorption factor – estimation of number of plates required.		
Unit - IV	**Design of extractor and crystallizer**	**9+3**
Extractor - Industrial applications of liquid-liquid extraction, choice of solvent, equipment used for liquid-liquid extraction, process design of counter current multistage extractor – steps involved in determination of number of stages. Design of crystallizers – Determination of length and number of sections		
Unit - V	**Design of Miscellaneous Equipment**	**9+3**
Design of cooling tower - Calculation of HTU, NTU, Height and diameter. Design of Reboiler – Typical design procedure for thermosyphon reboiler and estimation of various parameters. Design of dryers – Design of rotary dryer – Estimation of length and diameter, Design of fluid bed dryer – calculation of diameter of distributor grid and disengagement zone.		

Lecture:45; Tutorial : 15; Total: 60

REFERENCES:

1.	Sinnott Ray and Towler Gavin, “Coulson and Richardson’s Chemical Engineering series Chemical Engineering Design”, 6th edition, Volume 6, 2019.
2.	Kern, D.Q., “Process Heat Transfer”, International Student Edition, McGraw Hill, 2002.
3.	Mahajani, V.V. and Umarji, S.B., Joshi’s “Process Equipment Design”, 4th edition, Macmillan Publishers India Limited, New Delhi, 2010.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	determine the plate thickness and various stress analysis of vessels under combined loading and high pressure	Applying (K3)
CO2	solve and find the design parameters of shell and tube, double pipe heat exchangers and estimate the steam requirement and heat transfer area for a single effect evaporator	Applying (K3)
CO3	design distillation column using McCabe Thiele and Ponchon Savarit methods and estimate the diameter, height of absorption column	Applying (K3)
CO4	analyze the concepts involved in liquid-liquid extraction process and its industrial applications, estimating the number of stages and designing of crystallizers	Analyzing (K4)
CO5	examine the process of design of cooling towers, rotary and fluid bed dryers	Analyzing (K4)

Mapping of COs with POs and PSOs					
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1	1			3	
CO2	1			3	
CO3	1			3	
CO4	1			3	
CO5	1			3	
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy					

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	10	20	70	--	--	--	100
CAT2	10	20	70	--	--	--	100
CAT3	10	10	20	60	--	--	100
ESE	10	10	30	50	--	--	100

*** ±3% may be varied**

20MHT22 ADVANCED CHEMICAL ENGINEERING THERMODYNAMICS

Programme& Branch	**M.TECH. Chemical Engineering**	**Sem.**	**Category**	**L**	**T**	**P**	**Credit**
Prerequisites	Nil	**1**	**PC**	**3**	**1**	**0**	**4**

Preamble	This course presents the laws of thermodynamics and their applications in process industries	
Unit – I	**Laws of thermodynamics**	**9+3**
Basic concepts; first law of thermodynamics – applications to closed and open systems; second law of thermodynamics; Carnot theorem; applications of second law to the feasibility analysis of devices and processes; evaluation of entropy change – mixing and separation of gases, mixing and separation of liquids, heating and cooling of process fluids.		
Unit – II	**Properties of solutions**	**9+3**
Molar properties and partial molar properties; methods for determination of partial molar properties; ideal and non-ideal solutions; Gibbs-Duhem equation; mixing of liquids – volume change, enthalpy change, Gibbs free energy change.		
Unit – III	**Phase equilibrium**	**9+3**
Vapour-liquid equilibrium; fugacity and fugacity coefficient; activity and activity coefficient; Raoult's law; modified Raoult's law; phase diagram of binary system; models for excess Gibbs free energy - Margules two-suffix equation, Van Laar equation, Wilson equation; criterion for equilibrium between phases in multi-component non-reacting system in terms of chemical potential and fugacity; thermodynamic consistency test of VLE data.		
Unit – IV	**Chemical reaction equilibrium**	**9+3**
Thermodynamic analysis of chemical reactions – single reactions, simultaneous parallel reactions, prediction of equilibrium composition of reaction mixture; homogeneous gas phase reactions; homogeneous liquid phase reactions; standard Gibbs free energy change and reaction equilibrium constant; evaluation of standard free energy change; evaluation of equilibrium constant.		
Unit – V	**Refrigeration and liquefaction**	**9+3**
Refrigeration principles; Carnot refrigeration cycle; methods of refrigeration – vapour compression refrigeration, absorption refrigeration; evaluation of COP and capacity of refrigeration cycles; air refrigeration; refrigerants for low temperature refrigeration; ozone depletion potential of refrigerants; liquefaction of gases; methods for liquefaction of gases – Claude liquefaction process; Linde liquefaction process.		

Lecture:45; Tutorial : 15; Total: 60

REFERENCES:

1.	Smith J.M, Van Ness H.C, Abbott M.M, Swihart M.T, "Introduction to Chemical Engineering Thermodynamics", McGraw-Hill Education, 8th Edition, 2017
2.	Kyle B.G., "Chemical and Process Thermodynamics", Pearson Education India; 3rd Edition, 2015
3.	Tassios D.P., "Applied Chemical Engineering Thermodynamics", Springer-Verlag, Berlin Heidelberg GmbH, 2014.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	apply the laws of thermodynamics to engineering systems	Applying (K3)
CO2	evaluate the partial molar properties and molar properties of solutions	Evaluating (K5)
CO3	apply phase equilibrium concepts in the fields of separation of systems involving vapour and liquid, and test the thermodynamic consistency of experimental VLE data	Applying (K3)
CO4	analyze the homogeneous chemical reactions and predict the equilibrium composition	Analyzing (K5)
CO5	evaluate the performance of refrigeration and liquefaction processes	Evaluating (K5)

Mapping of COs with POs and PSOs					
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1	3	1	1	1	1
CO2	3	1		1	1
CO3	3	1		2	1
CO4	3	1		1	1
CO5	3	1		1	1
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy					

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	5	30	45	5	15	-	100
CAT2	5	30	30	20	15	-	100
CAT3	5	30	30	20	15	-	100
ESE	5	30	30	20	15	-	100

*** ±3% may be varied**

20MHT23 COMPUTER CONTROL OF PROCESSES

Programme& Branch	**M.TECH. Chemical Engineering**	**Sem.**	**Category**	**L**	**T**	**P**	**Credit**
Prerequisites	Nil	**1**	**PC**	**3**	**0**	**0**	**3**

Preamble	This course enables the students to acquire basic knowledge in recent control strategies of chemical processes, proper input – output pairing for multiple single input – single output controllers and gain exposure on process control with digital computers.	
Unit – I	**Advanced Control Strategies**	**9**
Advanced control loops - cascade, split range & selective control; feed forward and Ratio control; adaptive and inferential control		
Unit – II	**Internal Model Control**	**9**
Model based control – development and design of IMC structure; IMC based PID controller for stable and unstable process; Model Predictive Control – dynamic matrix control, constraints and multivariable systems		
Unit – III	**Multivariable Control**	**9**
MIMO systems –Control loop interaction – general pairing problem, relative gain array and application; Multivariable control – zeros and performance limitations, directional sensitivity and operability, decoupling.		
Unit – IV	**Discrete Systems**	**9**
Z – Transform and inverse Z – transform properties, Discrete – Time Response of dynamic system, Stability analysis of discrete time system		
Unit – V	**Digital Feedback Controllers**	**9**
Closed Loop System Stability, Design of digital feedback controllers and digital approximation of classical controllers, Effect of Sampling.		

Lecture: 45, Total: 45

REFERENCES:

1.	Stephanopoulos, G., “Chemical Process Control: An Introduction To Theory And Practice”, 1st edition, Prentice Hall of India, New Delhi, 2015
2.	Wayne Bequette , B. “Process Control: Modeling, Design, and Simulation”, Prentice Hall of India, New Delhi, 2012.
2.	Kannan M. Moudgalya, “Digital Process Control”, John Wiley & Sons Ltd, 2007.
3.	Chidambaram M., “Computer Control of Processes”, Alpha Science International Ltd, 2002.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	apply the concepts of various mathematical models and fundamentals laws	Applying (K3)
CO2	develop mathematical models for various fluid flow systems	Analyzing (K4)
CO3	develop mathematical models for various types of reactors	Analyzing (K4)
CO4	build up mathematical models for distillation and separation columns	Applying (K3)
CO5	apply the concepts of simulations and novel techniques to simulate chemical systems	Analyzing (K4)

Mapping of COs with POs and PSOs					
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1	3			3	2
CO2	3			3	2
CO3	3			3	2
CO4	3			3	2
CO5	3			3	2
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy					

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	5	45	50	-	-	-	100
CAT2	5	45	50	-	-	-	100
CAT3	5	30	45	20	-	-	100
ESE	5	30	50	15	-	-	100

*** ±3% may be varied**

20MHT24 INDUSTRIAL WASTEWATER TREATMENT

Programme& Branch	**M.TECH. Chemical Engineering**	**Sem.**	**Category**	**L**	**T**	**P**	**Credit**
Prerequisites	Nil	**3**	**PC**	**3**	**0**	**0**	**3**

Preamble	Waste water treatment constitutes a major role in environmental conservation. This course provides a broad overview about the waste water characterization and treatment practices followed in industries.	
Unit – I	**Sources and types of Industrial Wastewater**	**9**
Sources and types of industrial wastewater – Characterization: Physical, Inorganic non metallic constituents, metallic constituents, Organic constituents, Biological Characteristic, Toxicity tests		
Unit – II	**Introduction to process selection**	**9**
Physical unit operation: Screening, Coarse solid reduction, Mixing and flocculation, Equalization, Gravity separation, Grit removal, Sedimentation, Neutralization, Clarification, Flotation. Role of Chemical unit operations in waste water treatment, Chemical unit Process: Chemical Coagulation, Chemical Precipitation- Heavy metal Removal, Phosphorus removal, Chemical oxidation, Chemical Neutralization and stabilization		
Unit – III	**Biological Treatment**	**9**
Composition and Classification, Bacterial growth, Microbial growth, Aerobic biological oxidation, biological Nitrification, Anaerobic fermentation and oxidation, Biological removal of heavy metals, Activated sludge process, Trickling Filters, Rotating Biological Contactors, Combined aerobic treatment processes, Anaerobic treatment process, Anaerobic sludge blanket process, Attached growth process		
Unit – IV	**Advanced wastewater treatment**	**9**
Depth filtration, surface filtration Membrane filtration, Adsorption, Ion exchange, advanced oxidation process, Photo catalysis, Wet Air Oxidation, Evaporation. Disinfection Processes: Disinfection with chlorine, Disinfection with chlorine dioxide, Dechlorination, Disinfection with ozone, Ultraviolet radiation Disinfection. Other chemical Disinfection methods		
Unit – V	**Effluent Treatment Plants**	**9**
Individual and Common Effluent Treatment Plants – Zero effluent discharge systems –Wastewater reuse – Disposal of effluent on land – Quantification, characteristics and disposal of Sludge Industrial process description, wastewater characteristics, source reduction options and waste treatment flow sheet for Textiles – Tanneries – Pulp and paper – metal finishing – petrochemical – Pharmaceuticals – Sugar and Distilleries – Food Processing –fertilizers – Thermal Power Plants and Industrial Estates, Indian regulations		

Total: 45

REFERENCES:

1.	George Tchobanoglous, Franklin L. Burton ,” Wastewater Engineering: Treatment and Reuse Metcalf Eddy”, McGraw Hill, 2011
2.	Frank Woodard, “Industrial waste treatment Handbook”, Butterworth Heinemann, New Delhi, 2001

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	describe the sources and types of industrial waste water and estimate their physio-chemical properties	Applying (K3)
CO2	apply the principles of physical and chemical unit operations in waste water treatment	Applying (K3)
CO3	explain the biological waste water treatment techniques and apply them in industries	Applying (K3)
CO4	develop advanced waste water treatment methods	Applying (K3)
CO5	describe various effluent treatment plants and evaluate their operations	Evaluating (K5)

Mapping of COs with POs and PSOs					
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1	1	1		1	1
CO2	2	1	2	1	1
CO3	2	1	2	1	2
CO4	2	1	2	2	2
CO5	3	1	3	2	3
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy					

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	20	30	30	10	10		100
CAT2	20	30	30	10	10		100
CAT3	20	30	30	10	10		100
ESE	20	30	30	10	10		100

*** ±3% may be varied**

20MHL21 CHEMICAL ENGINEERING LABORATORY II

Programme & Branch	M.TECH. - Chemical Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	1	PC	0	0	2	1
Preamble	This course covers various methods of modeling , simulation and perform analysis of Chemical Plant Operations / Equipment						

List of Exercises / Experiments :

1.	Drawing of a Process Flow Diagram using AutoCAD
2.	3D equipment drawing using AutoCAD/ MS Vision
3.	Design of Shell and Tube Heat Exchanger using MATLAB
4.	Design of Double Pipe Heat Exchanger using MATLAB
5.	Design of Single Effect Evaporator using MATLAB
6.	Design of Reboiler using MATLAB
7.	Heat Integration by Pinch Technology for a Process Flow Diagram using Aspen Energy Analyzer
8.	Design of Experiments using Minitab
9.	Analysis of Variables and Optimization using Minitab
10.	3D modeling using Solid Works
11.	Introduction to Finite Element Analysis using ANSYS
12.	Introduction to Monte Carlo Simulation

Practical : 30,Total: 30

REFERENCES/MANUAL/SOFTWARE:

1.	Lab Manual

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	Create 2D and 3D models of Process equipment and plants using Autocad / MS Visio / ANSYS Solid works	Analyzing (K4), Imitation (S1)
CO2	Design and simulate heat and mass transfer equipment using MATLAB, simulate physical phenomena of transfer processes using FEA ANSYS and optimize heat exchanger network design using Aspen Energy Analyzer	Analyzing (K4), Manipulation (S2)
CO3	Analyze quality/design factors using Minitab (DOE) and perform risk analysis in various systems using Monte Carlo Simulation	Analyzing (K4), Imitation (S1)

Mapping of COs with POs and PSOs					
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1	3	3	2	2	
CO2	3	3	2	2	
CO3	3	3			
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom’s Taxonomy					

20MHE01 ADVANCED FLUIDIZATION ENGINEERING

Programme& Branch	**M.TECH. Chemical Engineering**	**Sem.**	**Category**	**L**	**T**	**P**	**Credit**
Prerequisites	Nil	**1**	**PE**	**3**	**0**	**0**	**3**

Preamble	This course provides an overview about the fluidization phenomena and technology. It gives vast knowledge about flow regimes, hydrodynamics of bubbling, turbulent, fast fluidized beds and pneumatic conveying.	
Unit – I	**Applications of Fluidized Beds**	**9**
Introduction, Industrial application of fluidized beds, physical operations and reactions.		
Unit – II	**Mapping of regimes and dense bed**	**9**
Fixed beds of particles, types of fluidization without carryover and with carryover of particles, mapping of fluidization regimes, distributor types, Davidson model for gas flow at bubbles.		
Unit – III	**Heat and Mass Transfer in Fluidized Bed Systems**	**9**
Mass and heat transfer between fluid and solid. Gas conversion in bubbling beds. Heat transfer between fluidized bed and surfaces.		
Unit – IV	**Elutriation and Entrainment**	**9**
RTD and distribution of solid in a fluidized bed, Circulation systems- circuits for the circulation of solids, flow of gas- solid mixtures in downcomers, flow in pneumatic transport lines.		
Unit – V	**Design of Fluidized Bed Systems**	**9**
Three –phase fluidization, design of fluidization columns for physical operations, catalytic and non- catalytic reactions.		

Total: 45

REFERENCES:

1.	Kunii Diazo and Levenspiel O., “Fluidization Engineering”, Second Edition, Butterworth Heinemann, 1991
2.	Davidson, J.F and Harrison, “Fluidization”, Academic Press, London, 1990

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	survey various applications of fluidized beds in industries	Applying (K3)
CO2	explain the types of fluidization, fluidizing regimes and develop model for gas flow	Applying (K3)
CO3	describe the concept of heat and mass transfer between fluid and solidand determine the design parameters	Applying (K3)
CO4	analyze the solid flow distribution in circulation systems	Analyzing (K4)
CO5	design fluidization columns for physical operations and reactions	Applying (K3)

Mapping of COs with POs and PSOs					
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1	1	1	1	1	1
CO2	3	2	2		2
CO3	1	2	2	1	1
CO4	1	2	2	2	1
CO5		1	1	2	
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy					

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	20	30	40	10			100
CAT2	20	30	40	10			100
CAT3	20	30	40	10			100
ESE	20	30	40	10			100

*** ±3% may be varied**

20MHE02 ENERGY MANAGEMENT IN CHEMICAL INDUSTRIES

Programme& Branch	**M.TECH. Chemical Engineering**	**Sem.**	**Category**	**L**	**T**	**P**	**Credit**
Prerequisites	Nil	**1**	**PE**	**3**	**0**	**0**	**3**

Preamble	This course gives a broad overview about renewable and non-renewable energy resources, energy consumption, planning, energy audit and optimization. It also outlines the need for energy recovery and heat recovery techniques.	
Unit – I	**General**	**9**
Energy Resources: Coal, Petroleum, Natural gas; Reserves and Depletion, need for conservation		
Unit – II	**Power Generation**	**9**
Fossil-fueled power plants: components, advanced cycles; Nuclear-fueled power plants: nuclear energy, radioactivity, nuclear reactors, nuclear fuel cycle, fusion; Co-Generation of power; Generation Process: Economical and technical efficiency, Socio economic factor		
Unit – III	**Alternative Energy**	**9**
Renewable Sources: Hydropower, wind energy, geothermal energy, tidal power, ocean wave power, ocean thermal power, solar Energy, biomass energy; Issues and challenges in using the renewable energy sources		
Unit – IV	**Energy Consumption and Audit**	**9**
Various types of Energy audit, Advantages of each type; Bureau of Energy Efficiency; Energy Conservation act of 2001. Concept of monitoring and targeting, energy targets, reporting techniques, waste avoidance, prioritizing. Energy Analysis		
Unit – V	**Optimisation Techniques in Energy Management**	**9**
Recovery of waste heat using recuperative and regenerative heat exchangers; optimum shell and tube exchanger networks, evaporator systems, boiler turbo generator system.		

Total: 45

REFERENCES:

1.	Twidell John and Weir Tony, “Renewable Energy Sources”, Second Edition, Taylor & Francis, New York, 2006
2.	Steve Doty and Wayne C Turner,” Energy Management Handbook”, CRC Press, 8th Edition 2012
3.	Fay James A. and Golomb Dan S., “Energy and the Environment”, Oxford University Press, Inc., New York, 2002
4.	Beggs Clive, “Energy: Management Supply and Conservation”, Butterworth-Heinemann, Oxford, 2002

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	employ the knowledge about various energy resources and their depletion	Applying (K3)
CO2	compute the efficiency and socio-economic factor in conventional power generation systems	Applying (K3)
CO3	describe the importance of harnessing energy from alternative resources and criticize the issues and challenges involved	Analyzing (K4)
CO4	monitor the energy consumption patterns and perform energy audit to ensure efficient utilization of energy	Applying (K3)
CO5	develop heat exchangers to avoid waste heat	Applying (K3)

Mapping of COs with POs and PSOs

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1	1	1	1		1
CO2	2	2	2		
CO3	1	2	2	1	
CO4	1	2	2	2	1
CO5		1	1	2	1

1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy

ASSESSMENT PATTERN - THEORY

Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	35	35	30	-	-	-	100
CAT2	30	40	30	-	-	--	100
CAT3	30	40	30	-	-	-	100
ESE	30	40	30	-	-	-	100

*** ±3% may be varied**

20MHE03 ENVIRONMENTAL IMPACT ASSESSMENT

Programme& Branch	**M.TECH. Chemical Engineering**	**Sem.**	**Category**	**L**	**T**	**P**	**Credit**
Prerequisites	Nil	**1**	**PE**	**3**	**0**	**0**	**3**

Preamble	This course outlines the means to verify environmental impacts within predicted or permitted limits and acquire knowledge on how to manage unanticipated impacts and unforeseen changes.	
Unit – I	**Basics of EIA**	**9**
Introduction to EIA Audit of Environment & Industries, Input information, Plant operation, Environmental Management planning		
Unit – II	**EIA and Society**	**9**
EIA and industrial development and Economic growth, Social issues, Waste Streams impact on water bodies		
Unit – III	**Planning and Audit**	**9**
Environmental Impact Assessment planning. Activities, Methodology for Environmental Impact Assessment, Role of Environmental Engineering firm, Role of Regulatory agencies and pollution control boards, Role of the Public.		
Unit – IV	**Environmental Audit**	**9**
Introduction, Environmental information Purpose and advantage of studies, General approach of environmental Auditing, Audit programs in India, Auditing program in major polluting Industries, Reports of the Environmental audit studies		
Unit – V	**Legislations Supporting Environment**	**9**
Pollution prevention and control laws & acts: Constitution of India & Environment, Constitution protection to Environment laws, Administrative & legislative arrangement for Environmental production, Indian Standards.		

Total: 45

REFERENCES:

1.	Canter, Larry. W., “Environment Impact Assessment”, Second Edition, McGraw-Hill Publishers, New York, 1996
2.	Bhatia S. C., “Environmental Pollution and Control in Chemical Process Industries,” Khanna Publishers, Delhi, 2014

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	apply the concept of EIA and management planning for a process industry	Applying (K3)
CO2	examine the role of EIA on economic growth and the impacts of wastes on water bodies	Analyzing (K4)
CO3	demonstrate the role of different agencies on EIA	Applying (K3)
CO4	categorize the concept of audit program for different polluting industries	Analyzing (K4)
CO5	employ different laws to prevent and control pollution in environment	Applying (K3)

Mapping of COs with POs and PSOs					
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1	1		3		
CO2	1		3		
CO3	1		3		
CO4	1	2	3		
CO5	1		3		
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy					

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	35	35	30	-	-	-	100
CAT2	30	40	30	-	-	--	100
CAT3	30	40	30	-	-	-	100
ESE	30	40	30	-	-	-	100

*** ±3% may be varied**

20MHE04 ADVANCED SEPARATION TECHNIQUES

Programme& Branch	M.TECH. Chemical Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	2	PE	3	0	0	3

Preamble	This course highlights the recent advancements in separation techniques and provides an exposure with the selection criteria of membrane materials, adsorbents, etc..	
Unit – I	**Recent Advancements in Separation Techniques**	**9**
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 and dual functional filter. Surface based solid – liquid separations involving a second liquid, sirofloc filter.		
Unit – II	**Membranes and Modules**	**9**
Types and choice of membranes; membrane manufacturing techniques; plate and frame, tubular, spiral wound and hollow fiber membrane reactors and their relative merits.		
Unit – III	**Membrane Processes**	**9**
Dialysis, reverse osmosis, nanofiltration, ultrafiltration, and microfiltration and donnan dialysis; design of the reverse osmosis plant – cleaning of membrane – economics of membrane operations.		
Unit – IV	**Adsorption and Ionic Separations**	**9**
Adsorption based Processes: Types and choice of adsorbents, Affinity chromatography and mmune chromatography; Ionic Separation Processes: Working principle, controlling factors, equipment employed for electrophoresis, dielectrophoresis, ion exchange chromatography and electro dialysis.		
Unit – V	**Other Techniques**	**9**
Separations involving lyophilisation, pervaporation and permeation techniques for solids, liquids and gases; zone melting; adductive crystallization; foam separation; supercritical fluid extraction; Industrial effluent treatment by modern techniques		

Total: 45

REFERENCES:

1.	Seader, J.D., Ernest J., Henley, Keith Roper D., "Separation Process Principles", 3rd Edition, John Wiley & Sons, United States of America, 2010.
2.	Ronald W Rosseau, " Handbook of Advanced Separation Process Technology", 1st Edition, Wiley India Pvt Ltd, 2008.
3.	Scott, K. and Hughe, R., "Industrial Membrane Separation Technology", Blackie academic and Professional Publications, 1996
4.	Humphrey, Jimmy L. and Killer, George E. "Separation Process Technology", McGraw- Hill Publications, New York, 1996

COURSE OUTCOMES: On completion of the course, the students will be able to		BT Mapped (Highest Level)
CO1	apply the recent developments in separation techniques	Applying (K3)
CO2	analyze various membrane modules and their uses	Analyzing (K4)
CO3	apply membrane processes for various applications	Applying (K3)
CO4	apply adsorption and ionic separation processes	Applying (K3)
CO5	make use of advanced separation methods for various applications	Applying (K3)

Mapping of COs with POs and PSOs					
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1	2		1	2	2
CO2	2		1	2	2
CO3	2		1	2	2
CO4	2		1	2	2
CO5	2		1	2	2
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy					

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	-	30	70	-	-	-	100
CAT2	-	30	70	-	-	-	100
CAT3	-	30	70	-	-	-	100
ESE	-	30	70	-	-	-	100

*** ±3% may be varied**

20MHE05 COMPUTATIONAL FLUID DYNAMICS

Programme& Branch	M.TECH. Chemical Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	2	PE	3	0	0	3

Preamble	With the advent of high speed computing, CFD has become an integral part of engineering design, simulation and performance analysis. This course deals with the fundamentals of CFD, grid generation, meshing and solution techniques using finite volume method.	
Unit – I	**Conservation Laws of Fluid Motion and Boundary Conditions**	**9**
Governing equations of fluid flow and heat transfer, equations of state, Navier-Stokes equations for Newtonian fluid, conservative form of governing equations of flow, differential and integral forms of general transport equations, classification of physical behaviour.		
Unit – II	**Finite Volume Method for Diffusion and Convective- Diffusion Problems**	**9**
Finite volume method for one-dimensional, two-dimensional and three-dimensional steady state diffusion, steady one-dimensional convection and diffusion, the central differencing scheme. Properties of discretization schemes, assessment of the central differencing scheme for convection-diffusion problems, the upwind differencing scheme, the hybrid differencing scheme, the power-law scheme, higher order differencing schemes for convection-diffusion problems – QUICK scheme.		
Unit – III	**Solution Algorithms for Pressure-Velocity Coupling in Steady Flows**	**9**
Staggered grid, momentum equations, SIMPLE algorithm, assembly of a complete method, SIMPLER, SIMPLEC, and PISO algorithms; Solution of discretised equations: tri-diagonal matrix algorithm, application of TDMA to two-dimensional and three-dimensional problems.		
Unit – IV	**Finite Volume Method for Unsteady Flows**	**9**
One-dimensional unsteady state heat conduction, implicit method for two-and three-dimensional problems, discretisation of transient convection-diffusion equation, transient convection-diffusion using QUICK differencing scheme, solution procedures for unsteady flow calculations, steady state calculations using pseudo-transient approach.		
Unit – V	**Turbulence and its Modeling**	**9**
Transition from laminar to turbulent flow, effect of turbulence on properties of the mean flow, Reynolds-averaged Navier-Stokes equations and classical turbulence models, mixing length model, K-$\mathcal{E}$ model, Reynolds Stress model and Algebraic Stress model		

Total: 45

REFERENCES:

1.	Versteeg H.K. and Malalasekara W., "An Introduction to Computational Fluid Dynamics: The Finite Volume Method", Second Edition, Pearson Education Limited, 2007.
2.	Anderson John D., "Computational Fluid Dynamics- The Basics with Applications", First Edition, Tata-Mcgraw Hill Publisher, 2012.

COURSE OUTCOMES: On completion of the course, the students will be able to		BT Mapped (Highest Level)
CO1	apply the knowledge of C.F.D techniques in developing fluid flow models	Applying (K3)
CO2	apply finite volume method for developing solution of steady state diffusion and convection diffusion problems	Applying (K3)
CO3	demonstrate the application of SIMPLER, SIMPLEC and PISO algorithms for solution of industrial and R & D problems	Applying (K3)
CO4	apply the knowledge of algorithms in solving unsteady flow heat conduction and convection diffusion processes	Applying (K3)
CO5	demonstrate the application of turbulent flows and models in simulation packages	Applying (K3)

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	3			3	2
CO2	3			3	2
CO3	3			3	2
CO4	3			3	2
CO5	3			3	2

1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy

ASSESSMENT PATTERN - THEORY

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT1	10	30	60	-	-	-	100
CAT2	10	35	55	-	-	-	100
CAT3	10	45	45	-	-	-	100
ESE	10	35	55	-	-	-	100

*** ±3% may be varied**

20MHE06 MIXING TECHNOLOGY

Programme& Branch	M.TECH. Chemical Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	**2**	**PE**	**3**	**0**	**0**	**3**

Preamble	This course gives a vast knowledge about the importance of mixing in process industries and technical aspects of mixing	
Unit – I	**Introduction**	**9**
Agitation and mixing, Impeller types and flow pattern, Impeller Power Number, Power correlation for Newtonian and Non Newtonian Liquids. Fundamentals of Blending and Emulsion		
Unit – II	**Flow Patterns, Fluid Velocities and Mixing in Agitated Vessel**	**9**
Relationship between flow pattern, fluid velocities, flow rates and mixing, Impeller discharge rates, Batch mixing and continuous mixing in agitated vessel, Flow regime and flow map in agitated vessel		
Unit – III	**Mass Transfer**	**9**
Dispersion in mass transfer, Measurement of physical properties of fluid dispersion, mechanics of dispersion of fluids, Theory of mass transfer in continuous phases, continuous phase heat and mass transfer properties of dispersion		
Unit – IV	**Suspension of Solids**	**9**
Variable which affects uniformity of solid suspension, impellers and circulation patterns- Effects of vessel and auxiliary equipment on suspension, operating techniques, extrapolation of small-scale tests		
Unit – V	**Equipment selection and Sizing**	**9**
Principles of similarity, design correlations, Common rules of thumb, agitation intensity, Scaling based on tests Procedure for scale-up, Design and selection of agitator-case study		

Total: 45

REFERENCES:

1.	Uhl, V.W., and Gray, J.B., “Mixing Theory and Practice”, Volume I, II and III Academic Press Inc: 1966
2.	James Y.Oldshue,”Fluid Mixing Technology”, McGraw hill-1983
3.	Shinji Nagata, “Mixing Principles and applications”,- 1976

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	explain the fundamentals of mixing process and develop power correlation	Applying (K3)
CO2	describe flow patterns in various agitation and mixing operations and develop flow regimes	Applying (K3)
CO3	familiarize mass transfer characteristics of mixing and analyzing fluid dispersion	Analyzing (K4)
CO4	analyze solid suspension of mixing vessels	Analyzing (K4)
CO5	apply the scale up methods for agitation and mixing equipment	Applying (K3)

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	1			2	2
CO2	1			2	2
CO3	3			3	3
CO4	3			3	3
CO5	3		2	3	3

1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy

ASSESSMENT PATTERN - THEORY

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT1	15	45	30	10	-	-	100
CAT2	18	45	27	10	-	-	100
CAT3	15	40	30	15	-	-	100
ESE	15	40	35	10	-	-	100

*** ±3% may be varied**

20MHE07 PROCESS INSTRUMENTATION AND AUTOMATION

Programme& Branch	M.TECH. Chemical Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	2	PE	3	0	0	3

Preamble	The purpose of this course is to introduce the key concepts in automatic control and instrumentation of process plants. Also to make the students understand the fundamentals of instruments for measuring temperature, pressure, flow, level, etc. The primary objective of this course is to provide knowledge about the fundamentals of automation and various automation systems used in industry such as PLC, DCS and SCADA. This enables the students to design any application based on these systems	
Unit – I	**Instrumentation**	**9**
Principles of measurement and classification of process control instruments; temperature, pressure, fluid flow, liquid level, velocity, fluid density, viscosity. Instrument scaling; sensors; transmitters and control valves; instrumentation symbols and labels.		
Unit – II	**Controller Tuning**	**9**
Evaluation criteria –IAE, ISE, ITAE and ¼ decay ratio –Tuning:-Process reaction curve method, Continuous cycling method and Damped oscillation method –Determination of optimum settings for mathematically described processes using time response and frequency response approaches –Pole placement –Lambda tuning		
Unit – III	**Distributed Control System (DCS)**	**9**
Evolution –Different architectures –Local control unit –Operator Interface –Factors to be considered in selecting DCS.		
Unit – IV	**Programmable Logic Controllers(PLC)**	**9**
Evolution of PLC –Sequential and Programmable controllers –Architecture –Programming of PLC –Relay logic and Ladder logic –Functional blocks –Communication Networks for PLC		
Unit – V	**SCADA**	**9**
Remote terminal units, Master station, Data acquisition, Supervisory control, Communication architectures –Open SCADA protocols –Direct digital control.		

Total: 45

REFERENCES:

1.	Nakara. B.C. and Choudary. K.K., “Instrumentation and Analysis”, Tata McGraw-Hill, New Delhi, 1993.
2.	Stephanopoulos. G., “Chemical Process Control”, Tata McGraw-Hill, New Delhi, 1993.
3.	Astrom. Karl J. and Willermans. Bjorn, “Computer Controlled Systems”, Prentice Hall of India Pvt. Ltd., New Delhi, 1994.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	employ the concept of measurement systems, automation and advanced control strategies	Applying (K3)
CO2	assess the methods of controller tuning	Evaluating (K5)
CO3	analyze the knowledge in selection of DCS	Analyzing (K4)
CO4	inspect the concepts of PLC and its applications	Analyzing (K4)
CO5	utilize the principles of SCADA and its protocols	Applying (K3)

Mapping of COs with POs and PSOs					
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1			1	3	
CO2	1		1	3	1
CO3			1	3	
CO4			1	3	
CO5	1		1	3	1
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy					

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	20	60	20	-	-	-	100
CAT2	20	60	20	-	-	-	100
CAT3	20	60	20	-	-	-	100
ESE	20	60	20	-	-	-	100

*** ±3% may be varied**

20MHE08 PROCESS INTENSIFICATION

Programme& Branch	M.TECH. Chemical Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	2	PE	3	0	0	3

Preamble	Process Intensification is a collective term which refers to cutting edge technologies implicated to improve the performance of a chemical industry. This course throws light upon various intensification techniques and their applications	
Unit – I	**Overview of Intensification and Miniaturized equipment**	**9**
Introduction – Philosophy, opportunities and merits of Process Intensification; Miniaturization – effects of miniaturized equipment, Implementation of micro systems, Pitfalls and Solutions.		
Unit – II	**Intensification of Mixing Operation**	**9**
Flow patterns in reactors, Mixing in stirred tanks: Scale up of mixing, Heat transfer. Principle and applications of High – Gravity Fields Atomizer, Ultra sound Atomization, Nebulizers, High intensity inline Mixers, Static mixers, Ejectors, Tee mixers, Rotor stator mixers, Higee reactors.		
Unit – III	**Intensification of Heat Transfer Operations**	**9**
Compact heat exchangers – Classifications, Heat transfer and Pressure drop in Plate, Spiral and micro channel Heat exchangers, Finned heat exchangers, Phase change heat exchangers, Regenerative heat exchangers for energy conservation, Selection of heat exchanger technology.		
Unit – IV	**Process Integration**	**9**
Combined systems: Integration of heat exchangers in separation systems, Principle and applications of Reactive absorption, Reactive distillation and Reactive Extraction.		
Unit – V	**Advanced Fields**	**9**
Intensification for energy conservation; Sono-chemical systems- Cavitation reactors, Sono-crystallization; Microwave assisted processes, Supercritical fluids in chemical processes.		

Total: 45

REFERENCES:

1.	Stankiewicz, A. and Moulijn, “Reengineering the Chemical Process Plants, Process Intensification”, Marcel Dekker, 2003.
2.	Reay D, Ramshaw C, Harvey A., “Process Intensification”, Second EditionButterworth Heinemann, 2013.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	apply the philosophy of process intensification in mini and micro systems	Applying (K3)
CO2	make use of novel mixers to improve mixing operations	Applying (K3)
CO3	employ compact heat exchanger and study the conservation of energy in them	Applying (K3)
CO4	apply the concepts of process integration in separation systems	Applying (K3)
CO5	attribute the role of ultra sound and microwave assisted processes	Analyzing (K4)

Mapping of COs with POs and PSOs					
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1	2		3	2	2
CO2	2		3	2	2
CO3	2		3	2	2
CO4	1		3	3	3
CO5	2		3	3	3
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom’s Taxonomy					

ASSESSMENT PATTERN - THEORY							
Test / Bloom’s Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	10	60	30	-	-	-	100
CAT2	10	60	30	-	-	-	100
CAT3	10	60	30	-	-	-	100
ESE	10	60	30	-	-	-	100

*** ±3% may be varied**

20MHE09 RISK ANALYSIS

Programme& Branch	M.TECH. Chemical Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	**2**	**PE**	**3**	**0**	**0**	**3**

Preamble	This course provides an awareness on the importance of risk assessment and enables the students to understand the methodology of assessing and evaluating risk.	
Unit – I	**Introduction**	**9**
Industrial accidents; accident costs; identification of accident spots; remedial measures; Identification and analysis of causes of injury to men and machines; Accident prevention; Accident proneness; Vocational guidance, Fire prevention and Fire protection.		
Unit – II	**Risk Assessment**	**9**
Risk methodologies and assessment steps; quantitative risk assessment, rapid risk analysis; comprehensive risk analysis; identification, Probability theory, Interaction between process units, Revealed and Unrevealed failures, Probability of coincidence, Application to chemical process problems.		
Unit – III	**Process Safety Analysis & Risk Management**	**9**
HAZOP, HAZAN, FAULT Tree Analysis. Safety system followed in Ammonia plants, refineries and power plants. Elements of a risk management program, risk assessment and risk management; Relief concepts, Location of relief, Relief types, Relief scenarios, Data for sizing reliefs and Relief systems.		
Unit – IV	**Risk Evaluation**	**9**
Risk analysis model, Developing accident scenario and initiating events, Event trees, Consequences determination, uncertainty, Risk evaluation, Calculating safety costs, Evaluation and control of risk.		
Unit – V	**Case studies**	**9**
Flixborough accident, Bhopal accident, Seveso accident, Binhai,-Tianjin China, Gazipur, Bangladesh and Kaohsiung gas explosions		

Total: 45

REFERENCES:

1.	Bahr Nicholas J., “System Safety Engineering and Risk Assessment: A Practical Approach”, First Edition, Taylor and Francis, 1997.
2.	Crown Daniel A. and Louvor Joseph F., “Chemical Process Safety: Fundamentals with Applications”, Prentice Hall International, New Jersey, 2001.
3.	Greenberg Harris R. and Cramer Joseph J., “Risk Assessment and Risk Management for the Chemical Process Industry”, Stone & Webster Engineering Corporation, 1991.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	demonstrate the awareness on the importance of Risk assessment	Understanding (K2)
CO2	apply the methodology of risk assessment	Understanding (K2)
CO3	analyze the safety in various processes	Applying (K3)
CO4	analyze and evaluate the risk and safety costs	Applying (K3)
CO5	survey various accidents and analyze the risks	Applying (K3)

Mapping of COs with POs and PSOs					
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1	3	2	1		
CO2	2	3			
CO3	3	2			
CO4	2	2			
CO5	3	3			
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy					

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	40	50	10	-	-	-	100
CAT2	40	50	10	-	-	-	100
CAT3	30	50	10	10	-	-	100
ESE	30	50	10	10	-	-	100

*** ±3% may be varied**

20MHE10 CHEMICAL PRODUCT DESIGN

Programme& Branch	**M.TECH. Chemical Engineering**	**Sem.**	**Category**	**L**	**T**	**P**	**Credit**
Prerequisites	Nil	**3**	**PE**	**3**	**0**	**0**	**3**

Preamble	This course provides an understanding of changes in the chemical industry and how these changes affect temperature.	
Unit – I	**Needs and Specifications**	**9**
Customer needs, Consumer Products, Converting needs to specifications, Revising product specifications.		
Unit – II	**Source and Screening of Ideas**	**9**
Human sources of ideas, Chemical sources of ideas, Sorting the ideas, Screening the ideas.		
Unit – III	**Selection Criteria**	**9**
Selection based on thermodynamics, Selection based on Kinetics, Loss objective criteria, Risk associated with product selection.		
Unit – IV	**Manufacturing Strategy**	**9**
Intellectual property, Collection of missing information, Final specifications, Development of Microstructured products, Device manufacture and Related approach strategy		
Unit – V	**Speciality Chemical Manufacture and Economic Considerations**	**9**
First steps toward production, Separation, Specialty Scale – up. Product versus Process design, Process Economics, Economics for products.		

Total: 45

REFERENCES:

1.	Cussler E.L. and G.D. Moggridge, "Chemical Product Design", Cambridge University Press, 2001
2.	Richard. Turton and Richard C.Bailie, "Analysis, Synthesis, and Design of Chemical Processes", Prentice Hall, New Jersey, 2003.
3.	Stanley M.Walas,"Chemical Process Equipment Selection and Design", Butterworth- Heinemann Publishers, 2001

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	describe the specifications for product design	Understanding (K2)
CO2	generate, sort and screen product design ideas	Analyzing (K4)
CO3	apply thermodynamic and kinetic knowledge for the selection of products	Applying (K3)
CO4	apply device manufacturing strategies to quantify and meet out the specifications	Applying (K3)
CO5	perform economic analysis of chemical product design	Evaluating (K5)

Mapping of COs with POs and PSOs					
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1	2	1	2	3	3
CO2	3	1	2	3	2
CO3	2	1	2	3	2
CO4	3	1	3	2	2
CO5	3	1	3	2	2
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy					

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	32	48	20	-	-	-	100
CAT2	32	44	24	-	-	-	100
CAT3	28	48	24	-	-	-	100
ESE	30	46	24	-	-	-	100

*** ±3% may be varied**

20MHE11 PROCESS OPTIMIZATION TECHNIQUES

Programme& Branch	M.TECH. Chemical Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	3	PE	3	0	0	3

Preamble	Optimization is an integral part in design and operation of a process industry. This course provides knowledge about the fundamentals of optimization techniques and its applications in process industries.	
Unit – I	**Basic Concepts of Optimization**	**9**
Problem formulation, degree of freedom analysis, objective functions, constraints and feasible region, types of optimization problems.		
Unit – II	**Non-linear Unconstrained Optimization**	**9**
Convex and concave functions unconstrained NLP, Scanning and bracketing procedures, Newton's method, Quasi-Newton's method.		
Unit – III	**Non-linear Constrained and Multi-Objective Optimization**	**9**
Direct substitution, Quadratic programming, Penalty, Barrier and Augmented Lagrangian Methods, weighted Sum of Squares method, Epsilon constraint method and Goal attainment.		
Unit – IV	**Linear Programming and Dynamic Programming**	**9**
Simplex method, Barrier method, sensitivity analysis, Introduction to integer and mixed integer programming.		
Unit – V	**Applications of Optimization in Chemical Engineering**	**9**
Heat transfer and energy conservation, separation processes and chemical reactor design and operation		

Total: 45

REFERENCES:

1.	Edgar, T. F., Himmelblau, D. M. and Ladson, L. S., "Optimization of Chemical Processes", 2nd Edition, McGraw Hill, New York, 2003.
2.	Diwaker, U. W. "Introduction to Applied Optimization", Second Edition, Springer, 2003.
3.	Rao, S. S., "Engineering Optimization: Theory and Practice", Fourth Edition, New Age Publishers, 2011.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	develop mathematical model of chemical engineering problems	Applying (K3)
CO2	apply the optimization principles to solve non- linear unconstrained problems	Applying (K3)
CO3	solve non- linear constrained and multi objective optimization problems	Applying (K3)
CO4	utilize linear and dynamic programming techniques and perform sensitivity analysis	Applying (K3)
CO5	perform optimization techniques in chemical engineering systems	Applying (K3)

Mapping of COs with POs and PSOs

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1	2		3	2	2
CO2	2		3	2	2
CO3	2		3	2	2
CO4	1		3	3	3
CO5	2		3	3	3

1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy

ASSESSMENT PATTERN - THEORY

Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	10	30	60	-	-	-	100
CAT2	10	30	60	-	-	-	100
CAT3	10	30	60	-	-	-	100
ESE	10	30	60	-	-	-	100

*** ±3% may be varied**

20MHE12 BIOPROCESS ENGINEERING

Programme& Branch	**M.TECH. Chemical Engineering**	**Sem.**	**Category**	**L**	**T**	**P**	**Credit**
Prerequisites	Nil	**3**	**PE**	**3**	**0**	**0**	**3**

Preamble	This course provides application of engineering principles to biological processes, to achieve commercial success in designing biochemical reactor with proper knowledge in enzyme engineering	
Unit – I	**Enzyme Kinetics**	**9**
Classification of enzymes, Commercial application of Enzyme, Immobilization of Enzymes, Michaelis –Menten kinetics, Evaluation of parameters in the Michaelis –Menten equation, Inhibition Kinetics		
Unit – II	**Sterilization and Fermentation**	**9**
Sterilization: Sterilization of medium, batch and continuous sterilization, Sterilization of air, Sterilization of fermenter. Fermentation: Medium requirements, Application of fermentation process, Types of fermentation process –aerobic and anaerobic, solid state and submerged fermentation.		
Unit – III	**Mass Transfer and Biochemical Reaction in Porous Catalyst**	**9**
Theories of diffusional and convective mass transfer, oxygen transfer methodology in fermenter, Factors affecting oxygen transfer rate, intra particle diffusion and reaction rate, effectiveness factor and Thiele Modulus.		
Unit – IV	**Product Recovery**	**9**
Removal of solids, Filtration, Sedimentation, Centrifugation, Cell disruption, Extraction, Membrane separation, Chromatography, Electrophoresis, Crystallization and Drying.		
Unit – V	**Design and Analysis of Bioreactors**	**9**
Stability and Analysis of bioreactors, Design and operation of continuous stirred tank bioreactor, fed batch bioreactor, air-lift bioreactor, Fluidized bed bioreactor, Introduction to Scale up of bioreactors, criteria for selection of bioreactors		

Total: 45

REFERENCES:

1.	Rao, D. G., “Introduction to Biochemical Engineering”, Second Edition, Tata McGraw-Hill, New Delhi, 2010.
2.	Bailey, J. E. and Ollis, D. F., “Biochemical Engineering Fundamentals”, Second Edition, Tata McGraw-Hill, New Delhi, 2010.
3.	Palmer.T and Bonner, P L, ”Enzymes Biochemistry, Biotechnology, Clinical Chemistry”, Second Edition Woodhead Publishing,2007.
4.	Rajiv Dutta, “Fundamentals of Biochemical Engineering”, Second Edition, Springer Verlag, 2010.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	apply the basic principles of enzyme technology	Applying (K3)
CO2	apply the sterilization and fermentation process in industries	Applying (K3)
CO3	apply the theories of mass transfer to microbial systems	Applying (K3)
CO4	identify suitable downstream processing techniques	Analyzing (K4)
CO5	analyze various aspects of industrial bioreactors	Analyzing (K4)

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	3	1		3	3
CO2	3	1		3	3
CO3	3	1		3	3
CO4	3	1		3	3
CO5	3	1		3	3

1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom’s Taxonomy

ASSESSMENT PATTERN - THEORY

Test / Bloom’s Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT1	-	40	30	30	-	-	100
CAT2	-	40	30	30	-	-	100
CAT3	-	40	30	30	-	-	100
ESE	-	40	30	30	-	-	100

*** ±3% may be varied**

20MHE13 MULTIPHASE FLOW

Programme& Branch	M.TECH. Chemical Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	4	PE	3	0	0	3

Preamble	This course provides knowledge about the fundamentals of transfer phenomena in multi phase systems to draw momentum and mass balance. It also gives understanding of design, scaling and application of multi phase reactors.	
Unit – I	**Flow Classification**	**9**
Fluid – solid systems, Flow through porous media, Fluid–fluid system- Flow pattern and flow regimes. Two–phase co–current flow of fluids-upward and downward flow in vertical pipes, Suspension rheology. Models for chemical reactor – Diffusion and bubbling bed model –Role of draft tube and wall baffles.		
Unit – II	**Flow – Power Correlation**	**9**
Theories of intensity and scale of turbulence, Calculation of circulation velocities and power consumption in agitated vessels for Newtonian/ Non-Newtonian fluids. Blending and Mixing of phases. Power required for aeration to suspend to an immiscible liquid or solids in Slurry reactors, Segregation phenomena, Prediction of optimum speed of impeller rotor and Design criteria for scale up.		
Unit – III	**Flow- Two Phase system**	**9**
Prediction of holdup and pressure drop of volume fraction, Bubble size in pipe flow, Lockhart – Martinelli parameters, Bubble Column and its design aspects, Minimum carryover velocity. Holdup ratios, Pressure drop and Transport velocities and their prediction.		
Unit – IV	**Flow – Three Phase Systems**	**9**
Gas, Solid and Liquid composite slurries in horizontal and vertical pipes, Flow through Porous media of composite mixtures, Prediction of holdup, pressure drop and throughput. Velocities in Three phase system. Design of multiphase contactors involving fluidization, pervaporation, lyophilisation and permeation for solids, liquids and gases.		
Unit – V	**Design and Development of Software programmes**	**9**
Design and development of software programmes in multiphase flow, simulation in packed and fluidized beds and Stirred tank process equipment. Selection of equipment for gaseous, particulate and liquid effluents of various industries such as scrubbers, stacks and chimneys, absorbers, combustion devices, electrostatic precipitators and filtration / reverse osmosis devices.		

Total: 45

REFERENCES:

1.	Govier, G.W. and Aziz K., “The Flow of Complex Mixture in Pipes”, Van Nostrand Reinhold Co., New York, 1972.
2.	Wallis, G.B. “One Dimensional Two Phase Flow”, McGraw Hill Book Co., New York, 1969.
3.	Gad Hestsroni, “Handbook of Multiphase systems”, McGraw Hill Book Company, London, 1982.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	explain the fundamental principles on flow pattern, flow regime and transfer phenomena and develop models	Applying (K3)
CO2	draw flow-power correlation for a multiphase system	Applying (K3)
CO3	describe two-phase hydrodynamics and determine the design aspects ofa multiphase contactors	Applying (K3)
CO4	explain three-phase hydrodynamics and estimate the design parameters	Applying (K3)
CO5	design and develop software programmes used in multiphaseflow	Evaluating (K5)

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	2			3	3
CO2			2	2	3
CO3		1	2	3	
CO4	3			2	
CO5	3	2		2	

1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy

ASSESSMENT PATTERN - THEORY

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT1	15	35	35	15	-	-	100
CAT2	12	35	38	15	-	-	100
CAT3	14	38	36	12	-	-	100
ESE	15	35	35	15	-	-	100

*** ±3% may be varied**

20MHE14 PIPING FLOW SHEETING PROCESS AND INSTRUMENTATION DIAGRAMS

Programme& Branch	**M.TECH. Chemical Engineering**	**Sem.**	**Category**	**L**	**T**	**P**	**Credit**
Prerequisites	Nil	**4**	**PE**	**3**	**0**	**0**	**3**

Preamble	This course enables the students to present a process flow diagram and flow sheeting principles from a chemical engineering point of view. The students will be well versed with the development of process flow diagrams and control systems. Main advantage of the course will be to deal with applications of process flow diagrams in design stage. The study further provides a comprehensive exposition to theory and application of P&ID in HAZOPS and Risk Analysis.	
Unit – I	**Flow Sheets & Process Flow Diagram**	**9**
Types of flow sheets, Flow sheet Presentation, Flow Sheet Symbols, Process Flow Diagram-Synthesis of Steady State Flow sheet. Flow sheeting software. P& I D objectives, guide rules, Symbols, Line numbering, Line Schedule		
Unit – II	**Piping and Instrumentation Diagrams (P&ID)**	**9**
P & I D development, typical Stages of P & ID, P & ID for rotating equipment and static pressure vessels, Process vessels, Absorber, Evaporator		
Unit – III	**Control System –I**	**9**
Heat Transfer Equipment and Reactors: Control System for Heater, Heat exchangers, Reactors.		
Unit – IV	**Control System – II**	**9**
Mass Transfer Equipment: Control System for Dryers, Distillation Column, Expander.		
Unit – V	**Applications of P & ID**	**9**
Applications of P & ID in design stage –Construction stage –Commissioning stage –Operating stage –Revamping stage – Applications of P & ID in HAZOPS and Risk analysis.		

Total: 45 (3-0-0-3)

REFERENCES:

1.	Ernest E. Ludwig, “Applied Process Design for Chemical and Petrochemical Plants”, Vol.-I Gulf Publishing Company, Houston, 1989.
2.	Max. S. Peters and Timmerhaus K.D., “Plant Design and Economics for Chemical Engineers”, McGraw Hill, Inc., New York, 2002.
3.	Anil Kumar, “Chemical Process Synthesis and Engineering Design”, Tata McGraw-Hill, New Delhi, 1981.
4.	Moe Toghrael,”Piping and Instrumentation diagram development”, John Wiley & Sons, Inc., 2019.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	employ the methods of presentation of flow sheet for a chemical manufacturing process	Applying (K3)
CO2	demonstrate the typical stages of PID and its applications in process equipment	Applying (K3)
CO3	implement control system for heat exchangers and reactors	Applying (K3)
CO4	develop control system for mass transfer equipment	Applying (K3)
CO5	examine the applications of PID controllers in design, construction and commissioning	Analyzing (K4)

Mapping of COs with POs and PSOs					
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1			1	3	
CO2			1	3	
CO3			2	3	
CO4			2	3	
CO5			1	3	
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy					

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	20	20	60	--	--	--	100
CAT2	10	20	70	--	--	--	100
CAT3	10	20	40	30	--	--	100
ESE	10	20	40	30	--	--	100

*** ±3% may be varied**

20MHE15 CHEMICAL PROCESS DESIGN

Programme& Branch	**M.TECH. Chemical Engineering**	**Sem.**	**Category**	**L**	**T**	**P**	**Credit**
Prerequisites	Nil	**4**	**PC**	**3**	**0**	**0**	**3**

Preamble	This course provides knowledge in selection of a series of processing steps and their interconnection in a flow sheet. It enables the students to make decisions during development of process design.	
Unit – I	**Introduction To Process Design**	**9**
Chemical products, process creation, simulation to assist the process creation, the hierarchy of chemical process design and integration – Approaches to process design. Design layout importance in Projects.		
Unit - II	**Choice of Reactors**	9
Reactor performance: Reaction path, reaction systems, idealized reactor models. Reactor conditions: Equilibrium, temperature, pressure, phase and concentration. Reactor configuration: Temperature control, catalyst degradation.		
Unit - III	**Choice of Separators and Synthesis of Reactor – Separation Systems**	**9**
Separation of heterogeneous mixtures, Homogenous fluid mixtures, Selection and choice of distillation, absorption, evaporators, dryers; Reaction, separation and recycle system for batch process.		
Unit - IV	**Distillation Sequencing**	**9**
Distillation sequencing using single columns, Practical constrains, Using column with more than two products, Distillation sequencing using thermal Coupling, Retrofit of distillation sequences and Optimization of a reducible structure. Introduction to sequencing for azeotropic distillation: Pressure shift, use of an entrainer and membrane separation.		
Unit - V	**Heat Exchanger Network Analysis**	**9**
Energy targets: Heat recovery pinch, threshold problems, the problem table algorithm, utilities selection. Capital and total cost targets: Number of heat exchanger units, heat exchange area targets, number of shells targets, capital cost targets, total cost targets.		

Total: 45

REFERENCES:

1.	Robin Smith, "Chemical Process Design and Integration", Wiley India (P) Ltd , 2005.
2.	Douglas J.M., "Conceptual Design of Chemical Processes", 1st edition, McGraw-Hill, New York, 1988.
3.	Seider, W.D., Seader, J.D. and Lewin, D.R. "Product and Process Design Principles - Synthesis, Analysis and Evaluation", 3rd edition, John Wiley and Sons Inc., 2008.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	explain the fundamentals of chemical process design and apply the approaches to process design	Applying (K3)
CO2	choose and synthesize reactors	Applying (K3)
CO3	select separators and synthesize reactor-separation systems	Applying (K3)
CO4	perform distillation sequencing with thermal coupling	Applying (K3)
CO5	analyze the performance of heat exchanger network based on energy and capital cost targets	Analyzing (K4)

Mapping of COs with POs and PSOs					
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1	2	1	2	3	3
CO2	3	1	2	3	2
CO3	2	1	2	3	2
CO4	3	1	3	2	2
CO5	3	1	3	2	2
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy					

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	20	30	30	20	-	-	100
CAT2	20	30	30	20	-	-	100
CAT3	20	30	30	20	-	-	100
ESE	20	30	30	20	-	-	100

*** ±3% may be varied**

20MHE16 ADVANCED MATERIALS FOR CHEMICAL ENGINEERS

Programme& Branch	M.TECH. Chemical Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	4	PE	3	0	0	3

Preamble	This course aims to introduce elementary concepts and implicate expertise with selection of materials for prevention and control of corrosion	
Unit – I	**Materials – Structure & Analysis**	**9**
Classification of Materials - Functional, Structural; Atomic Structure, Atomic Bonding, Binding Energy and interatomic spacing, Atomic arrangement and Crystal Structure; Imperfections: Point defect, Dislocations, Surface defects; Deformation of Materials – Elastic & Plastic, Deformation of Single and Polycrystalline materials, Recovery, Recrystallization, and Grain growth.		
Unit - II	**Fracture Mechanics and Materials Characterization**	**9**
Fracture – Ductile, Brittle, Fracture Mechanism, Impact Fracture testing; Fatigue – Cyclic stresses, The S-N Curve, Crack initiation and propagation, Factors affecting fatigue life, Fatigue testing; Creep – Creep Behavior, Stress and Temperature effects; MechanicalTesting – Tensile tests, Compression tests, Hardness tests, Creep and Stress rupture tests.		
Unit - III	**Ceramics & Polymer**	**9**
Ceramics: Properties, Synthesis and processing of Ceramic powders, Characteristics – Sintered Ceramics, Grains and Grain Boundaries, Porosity; Inorganic Glasses; Refractories; Polymers: Structure, Polymer Crystallinity, Crystallization, Melting, and Glass Transition Phenomena in Polymers, Polymerization, Forming Techniques for Plastics, Fabrication of Elastomers, Fabrication of Fibers and Films.		
Unit - IV	**Composite Materials**	**9**
Introduction - Particle-Reinforced Composites, Fiber-Reinforced Composites – Influence of Fiber length, Orientation, Concentration , Fiber & Matrix Phase, Polymer-Matrix, Metal-Matrix, Ceramic-Matrix, Carbon–Carbon, Hybrid Composites; Structural Composites: Laminar Composites and Sandwich Panels		
Unit - V	**Materials Selection and Design Consideration**	**9**
Introduction - Materials selection for a torsionallystressed cylindrical shaft; Artificial Total Hip Replacement; Chemical Protective Clothing; Materials for Integrated CircuitPackages; Economic Considerations - Component Design, Materials, Manufacturing Techniques; Environmental and Societal Considerations - Recycling Issues in Materials Science and Engineering		

Total: 45

REFERENCES:

1.	Donald Askeland and Wendelin Wright., :Essentials of Materials Science and Engineering, SI Edition", 3rd Edition, Cengage Learning, 2013
2.	William D. Callister, "Materials Science and Engineering",7thedn, John Wiley & Sons, Inc. 2007
3.	Smallman RE, Ngan AH. "Physical metallurgy and advanced materials". Butterworth-Heinemann; 2011
4.	Li, Lin, Ashok Kumar Sam Zhang, "Materials Characterization Techniques" CRC Press, 2008.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	adapt the principles of atomic structure and study the defectiveness of materials	Applying (K3)
CO2	analyze the flaw and mechanical testing of material	Analyzing (K4)
CO3	demonstrate the properties, characteristics and fabrication of ceramicsand polymers	Applying(K3)
CO4	examine the properties and fabrication of advanced composite materials	Analyzing (K4)
CO5	inspect the knowledge in material selection and design consideration	Analyzing (K4)

Mapping of COs with POs and PSOs

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1	3	1	2	3	3
CO2	3	1	2	3	3
CO3	3	1	2	3	3
CO4	3	1	2	3	3
CO5	3	1	2	3	3

1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy

ASSESSMENT PATTERN - THEORY

Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	5	50	30	15			100
CAT2	5	50	30	15			100
CAT3	5	50	30	15			100
ESE	5	50	30	15			100

*** ±3% may be varied**

20MHE17 INDUSTRIAL DRYING

Programme& Branch	**M.TECH. Chemical Engineering**	**Sem.**	**Category**	**L**	**T**	**P**	**Credit**
Prerequisites	Nil	**4**	**PE**	**3**	**0**	**0**	**3**

Preamble	The objective of this course is to study the types, selection and applications of industrial dryers.	
Unit – I	**Fundamentals Aspects of Drying**	**9**
Principles, classification and selection of dryers. Basic process calculation and transport properties in drying		
Unit - II	**Types of Industrial Dryers**	**9**
Rotary dryer, fluidized bed dryer, industrial spray drying, solar drying, spouted bed drying ,impingement drying and infrared drying		
Unit - III	**Dryers for Food and Pharmaceuticals**	**9**
Drying of food stuff, drying of pharma products, drying of nano size products		
Unit - IV	**Dryers for Textile and Polymers**	**9**
Drying of textile products, Drying of bio products , drying of polymers		
Unit - V	**Control and safety aspects of Industrial Dryers**	**9**
Drying emission control system control of industrial dryers. Safety aspects of industrial dryers. Cost estimation methods for dryers		

Total: 45

REFERENCES:

1.	Arun S. Mujumdar "Handbook of Industrial Drying, 4th Edition, CRC Publishers, 2014
2.	TadeuszKudra and Arun S. Mujumdar "Advanced Drying Technologies" 2nd edition, CRC Publishers, 2015
3.	Ibrahim Dinces AND CalinZamtiresu" Drying Phenomena : Theory and applications, John Wiley Publishers, 2015
4.	Delgdo, J.M.P.Q and Gilson Barbosa "Drying and Energy Technology" Springler,2015

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	describe the classification, applications of drying and calculate the transport properties	Applying (K3)
CO2	employ various dryers in process industries	Applying (K3)
CO3	utilize dryers for pharma and food industries	Applying (K3)
CO4	apply dryers for drying of bio, polymers and textile products	Applying (K3)
CO5	comprehend the emission control systems and analyze the safety and economics of dryers	Analyzing (K4)

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1				1	1
CO2	2		2	1	3
CO3	2		2	3	3
CO4	2		2	3	3
CO5	3	2	3	3	3

1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy

ASSESSMENT PATTERN - THEORY

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT1	10	10	80				100
CAT2	10	10	60	20			100
CAT3	10	10	60	20			100
ESE	10	10	70	10			100

*** ±3% may be varied**

20MHE18 DESIGN AND ANALYSIS OF EXPERIMENTS

Programme& Branch	**M.TECH. Chemical Engineering**	**Sem.**	**Category**	**L**	**T**	**P**	**Credit**
Prerequisites	Nil	**4**	**PE**	**3**	**0**	**0**	**3**

Preamble	The objective of this course is to introduce concepts of Design of Experiments	
Unit – I	**Introduction to Experimental Design**	**9**
Introduction – Principles and applications of Design of Experiments, Design of a process and product, Guidelines for designing experiments, Using statistical techniques for experimentation, Case studies		
Unit - II	**Foundations of Statistics**	**9**
Sampling and Sampling Distributions, Inferences on Randomized and paired comparison designs, Analysis of Variables, Regression Analysis – Linear, Multiple regression, Testing for lack of fit		
Unit - III	**Randomized Complete Block Design**	**9**
Framing RCBD experiments, Latin Square Desing, Graeco-Latin Square Design,Central Composite Design, Balanced Incomplete Block Design, Model adequacy checking, Leas Square estimation, regression, Case Studies in Chemical Engineering		
Unit - IV	**Factorial Experiments**	**9**
Principles and Merits of Factorial design, Analysis of two factorial experiments, Analysis of two level Fractional factorial experiments, Three level Factorial experiments, Introduction to mixed and non regular factorial designs, Case Studies in Chemical Engineering		
Unit - V	**Response Surface Methodology using software tools**	**9**
Introduction to RSM, Steepest Ascent method, Analysis of Second order response surface, Designs for Fitting Response surfaces, Mixture experiments, Case Studies in Chemical Engineering Introduction to software tools – Minitab		

Total: 45

REFERENCES:

1.	Douglas.C.Montgomery, Design and Analysis of Experiments, Eighth Edition, Wiley, 2017
2.	Angela Dean, Daniel Voss, Design and Analysis of Experiments, Springer, 2013

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	apply the basic principles and strategies of experimental design to real time experimental data	Applying (K3)
CO2	apply fundamental concepts of statistics for testing a hypothesis	Applying (K3)
CO3	formulate and analyze Randomized complete block experiments	Analyzing (K4)
CO4	analyze Factorial experiments for deriving conclusions	Analyzing (K4)
CO5	perform response surface analysis using software tools and interpret the results	Analyzing (K4)

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	2		2	2	1
CO2	2		2	2	1
CO3	1		2	2	1
CO4	1		2	2	1
CO5	2		2	2	1

1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy

ASSESSMENT PATTERN - THEORY

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT1	20	40	32	8	-	-	100
CAT2	17	38	35	10	-	-	100
CAT3	20	37	33	10	-	-	100
ESE	18	37	35	10	-	-	100

*** ±3% may be varied**