NATIONAL INSTITUTE OF TECHNOLOGY WARANGAL

RULES AND REGULATIONS
SCHEME OF INSTRUCTION AND SYLLABI
FOR M.TECH PROGRAM
(CHEMICAL ENGINEERING)

Effective from 2016-17

DEPARTMENT OF CHEMICAL ENGINEERING

NATIONAL INSTITUTE OF TECHNOLOGY WARANGAL

VISION

Towards a Global Knowledge Hub, striving continuously in pursuit of excellence in Education, Research, Entrepreneurship and Technological services to the society.

MISSION

- Imparting total quality education to develop innovative, entrepreneurial and ethical future professionals fit for globally competitive environment.
- Allowing stake holders to share our reservoir of experience in education and knowledge for mutual enrichment in the field of technical education.
- Fostering product oriented research for establishing a self-sustaining and wealth creating centre to serve the societal needs.

DEPARTMENT OF CHEMICAL ENGINEERING

VISION

To attain global recognition in research and training students for meeting the challenging needs of chemical & allied industries and society.

MISSION

- Providing high quality education in tune with changing needs of industry.
- Generating knowledge and developing technology through quality research in frontier areas of chemical and interdisciplinary fields.
- Fostering industry-academia relationship for mutual benefit and growth.

GRADUATE ATTRIBUTES

The Graduate Attributes are the knowledge, skills and attitudes which the students have at the time of graduation. These attributes are generic and are common to all engineering programs. These Graduate Attributes are identified by National Board of Accreditation.

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

DEPARTMENT OF CHEMICAL ENGINEERING

M.TECH IN CHEMICAL ENGINEERING

PROGRAM EDUCATIONAL OBJECTIVES

PEO1.	Pursue successful industrial, academic and research careers in specialized fields of Chemical Engineering.
PEO2.	Apply the knowledge of advanced topics in Chemical Engineering to meet contemporary needs of industry and research.
PEO3.	Use modern software tools for design of processes and equipment.
PEO4.	Identify issues related to ethics, society, safety, energy and environment in the context of Chemical Engineering applications.
PEO5.	Pursue self-learning to remain abreast with latest developments for continuous professional growth.

Mapping of Departmental Mission statements with Program Educational Objectives

Mission Statement	PEO1	PEO2	PEO3	PEO4	PEO5
Providing high quality education in tune with changing needs of industry.	3	3	3	2	-
Generating knowledge and developing technology through quality research in frontier areas of chemical and interdisciplinary fields.	3	2	2	1	-
Fostering industry-academia relationship for mutual benefit and growth.	3	2	2	-	2

1: Slightly   2: Moderately   3: Substantially

Mapping of Program Educational Objectives with Graduate Attributes

PEO	GA1	GA2	GA3	GA4	GA5	GA6	GA7	GA8	GA9	GA10	GA11
PEO1	3	3	3	3	3	3	3	3	3	3	2
PEO2	2	1	3	3	2	2	1	-	-	-	-
PEO3	2	1	3	1	3	2	2	-	-	-	1
PEO4	2	3	2	1	-	-	-	-	2	3	2
PEO5	2	-	2	2	1	-	-	2	3	2	3

PROGRAM OUTCOMES: At the end of the program, the student will be able to:

PO1	Model chemical engineering processes including multi-component mass transfer, multi-phase momentum transfer and multi-mode heat transfer from advanced engineering perspective.
PO2	Apply modern experimental, computational and simulation tools to address the challenges faced in chemical and allied engineering industries.
PO3	Implement techniques for minimizing cost and energy requirements in chemical plants.
PO4	Design measures to take care of environment, health and safety issues pertaining to chemical industries.
PO5	Communicate effectively and demonstrate leadership skills
PO6	Carry out research work independently and innovate novel processes and products
PO7	Practice professional ethics
PO8	Pursue life-long learning as a means of updating knowledge and skills.

Mapping of Program Outcomes with Program Educational Objectives

	PEO1	PEO2	PEO3	PEO4	PEO5
PO1	3	3	-	-	2
PO2	3	3	3	-	2
PO3	3	3	2	2	2
PO4	2	2	1	3	2
PO5	2	-	-	2	2
PO6	2	2	2	2	3
PO7	2	-	-	3	-
PO8	2	2	1	2	3

RULES AND REGULATIONS

NATIONAL INSTITUTE OF TECHNOLOGY
M.Tech DEGREE PROGRAMS

1. INTRODUCTION:

Provision of these regulations shall come into force with effect from the academic year 2014 - 2015 and shall be applicable to all M.Tech courses (unless otherwise stated) offered by the Institute.

1.1 M.Tech Degree Programs are offered in the following specializations by the respective departments as listed below:

Department	Program	Course / Specialization (s)
Civil Engineering	M. Tech	1. Engineering Structures 2. Geotechnical Engineering 3. Transportation Engineering 4. Water Resources Engg. 5. Remote Sensing and GIS 6. Environmental Engineering 7. Construction Technology and Management
Electrical Engineering	M. Tech	1. Power Systems Engineering 2. Power Electronics and Drives
Mechanical Engineering	M. Tech	1. Thermal Engineering 2. Manufacturing Engineering 3. Computer Integrated Manufacturing 4. Machine Design 5. Automobile Engineering 6. Materials and Systems Engineering Design 7. Additive Manufacturing
Electronics and Communication Engineering	M. Tech	1. Electronic Instrumentation 2. VLSI System Design 3. Advanced Communication Systems
Metallurgical and Materials Engg.	M. Tech	1. Industrial Metallurgy 2. Materials Technology
Chemical Engineering	M. Tech	1. Chemical Engineering 2. Process Control
Computer Science and Engineering	M. Tech	1. Computer Science and Engineering 2. Computer Science and Information Security

1.2 The provisions of these regulations shall be applicable to any new discipline that may be introduced from time to time.

1.3 The sanction of stipend will be as per the guidelines prescribed AICTE/MHRD from time to time.

2. ADMISSION:

Admissions are made on All India basis for all the programs, with reservations as per Government of India norms. The selection criterion for admission into all the M.Tech. programs is based on valid GATE score. Candidates seeking admission into M.Tech. in Engineering should have passed BE/B.Tech. or equivalent degree in the subject concerned from a recognized University/Institute with First Class not less than 60% marks or equivalent CGPA of 6.5/10. In case of SC/ST candidates 55% marks or equivalent CGPA of 6.0/10 is the eligibility requirement. Eligibility and other criteria for admissions to M. Tech. courses of the Institute will be reviewed and decided by the Senate from time to time.

3. COURSE STRUCTURE:

An M.Tech.program is of 4-semester duration, out of which 2 semester course work followed by two semester dissertation work.

The total course package for an M. Tech. Degree program will typically consist of the following components.

a) Core Courses	≥ 30 Credits
b) Elective Courses	≥ 15 Credits
c) Dissertation	= 18 Credits

3.3 The required credits for the completion of the program is 72. the semester-wise distribution of the courses and credits, as well as the syllabi of all M. Tech. Programs offered by the department from time to time and recommend the same to the Senate for consideration and approval.

3.4 In order to qualify for a post graduate degree of the Institute, a student is required to complete all the credits specified in the scheme of instruction for that program as approved by the Senate from time to time.

4. ACADEMIC CALENDAR:

4.1 The academic year is divided into two semesters.

4.2 The senate shall approve the schedule of academic activities for an academic year including the dates of registration, Mid semester and End semester examinations, which shall be referred to as academic calendar of the year. Each semester will normally be of 19 weeks, which includes End semester examinations. It may be ensured that the minimum number of effective teaching weeks in a semester is 16.

4.3 Academic calendar declared by the Senate in the beginning of a semester shall also fix fest dates during which all the co-curricular and extra-curricular programs like Technical seminars / Spring Spree/Institute day/etc. must be organized.

5. RESIDENTIAL REQUIREMENT:

The Institute is essentially residential and unless otherwise exempted/permitted, every student shall be required to reside in and be a boarder of one of the halls of residence and mess to which he/she is assigned.

6. ATTENDANCE:

Attendance in all classes (lectures/tutorials, laboratories etc.) is compulsory. A student will not be permitted to appear in the end semester examination on grounds of unsatisfactory attendance. Minimum required attendance in each theory /laboratory course is 80% for appearing in the End Semester examination.

Attendance for both theory and laboratory courses shall be entered before the end of each working week by the concerned teacher through faculty portal of the Institute website. Students are advised to monitor the status of their attendance through student portal of the Institute website.

Absence without obtaining sanction of leave will be considered as an act of indiscipline and shall entail deduction from scholarship on pro rata basis.

No student can receive scholarship/fellowship from more than one source, either Government or Private.

7. LEAVES:

7.1 A post graduate student shall be entitled to the following kinds of leave during every academic year, counted from the date of commencement of the session concerned as prescribed in the academic calendar of the institute.

7.2 Any absence over and above the prescribed type of admissible leave shall entail deduction from the scholarship, beside other action as may be decided by the Institute.

Sl.No.	Leave	Maximum Number of days	Sanctioning authority
1.	Casual Leave	8 days per semester subjected to the condition that such leave will not be allowed for more than 6 days at a time. Casual leave cannot be combined with medical leave.	Head of the Department (HOD)
2.	Medical Leave	8 days per semester	HOD with Medical Certificate from the Institute Medical Officer.

8. REGISTRATION:

8.1 Every Student of the M.Tech. courses is required to be present and register at the commencement of each semester on the day fixed for and notified in the Academic calendar.

8.2 The registration will be organized departmentally under the supervision of the Head of the Department/ Coordinator of a respective specialization / program.

8.3 A student who does not register on the day announced for the purpose may be permitted, in consideration of any compelling reason, late registration within the first week on payment of additional late fee as prescribed by the Institute from time to time. Normally no late registration shall be permitted after the first week from the scheduled date.

8.4 Only those students will be permitted to register who have: (a) cleared all Institute and Hostel dues of the previous semesters (b) paid all required fees for the current semester, and (c) not been debarred from registering for a specified period on disciplinary action or any other ground.

8.5 The students will choose the subjects for registration in consultation with the Faculty Advisor. The students may also consult the Head of the Department/Division /Centre/Section/ any other teacher.

8.6 A student who has already registered may

(a) register for a new course in addition to the courses he/she has already registered for (OR)

(b) opt for a new course in place of the one already registered for with the concurrence of the faculty advisor.

Any change of the course as permissible by sub-paras (a) and (b), above must however, be done within two weeks after registration.

8.7 A Student can register for a backlog subject either for (i) Study or for (ii) Examination. In case of Study, his / her previous marks are cancelled and will have to attend all classes and examinations along with next batch of students. Major changes in the time table shall not be entertained to accommodate backlog students. In case of registration for examination, he/she will not attend the classes, but will appear only for the end-semester examinations or make-up examinations as and when they are conducted. In such a case, the student shall be awarded only P grade, if he/she gets 40% or more marks in the end semester/makeup examination. Backlog students registering for study or examinations have to submit an undertaking that they will not change the status of their registration in the subject during the semester.

9. ASSESSMENT OF ACADEMIC PERFORMANCE:

9.1 There will be continuous assessment of the performance of students throughout the semester and grades will be awarded by the subject teacher.

9.2 Each theory subject in a semester is evaluated for 100 marks, with the following weightages.

Sub-component	**Weightage**
Continuous Evaluation	20 marks
Mid-semester Examination	30 marks

End-semester Examination	50 marks

9.3 The mid-semester examination will be conducted after 7 or 8 weeks of instruction. The Mid semester and End semester examinations will be conducted centrally by the examination section.

9.4 For assigning marks in continuous evaluation, minor(s)/surprise test/ assignment / quiz etc. may be conducted.

9.5 The mode and nature of the evaluation and the corresponding weightages may be intimated to the students at the beginning of the semester along with the lecture schedule.

9.6 Each laboratory course in a semester is evaluated for 100 marks, with the following weightages:

Sub-component	**Weightage**
Continuous evaluation (Lab report, Viva, Quiz etc.)	25 marks
Skill test	25 marks
End Semester examination	50 marks

9.7 COMPREHENSIVE VIVA-VOCE: The oral examination carrying 4 credits will cover the entire course of study up to I year II semester. The viva voce shall be conducted by an external examiner. A committee nominated by the Head of the Department shall be associated with the conduct of the comprehensive viva-voce.

9.8 A Seminar Assessment Committee will be formed by the Head of the Department/Centre for the evaluation of performance at Seminars. Every student is expected to attend all the seminars of all the students of the batch held in the Department/Centre during the semester. Due weightage shall be given to a student's attendance in the overall evaluation of this requirement.

10. DISSERTATION EVALUATION:

10.1 18 credits are assigned to the dissertation carried out by a student. The dissertation shall be submitted preferably by 15th June (but not earlier than 15th May). The method of evaluation is as per the guidelines given in Appendix-I.

10.2 The dissertation supervisor will periodically review the progress of the student and finally give his/her assessment of the work done by the student.

10.3 Dissertation and Viva-Voce: A student shall be required to submit a dissertation on the project work carried out by him/her. The guidelines for preparation of Dissertation shall be followed by every student as per guidelines given Appendix III. Three/four bound copies along with a soft copy of the dissertation shall be submitted to the Head of the Department/Centre within the last date prescribed in the Academic Calendar for the purpose.

10.4 Dissertation viva - voce will be held within the date fixed in the academic calendar and the grades will be finalized. External examiner for the evaluation of the dissertation at the end of fourth semester shall be from outside the Institution. The dissertation assessment committee constituted by the Head of the Department, along with the dissertation supervisor, shall be associated with the evaluation. The external expert who examines the Dissertation will conduct the viva voce.

10.5 Extension of dissertation work beyond the deadline of submission in very special case may be granted by the Dean - Academic on recommendation of the department/centre for a maximum period of 3 months. The viva-voce has to be completed within the extension period. The student shall not be eligible either for award of scholarship during the extension period or any medal/prize. However, if the student had been absent on medical grounds and his/her project had been extended, he/she may be eligible for award of medal or prize, if any. If the above mentioned extension period encroaches into the next semester, the student will have to pay the tuition fee on par with full time student.

11. DISSERTATION WORK IN COLLABORATION WITH INDUSTRY:

11.1 A student may, with the approval of the Head of the Department/Centre, visit an industry or a Research Laboratory for data collection, discussion of the dissertation, experimental work, survey, field studies, etc. during the project period. Projects sponsored by the industry or Research Laboratories will be encouraged and a close liaison with such organizations will be maintained.

11.2 A student may, with the approval of Head of the Department/Centre, do the dissertation work in collaboration with an industry, a Research and Development Organization. The student shall acknowledge the involvement and / or contribution of an industry, R&D organization in completing the project in his/her dissertation and a certificate to this effect, issued by the supervisor from the industrial organization, will be included in the dissertation.

11.3 It is mandatory for all students (especially those who do their project in an Industry, R&D organization in India or abroad) to make full disclosure of all data on which they wish to base their dissertation. They cannot claim confidentiality simply because it would come into conflict with the Industry's or R&D laboratory's own interests. Any tangible intellectual property other than copyright of dissertation may have to be assigned to the Institute. The copyright of the dissertation itself would however lie with the student as per the IPR policy in force.

11.4 In addition to the Supervisor from the department/centre guiding the project work, a Joint Supervisor may be appointed from the Industry and Research Laboratory with the approval of the DAC - PG &R. A certificate from the joint supervisor will be included in the dissertation. A member of faculty of the Institute, who is the internal supervisor, may, if felt necessary, visit the industry or the Research Laboratory in connection with the dissertation work of his/her student.

12. INDUSTRIAL TRAINING:

A student may undergo Industrial training for a period of eight weeks, if he/she wishes, immediately after the completion of I Year II semester.

13. EVALUATION – GRADING SYSTEM:

As a measure of student's performance a 7-scale grading system using the following letter grades and corresponding grade points per credit shall be followed.

Letter Grade	**Ex**	**A**	**B**	**C**	**D**	**P**	**F**
Grade Point	**10**	**9**	**8**	**7**	**6**	**5**	**0**

No student can pass without securing at least 40% marks.

Relative grading scheme shall be followed for all the PG Programs.

The cut-off (lower limit) for EX grade should not be less than 85%.

The cut-offs for other grades between P and EX are to be fixed carefully.

a) In case of bunching, the DAC-PG&R may review the reasons for bunching and modify the ranges, marginally. In all such cases, the modified ranges and the reasons should be presented to the Senate for its approval.

b) In addition, there shall be four transitional grading symbols, which can be used by the examiners to indicate the special position of a student in a subject.

- I for "Incomplete assessment", when the student misses the End- semester examination on Medical grounds (see rule 15.1).
- R - for 'Insufficient attendance in the course (see rule 15.4).
- W - for "Temporary withdrawal' from the Institute (see rule 19)
- X - for "Debarred" on grounds of indiscipline /malpractices in examinations (see rule 20).

13.2.1 A semester Grade Point Average (SGPA) will be computed for each semester. The SGPA will be calculated as follows:

$$SGPA = \frac{\sum_{1}^{n} C_i GP_i}{\sum_{1}^{n} C_i}$$

Where C_i = Credit for the course

GP_i= the grade point obtained for the course

n = Number of subjects registered for the semester.

13.3 Starting from I Year II Semester a Cumulative Grade Point Average (CGPA) will be computed for every student at the end of every semester.

13.4 The CGPA would give the Cumulative performance of the student from the I Year I semester upto the end of the semester to which it refers and calculated as follows.

$$CGPA = \frac{\sum_{1}^{m} S_i C_i}{\sum_{1}^{m} C_i}$$

Where m= total number of semesters under consideration

C_i= total number of credits registered for during a particular semester.

S_i= SGPA of the semester.

13.5 The CGPA, SGPA and the grades obtained in all the subjects in a semester will be communicated to every student at the end of every semester.

13.6 Both SGPA and CGPA will be rounded off to the second place of decimal and recorded as such. Whenever these grade point averages are to be used for the purpose of determining the inter se merit ranking of a group of students, only the rounded off values will be used.

13.7 Transition Grades

(a) Grade I: When a student gets I Grade for any subject(s) during a semester, the SGPA of that semester and the CGPA at the end of that semester will be tentatively calculated ignoring this (these) subjects. After these transitional grades have been converted to appropriate grades, the SGPA for the semester and CGPA at the end of the semester will be recalculated after taking into account the new grades.

(b) About Grade F: When a student gets the 'F' grade in any subject during a semester, the SGPA and the CGPA from that semester onwards will be tentatively calculated, taking only 'zero point' for each such 'F' grade. After the 'F' grade has been substituted by better grades during a subsequent semester, the SGPA and CGPA of all the semesters starting from the earliest semester in which the 'F' grade has been updated, will be recomputed and recorded to take this change of grade into account.

(c) About grades R, W and X:When a student gets any of these transitional grades in any subject(s) during a semester, the SGPA of that semester and the CGPA at the end of that semester will be tentatively calculated by taking 'zero point' for these subject(s). After these transitional grades have been converted to appropriate grades, the SGPA for the semester and CGPA at the end of the semester will be recalculated after taking into account the new grades.

14. EXAMINATIONS:

14.1 The Institute Scholarship of a student will be withheld in case his/her CGPA at the end of any semester falls below 6.5. However, in the case of students belonging in to SC/ST it is 6.0. However, the scholarship will be restored with retrospective effect, based on recommendation of Head of the Department, the moment the CGPA crosses at least 6.5 (for SC/ST 6.0).

14.2 A student will be permitted to submit the dissertation only if he/she completes all the courses as required in the program.

14.3 Student with "F" grade is eligible to appear for makeup examination(s) as and when they are conducted by the Institute.

14.4 A student whose performance in the project work has been unsatisfactory may be assigned additional work on the same problem or assigned a new problem. If the student is assigned additional work the student will have to complete the work and appear at the viva-voce as per the academic calendar fixed by the Senate. If the student is assigned a new problem on account of any reason, the student will have to submit the dissertation and complete the viva-voce by December 31 of that calendar year. The student will not be eligible for scholarship during the extended period of his/her stay but will have to pay semester fees during the extended period of stay.

14.5 A student who has failed in the comprehensive viva-voce shall be required to present himself/herself again within a period of two months for the viva-voce on a date to be fixed by the concerned Head of the Department /Centre.

15. THE GRADES ‘I’ AND ‘R’

15.1 The grade “I” may be temporarily given to a student who is unable to appear in the end semester examination because of:
(a) Illness or accident, which disables the student from appearing in the examination. This must be duly certified by the Institute Medical Officer.
(b) A calamity in the family at the time of the examination which in the opinion of the Head of the Department/Centre and Dean-Student Affairs required the student to be away from the campus.

15.2 If a student is unable to appear in a mid-semester examination for any of the compelling reasons mentioned above, the teacher(s) concerned may use discretion, and take a test with the same weightage.

15.3 A student who has been awarded grade ‘I’ in a subject in the end-semester examination shall have to appear the makeup examination as and when conducted.

15.4 A Student who has insufficient attendance in a particular subject shall be awarded grade 'R'. He/she has to re-register for that course in the subsequent semester in which it is offered.

16. MAKEUP EXAMINATION:

16.1 Students appearing in Makeup examination shall be governed by the following rules:
Students with “F” or “I” Grade only are eligible to write makeup examination.
Students with “R” Grade are not eligible for writing the makeup examination.
A student, who has obtained ‘F’ grade in makeup examination, may register for the course either for “Study” or for “Examination”. (See rule 8.7).

16.2 The schedule for makeup examination is given in the Academic calendar.

16.3 A student can register for makeup examinations in any number of courses.

16.4 Students registering for examination shall be awarded only P grade, if they get 40% or more marks in the end semester/makeup examination.

16.5 Students who have registered under study mode during an academic year and have appeared for makeup examination, will be graded according to the study mode grading applicable to the regular batch of students. In case, they get an ‘F’ grade as per the above criteria, the students who get 40% or more marks in the make-up examination shall be awarded ‘P’ grade by treating them as registered under ‘Examination’ Mode.

17. GRADUATION REQUIREMENTS:

17.1 In order to qualify for a PG degree of the institute, a student:

i) Must have completed all the credit requirements for the degree, as prescribed by the senate with grade “P” or a higher grade in each of the subjects for which the student registered in all the semesters.

ii) Must have obtained a CGPA of at least 5.0 at the end of the semester in which the student completes all the requirements (including the dissertation) for the degree.

17.2 The degree will be awarded to a qualified student only after

(a) The student has cleared all Institute and Hall/Hostel dues, if any, outstanding against the student and
(b) The student has returned all library books borrowed by him/her and also returned instruments, apparatus issued to him/her in good condition.

17.3 A student with a CGPA of 8.0 and above, passing all subjects in the first attempt, is considered eligible for the award of First Division with Distinction.

17.4 A student with a CGPA of 6.5 and above but less than 8.0 is considered eligible for the award of First Division.

17.5 A student with a CGPA of 5.0 and above but less than 6.5 is considered eligible for the award of Second Division.

18. CONDUCT AND DISCIPLINE:

Students shall conduct themselves within and outside the precincts of the institute in a manner befitting the students of an Institute of National importance. Detailed rules regarding conduct and discipline are given in Appendix-III.

19. TEMPORARY WITHDRAWAL:

19.1 A student who has been admitted to M.Tech. program may be permitted to withdraw temporarily for a period of one semester or more from the Institute on account of prolonged illness/acute problem in the family provided that:

19.2 The student applies to the Institute within 15 days of commencement of the semester or from the last date of attending the classes, stating fully the reasons for such withdrawal together with supporting documents and endorsement of the parent/guardian.

19.3 The institute is satisfied that, inclusive of the period of withdrawal, the student is likely to complete all the requirements for the degree within 5 years of admission to the Program.

19.4 There are no outstanding dues or demand from the Institute/Department/Centre/Hall of Residence / Library.

19.5 A student who has been granted temporary withdrawal will be required to pay tuition fee and other fees for the current semester when the student rejoins the program.

19.6 A student shall be granted only one such temporary withdrawal during the program.

19.7 A student, who wishes to join the job, after completion of the entire course work, may be permitted to pursue his dissertation on part-time basis provided:

i. sufficient facilities are available in the organization where he/she is working
ii. there is a competent supervisor in the organization
iii. the minimum period for submission of dissertation work shall be double the amount of the balance period.
iv. the dissertation of such a part time student shall be under the guidance of two supervisors, one from the organization and the other from the Institute.

20. MALPRACTICES:

Students are not allowed to leave the Examination Hall without submitting the answer script. They will not be permitted to enter the exam hall after 30 minutes of commencement of the exam and to leave the exam hall before 30 minutes of the closure of examination.

The nature of malpractice and the minimum punishment are indicated in the following table:

Sl. No	Nature of the Malpractice	Punishment
1	Taking answer booklets out of the examination hall, used or unused.	Fine of Rs. 1000/- per paper. In case of used answer booklets. In addition to the above, the candidate shall be awarded F Grade in that subject.
2	Verbal or oral communication to neighbouring students even after warning.	Taking away the answer script and asking the student to leave the hall.
3	Possession of any incriminating material inside the examination hall (whether used or not). For example: written or printed materials, bits, writings on scale, calculator, hand kerchief, dress, part of the body and hall Ticket etc., Possession of cell phones, programmable calculator, recording apparatus or any unauthorized electronic equipment. Copying from neighbour Exchange of question papers and other materials with some answers	In case of Mid /Sessional examination, award zero marks. In case of End semester examinations, award 'F' Grade. The candidate may be allowed to write make-up examination.
4	Possession of answer book of another candidate. Giving answer book to another candidate.	The candidate shall be awarded 'F' Grade in that particular subject.

5	Misbehaviour in the examination hall (Unruly conduct, threatening the invigilator, or any other examination officials). Involved in malpractice for the second or subsequent times of serial number 2–4.	Cancellation of all theory examinations registered in that semester and further debarred from continuing his/her studies for one year (two subsequent semesters). However the students are permitted to appear for makeup examinations of the previous semesters.
6	Cases of Impersonation	a)Handing over the impersonator (outsider) to the police with a complaint to take appropriate action. b)Cancelation of all examinations (all papers registered) for the bonafide student for whom the impersonation was done and further the bonafide student will be debarred from continuing his/her studies and writing all examinations for two years. c) If a student of this institute is found to impersonate a bonafide student, the impersonating student will be debarred from continuing his/her studies and writing all examinations for two years.
7	Physical assault causing injury to the invigilator or any examination officials.	Rustication from the Institute.

Any other type of malpractices reported, the enquiry committee may recommend appropriate punishment.

21. CERTIFICATE RETENTION FEE:

Students shall be charged with Certificate retention fees as per the details shown below:

All students –

- Who have passed in current and previous academic year - No charge.
- Who have passed in the last 2 to 10 academic years - Rs. 1,000
- Who have passed in the last 11 to 20 academic years - Rs. 5,000.
- Who have passed more than 20 academic years back - Rs. 10,000

22. STUDENT APPRAISAL:

It is mandatory for every student to submit the feedback on each and every course, he/she has undergone, at the end of every semester.

23. CHANGE OF REGULATIONS:

Not withstanding all that has been stated above, the Senate, has the right to modify any of the above rules and regulations from time to time. All such modifications shall be documented and numbered sequentially and shall be made available in the Institute website for the information of the students.

ACADEMIC COMMITTEES
FUNCTIONS AND RESPONSIBILITIES

DEPARTMENTAL ACADEMIC COMMITTEE
POSTGRADUATE & RESEARCH (DAC -PG&R)

Head of the Department	Chairman
All Professors of the Dept. having Ph. D.	Members
All Associate Prof. of the Dept. having Ph. D.	Members
Two Assistant prof. of the Dept. having Ph. D. (by rotation for two years)	Members

NOTE:
The Head of the department will nominate one of the members as secretary.
There shall be one DAC-PG&R for every department, which is involved in the teaching for any of the PG degree program.

FUNCTIONS:

i. To monitor the conduct of all postgraduate courses and course work of M.Tech program.
ii. To ensure academic standards and excellence of the courses offered by the department.
iii. Review and approval of the grades.
iv. To consolidate the registration of the M.Tech students and communicate to the course instructors and Dean-Academic.
v. To consider any matter related to the postgraduate program(s) of the Department and make a suitable recommendation to the Senate.
vi. To monitor the progress of research of all the candidates of the Department
vii. To forward the recommendations of the Doctoral Scrutiny Committee and the panel of External Examiners as recommended by the DSC to the Dean-Academic.
viii. To take up any responsibility or function assigned by the Senate.

DEPARTMENTAL ACADEMIC APPEALS COMMITTEE (DAAC)

Head of the Department	Chairman
Three faculty members of the Department (1 Professor. 1 Associate Prof. and 1 Asst. Professor)	Members
One Professor from outside the Department (Nominated by Dean-Academic)	Member

NOTE:

- There shall be one DAAC for every department.
- The Chairman may co-opt and / or invite more members.
- If the concerned instructor is a member of DAAC then he/she shall keep himself out of the Committee during deliberations.
- The quorum for each meeting shall be a minimum of THREE (Professor from outside department is mandatory).

FUNCTIONS:

i. To receive grievance /complaints in writing from the students regarding anomaly in award of grades due to bias, victimization, erratic evaluation, etc. and redress the complaints.

ii. To interact with the concerned course instructor and the student separately before taking the decision.
iii. The decision of the DAAC will be based on simple majority
iv. The recommendations of the DAAC shall be communicated to the Dean-Academic for further appropriate action as required.

DEPARTMENTAL BOARD OF STUDIES (PG&R)

1. Head of the Department	Chairman
2. All Professors of the Department	Members
3. All Associate Professors of the Dept.	Members
4. One Professor (Allied Department)	Member
5. Two Experts(One from Industry and one from Academia)	Members

Note:

- All the members must possess Ph. D.
- The Chairman will nominate one of the members as secretary.
- The Chairman may co-opt and / or invite more members including external experts while framing / revising the curriculum.

FUNCTIONS:

i. To develop the curriculum for the postgraduate courses offered by the department and recommend the same to the Senate.
ii. The Board of studies is required to meet at least once in two years.

Academic Audit Committee – Department (AACD)

Director's nominee	Chairman
Head of the Department	Convener
Department nominee	Member

Functions:

- To review the internal audit reports submitted by faculty
- To recommend corrective measures, if any.
- To send a consolidated report to Academic Audit Committee – Institute

Academic Audit Committee – Institute (AACI)

Director	Chairman
Dean – Academic	Member
Two Professors nominated by Director	Members
Associate Dean – Academic Audit	Convener

Functions:

- To review the recommendations of AACD of each department
- To initiate appropriate measures (counseling/ training etc.).

APPENDIX- I

DISSERTATION EVALUATION

Dissertation Evaluation:

The evaluation of the Dissertation work carrying 18 credits, is divided into two modules:

Part-A (at the end of II Year I Semester) 6 Credits

Part-B (at the end of II Year II Semester) 12 Credits

A student has to select a topic for his/her dissertation, based on his/her interest and the available facilities at the commencement of dissertation work. The supervisor will evaluate execution of the dissertation periodically.

The dissertation report shall have to be submitted as per the approved guidelines given in Appendix-IV.

For the purpose of assessment, the performance of a student in the dissertation may be divided into the following sub components:

At the end of II Year I semester (for 6 credits)

Assessment by the supervisor	50%
Assessment by the dissertation assessment committee of the Department	50%

At the end of IV semester (for 12 credits)

Assessment by the supervisor	50%
Assessment by the External Examiner	50%

An external examiner shall conduct the viva-voce Examination. A dissertation assessment committee constituted by the Head of the Department, along with the supervisor shall be involved in the conduct of the viva-voce examination.

APPENDIX-II

RULES RELATING TO RESIDENTIAL REQUIREMENT

1. All the students are normally expected to stay in the hostels and be a boarder of one of the messes.
2. Under special circumstances, the Director/Dean-Academic may permit a student to reside with his parent(s) within a reasonable distance from the institute. However, this permission may be withdrawn at the discretion of the Institute at any time considered appropriate without assigning any reason.
3. Married accommodation shall not be provided to any student of the undergraduate courses.
4. No student shall come into or give up the assigned accommodation in any Hall of residence without prior permission of the Chief Warden.
5. A student shall reside in a room allotted to him/her and may shift to any other only under the direction/permission of the Chief Warden.
6. Students shall be required to make their rooms available whenever required for inspection, repairs, maintenance or disinfecting and shall vacate the rooms when leaving for the vacation/ holidays.
7. Students shall be responsible for the proper care of the furniture; fan and other fittings in the rooms allotted to them and shall generally assist the Warden in ensuring proper use, care and security of those provided in the Halls for common use of all students.
8. Students will be responsible for the safe keeping of their own property. In the event of loss of any personal properly of a student due to theft, fire or any other cause the Institute shall accept no responsibility and shall not be liable for payment of any compensation.
9. Engaging personal attendants, keeping pets and use of appliances like electric heater, refrigerator, etc. by a student in Halls of Residence are prohibited.
10. All students must abide by the rules and regulations of the Halls of Residence as may be framed from time to time.
11. **It is mandatory for all ICCR students to stay in the Hostels.**

APPENDIX-III

STUDENTS' CONDUCT AND DISCIPLINARY CODE

It is the responsibility and duty of each and every student of the Institute to become acquainted with "Students Conduct and Disciplinary Code". It is presumed that every student from the date of his/her admission to the Institute has knowledge of this code. All students are required to strictly adhere to this code as a condition of their admission to the Institute and these rules would be binding on and enforceable against them or any one among them.

Section 1: Responsibilities of the Students

It shall be the responsibility of the students

I. To behave and conduct themselves in the Institute campus, hostels and premises in a dignified and courteous manner and show due respect to the authorities, employees and elders.
II. To follow decent and formal dressing manners. Students should avoid clothing depicting illegal drugs, alcohol, prophane language, racial, sexual and vulgar captions etc.
III. To access all educational opportunities and benefits available at the Institute and make good use of them to prosper academically and develop scientific temper.
IV. To respect the laws of the country, human rights and to conduct in a responsible and dignified manner at all times.
V. To report any violation of this Code to the functionaries under this Code.

Section 2: Behaviour of the Students

1. Groupism of any kind that would distort the harmony is not permitted.
2. Students are expected to spend their free time in the library. They shall not loiter along the verandas or crowd in front of the offices or the campus roads. Students should refrain from sitting on places such as parapets, stairs, footpaths etc.
3. Possession or consumption of narcotic drugs and other intoxicating substances are strictly prohibited in the campus and hostels.
4. Silence shall be maintained in the premises of the Institute.
5. Students are not permitted to use mobile phones in the class room, library, computer centre, examination halls, etc.
6. **Students shall refrain from all activities considered as ragging which is a criminal offence.**
7. Students are prohibited from indulging in anti-institutional, anti-national, antisocial, communal, immoral or political expressions and activities within the campus and hostels.
8. Politically based students' and other organizations or outfits are not allowed in the campus. Students are strictly prohibited from organizing, attending or participating in any activity or agitation sponsored by politically based organizations.
9. Students shall not deface, disfigure, damage or destroy or cause any loss in any manner to all the public, private or Institute properties.
10. Without specific permission of the authorities, students shall not bring outsiders to the Institute or hostels.
11. No one shall bring, distribute or circulate unauthorized notices, pamphlets, leaflets etc within the campus or hostels. The possession, distribution or exhibition of any item by any means which is *per se* obscene is prohibited within the campus or on any property owned/ managed by the Institute.
12. No student shall collect money either by request or by coercion from others within the campus or hostels.

13. The Institute being a place of learning and an exclusive academic zone, nobody shall respond to any call for any form of strike, procession or agitation including slogan shouting, *dharna, gherao,* burning of effigy or indulge in anything which may harm the peaceful atmosphere of the Institution and shall eschew from violence in the campus and hostels and even outside.
14. Possession or usage of weapons, explosives or anything that causes injury/ damage to the life and limb or body of any human being or property is prohibited.
15. **Use of motorized vehicles within the Institute premises is strictly prohibited.**
16. Students shall only use the waste bins for dispensing waste materials within the campus including classrooms, hostels, offices, canteen and messes.
17. Any conduct which leads to lowering of the esteem of the Institute is prohibited.
18. **Any unauthorized tour/visit by individual or group of students shall be treated as a serious conduct violation and all such students will be imposed disciplinary penalties.**

Section 3: Disciplinary Sanctions

Any student exhibiting prohibited behaviour mentioned in this Code shall, depending upon the gravity of the misconduct or depending on its recurrence, be subjected to any of the following disciplinary sanctions. Any student who is persistently insubordinate, who is repeatedly or wilfully mischievous, who is guilty of fraud, in the opinion of the competent authority, is likely to have an unwholesome influence on his/ her fellow students, will be removed from the rolls.

I. Minor Sanctions

i. Warning or Reprimand: This is the least sanction envisaged in this Code. The student engaged in any prohibited behaviour will be issued a warning letter.
ii. Tendering Apology: The student engaged in any prohibited behaviour may be asked to tender an apology for his/her act and undertaking that he/she shall not indulge in such or any of the prohibited behaviour in future.

II. Major Sanctions

i. Debarring from Examinations: A student/group of students may be debarred from writing all/any/some of the examinations, which forms part of the academic program for which he/she/they has/ have joined.
ii. Suspension: A student may be suspended from the Institute for violation of any of the provisions of this Code. The period of suspension and conditions, if any, shall be clearly indicated in the communication addressed to the student. The student shall lose his/her attendance for the suspended period.
iii. Restitution: Restitution implies reimbursement in terms of money and/or services to compensate for personal injury or loss, damage/disfiguration to property of the Institute or any property kept in the premises of the Institute in any manner. The students/group of students may be asked to compensate for the loss that has been caused to any person or property of the Institute or any property kept in the premises of the Institute due to the act of vandalism perpetrated by the students. The students/group of students shall also be liable to put in their service to restore any loss or damage caused to any property and thereby bringing it to its original form if it is possible.
iv. Forfeiture: Caution deposit of any student engaged in any prohibited behaviour shall be forfeited.
v. Expulsion: This is the extreme form of disciplinary action and shall be resorted to only in cases where stringent action is warranted. Expulsion is the permanent dismissal of a student from the Institute. Such a student will not be eligible for readmission to any of the courses of this Institute.

Section 4: Functionaries under the Code

i) Heads of the Departments/ Faculty Advisors/Chief Warden/ Wardens of Hostels: As the persons in charge of the Departments/Hostels, the respective functionaries of all Teaching Departments and Hostels shall have the power and duty to take immediate action to curb any prohibitory behaviour as envisaged under this code. As these functionaries cannot single handedly manage all the issues, they can assign part of the work to the teachers and the teachers of all the departments/wardens have the responsibility to inform any incident of prohibited behaviour to the Heads of the Departments/Chief Warden so that any serious issue can be settled before the same goes out of control. The Head of the Departments/Chief Warden shall have the power to impose minor sanctions as envisaged under section 3(I) of this Code.

They can also recommend imposition of major sanctions as envisaged under Section 3(II) of this Code to the Director. The Head of the Departments/ Faculty Advisors/Chief Warden/ Wardens of Hostels while taking any action as envisaged in the code shall do so in an impartial manner and see to it that the sanction imposed/proposed is commensurate with the gravity of the prohibited behaviour. Any lapse on the part of a teacher/ Warden to report any instance of violence and misconduct on the part of the students shall be reported to the Director by the respective Head of the Departments/Chief Warden. The Wardens of Hostels shall be responsible for maintaining strict discipline and decorum in the hostel. He/she shall specifically see to it that the inmates of the hostel do not involve themselves in violation of any clause under Section 2 of this Code.

ii) Deans

Any authority of the Institute with delegated powers shall have the power to visit/inspect any premises, buildings or any property of the Institute when there is a genuine doubt that any act of prohibited behaviour is taking place and can take any lawful actions to curb such behaviour. The HODs/ Faculty Advisors/Chief Warden/ Wardens of Hostels shall report to the Dean (Students) any instances of prohibited behaviour, who in turn shall bring it to the notice of the Director. The Dean (Students) shall forward the recommendations from the HODs/ Chief Warden to impose a major sanction under Section 3(II) of this Code to the Director after noting his observations. The Dean (Students) can also *suomoto* recommend action against any student/students indulging in prohibited behaviour which is brought to his/ her notice.

iii) Director

The Director shall be the ultimate authority in imposing major sanctions as envisaged under Section 3(II) against the students for acts of prohibited behaviour. The Director can also entertain any appeal from any student/students aggrieved by the action of any authority of the Institute under or subordinate to the Director and decide the case on merit.

Section 5: Right to Appeal

The student/students aggrieved by the action of any authority of the Institute under or subordinate to the Director can appeal to the Director and any student aggrieved by the action of the Director can appeal to the Senate. The decision of the Senate shall be final and binding on the students.

Section 6: Assistance from Law Enforcement Agencies

The Deans/ HoDs/ Chief Warden shall have the power and duty to call the Police immediately with the concurrence of the Director when there is a threat of Law and Order situation in the Campus and also when there is a genuine apprehension that any incident of rioting, vandalism or any other act prohibited by law is likely to take place. The Deans/ HoDs/ Chief Warden shall in such a case give a detailed report to the Director. The Director/ Deans/ HoDs/ Chief Warden can also arrange for video recording of the entire situation and take requisite actions through police and other concerned authorities.

Section 7: Grievance Redressal Committee

The Institute will also set up “Grievance Redressal Committee” where the students can air their grievances. The Committee shall consist of the Deans/HoDs/Chief Warden and also members of the Parent-Teacher Association. Till these committees are constituted, *ad-hoc* committees shall be formed by the Director.

Section 8: Undertaking by the Students

The students joining any academic program of the Institute will have to give an undertaking to the effect that he/she will comply with the provisions envisaged in this Code in letter and spirit and even if it is not given them, will be bound by the provisions of this Code.

Section 9: Opportunity for Hearing

No order other than the order suspending or warning a student shall be passed without giving an opportunity of hearing to the Student/ Students.

Section 10: Ultimate Authority

For all disciplinary matters related to students, the Director shall be the ultimate authority as provided herein.

Section 11: Amendments to the Code

The Senate of the Institute shall have the power to amend any of the provisions in this Code. The amendments shall be brought to the notice of the students and faculty of the Institute through notice put on the Institute web site, notice boards of the Institute or through emails.

APPENDIX-IV
GUIDELINES FOR PREPARATION OF DISSERTATION REPORTS

Preamble

While utmost attention must be paid to the content of the dissertation report, which is being submitted in partial fulfilment of the requirements of the M.Tech degree, it is imperative that a standard format be prescribed. The same format shall also be followed in preparation of the final soft copies to be submitted to the Library in future.

1. Organisation of the Dissertation

The dissertation report shall be presented in a number of chapters, starting with Introduction and ending with Summary and Conclusions. Each of the other chapters will have a precise title reflecting the contents of the chapter. A chapter can be subdivided into sections, subsections and sub-subsection so as to present the content discretely and with due emphasis. When the work comprises two or more mutually independent investigations, the dissertation report may be divided into two or more parts, each with an appropriate title. However, the numbering of chapters will be continuous right through, for example Part 1 may comprise Chapters 2 - 5, Part 2, Chapters 6 - 9.

1.1 Introduction

The title of Chapter 1 shall be Introduction. It shall justify and highlight the problem posed, define the topic and explain the aim and scope of the work presented in the dissertation report. It may also highlight the significant contributions from the investigation.

1.2 Review of Literature

This shall normally form Chapter 2 and shall present a critical appraisal of the previous work published in the literature pertaining to the topic of the investigation. The extent and emphasis of the chapter shall depend on the nature of the investigation.

1.3 Report on the present investigation

The reporting on the investigation shall be presented in one or more chapters with appropriate chapter titles. Due importance shall be given to experimental setups, procedures adopted, techniques developed, methodologies developed and adopted. While important derivations/formulae should normally be presented in the text of these chapters, extensive and long treatments, copious details and tedious information, detailed results in tabular and graphical forms may be presented in Appendices. Representative data in table and figures may, however, be included in appropriate chapters. Figures and tables should be presented immediately following their first mention in the text. Short tables and figures (say, less than half the writing area of the page) should be presented within the text, while large table and figures may be presented on separate pages. Equations should form separate lines with appropriate paragraph separation above and below the equation line, with equation numbers flushed to the right.

1.4 Results and Discussion

This shall form the penultimate chapter of the dissertation report and shall include a thorough evaluation of the investigation carried out and bring out the contributions from the study. The discussion shall logically lead to inferences and conclusions as well as scope for possible further future work.

1.5 Summary and Conclusions

This will be the final chapter of the dissertation report. A brief report of the work carried out shall form the first part of the Chapter. Conclusions derived from the logical analysis presented in the Results and Discussions Chapter shall be presented and clearly enumerated, each point stated separately. Scope for future work should be stated lucidly in the last part of the chapter.

1.6 Appendix

Detailed information, lengthy derivations, raw experimental observations etc. are to be presented in separate appendices, which shall be numbered in Roman Capitals (e.g. "Appendix IV"). Since reference can be drawn to published/unpublished literature in the appendices these should precede the "Literature Cited" section.

1.7 Literature Cited

This should follow the Appendices, if any, otherwise the Summary and Conclusions chapter. The candidates shall follow the style of citation and style of listing in one of the standard journals in the subject area consistently throughout his/her report, for example, IEEE in the Department of Electrical Engineering, Materials Transactions in Department of Metallurgical Engineering and Materials Science. However, the names of all the authors along with their initials and the full title of the article/monogram/book etc. have to be given in addition to the journals/publishers, volume, number, pages(s) and year of publication. Citation from websites should include the names(s) of author(s) (including the initials), full title of the article, website reference and when last accessed. Reference to personal communications, similarly, shall include the author, title of the communication (if any) and date of receipt.

1.8 Publications by the candidate

Articles, technical notes etc. on the topic of the dissertation report published by the candidate may be separately listed after the literature cited. This may also be included in the contents. The candidates may also include reprints of his/her publications after the literature citation.

1.9 Acknowledgements

The acknowledgments by the candidate shall follow the citation of literature, signed by him/her, with date.

2. DISSERTATION FORMAT

2.1 Paper

2.1.1 Quality: The dissertation report shall be printed / photo copied on white bond paper, whiteness 95% or above, weight 70 gram or more per square meter.

2.1.2 Size: The size of the paper shall be standard A4; height 297 mm, width 210 mm.

2.1.3 Type Setting, Text Processing and Printing: The text shall be printed employing Laserjet or Inkjet printer, the text having been processed using a standard text processor. The standard font shall be Times New Roman of 12 pts with 1.5 line spacing.

2.1.4 Page Format: The Printed Sheets shall have the following written area and margins:

Top Margin 15 mm
Head Height 3 mm
Head Separation 12 mm
Bottom Margin 22 mm
Footer 3 mm
Foot Separation 10 mm
Text Height 245 mm

Text Width 160 mm
When header is not used the top margin shall be 30 mm.

Left and Right Margins
Single sided
Left Margin 30mm
Right Margin 20 mm

2.1.5 Pagination: Page numbering in the text of the report shall be Hindu Arabic numerals at the centre of the footer. But when the candidate opts for header style the page number shall appear at the right and left top corner for the odd and even number pages, respectively. Page number "1" for the first page of the Introduction chapter shall not appear in print, only the second page will bear the number "2". The subsequent chapters shall begin on a fresh page. When header style is chosen the first page of each chapter will not have the header and the page number shall be printed at the centre of the footer. Pagination for pages before the Introduction chapter shall be in lower case Roman numerals, e.g., "iv".

2.1.6 Header: When the header style is chosen, the header can have the Chapter number and Section number (e.g., Chapter 2, Section 3) on even numbered page headers and Chapter title or Section title on the odd numbered page header.

2.1.7 Paragraph format: Vertical space between paragraphs shall be about 2.5 line spacing. The first line of each paragraph should normally be indented by five characters or 12mm. A candidate may, however, choose not to indent if he/she has provided sufficient paragraph separation. A paragraph should normally comprise more than one line. A single line of a paragraph shall not be left at the top or bottom of a page (that is, no windows or orphans should be left). The word at the right end of the first line of a page or paragraph should, as far as possible, not be hyphenated.

2.2 Chapter and Section Format

2.2.1 Chapter: Each chapter shall begin on a fresh page with an additional top margin of about 75mm. Chapter number (in Hindu-Arabic) and title shall be printed at the centre of the line in 6mm font size (18pt) in bold face using both upper and lower case (all capitals or small capitals shall not be used). A vertical gap of about 25mm shall be left between the Chapter number and Chapter title lines and between chapter title line and the first paragraph.

2.2.2 Sections and Subsections: A chapter can be divided into Sections, Subsections and Sub-sub Sections so as to present different concepts separately. Sections and subsections can be numbered using decimal points, e.g. 2.2 for the second section in Chapter 2 and 2.3.4 for the fourth Subsection in third Section of Chapter 2. Chapters, Sections and Subsections shall be included in the contents with page numbers flushed to the right. Further subsections need not be numbered or included in the contents. The Section and Sub-Section titles along with their numbers in 5 and 4mm (16 and 14 pt) fonts, respectively, in bold face shall be flushed to the left (not centred) with 15 mm space above and below these lines. In further subdivisions character size of 3 and 3.5 with bold face, small caps, all caps and italics may be used for the titles flushed left or centred. These shall not feature in the contents.

2.2.3 Table / Figure Format: As far as possible, tables and figures should be presented in portrait style. Small size table and figures (less than half of writing area of a page) should be incorporated within the text, while larger ones may be presented on separate pages. Table and figures shall be numbered chapter wise.

For example, the fourth figure in chapter 5 will bear the number Figure 5.4 or Fig 5.4 Table number and title will be placed above the table while the figure number and caption will be located below the figure. Reference for Table and Figures reproduced from elsewhere shall be cited in the last and separate line in the table and figure caption, e.g. (after McGregor[12]).

3 Auxiliary Format

3.1 Binding: The evaluation copies of the dissertation report may be spiral bound or soft bound. The final hard bound copies to be submitted after the viva-voce examination will be accepted during the submission of dissertation report with the following colour specification:

M.Tech. Dissertation Grey

3.2 Front Covers: The front covers shall contain the following details:
Full title of report in 6 mm 22 point's size font properly centred and positioned at the top. Full name of the candidate in 4.5 mm 15 point's size font properly centred at the middle of the page. A 40 mm dia replica of the Institute emblem followed by the name of department, name of the Institute and the year of submission, each in a separate line and properly centred and located at the bottom of page.

3.2.1 Lettering: All lettering shall be embossed in gold.

3.2.2 Bound back: The degree, the name of the candidate and the year of submission shall also be embossed on the bound (side) in gold.

3.3 Blank Sheets: In addition to the white sheets (binding requirement) two white sheets shall be put at the beginning and the end of the report.

3.4 Title Sheet: This shall be the first printed page of the Dissertation and shall contain the submission statement: the Dissertation Report submitted in partial fulfilment of the requirements of the M.Tech Degree, the name and Roll No. of the candidate, name(s) of the Supervisor and Co-supervisor(s) (if any), Department, Institute and year of submission. Sample copy of the 'Title Sheet' is appended (Specimen 'A').

3.5 Dedication Sheet: If the candidate so desires(s), he/she may dedicate his/her report, which statement shall follow the title page. If included, this shall form the page 1 of the auxiliary sheets but shall not have a page number.

3.6 Approval Sheet: In the absence of a dedication sheet this will form the first page and in that case shall not have a page number. Otherwise, this will bear the number two in Roman lower case “ii” at the centre of the footer. The top line shall be:

Dissertation Approval for M.Tech

A sample copy of the Approval Sheet is appended (Specimen `B')

3.7 Abstract: The 500 word abstract shall highlight the important features of the dissertation report and shall correspond to the electronic version to be submitted to the Library for inclusion in the website. The Abstract in the report, however, shall have two more parts, namely, the layout of the report giving a brief chapter wise description of the work and the key words.

3.8 Contents: The contents shall follow the Abstract and shall enlist the titles of the chapters, section and subsection using decimal notation, as in the text, with corresponding page number against them, flushed to the right.

3.8.1 List of Figures and Tables: Two separate lists of Figure captions and Table titles along with their numbers and corresponding page numbers against them shall follow the Contents.

3.9 Abbreviation Notation and Nomenclature: A complete and comprehensive list of all abbreviations, notations and nomenclature including Greek alphabets with subscripts and superscripts shall be provided after the list of tables and figures. As far as possible, generally accepted symbols and notation should be used.

Auxiliary page from dedication (if any) to abbreviations shall be numbered using Roman numerals in lower case, while the text starting from the Introduction shall be in Hindu Arabic.

The first pages in the both the cases shall not bear a page number.

3.10 A Declaration of Academic Honesty and Integrity: A declaration of Academic honesty and integrity is required to be included along with every dissertation report after the approval sheet. The format of this declaration is given in Specimen 'C' attached.

****

Specimen 'A': Title Sheet

(Title)

Submitted in partial fulfilment of the requirements

of the degree of

(Master of Technology)

by

(Name of the Student)

(Roll No._______)

Supervisor (s):

____

____

____

(Name of the Department)

NATIONAL INSTITUTE OF TECHNOLOGY WARANGAL

(Year)

Specimen `B': Approval Sheet

This dissertation entitled (Title) by (Author Name) is approved for the degree of ____________ (Degree details).

Examiners

____

____

____

Supervisor (s)

____

____

____

Chairman

____

Date :____________

Place :____________

Specimen `C' – Declaration

I declare that this written submission represents my ideas in my own words and where others' ideas or words have been included, I have adequately cited and referenced the original sources. I also declare that I have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in my submission. I understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

____

(Signature)

____

(Name of the student)

____

(Roll No.)

Date: __________

Specimen `D' – Certificate

This is to certify that the dissertation work entitled " *name of the dissertation* " is a bonafide record of work carried out by "*Mr/Ms name of the student with Roll No.*", submitted to the faculty of "*name of the department* ", in partial fulfilment of the requirements for the award of the degree of Master of Technology in "*name of the program*" at National Institute of Technology, Warangal during the academic year --------------.

Name of the HOD
Head of the Department
Department of ----------
NIT Warangal

Name of the Supervisor
Designation
Department of ------
NIT Warangal

CURRICULAR COMPONENTS

Degree Requirements for M. Tech in Chemical Engineering

Category of Courses	Credits Offered	Min. credits to be earned
Program Core Courses (PCC)	36	36
Departmental Elective Courses (DEC)	18	18
Dissertation	18	18
Total	**72**	**72**

SCHEME OF INSTRUCTION
M.Tech. (Chemical Engineering) Course Structure

I - Year I - Semester

S. No.	Course Code	Course Title	L	T	P	Credits	Cat. Code
1	CH5101	Advanced Transport Phenomena	4	0	0	4	PCC
2	CH5102	Advanced Reaction Engineering	4	0	0	4	PCC
3	CH5103	Computational Techniques	4	0	0	4	PCC
4		Elective – I	3	0	0	3	DEC
5		Elective – II	3	0	0	3	DEC
6		Elective – III	3	0	0	3	DEC
7	CH5104	Computational Lab	0	0	3	2	PCC
8	CH5105	Advanced Chemical Engineering Lab	0	0	3	2	PCC
9	CH5141	Seminar	0	0	0	1	PCC
		TOTAL	**21**	**0**	**6**	**26**	

I - Year II - Semester

S. No.	Course Code	Course Title	L	T	P	Credits	Cat. Code
1	CH5251	Advanced Process Control	4	0	0	4	PCC
2	CH5151	Molecular Thermodynamics	4	0	0	4	PCC
3	CH5152	Steady State Process Simulation	4	0	0	4	PCC
4		Elective – IV	3	0	0	3	DEC
5		Elective – V	3	0	0	3	DEC
6		Elective – VI	3	0	0	3	DEC
7	CH5153	Process Synthesis and Simulation Lab	0	0	3	2	PCC
8	CH5154	Flow Modeling & Simulation Lab	0	0	3	2	PCC
9	CH5191	Seminar	0	0	0	1	PCC
		TOTAL	**21**	**0**	**6**	**26**	

II - Year I - Semester

S. No.	Course Code	Course Title	Credits	Cat. Code
1	CH6142	Comprehensive Viva-voce	2	PCC
2	CH6149	Dissertation Part-A	6	
		TOTAL	**8**	

II - Year II - Semester

S. No.	Course Code	Course Title	Credits	Cat. Code
2	CH6199	Dissertation Part-B	12	
		TOTAL	**12**	

List of Electives

IYear I Semester

CH5111 Process Modelling and Analysis

CH5112 Advanced Heat Transfer

CH5113 Risk Analysis and Hazop

CH5114 Statistical Design of Experiments

CH5115 Chemical Process Synthesis

CH5116 Environmental Engineering

CH5117 Nuclear Power Technology

CH5118 Bioprocess Engineering

CH5119 Piping Engineering

CH5211 Industrial Instrumentation

CH5212 Data Analytics

I Year II Semester

CH5161 Optimization Techniques

CH5162 Process Scheduling & Utility Integration

CH5163 Membrane Separation Techniques

CH5164 Advanced Mass Transfer

CH5165 Computational Fluid Dynamics

CH5166 Process Intensification

CH5167 Electrochemical Engineering

CH5168 Industrial Wastewater Treatment

CH5169 Energy Audit and Conservation

CH5170 Petroleum Refining

CH5261 Nonlinear Systems Analysis & Control

CH5262 Soft Computing Techniques

Note: One Elective course may be taken from other Departments' Electives in each semester

CH5101	ADVANCED TRANSPORT PHENOMENA	PCC	4 – 0 – 0	4 Credits

Pre-requisites: None

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

CO1	Understand the mechanism of momentum, heat and mass transport for steady and unsteady flow.
CO2	Perform momentum, energy and mass balances for a given system at macroscopic and microscopic scale.
CO3	Solve the governing equations to obtain velocity, temperature and concentration profiles.
CO4	Model the momentum, heat and mass transport under turbulent conditions.
CO5	Develop analogies among momentum, energy and mass transport.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	3	2	2	-	3	1	-
CO2	3	2	2	2	-	2	1	2
CO3	3	3	2	2	-	3	1	2
CO4	3	2	2	2	-	3	1	2
CO5	2	2	-	-	-	2	1	-

Detailed syllabus

Equations of Change for Isothermal Systems: Equation of Continuity, Equation of Motion, Equation of Mechanical Energy, Equations of Change in terms of the Substantial Derivative, Use of the Equations to solve Flow Problems, Dimensional Analysis of the Equations of Change.

Velocity Distributions with more than one Independent Variable: Time Dependent Flow of Newtonian Fluids. Velocity Distributions in Turbulent Flow -Comparisons of Laminar and Turbulent Flows, Time Smoothed Equations of Change for Incompressible Fluids, Time Smoothed Velocity Profile near a wall, Empirical Expressions for the Turbulent Momentum Flux, Turbulent Flow in Ducts, Turbulent Flow in Jets.

Macroscopic Balances for Isothermal Systems: The Macroscopic Mass Balance, The Macroscopic Momentum Balance, The Macroscopic Mechanical Energy Balance, Estimation of the Viscous loss, Use of the Macroscopic Balances for Steady-State Problems, Derivation of the Macroscopic Mechanical Energy Balance.

Equations of Change for Non-Isothermal Systems - The Energy Equation, Special forms of the Energy Equation, The Boussinesq Equation of Motion for Forced and Free Convection, Use of the Equations of change to Solve Steady-State Problems, Dimensional Analysis of the Equations of Change for Non-Isothermal Systems,

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

Macroscopic Balances For Non-Isothermal Systems: Macroscopic Energy Balance, Macroscopic Mechanical Energy Balance, Use Of The Macroscopic Balances To Solve Steady State Problems With Flat Velocity Profiles,

Concentration Distributions in Solids and in Laminar Flow: Shell Mass Balances Boundary Conditions, Diffusion through a Stagnant Gas Film, Diffusion with a Heterogeneous Chemical Reaction. Concentration Distributions with more than One Independent Variable: Time-Dependent Diffusion, Steady-State Transport in Binary Boundary Layers, Concentration Distributions in Turbulent Flow - Concentration Fluctuations and the Time-Smoothed Concentration, Time-Smoothing of the Equation of Continuity of A, Semi-Empirical Expressions for the Turbulent Mass Flux, Enhancement of Mass Transfer by a First-Order Reaction in Turbulent Flow

Interphase Transport in Multi-Component Systems: Definition of Transfer Coefficients in One Phase, Analytical Expressions for Mass Transfer Coefficients, Correlation of Binary Transfer Coefficients in One Phase, Definition of Transfer Coefficients in Two Phases, Mass Transfer and Chemical Reactions

Macroscopic Balances For Multi-Component Systems: Macroscopic Mass Balances, Macroscopic Momentum, Use of the Macroscopic Balances to solve Steady-State Problems

Reading:

1. Bird R. B., Stewart W. E. and Light Foot E. N., Transport Phenomena, Revised 2nd Edition, John Wiley & Sons, 2007.
2. Geankopolis C. J., Transport Processes and Unit Operations, 4th Ed., Prentice Hall (India) Pvt. Ltd., New Delhi. 2004.
3. Mauri Robert., Transport Phenomena in Multiphase Flows, Springer International Publishing, Switzerland, 2015.
4. Koichi Asano, Mass Transfer: From Fundamentals to Modern Industrial Applications, Wiley-VCH Verlag Gmbh & Co, KGaA, Weinheim, Germany, 2006.
5. Thomson W. J., Transport Phenomena, Pearson education, Asia, 2001.

CH5102	**ADVANCED REACTION ENGINEERING**	**PCC**	**4 – 0 – 0**	**4 Credits**

Pre-requisites: None

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

CO1	Evaluate heterogeneous reactor performance considering mass transfer limitations
CO2	Perform the energy balance and obtain concentration profiles in multiphase reactors.
CO3	Estimate the performance of multiphase reactors under non-isothermal conditions.
CO4	Understand modern reactor technologies for mitigation of global warming

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	-	-	-	-	-	-	-
CO2	2	2	-	-	-	-	-	-
CO3	3	1	-	-	-	-	-	-
CO4	3	2	2	3	-	-	-	-

Detailed syllabus

Non elementary Kinetics Importance: Approximations for formulations of Rate laws, Formulations of Kinetic model.

Effect of flow on conversions in Reactors: Semibatch Reactors : Importance and examples of applications , Material Balance on Semibatch Reactor, Multiple reaction in Semibatch Reactors, Conversion Vs Rate in Reactors, Use of POLYMATHS to solve the equations and understanding the profiles

Non-Isothermal reaction modeling in CSTR & Semi-Batch reactor: Energy Balance equations for CSTR, PFR and Batch reactors, Adiabatic operations Temperature conversion profiles in PFR, CSTR, Steady state tubular reactor with heat exchange,

Need for Multi-staging CSTR with multiple stages: Exothermic and Endothermic Reaction with examples, CSTR with heat effects, Multiple reactions in CSTR and PFR with heat effects, Semi batch Reactors with heat exchange.

Design of PFR and Packed Bed Tubular Reactors: Radial and Axial mixing in Tubular reactors, Unsteady state in non isothermal energy balance, CSTR, Energy balance in Batch Reactors, Volume of reactors calculations for non isothermal reactors.

Optimal Design of Reactors for Reversible exothermic reactions: Unsteady state non isothermal reactor design, Adiabatic operation in batch, Heat effects in semibatch Unsteady state operation. Autothermal Plug flow reactors and Packed tubular reactors.PFR with interstage cooling.Shift of Energy and material balance lines for reversible reactions in CSTR, Examples of optimal design of PFR and Semibatch and CSTR Exothermic Reactions

Catalytic reactions: theory and modeling: Global rate of reaction, Types of Heterogeneous reactions Catalysis, Different steps in catalytic reactions, Theories of heterogeneous catalysis . Steady State approximation, formulations of rate law Rate laws derived from the PSSH, Rate controlling steps, Eiley-Rideal model, Reforming catalyst example :Finding mechanism consistent with experimental observations Evaluation of rate law parameters, packed beds : Transport and Reactions, Gradients in the reactors : temperature.

Porous media reactors: Mass transfer coefficients, Flow effects on spheres tube and cylinders, External Mass Transfer pore diffusion, structure and concentration gradients Internal Effectiveness Factor Catalytic wall reactor: limiting steps reactions and mass transfer limiting Porous catalyst on tube wall reactors Design of packed bed porous catalytic reactors: Mass transfer limited reactions in Packed bed

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

Application of Population Balance Equations for reactor modeling: Particle size distribution, Distribution Functions in Particle Measuring Techniques, Particle distribution model in colloidal particle synthesis in batch reactor, Moments of Distribution, Nucleation rate based on volumetric holdup versus crystal growth rate.

Reaction engineering and mitigation of Global warming: CO_2 absorption in high pressure water, different techniques of mitigation of CO_2, methods of separations. Recent advancements, automotive monolith catalytic converter example, removal and utilization of CO_2 for thermal power plants.

Reading:

1. Foggler,H.S., Elements of Chemical Reaction Engineering, Prentice Hall of India, 2008.
2. Levenspiel O., Chemical Reaction Engineering, Third Edition, John Wiley & Sons, 1999.
3. Froment G.F. and Bischoff K.B., Chemical Reactor Analysis and Design, John Wiley, 2010.
4. Schmidt L. D , The Engineering of Chemical Reactions, Oxford, 2007.
5. Harriott P., Chemical Reactor Design, CRC Press, 2002.

CH5103	COMPUTATIONAL TECHNIQUES	PCC	4 – 0 – 0	4 Credits

Pre-requisites: None

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

CO1	Apply linear algebra to solve engineering problems
CO2	Solve ordinary differential equations (ODEs) and partial differential equations (PDEs)
CO3	Analyze engineering problems using graph theory
CO4	Apply Statistical techniques to solve engineering problems

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	3	2	2	-	-	1	3
CO2	3	3	2	-	-	-	1	3
CO3	3	3	2	-	-	-	1	3
CO4	3	3	2	-	-	-	1	3

Detailed syllabus

Linear Algebra: Linear spaces, Vector spaces, Function spaces, Linear operator theory, self-adjoint operators, Eigenvalues and eigenvectors-eigenfunctions, Cayley-Hamilton theorem, Polynomials and functions defined on matrices, Similarity transformations, Jordan forms, quadratic forms, Strum-Liouville equations and solution of boundary value problems, Finite difference equations, Difference operators.

Review of Linear Ordinary Differential Equations Solution Methods. Nonlinear Ordinary Differential Equations: Autonomous/ nonautonomous systems of odes, Phase plane analysis, Limit cycle and bifurcation, regular and singular perturbation techniques, Chaos, Differential-Algebraic equations.

Partial Differential Equations: Partial differential operators, First order partial differential equations, Method of characteristics, Classification of the second order partial differential equations and boundary conditions, Method of separation of variables, Similarity solutions, Greens functions, Laplace and Fourier transforms.

Graph theory: Classification of graphs, matrix representation of graphs, Analysis of trees, directed graphs and networks.

Statistical methods: Random variables, Probability distributions, Stochastic Processes, Random numbers and their generation, Monte-Carlo simulation, Response surface methodology, First and second order orthogonal factorial design, Regression analysis, Least square estimation of regression parameters.

Reading:

1. Gilbert Strang, Introduction to Applied Mathematics, Wellesley Cambridge Press. 2009.
2. Gilbert Strang, Linear Algebra and Its Applications, 4th Edition, Wellesley Cambridge Press, 2009.
3. Gourdin, A. and M Boumhrat; Applied Numerical Methods. Prentice Hall India, 2000.
4. Gupta, S. K.; Numerical Methods for Engineers. New Age International, 3rd Edition, 2015.
5. Singiresu S. Rao, “Applied Numerical Methods for Engineers and Scientists” Prentice Hall, 2001.
6. Peihua Qiu, Introduction to Statistical Process Control, CRC Press, 2014.
7. Yuri A.W. Shardt, Statistics for Chemical and Process Engineers, Springer, 2015.

CH5104	COMPUTATIONAL LAB	PCC	0– 0 – 3	2 Credits

Pre-requisites: None

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

CO1	Apply numerical methods for solving engineering problems using MATLAB
CO2	Apply statistical methods for data analysis using MATLAB
CO3	Simulate process dynamics using SIMULINK
CO4	Analyze processes using Design Expert and Pipeline Studio

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	2	3	2	1	1	1	3	3
CO2	2	2	3	1	1	1	3	3
CO3	2	3	3	1	1	1	3	3
CO4	2	3	3	1	1	1	3	3

Detailed syllabus

1. Solution of linear initial value ODEs
2. Solution of linear boundary value ODEs
3. Solution of non-linear initial value ODEs
4. Solution of non-linear boundary value ODEs
5. Solution of Elliptic PDEs
6. Solution of Parabolic PDEs
7. Solution of Hyperbolic PDEs
8. Linear Regression Method
9. Non-linear Regression Method
10. Statistical analysis of data – mean, variance, distribution characteristics
11. Dynamic analysis of first and second order proceses
12. Design Expert based analysis
13. Analysis using Pipeline Studio

Out of all experiments, 10 experiments are offered.

Reading:

Lab Manual.

CH5105	ADVANCED CHEMICAL ENGINEERING LAB	PCC	0– 0 – 3	2 Credits

Pre-requisites: None

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

CO1	Analyze characteristics of a fluidized bed dryer
CO2	Estimate efficiency of compact heat exchangers
CO3	Evaluate the performance of a process intensification in catalytic reactions, ultrasound assisted reactions, reactive distillation column, micro reactor and advanced flow reactor
CO4	Design controller for a given process
CO5	Evaluate the performance of membrane separation process for water purification
CO6	Characterize electrochemical phenomena such as corrosion

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	3	2	1	1	1	2	2
CO2	3	3	2	1	1	1	2	2
CO3	3	3	2	1	1	1	2	2
CO4	3	3	2	1	1	1	2	2
CO5	3	3	2	1	1	1	2	2
CO6	3	3	2	1	1	1	2	2

Detailed syllabus

1. Characteristics of a Fluidized bed dryer
2. Helical Coil heat exchanger
3. Determination of Effective thermal conductivity (ETC) in granular material
4. Plate Type Heat Exchanger
5. Kinetics for solid catalyzed esterification reaction in a batch reactor
6. Reactive distillation in Packed Column
7. Ultrasonic cavitation based reactions
8. Micro-reactor
9. Advanced Flow Reactor
10. Membrane Separation for water purification
11. Corrosion characteristics of a metal in a given electrolyte
12. Control of liquid level in non-interacting systems.
13. Identification and control of a three tank system.
14. pH control in a process.

Out of all experiments, 10 experiments are offered.
Reading: Lab Manual.

CH5251	ADVANCED PROCESS CONTROL	PCC	4 – 0 – 0	4 Credits

Pre-requisites: None

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

CO1	Develop parametric and non-parametric models for LTI systems.
CO2	Design PID controller for a given process
CO3	Analyze the controlled and manipulated variables in multivariable processes.
CO4	Implement model predictive control.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	3	3	1	-	-	-	1
CO2	3	3	3	1	-	-	-	-
CO3	3	3	3	1	-	-	-	-
CO4	3	3	3	1	-	-	-	-

Detailed syllabus

Review of basics, advanced control schemes - Cascade control, feed-forward control, ratio control, split-range control, time delay compensator, inverse response compensator, combinations of cascade and feed-forward control schemes.

Models of Discrete-Time LTI Systems - Convolution equation, Difference equations, Transfer functions. State-space models. Discretization, Sampling and Hold operations, sampling theorem.

Digital PID controllers: Position and Velocity forms; Design and implementation. IMC method. Controller design in state-space domain: Stability and transient response in closed loop.

Multivariable control - Challenges; Control pairing; Interactions in closed-loop systems; Relative Gain Array (RGA) and variants. Introduction to decentralized, decoupled control schemes.

Non-parametric models - impulse response, step response and frequency response models. Parametric model structures - ARX, ARMAX, OE, BJ and PEM – structures and identification.

Introduction to Model Predictive Control (MPC) - Concepts; Theory and implementation; Relation with LQ-control. Implementation of MPC: Step response model; State update and model prediction. Receding Horizon implementation; Variants and customizations; Issues and Challenges.

Identification of models for MPC - estimation of step response models, disturbance models for MPC; least squares estimation. Case studies.

Reading:

1. Seborg, D. E., Edgar, T. F., Millechamp, D. A., Doyle III, F. J., Process Dynamics and Control, 3rd Edition, Wiley, 2014.
2. K.J. Astrom and B. Wittenmark, Computer Controlled Systems: Theory and Design, Prentice-Hall, 2000.
3. Kannan Moudgalya, Digitial Control, Wiley, 2007.
4. Liuping Wang, Model Predictive Control System Design and Implementation using MATLAB, Springer, 2009.
5. E. F. Camacho and Carlos Bordons, Model Predictive Control, Springer, 1999.
6. Biao Huang, Ramesh Kadali, Dynamic Modeling, Predictive Control and Performance Monitoring, Springer, 2008.

CH5151	MOLECULAR THERMODYNAMICS	PCC	4 – 0 – 0	4 Credits

Pre-requisites: None

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

CO1	Solve problems involving multiphase equilibrium with/without reactions
CO2	Apply intermolecular forces concept to thermodynamic properties
CO3	Apply statistical thermodynamic models for phase equilibrium calculations
CO4	Design separation systems such as distillation and liquid-liquid extraction and by using molecular thermodynamics

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	2	2	1	1	1	2	2
CO2	3	2	1	1	1	1	2	2
CO3	3	2	1	1	1	1	2	2
CO4	3	2	2	1	1	1	2	2

Detailed syllabus

Classical Thermodynamics: First and Second laws, Property relationships, Phase equilibria and Phase diagrams.

Intermolecular forces and corresponding states theory: Potential-Energy functions, Electrostatic forces, Polarizability & Induced dipoles, Mie's potential-energy function for non-polar molecules, Structural effects, Chemical Forces.

Statistical thermodynamics: Ensembles, Partition function, Partition function for ideal gases, Chemical equilibrium via partition function

Fugacities in Gas Mixtures: Lewis fugacity rule, Virial Equation of State, Fugacities from Virial equation, Virial coefficients from potential functions and corresponding state correlations.

Fugacities in Liquid Mixtures: The Ideal solution, excess functions, activity coefficients and their evaluation, Wilson, NRTL, UNIQUAC equations, van Laar theory, Scatchard-Hildebrand theory, Lattice model, two liquid theory, group contribution method and chemical theory.

Applications: Vapor-liquid equilibrium, Solubility of gases in liquids, Solubility of solids in liquids, liquid-liquid equilibrium, Electrolyte solutions, Reaction Equilibria.

Reading:

1. Prausnitz J. M., Lichtenthaler R. N., Azevedo E. G., Molecular Thermodynamics of Fluid-Phase Equilibria, 3rd Edition, Prentice-Hall, 1999.
2. Modell M., Reid R. C, Thermodynamics and its Applications, Prentice-Hall, 1983.
3. Smith J. M., Van Ness H. C., Abbott M.M., Introduction to Chemical Engineering Thermodynamics, 5th edition, McGraw Hill, 2001.
4. Tester J. W., Modell M., Thermodynamics and its Applications, third edition, Prentice-Hall, 1997.
5. Sandler S. I., An Introduction to Applied Statistical Thermodynamics", Wiley, 2011.
6. Dill K. A., Bromberg S., Molecular driving forces: Statistical Thermodynamics in Biology, chemistry, physics and nanoscience, second edition, Taylor and Francis, 2011.

CH5152	STEADY STATE PROCESS SIMULATION	PCC	4 – 0 – 0	4 Credits

Pre-requisites: None

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

CO1	Understand the role and importance of property estimation methods in process simulation.
CO2	Identify degrees of freedom for a stream, a process unit and a flowsheet.
CO3	Apply suitable mathematical methods for solving explicit iterative loops, sparse sets of equations, partitioning & precedence ordering and to find best tear stream sets.
CO4	Carry out steady state process simulation using sequential modular approach and equation oriented approach.
CO5	Distinguish between sequential and simultaneous convergence and convergence promotion techniques.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	3	1	1	1	1	-	1
CO2	3	3	-	-	2	-	-	-
CO3	3	2	1	-	-	-	1	1
CO4	3	3	2	2	-	-	1	1
CO5	3	3	1	-	-	-	1	1

Detailed syllabus

Introduction: Steady-state flowsheeting and the design process, the total design project.

Flowsheeting on the computer: Motivation for development, Developing a simulation model, Approaches to flowsheeting systems-examples.

Solving linear and nonlinear algebraic equations: Solving one equation in one unknown, Solution methods for linear equations, General approaches to solving sets of nonlinear equations, Solving sets of sparse nonlinear equations.

Physical property service facilities: The data cycle, Computerized physical property systems, Physical property calculations.

Degrees of freedom in a flowsheet: Degrees of freedom, Independent stream variables, Degrees of freedom for a stream and a unit, Degrees of freedom for a flowsheet.

The sequential modular approach to flowsheeting: The solution of an example flowsheeting problem, Other features: Handling design specifications, information streams and control blocks,
Convergence of tear streams: Sequential convergence and simultaneous convergence, Partitioning and precedence ordering set of equations and a flowsheet, tearing a flowsheet, Finding the best tear set family.

Flowsheeting by equation solving methods based on tearing: A simple example, An example system based on equation solving, A complex example of selecting decision and tear variables for a flowsheet, Handling the iterated variables.

Simulation by linear methods: Introduction to linear simulation, Application to staged operations, Application to management problem.

Simulation by Quasi-linear approach: Introduction to Quasi-linear methods, Simulation of flows in pipe networks, Application to distillation, Application to multiple reaction equilibrium, Towards process simulation by Quasi-linear methods.

Reading:

1. Westerberg A. W., Hutchison H. P., Motard R. L. and Winter P., Process Flowsheeting, Cambridge University Press, 2011.
2. Ivan Dano Gill Chaves, Javier Ricardo Guevara Lopez, Jpose Luis Garcia Zapata, Alexander Leguizamon Robayo and Gerardo Rodrigue Nino, Process Analysis and Simulation in Chemical Engineering, Springer, 2016.
3. Babu B. V., Process Plant Simulation, Oxford University Press, 2004.
4. Mariano Martin Martin, Introduction to Software for Chemical Engineers, CRC Press, 2015.

CH5153	PROCESS SYNTHESIS AND SIMULATION LABORATORY	PCC	0 – 0 – 3	2 Credits

Pre-requisites: None

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

CO1	Carry out thermodynamic property estimations using property estimation and property analysis in Aspen
CO2	Simulate Mixer, splitter, heat exchangers, pumps, compressors, flash units, reactors, distillation columns, calculator block and solid handling units.
CO3	Apply sensitivity, design specification and case study tools in Aspen.
CO4	Optimize process flowsheets using sequential modular approach as well as equation oriented approach.
CO5	Carry out dynamic simulation, pinch analysis and cost estimation using suitable examples.
CO6	Solve linear and non-linear programming problems.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	1	3	**-**	**-**	**-**	**-**	**1**	**1**
CO2	1	3	-	-	-	-	1	1
CO3	2	3	2	1	-	-	1	1
CO4	2	3	2	2	-	-	1	1
CO5	2	3	2	-	-	-	1	1
CO6	1	3	-	2	1	-	1	1

Detailed syllabus

Solve the following steady state simulation exercises using **Aspen, MATLAB & GAMS**:

1. Physical property estimations.
2. Simulation of individual units like, mixers, splitters, heat exchangers, flash columns and reactors
3. Design and rating of heat exchangers
4. Design and rating of distillation columns.
5. Mass and Energy balances.
6. Handling user specifications on output streams – Sensitivity and design Spec tools.
7. Simulation of a flowsheet
8. Simulation exercises using calculator block
9. Optimization Exercises
10. Simulation using equation oriented approach
11. Simulation of processes involving solids

12. Costing and economic analysis using Aspen capital Cost estimation.
13. Pinch analysis and design Heat exchanger networks using Aspen Energy Analyser.
14. Dynamic Simulation
15. Linear and non-linear programing problems

Out of all experiments, 10 experiments are offered.

Reading:

1. Lab manuals / Exercise sheets

CH5154	FLOW MODELING AND SIMULATION LAB	PCC	0– 0 – 3	2 Credits

Pre-requisites: None

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

CO1	Solve heat/mass/momentum balance equations using COMSOL Multiphysics/Ansys Software
CO2	Visualize flow/temperature/concentration distribution in coupled phenomena between heat, mass & momentum transfer
CO3	Design equipment for fluidized beds, heat exchangers and microfluidic devices.
CO4	Optimize operating conditions for of a given processes based on flow behavior.
CO5	Solve models for specific chemical engineering problems using g-PROMS

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	3	2	1	1	1	2	2
CO2	3	3	2	1	1	1	2	2
CO3	3	3	2	1	1	1	2	2
CO4	3	3	2	1	1	1	2	2
CO5	3	3	2	1	1	1	2	2

Detailed syllabus

Simulation using COMSOL, ANSYS, g-PROMS

1. Hagen-Poisuelle flow
2. Flow past a cylinder
3. Flow through micro-channels with obstacles like air bubbles
4. RTD determination in tubular reactor
5. Conversion in PFR/Tubular reactor
6. Fluidization
7. Flow through Packed bed
8. Lid-driven cavity flow
9. Reaction & Diffusion in and around a catalyst particle
10. Effective thermal diffusivity/conductivity of granular material
11. Rayleigh Bernard Convection
12. Natural convection between vertical walls
13. Double pipe heat exchanger

Out of all experiments, 10 experiments are offered.
Reading: Lab Manual.

CH5111	PROCESS MODELING & ANALYSIS	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Understand model building techniques
CO2	Develop first principles, grey box and empirical models for systems.
CO3	Develop mathematical models for engineering processes
CO4	Model discrete time systems

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	2	2	-	-	-	-	-
CO2	3	2	2	-	-	-	-	-
CO3	3	2	2	-	-	-	-	-
CO4	3	2	2	1	1	-	-	-

Detailed syllabus

Introduction to modeling, a systematic approach to model building, classification of models.

Development of steady state and dynamic lumped and distributed parameter models based on conservation principles. The transport phenomena models: Momentum, energy and mass transport models. Analysis of ill-conditioned systems.

Classification of systems, system’s abstraction and modeling, types of systems and examples, system variables, input-output system description, system response, analysis of system behavior, linear system, superposition principle, linearization, non-linear system analysis, system performance and performance targets.

Development of grey box models. Empirical model building. Statistical model calibration and validation. Population balance models. Examples.

Mathematical model development for electromagnetic forces in high field magnet coils, free and forced vibration of an automobile, cantilever beam subjected to an end load.

Mathematical model development for different chemical engineering processes – distillation columns, reactors, heat exchangers.

Discrete systems: difference equations, state-transition diagrams, cohort simulation of Markov models, random processes, descriptive statistics, hypothesis testing, probabilistic distributions, pseudo-random numbers, Monte Carlo methods, numerical simulation of continuous-time dynamics, discrete-event systems, cellular automata, Moore machines, real-world system examples: Mechanical, Electrical, Electro-Mechanical, Chemical Systems.

Reading:

1. Ashok Kumar Verma, Process Modeling and Simulation in Chemical, Biochemical and Environmental Engineering, CRC Press, 2014.
2. Amiya K. Jana, Chemical Process Modeling and Computer Simulation, 2nd Edition, Prentice Hall, 2011.
3. Jim Caldwell, Douglas K. S. Ng, Mathematical Modeling: Case Studies, Kluwer Academic Publishers, 2004.
4. Said S. E. H. Elnashaie, Parag Garhyan, Conservation Equations and Modeling of Chemical and Biochemical Processes, Marcel Dekker Publishers, 2003.
5. K. M. Hangos and I. T. Cameron, “Process Modelling and Model Analysis”, Academic Press, 2001.
6. John Ingham, Irving J. Dunn, Elmar Heinzle, J. E. Prenosil, Jonathan B. Snape, Chemical Engineering Dynamics, Wiley, 2007.

CH5112	ADVANCED HEAT TRANSFER	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Derive the governing differential equation for conduction and convection heat transfer
CO2	Solve the differential equation to obtain temperature profile in solid or fluid
CO3	Apply finite difference methods to solve heat transfer problems
CO4	Calculate the net radiation loss from a surface in an enclosure of many surfaces

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	1	2	-	-	-	-	-
CO2	2	1	2	-	-	-	-	-
CO3	3	1	-	-	-	-	-	-
CO4	3	1	3	-	-	-	-	-

Detailed syllabus

Steady state heat conduction: General conduction equation, side conditions. One dimensional heat conduction without generation, Plane slab, Circular cylindrical shell, Spherical shell, Variable thermal conductivity, Conduction across composite barriers, Critical insulation thickness. Finite difference methods in steady state conduction.

Unsteady state condition: Exact analytical solutions and charts for infinite slab, cylinder and sphere, Semi-infinite slab, Lumped parameter method of transient analysis; Finite difference method; Transient finite difference solutions.

Natural Convection: Governing equations for velocity and temperature fields, partial differential equations, vertical plate solution.

Forced Convection: The fundamental problem, analytical and semi-analytical solutions.

Radiation Heat transfer - Concepts, physical mechanism, properties, radiation shape factors, heat exchange between nonblack bodies, infinite parallel planes, Calculation of the net radiant loss; Net radiant loss from non-gray surfaces.

Reading:

1. Sucec J, Heat Transfer, Jaico Publishing House, 2006.
2. Holman, J.P. and White P.R.S., Heat Transfer, 7th Ed., McGraw Hill, 2009.
3. Ozisik M. N., Heat Transfer: A Basic Approach, McGraw-Hill, 1984.
4. Crawford M., Kays B. W., Convective Heat and mass transfer, McGraw-Hill, 2012.

CH5113	RISK ANALYSIS & HAZOP	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Identify the type of risk involved in a chemical plant operation
CO2	Manage risk and prepare disaster management options
CO3	Understand safety, energy and environmental impact audit
CO4	Implement the procedure of root cause/fault tree analysis
CO5	Conduct HAZOP study for 'to be commissioned' chemical plants

Mapping of course outcomes with program outcomes

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO1	1	-	-	3	-	-	-	-
CO2	-	-	2	3	-	-	2	-
CO3	1	-	-	3	-	-	1	-
CO4	-	-	-	3	-	-	1	-
CO5	-	-	-	3	-	-	-	-

Detailed syllabus

Types of Risk analysis: What are Risks, threats and vulnerabilities? What are Risk assessment, Risk management and Risk communication?. Basics and structure of Risk analysis. Qualitative and quantitative risk analysis. Types of failure: What is failure? Design failure, catastrophic failure, compounding failure and Human error failure.

Dispersion and toxic models: Parameters affecting dispersion, Neutrally buoyant dispersion models, Steady-State Continuous Point Release with No Wind, Puff with No Wind, Non-Steady-State Continuous Point Release with No Wind, Steady-State Continuous Point Source Release with Wind, Puff with No Wind and with Source on Ground, Steady-State Plume with Source on Ground,

Fire and explosion models: The Fire Triangle, Distinction between Fires and Explosions, Flammability Characteristics of Liquids and Vapors, Liquids, Gases and Vapors, Vapor Mixtures, Flammability Limit, Dependence on Temperature, Flammability Limit Dependence on Pressure, Estimating Flammability Limits, Limiting Oxygen Concentration and Inerting, Flammability Diagram, Ignition Energy, Auto ignition, Auto-Oxidation, Adiabatic Compression, Ignition Sources, Sprays and Mists, Explosions, Detonation and Deflagration.

Risk Management and ISO14000: Disaster management plan: Scale of disaster, elements at risk, aims of disaster management, disaster management cycle, role players in disasters, disaster preparedness,disaster preparedness framework, disaster response activities.

Emergency Planning: Internal Emergency Plan (for the employees of the company), Objectives of an internal emergency plan, The Preparation of an Emergency plan, Elements of an Emergency plan, Emergency Organization and Management. External Emergency Plan (for the surrounding communities).

Case studies: Static Electricity, Tank Car Loading Explosion, Explosion in a Centrifuge, Duct System Explosion, Conductor in a Solids Storage Bin, Pigment and Filter, Pipefitter's Helper, Lessons Learned, Chemical Reactivity, Bottle of Isopropyl Ether, Nitrobenzene Sulfonic Acid Decomposition,

Hazard identification: Process Hazards Checklists, Hazards Surveys, Hazards and Operability Studies, Safety Reviews, Other Methods. Safety Audits: Types of audits (Internal &External), Audits objectives, Methodology in Conducting Safety audits (Pre-audit activities, Key on-sites activities and Post-audit activities).

Checklists: Process hazard checklists.What if Analysis: Examination of possible deviations from the design, construction, modification or operating intent of a process.

Vulnerability models: Definitions of vulnerability, Characteristics of vulnerability, Types of vulnerability, Conceptual frame-works of vulnerability, Methods of Measuring physical vulnerability, Analytical Methods and Earthquake vulnerability curves. Event tree and Fault tree Analysis: Guidelines, examples, fault tree analysis symbols, building fault tree, DOs and DONOTs in fault tree analysis, Past accident analysis, Hazops, Principles, Risk ranking, Guide word, Parameter, Deviation, Causes, Consequences, Recommendation, Coarse HAZOP study, Case studies

Reading:

1. Raghavan K. V. and Khan A. A., Methodologies in Hazard Identification and Risk Assessment, Manual by CLRI, 1990.
2. Marshal V. C., Major Chemical Hazards, Ellis Horwood Ltd., Chichester, United Kingdom, 1987.
3. Mannan S., Butterworth Heineman, Lees' Loss Prevention in the Process Industries, 4th Ed., Hazard Identification, Assessment and Control, 2012.
4. D. A. Crowl and J.F. Louvar, Chemical Process Safety (Fundamentals with Applications), Prentice Hall, 2011.
5. R.K. Sinnott, Coulson & Richardson's Chemical Engineering, Vol. 6, Elsevier India, 2006.

CH5114	STATISTICAL DESIGN OF EXPERIMENTS	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Plan experiments for a critical comparison of outputs
CO2	Include statistical approach to propose hypothesis from experimental data
CO3	Implement factorial and randomized sampling from experiments
CO4	Estimate parameters by multi-dimensional optimization

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	2	-	-	3	-	-	-	-
CO2	2	1	-	-	-	-	-	-
CO3	2	1	-	-	-	-	-	-
CO4	-	3	-	2	-	-	-	-

Detailed syllabus

Introduction: Strategy of experimentation, basic principles, guidelines for designing experiments.

Simple Comparative Experiments: Basic statistical concepts, sampling and sampling distribution, inferences about the differences in means: Hypothesis testing, Choice of samples size, Confidence intervals, Randomized and paired comparison design.

Experiments with Single Factor; An example, The analysis of variance, Analysis of the fixed effect model, Model adequacy checking, Practical interpretation of results, Sample computer output, Determining sample size, Discovering dispersion effect, The regression approach to the analysis of variance, Nonparametric methods in the analysis of variance, Problems.

Design of Experiments: Introduction, Basic principles: Randomization, Replication, Blocking, Degrees of freedom, Confounding, Design resolution, Metrology considerations for industrial designed experiments, Selection of quality characteristics for industrial experiments.

Parameter Estimation.

Response Surface Methods: Introduction, The methods of steepest ascent, Analysis of a second-order response surface, Experimental designs for fitting response surfaces: Designs for fitting the first-order model, Designs for fitting the second-order model, Blocking in response surface designs, Computer-generated (Optimal) designs, Mixture experiments, Evolutionary operation, Robust design, Problems.

Design and Analysis: Introduction, Preliminary examination of subject of research, Screening experiments: Preliminary ranking of the factors, active screening experiment-method of random balance, active screening experiment Plackett-Burman designs, Completely randomized block design, Latin squares, Graeco-Latin Square, Youdens Squares, Basic experiment-mathematical modeling, Statistical Analysis, Experimental optimization of research subject: Problem of optimization, Gradient optimization methods, Nongradient methods of optimization, Simplex sum rotatable design, Canonical analysis of the response surface, Examples of complex optimizations.

Reading:

1. Lazic Z. R., Design of Experiments in Chemical Engineering, A Practical Guide, Wiley, 2005.
2. Antony J., Design of Experiments for Engineers and Scientists, Butterworth Heinemann, 2004.
3. Montgomery D. C., Design and Analysis of Experiments, 5th Ed., Wiley, 2010.
4. Doebelin E. O., Engineering Experimentation: Planning, Execution, Reporting, McGraw-Hill, 1995.

CH5115	CHEMICAL PROCESS SYNTHESIS	PCC	4 – 0 – 0	4 Credits

Pre-requisites: None

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

CO1	Analyze alternative processes and equipment
CO2	Synthesize a chemical process flow sheet that would approximate the real process
CO3	Design best process flow sheet for a given product
CO4	Perform economic analysis related to process design and evaluate project profitability

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	-	1	3	2	-	-	-	-
CO2	2	2	-	-	-	-	-	-
CO3	2	2	3	2	-	-	-	-
CO4	-	-	3	-	-	-	-	-

Detailed syllabus

Synthesis of steady state flow sheet: Introduction, Flow sheets, The problem of steady state flow sheeting, General semantic equation of equipment, Generalization of the method of synthesis of process flow sheet, Recycle structure of the flow sheet, separation systems.

Heuristics for process synthesis:
Raw materials and Chemical reactions, Distribution of chemicals, Separations, Heat exchangers and furnaces, pumping pressure reduction and conveying of solids

Algorithmic methods for process synthesis :
Reactor design and reactor network synthesis, Synthesis of separation trains , sequencing of ordinary distillation columns

Optimization of flow sheet with respect to heat exchanger network: Introduction, Network of heat exchanger, Some necessary conditions for the existence of an optimal exchanger network, Maximum heat transfer in a single exchanger (rule 1), Hot and cold utilities (rule2), Condition of optimality for the minimum area network, Three special situations in energy transfer, Heat content diagram representation of the network problem, Matching of heat content diagram for minimum network area, Rules of adjustment of the minimum heat exchanger network to find the optimal solution.

Safety in Chemical plant design: Introduction, Reliability of equipment, prevention of accidents, Flammability of chemicals, Safety considerations in plant layout, Classification of chemicals and handling problem, Venting of tanks and vessels, Design of safety valves, Safety consideration in reactor design, Leakages, Handling of fluids, Trouble-shooting analysis of equipment and chemical plants, Fault tree analysis of accidents. Reliability consideration in maintenance policies of a chemical plant

Economic evaluation: Time value of money, Methods for Profitability evaluation, Rate of return, Net Present Worth, Capitalised cost , Discounted Cash flow analysis.

Reading:

1. Seider W. D., SeaderJ. D. and Lewin D. R., Product and Process Design Principles: Synthesis, Wiley, 2005.
2. Robin Smith , Chemical Process Design and Integration, John Wiley & sons Ltd,2005.
3. Bieglar L.T, Grossman E.I and Westerberg A.W., Systematic Methods of Chemical Process Design, Prentice Hall Inc.,
4. Douglas J. M., Conceptual Design of Chemical Processes, McGraw Hill International, 1988.

CH5116	ENVIRONMENTAL ENGINEERING	DEC	3– 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Recognize the causes and effects of environmental pollution
CO2	Analyze the mechanism of proliferation of pollution
CO3	Develop methods for pollution abatement and waste minimization
CO4	Design treatment methods for gas, liquid and solid wastes

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	3	3	3	1	-	2	-
CO2	3	3	3	3	1	-	2	-
CO3	3	3	3	3	-	1	2	-
CO4	3	3	3	3	-	1	2	-

Detailed syllabus

Ecological concepts and natural resources: ecological perspective, value of the environment. Ecosystem processes, human dimension, environmental changes and threats to environment.

Sources of pollution: Environment and environmental pollution from chemical process industries, characterization of emission and effluents.

Standards: environmental Laws and rules, standards for ambient air, noise emission and effluents.

Pollution Prevention: Process modification, alternative raw material, recovery of by co-product from industrial emission effluents, recycle and reuse of waste, energy recovery and waste utilization. Material and energy balance for pollution minimization. Water use minimization, Fugitive emission/effluents and leakages and their control-housekeeping and maintenance.

Air Pollution Control: Particulate emission control by mechanical separation and electrostatic precipitation, wet gas scrubbing, gaseous emission control by absorption and adsorption, Design of cyclones, ESP, fabric filters and absorbers.

Water Pollution Control: Physical treatment, pre-treatment, solids removal by setting and sedimentation, filtration centrifugation, coagulation and flocculation.

Biological Treatment: Anaerobic and aerobic treatment biochemical kinetics, trickling filter, activated sludge and lagoons, aeration systems, sludge separation and drying.

Solids Disposal: Solids waste disposal - composting, landfill, briquetting / gasification and incineration.

Waste minimization: Life cycle assessment, elements of a waste minimization strategy, benefits of waste minimization, waste minimization techniques.

Reading:

1. "Pollution Control Acts, Rules, Notifications issued there under" CPCB, Ministry of Env. and Forest, G.O.I., 3rd Ed. (2006.)
2. Vallero D; "Fundamentals of Air Pollution", 4 th Ed; Academic Press (2008).
3. Pichtel J; "Waste Management Practices: Municipal, Hazardous and Industrial", CRC (2005).
4. Tchobanoglous G., Burton F. L. and Stensel H.D., "Waste Water Engineering: Treatment and Reuse", 4th Ed; Tata McGraw Hill (2002).
5. Gerard Kiely, "Environmental Engineering", Tata McGraw Hill (2007).
6. Reynolds and Richards, "Unit operations and processes in environmental engineering" PWS Publishing company, 1996.
7. N. Hanley, S.C. Bhatia, "Pollution Control in Chemical and allied industries", CBS Publishers (2010)

CH5117	NUCLEAR POWER TECHNOLOGY	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Understand radioactivity, nuclear fission and fusion, interaction of particles with matter
CO2	Design and operate nuclear power plants
CO3	Select materials for nuclear reactor systems
CO4	Design and operate plants for the nuclear fuel cycle with emphasis on environmental and ethical aspects.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	2	2	1	3	1	1	-	1
CO2	1	2	2	-	-	1	-	1
CO3	1	2	2	2	-	1	-	1
CO4	2	3	3	3	-	1	3	1

Detailed syllabus

Nuclear Reactions and radiations: Atomic structure, Radioactivity and Radio isotopes, interaction of alpha and beta particles with matter, decay chains, neutron reactions, fission process, growth and decay of fission products in a reactor with neutron burnout and continuous processing. Nuclear fission and fusion, types and classification of nuclear reactors, nuclear fuels, other reactor materials.

Nuclear Reactor theory: The neutron cycle, critical mass, neutron diffusion, the diffusion equation, slowing down of neutrons, reactor period, transient conditions and reflectors.: Introduction to nuclear power systems, Thermal-hydraulics: Thermal parameters: definitions and uses. Sources and distribution of thermal loads in nuclear power reactors. Thermal analysis of nuclear fuel, Single-phase flow and heat transfer, Two-phase flow and heat transfer.

Nuclear reactor materials: General requirements (neutronic and physical) of nuclear materials: Core, structural, moderator, coolant and control rod, properties of moderator and coolant materials: graphite, beryllium, Boron, water, heavy water, liquid metals. Brief description of different systems. Selection Criteria of Materials for different systems. Materials behaviour under extreme environments, radiation, high temperature, corrosion. Zr alloys and Austenitic stainless steels.

Nuclear fuel cycle:Uranium mining, milling and enrichment. Fuel reprocessing, PUREX flow sheet, Solvent extraction, Selection of solvents, Non aqueous reprocessing. Waste management, classification of wastes, treatment of radioactive wastes, partitioning and transmutation. deep geological disposal.

Environmental effects of nuclear Power generation. Ethical aspects of nuclear power production.

Reading:

1. Glasstone S and Alexender Seasonske, Nuclear Reactor Engineering, 3rd Edition, CBS publisher, USA, 1994.

2. W Marshall, Nuclear Power Technology, Vol I, II, and III, Oxford University Press, New York 1983.

3. G. Vaidyanathan, Nuclear Reactor Engineering (Principles and Concepts), S. Chand Publishers, 2013

4. J.R. Lamarsh and A.J. Baratta Introduction to Nuclear engineering, 3rd Edition, 2001

5. K.D. Kok, Nuclear Engineering Handbook, CRC Press, 2009

6. Manson Benedict, Thomas H. Pigford,. Dr. Hans Wolfgang Levi: Nuclear Chemical Engineering, Second Edition, McGraw-Hill Professional, 1981

CH5118	BIOPROCESS ENGINEERING	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Understand enzyme kinetics and cell kinetics.
CO2	Assess the immobilization techniques.
CO3	Analyze the kinetics of biological reactions.
CO4	Select a suitable downstream processing method for purification.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	2	3	-	2	-	-	-	-
CO2	3	2	-	-	-	-	-	-
CO3	3	2	-	1	-	-	-	-
CO4	2	-	3	-	-	-	-	-

Detailed syllabus

Introduction: Biotechnology, Biochemical Engineering, Biological Process, Definition of Fermentation.

Enzyme & Cell Kinetics: Introduction, Simple Enzyme Kinetics, Enzyme Reactor with Simple Kinetics, Inhibition of Enzyme Reactions, Other influences on Enzyme Reactions, Experiment: Enzyme Kinetics, Growth Cycle for Batch Cultivation.

Transport Phenomena in Bioprocess Systems, Bioreactor Design and Analysis.

Instrumentation and Control: Introduction, Instrumentation for Measurements of Active Fermentation, Sterilization.

Product Recovery Operations: Strategies to Recover and Purify Products, Separation of Insoluble Products, Cell Disruption, Separation of Soluble Products, Finishing Steps for Purification, Integration of Reaction and Separation.

Reading:

1. Veith W. R., Bioprocess Engineering, John Wiley & Sons, 1994.
2. Blanch H. W. and Clark D. S., Biochemical Engineering, Marcell and Dekker Inc., 1997.
3. Shuler M. L., Kargi F., Bioprocess Engineering: Basic Concepts,2nd Edition, Prentice Hall International, 2001.

CH5119	PIPING ENGINEERING	DEC	3– 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Understand the key steps in a pipeline's lifecycle: design, construction, installation and maintenance.
CO2	Draw piping and instrumentation diagrams (P&ID).
CO3	Understand codes, standards and statutory regulations.
CO4	Select pipe and pipe fittings.

Mapping of course outcomes with program outcomes

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO1	1	2	2	1	1	1	1	1
CO2	1	2	3	1	1	1	1	1
CO3	1	2	2	1	1	1	1	1
CO4	1	2	3	1	1	1	1	1

Detailed syllabus

Introduction to piping: piping classification, other pipe ratings, definitions of forces, moments, equilibrium, work, power, and energy

Piping components: pipe and tube products, traps, strainers, expansion joints, threaded joints, bolted flange joints, welded and brazed joints

Piping materials: material properties of piping materials, metallic materials, degradation of materials in service

Piping codes and standards: ASME, BIS, ISO standards relevant to chemical engineering.

Piping layout: Line diagram, process flow diagram, piping and instrumentation diagram, codes and standards

Application of computer-aided design to piping layout

Fabrication and installation of piping systems: introduction, fabrication, installation, Selection and application of valves, Pressure and leak testing

Flow of fluids and calculations: introduction, theoretical background, steady single-phase incompressible flow in piping, steady single-phase compressible flow in piping, single-phase flow in nozzles, venturi tubes, and orifices, steady two-phase flow

Reading:

1. McAllister E.W., Pipeline Rules of Thumb Handbook, 7th Edition, Gulf Publication, 2009.
2. Kellogg, Design of Piping System, 2nd Edition, M.W. Kellogg Co. 2009.
3. Weaver R., Process Piping Design Vol .1 and 2, Gulf Publication, 1989.
4. Nayyar M. L.,Piping Handbook, Seventh Edition, Mc-Graw Hill, 2000.

CH5211	INDUSTRIAL INSTRUMENTATION	PCC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Understand techniques for measurement of level, pressure.
CO2	Measure temperature using contact / non-contact techniques.
CO3	Analyze methods for torque and velocity.
CO4	Select methods for acceleration, vibration and density measurement.
CO5	Identify a suitable technique for flow measurement.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	2	3	1	-	1	-	-	1
CO2	2	3	1	-	1	-	-	1
CO3	2	3	1	-	1	-	-	1
CO4	2	3	1	-	1	-	-	1
CO5	2	3	1	-	1	-	-	1

Detailed syllabus

Level measurement: Gauge glass technique coupled with photo electric readout system, float type level indication, different schemes, measurement using displacer and torque tube – bubbler system. Differential pressure method. Electrical types of level gauges using resistance, capacitance, nuclear radiation and ultrasonic sensors.

Pressure measurement: Manometers, pressure gauges – Bourde type bellows, diaphragms. Electrical methods – elastic elements with LVDT and strain gauges. Capacitive type pressure gauges. Measurement of vacuum – McLeod gauge – thermal conductivity gauges – Ionization gauge cold cathode and hot cathode types – testing and calibration.

Temperature measurement: Thermometers, different types of filled in system thermometer, bimetallic thermometers. Electrical methods, signal conditioning of industrial RTDs and their characteristics –3 lead and 4 lead RTDs. Thermocouples and pyrometers.

Measurement of force torque, velocity: Electric balance – different types of load cells – magnets – elastics load cell-strain gauge load cell. Different methods of torque measurement, strain gauge, relative regular twist-speed measurement-revaluation counter- capacitive tacho-drag up type tacho D.C and A.C tacho generators – stroboscope.

Measurement of acceleration, vibration and density: Accelerometers – LVDT, piezo-electric, strain gauge and variable reluctance type accelerometers, calibration of vibration pickups, Baume scale API scale – pressure head type densitometer – float type densitometer.

Flow measurement: Volumetric flow measurement through electromagnetic, ultrasonic and vortex techniques. Mass flow measurement through Coriolis principle. Basics of analyzers - single and multiple components through chromatography. Control valves – different types, characteristics and smart valves.

Reading:

1. William C. Dunn, Fundamentals of Industrial Instrumentation and Process Control, McGraw-Hill, 2005.
2. R. K. Jain, Mechanical and Industrial Measurements, Khanna Publishers, New Delhi, 1999.
3. E. L. Upp, Paul J. LaNasa, Fluid Flow Measurement, 2nd Edition, Gulf Professional Publishers, 2002.
4. Bela G. Liptak, Instruments Engineers Handbook, 4th Edition, CRC Press, 2003.
5. D. Patranabis, Principles of Industrial Instrumentation, Tata McGraw Hill, 1999.

CH5212	DATA ANALYTICS	DEC	3– 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Apply the concepts of probability, statistics, linear algebra, and calculus for data analysis
CO2	Understand Machine learning and graph structure learning concepts
CO3	Analyze data using Regression and Classification techniques
CO4	Apply Learning techniques and Dimensionality reduction techniques

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	3	1	-	-	-	3	1
CO2	3	3	1	-	-	-	3	1
CO3	3	3	1	-	-	-	3	1
CO4	3	3	1	-	-	-	3	1

Detailed syllabus

Review of basics basic concepts on probability, statistic, linear algebra, and calculus.

Descriptive Statistics, Distributions. Inferential Statistics through hypothesis tests, Permutation & Randomization Test. Regression & ANOVA (Analysis of Variance).

Machine Learning: Introduction and Concepts Differentiating algorithmic and model based frameworks Regression: Ordinary Least Squares, Ridge Regression, Lasso Regression, K Nearest Neighbors Regression & Classification.

Graph structure learning: Traditional structure learning techniques – constraint based and score-based algorithms, L1-based structure learning algorithm, Structure learning with priors and applications.

Supervised Learning with Regression and Classification techniques-1: Bias-Variance Dichotomy, Model Validation Approaches Logistic Regression, Linear Discriminant Analysis Quadratic Discriminant Analysis Regression and Classification Trees Support Vector Machines

Supervised Learning with Regression and Classification techniques-2: Ensemble Methods: Random Forest, Neural Networks, Deep learning. Unsupervised Learning and Challenges for Big Data Analytics Clustering Associative Rule Mining Challenges for big data analytics

Prescriptive analytics Creating data for analytics through designed experiments Creating data for analytics through Active learning Creating data for analytics through Reinforcement learning.

Dimensionality reduction techniques - PCA, KPCA, PCR. Data collection and pre-processing.

Reading:

1. Trevor Hastie, Robert Tibshirani, Jerome Friedman, The Elements of Statistical Learning, Springer, 2009.
2. Montgomery, Douglas C., and George C. Runger, Applied Statistics and Probability for Engineers, John Wiley & Sons, 2010.
3. David J. Hand, Statistics, Sterling Press, 2008.
4. J. Han, M. Kamber, J. Pei, Data Mining: Concepts and Techniques, Morgan Kaufmann, 2012.
5. I.H. Witten, E. Frank, M. A. Hall, Data Mining: Practical Machine Learning Tools and Techniques, Morgan Kaufmann, 2011.
6. N. Matloff, The Art of R Programming, No Starch Press, 2011.

CH5161	OPTIMIZATION TECHNIQUES	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None **Course Outcomes:** At the end of the course, the student will be able to:

CO1	Formulate objective function for a given problem
CO2	Understand unconstrained single variable optimization and unconstrained multi variable optimization
CO3	Understand linear programming and nonlinear programming techniques
CO4	Use dynamic programming and semi definite programming for optimization

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	3	-	-	-	-	-	-
CO2	3	3	-	-	-	-	-	-
CO3	3	3	-	-	-	-	-	-
CO4	3	3	-	-	-	-	-	-

Detailed syllabus

The Nature and Organization of Optimization Problems: What Optimization is all about, Why Optimize?, Scope and Hierarchy of Optimization, Examples of applications of Optimization, The Essential Features of Optimization Problems, General Procedure for Solving Optimization Problems, Obstacles to Optimization.

Basic Concepts of Optimization: Continuity of Functions, Unimodal vs multimodal functions, Convex and concave functions, convex region, Necessary and Sufficient Conditions for an Extremum of an Unconstrained Function, Interpretation of the Objective Function in terms of its Quadratic Approximation.

Optimization of Unconstrained Functions: One Dimensional search Numerical Methods for Optimizing a Function of One Variable, Scanning and Bracketing Procedures, Newton and Quasi-Newton Methods of Unidimensional Search, Polynomial approximation methods, How One-Dimensional Search is applied in a Multidimensional Problem, Evaluation of Unidimensional Search Methods.

Unconstrained Multivariable Optimization: Direct methods, Indirect methods – first order, Indirect methods – second order.

Linear Programming and Applications: Basic concepts in linear programming, Degenerate LP's – Graphical Solution, Natural occurrence of Linear constraints, The Simplex methods of solving linear programming problems, standard LP form, Obtaining a first feasible solution, Sensitivity analysis, Duality in linear programming

Nonlinear programming with constraints The Lagrange multiplier method, Necessary and sufficient conditions for a local minimum, introduction to quadratic programming.

Optimization of Stage and Discrete Processes: Dynamic programming, Introduction to integer and mixed integer programming.

Applications to different processes.

Reading:

1. Edgar T.F. and D. M. Himmelblau, 'Optimization of Chemical Processes', 2nd Edition, McGraw Hill, 2001.
2. Stoecker W. F., Design of Thermal Systems, McGraw-Hill, 3rd Edition, 2011.
3. Singiresu S Rao, 'Engineering Optimization: Theory and Practice', 4th Edition, John Wiley & Sons Ltd., 2009.
4. Mohan C. Joshi and Kannan M. Moudgalya, 'Optimization: Theory and Practice', Alpha Science International Limited, 2004.
5. Stephen Boyd, Lieven Vandenberghe, Convex optimization, Cambridge University Press, 2004.
6. P. Venkataraman, Applied Optimization with MATLAB Programming, 2nd Edition, Wiley, 2009.

CH5162	PROCESS SCHEDULING AND UTILITY INTEGRATION	DEC	3 – 0 – 0	3 Credits

Prerequisites: Computational Techniques.

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

CO1	Identify the objectives of scheduling problem
CO2	Develop a model for batch process scheduling
CO3	Integrate process scheduling and resource conservation
CO4	Design and synthesize batch plants

Mapping of the Course Outcomes with Program Outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	2	1	3		1			
CO2	2	2	3		1	2		
CO3	2	2	3		1	1		
CO4	2	2	3	3	1	2		

Detailed Syllabus:

Introduction to Batch Chemical Processes: Definition of a batch process, Operational philosophies, Types of batch plants, Recipe representations, Batch chemical process integration.

Short-Term Scheduling: Effective technique for scheduling of multipurpose and multi-product batch plants, Different storage policies for intermediate and final products, Evolution of multiple time grid models in batch process scheduling, Short-term scheduling of multipurpose pipeless plants, Planning and scheduling in biopharmaceutical industry.

Resource Conservation: Integration of batch process schedules and water allocation network, Water conservation in fixed scheduled batch processes, Wastewater minimization in multiproduct batch plants: single contaminants, Storage design for maximum wastewater reuse in batch plants, Wastewater minimization in multipurpose batch plants: multiple contaminants, Wastewater minimization using multiple storage vessels, Wastewater minimization using inherent storage, Zero effluent methodologies, Heat integration in multipurpose batch plants: direct and indirect heat integration, Simultaneous optimization of energy and water use in multipurpose batch plants, Flexibility analyses and their applications in solar-driven membrane distillation desalination system designs, Automated targeting model for batch process integration.

Design and Synthesis: Design and synthesis of multipurpose batch plants, Process synthesis approaches for enhancing sustainability of batch process plants, Scheduling and design of multipurpose batch facilities: Periodic versus non periodic operation mode through a multi objective approach, Mixed-integer linear programming model for optimal synthesis of polygeneration systems with material and energy storage for cyclic loads.

Reading:

1. Thokozani Majozi, Esmael Reshid Seid, Jui-Yuan Lee “Synthesis, Design, and Resource Optimization in Batch Chemical Plants”, CRC Press Taylor & Francis, 2015.
2. Thokozani Majozi “Batch Chemical Process Integration - Analysis, Synthesis and Optimization”, Spinger, 2010.
3. Gintaras V. Reklaitis, Aydin K. Sunol, David W. T. Rippin, Oner Hortacsu “Batch Processing Systems Engineering”, Spinger, 1996.
4. Mariano Martin, Introduction to Software for Chemical Engineers, CRC Press, 2015.

CH5162	MEMBRANE SEPARATION TECHNIQUES	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Classify the membranes.
CO2	Assess competing membrane processes.
CO3	Understand the methods of membrane preparation.
CO4	Select a membrane and membrane process for a given application.
CO5	Evaluate the flux of solvent and solute through membrane.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	-	-	-	-	-	-	-
CO2	3	-	-	-	-	-	-	-
CO3	-	-	2	-	-	-	-	-
CO4	-	-	2	-	-	-	-	-
CO5	-	-	-	3	-	-	-	-

Detailed syllabus

Introduction: Membrane separation process, Definition of Membrane, Membrane types, Advantages and limitations of membrane technology compared to other separation processes, Membrane materials and properties.

Preparation of synthetic membranes: Phase inversion membranes, Preparation techniques for immersion precipitation, Synthesis of asymmetric and composite membranes and Synthesis of inorganic membranes.

Transport in membranes: Introduction, Driving forces, Non-equilibrium thermodynamics, Transport through porous membranes, transport through non-porous membranes, Transport through ion-exchange membranes.

Membrane processes: Pressure driven membrane processes, Concentration as driving force, Electrically driven membrane processes

Polarisation phenomena and fouling: Concentration polarization, Pressure drop, Membrane fouling, methods to reduce fouling.

Modules: Introduction, membrane modules, Comparison of the module configurations

Reading:

1. Mulder M, Basic Principles of Membrane Technology, Kluwer Academic Publishers, London, 1996.
2. Baker R. W., Membrane Technology and Research, Inc.(MTR), Newark, California, USA, 2004.
3. Nath K., Membrane Separation Processes, Prentice-Hall Publications, New Delhi, 2008.
4. Richard W. Baker, Membrane Technology and Research, Inc. (MTR), Newark, California, USA, 2004.

CH5164	ADVANCED MASS TRANSFER	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Understand the concept of separation factor and separating agent.
CO2	Classify the separation processes based on the energy requirements.
CO3	Determine the degrees of freedom using phase rule and description rule.
CO4	Compare multi-stage operations.
CO5	Design binary distillation column using McCabe Thiele and Ponchon-Savarit methods.
CO6	Design multi-component distillation columns using short cut and rigorous calculation methods.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	2	2	2	-	-	2	-	-
CO2	2	-	3	-	-	2	-	-
CO3	2	3	2	-	-	2	-	-
CO4	2	3	2	2	-	2	-	-
CO5	3	3	2	-	-	3	-	-
CO6	3	3	2	-	-	3	-	-

Detailed syllabus

Characterization of Separation processes: Inherent Separation Factors: Equilibration Processes, Inherent Separation Factors: Rate-governed Processes.

Simple equilibrium processes: Equilibrium Calculations, Checking Phase Conditions for a Mixture.

Multistage separation processes: Increasing Product Purity, Reducing Consumption of Separating Agent, Cocurrent, Crosscurrent, and Countercurrent Flow.

Binary multistage separation: Binary Systems, Equilibrium Stages, McCabe-Thiele Diagram, The Design Problem, Choice of Column Pressure.

Binary multistage separations-general graphical approach: Straight Operating Lines, Curved Operating Lines, Extraction, Absorption, Processes without Discrete Stages, Packed tower distillation, General Properties of the yx Diagram.

Energy requirements of a separation process: Minimum Work of Separation, Net Work Consumption, Thermodynamic Efficiency, network of potentially reversible process, partially reversible process and irreversible processes.

Ternary and multi-component system fractionation: preliminary calculations, feed condition, column pressure, design procedure, number of equilibrium stages, feed location, estimation of number of theoretical plates – shortcut methods and rigorous calculation methods.

Reading:

1. King C. J., Separation Processes, Tata McGraw Hill Book Company, 2nd Ed., New Delhi, 1983.
2. Vanwinkle M, Distillation, McGraw Hill Chemical Engineering Series, New York, 1967.
3. Holland C. D., Multi-component Distillation, Prentice Hall of India Pvt. Ltd., 1981.
4. Geankoplis C. J., Transport Processes and Unit Operations, 4thEdition, Prentice Hall of India Pvt. Ltd., New Delhi, 2004.

CH5165	COMPUTATIONAL FLUID DYNAMICS	DEC	3 – 0 – 0	3 Credits

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

CO1	Derive governing equations of fluid flow and heat transfer and classify them
CO2	Discretise the equations using Finite difference and volume formulation
CO3	Solve the discretized equations using different techniques
CO4	Implement pressure velocity coupling algorithms
CO5	Understand grid generation techniques

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	3	1	2	-	3	2	1
CO2	3	3	1	2	-	3	2	1
CO3	3	3	1	2	-	3	2	1
CO4	3	3	1	2	-	3	2	1
CO5	3	3	1	2	-	3	2	1

Detailed syllabus

Introduction – CFD approach, Need for CFD.
Governing equations of fluid flow and heat transfer - Laws of conservation: Mass – Momentum - Energy, Initial and boundary conditions - Conservative form – Differential and Integral forms of general transport equations – Classification of physical behaviours – Classification of fluid flow equations.

Discretization of equations – Finite difference / volume methods – 1D, 2D and 3D Diffusion problems - Convection and diffusion problems - Properties of discretisation schemes- Central, upwind, hybrid and higher order differencing schemes.

Solution methods of discretised equations- Tridiagonal matrix algorithm (TDMA)-Application of TDMA for 2D and 3D problems – Iterative methods – Multigrid techniques.

Pressure – velocity coupling algorithms in steady flows – Staggered grid – SIMPLE, SIMPLEC and PISO - Unsteady flows- Explicit scheme, Crank Nicholson scheme, fully implicit scheme

Turbulence modelling - Prantl mixing length mode - One equation model, k - ε model, RSM equation model - Applications.

Structured and unstructured grids – Grid generation methods

Reading:

1. H. K. Versteeg, W. Malalasekera, An Introduction to Computational Fluid Dynamics - The finite volume method, 2^{nd} Edition, Prentice Hall 2007.
2. T. J. Chung, Computational Fluid Dynamics, 2^{nd} Edition, Cambridge University Press, 2010.
3. C. Hirch, Numerical Computation of internal and external flows, 2^{nd} Edition, Wiley, 2007.
4. J. D. Anderson Jr., Computational Fluid Dynamics - The basics with Applications, McGraw Hill, 1995.
5. J. H. Ferziger, M. Peric, Computational Methods for Fluid Dynamics, Springer, 2002.

CH5166	PROCESS INTENSIFICATION	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Identify the scope for process intensification in chemical processes.
CO2	Implement methodologies for process intensification
CO3	Understand scale up issues in the chemical process.
CO4	Solve process challenges using intensification technologies.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	2	-	-	-	-	-	-	-
CO2	-	2	1	-	-	-	-	-
CO3	3	2	-	-	-	-	-	-
CO4	2	2	3	1	-	-	-	-

Detailed syllabus

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

Process Intensification through micro reaction technology: Effect of miniaturization on unit operations and reactions, Implementation of Microreaction Technology, From basic Properties To Technical Design Rules, Inherent Process Restrictions in Miniaturized Devices and Their Potential Solutions, Microfabrication of Reaction and unit operation Devices - Wet and Dry Etching Processes.

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

Combined chemical reactor heat exchangers and reactor separators: Principles of operation; Applications, Reactive absorption, Reactive distillation, Applications of RD Processes, Fundamentals of Process Modelling, Reactive Extraction Case Studies: Absorption of NOx Coke Gas Purification.

Compact heat exchangers: Classification of compact heat exchangers, Plate heat exchangers, Spiral heat exchangers, Flow pattern, Heat transfer and pressure drop, Flat tube-and-fin heat exchangers, Microchannel heat exchangers, Phase-change heat transfer, Selection of heat exchanger technology, Feed/effluent heat exchangers, Integrated heat exchangers in separation processes, Design of compact heat exchanger - example.

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

Reading:

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

CH5167	ELECTROCHEMICAL ENGINEERING	DEC	3– 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Analyze an electrochemical process through mathematical approach
CO2	Characterize electrochemical systems using analytical instruments
CO3	Develop unit operations involving electrochemical applications
CO4	Design batteries and fuel cells for power generation and storage

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	2	1	2	1	1	1	1	2
CO2	2	1	2	1	1	1	1	2
CO3	2	1	2	1	1	1	1	2
CO4	2	1	3	1	1	1	1	2

Detailed syllabus

Electrode Potentials and Thermodynamics of Cells: basic electrochemical thermodynamics, free energy, cell emf and Nernst equation, half cell reactions and redox potentials, reference electrodes

Electrode Kinetics: Arrhenius equation and potential energy surfaces, transition state theory, Butler-Volmer model of electrode kinetics, current-over potentials, Tafel plots

Electroplating: electrochemistry fundamentals, anode-cathode reactions, Faraday's law of electrolysis, current efficiency, current density, current distribution, voltage-current relationship, over potential and over voltage, surface preparation, electrolytic metal deposition, Electrolyte, types of electroplating processes and coatings

Anodizing: Aluminum anodizing, nanopores in anodized alumina,

Electropolishing: Types of metals and electrolytes, characteristics of electropolished surfaces, electropolishing vs mechanical polishing, applications

Batteries: Basic concepts, battery characteristics, classification of batteries– primary, secondary and reserve batteries, modern batteries - construction, working and applications of zinc–air, nickel-metal hydride and Li-MnO_2 batteries

Fuel cells: Introduction, types of fuel cells - alkaline, phosphoric acid, molten carbonate, solid polymer electrolyte and solid oxide fuel cells, construction and working of methanol-oxygen fuel cell

Corrosion Protection: Sacrificial anodes, impressed current techniques, polarization characteristics, galvanic series, coatings

Reading:

1. Bard A. J., Faulkner L. R., Electrochemical Methods: Fundamentals and Applications, Second Edition, Wiley (2010).
2. Bagotsky V.S., Skundin A. M., Electrochemical Power Sources: Batteries, Fuel Cells, and Supercapacitors (The ECS Series of Texts and Monographs) (2015).
3. Fontana M. G., Corrosion Engineering, Third Edition, McGraw-Hill (2008).
4. Solanki C. S., Solar Photovoltaics – Fundamentals, Technologies and Applications, PHI Publishers (2015).

CH5168	INDUSTRIAL WASTEWATER TREATMENT	DEC	3– 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Understand the principles and operation of water treatment systems
CO2	Appraise the suitability of the design of treatment plants and unit processes
CO3	Evaluate process operations and performance
CO4	Understand coagulation, flocculation, and sedimentation, filtration, and disinfection processes.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	3	3	3	-	3	2	-
CO2	3	3	3	3	-	3	2	-
CO3	3	3	3	3	-	3	2	-
CO4	3	3	3	3	-	3	-	-

Detailed syllabus

Introduction: Sources of water, necessity of treatment, Critical Water quality parameters, water quality guidelines and standards for various water uses.

Unit operations: Principles and design of aeration systems – two film theory, water in air system, air in water system.

Intake structures: Different types, design criteria

Principles of sedimentation: Types of settling and settling equations, design criteria and design of settling tanks.

Principle of Coagulation and Flocculation: types of coagulants, coagulant aids, coagulation theory, optimum dose of coagulant, design criteria and numerical examples

Filtration:Theory, types, hydraulics of filter bed, design criteria and design of filters, filter backwash, operational problems and trouble shooting.

Adsorption Process: Types, factors affecting adsorption, kinetics and equilibrium – different isotherm equations and their applications
Ion Exchange: principles, breakthrough capacities, column design, operation and regeneration.

Unit processes: disinfection – different types, disinfectants, factors affecting disinfection, methods of disinfection, chemistry of chlorination. Water Softening – Ions causing hardness, Langelier index, various methods. Fluoridation and defluoridation – Principles and design

Trace organic contaminants in water supplies and their removal.

Membrane processes; Microfiltration, ultrafiltration, reverse osmosis

Advanced treatment processes

Biological treatment: Fundamentals of biological wastewater treatment: Composition and classification of microorganisms, bacterial growth and energetics, Suspended growth biological treatment processes for BOD, Nitrogen and Phosphorous removal, Attached growth and combined biological treatment processes.

Reading:

1. MetCalf, Eddy, Wastewater engineering, Treatment and Reuse, Tata McGraw-Hill, 2003.
2. S.J. Arceivala, S.R. Asolekar, Wastewatwer Treatment for Pollution Control and Reuse, 3rd edition, Tata McGraw-Hill, 2007.
3. N. Hanley, S.C. Bhatia, Pollution Control in Chemical and allied industries, CBS Publishers, 2010.
4. C.A. Sastry, M.A. Hashim, P.Agamuthu, Waste Treatment Plants, Narosa Publishing House, 1995.
5. Tchobanoglous G., Burton F. L. and Stensel H.D., "Waste Water Engineering: Treatment and Reuse", 4th Ed; Tata McGraw Hill (2002).
6. Fair, G.M., Geyer J.C and Okun, Water and Waste water Engineering" Vol II, John Wiley Publications.

CH5169	ENERGY AUDIT AND CONSERVATION	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Implement energy audit for a chemical plant
CO2	Plan energy conserving strategies
CO3	Evaluate the suitability of renewable energy resources
CO4	Analyze the energy utilization of a process equipment

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	3	3	2	1	2	-	-
CO2	3	3	3	2	1	2	-	-
CO3	3	3	3	2	-	2	-	-
CO4	3	3	3	2	-	2	-	-

Detailed syllabus

Energy Scenario: Energy use patterns, energy resources, Oil a critical resource, economic and environmental consideration, Future scenario

Heat & work: First & second law of thermodynamics, Heat Engines.

Energy Audit: Energy conversion, Energy index, Energy consumption representation - pie chart, Sankey diagram & load profile, general audit, detailed audit, waste heat recovery.

Targeting and Conservation: Energy utilization and conversion – thermal efficiency, Heat Exchangers – heat recovery , Air conditioners – supply and removal of heat.

Use of alternate energy: Solar energy, Wind energy, Nuclear energy, Biomass, Geothermal energy, Future Energy Alternatives.

Pinch Analysis and Process Heat Integration

Energy Management Key Performance Indicators and Energy Dashboards

Case Studies: Energy conservation in alcohol industry, fertilizer industry, and pulp and paper industry, Energy conservation in different units of refinery like FCCU, HCU and ADU.

Reading:

1. Murphy W.R. and Mckay G., Energy Management, Elsevier, 2007.
2. HinrichsR. A. and Kleinbach M. H., Energy: Its Use and the Environment, Cengage Learning, 2012.
3. Capehart B. L., Turner W. C. and Kennedy W. J., Guide to Energy Management, 7 th Ed., KeinneduFairmant press (2011).
4. Rai G. D., Non-conventional Energy Sources, Khanna Publishers, New Delhi, 2010.
5. A.P Rossiter, B.P Jones, “Energy Management and Efficiency for the process industries”, AIChE, Wiley (2015)

CH5170	PETROLEUM REFINING	DEC	3 – 1 – 0	4 Credits

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

CO1	Understand the chemistry and processes involved in converting the crude oil into valuable products
CO2	Evaluate the effects of process variables on the properties of the products, yield and selectivity
CO3	Identify Hydrogen production processes and sulphur recovery processes

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	3	0	0	0	0	1	3
CO2	3	3	3	3	0	3	0	1
CO3	3	3	3	3	0	2	3	3

Detailed syllabus:

Characterization of crude oil and refinery products-physical properties, chemical properties.

Crude distillation process- atmospheric distillation unit (ADU)-process description-design characteristics; vacuum distillation unit (VDU)-process description-calculating tower loading; Thermal and Catalytic cracking- coking, visbreaking, Fixed-bed, moving bed, Fluid bed processes-process variables-catalysts

Catalytic reforming-Feedstock, Catalysts, Process flow schemes

Hydrotreating and Hydrocracking-Flow schemes, chemistry-catalysts-design and operation

Light end processes- alkylation, isomerization and polymerization-process variables, feedstock, reactor design

Hydrogen Production-Process variables, Commercial processes, Catalysts, Hydrogen Purification.

Sulphur recovery processes

Reading:

1. J. H. Gary and G. E. Handwerk, Petroleum Refining: Technology and Economics, 4th Ed., Marcel Dekker, 2001.
2. D.S.J. Jones and P. R. Pujadó, Handbook of Petroleum Processing, Springer, 2006.
3. C.S. Hsu and P. R. Robinson, Practical Advances in Petroleum Processing, Springer, 2006.
4. J. G. Speight and B. Ozum, Petroleum Refining Process, Marcel Dekker, 2002.

CH5261	NONLINEAR SYSTEMS ANALYSIS & CONTROL	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Understand nonlinear systems and their dynamics
CO2	Apply realization theory to linear systems and stability concepts
CO3	Understand nonlinear control and the concepts of controllability and observability
CO4	Apply Lyapunov method for stability of linear and nonlinear systems

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	2	2	-	-	-	-	-
CO2	3	2	2	-	-	-	-	-
CO3	3	2	2	-	-	-	-	-
CO4	3	2	2	-	-	-	-	-

Detailed syllabus

Introduction to nonlinear systems, Phase plane analysis – generalization of phase plane behavior. Limit cycle behavior of nonlinear systems.

Nonlinear dynamics –Bifurcation and orbit diagrams. Stability of fixed point solutions. Cascade of period doublings. Bifurcation behavior of single ODE systems. Bifurcation behavior of two state systems – limit cycle behavior, Hopf bifurcation.

Realization theory – Realization of LTI systems, realization of bilinear systems, examples. Stability and the Lyapunov method – local stability, Lyapunov theory.

Introduction to nonlinear control – importance. Singular perturbation theory, Properties of ODE systems with small parameters, Nonstandard singularly perturbed systems with two time scales, Singularly perturbed systems with three or more time scales.

Controllability and Observability: controllability and Observability of LTI Systems, local Controllability and Observability of Nonlinear Systems.

Stability and The Lyapunov Method: Stability Notions, BIBO (Bounded-input-bounded-output)Stability Conditions for LTI Systems, L_2-gain of Linear and Nonlinear Systems, the Small-gain Theorem, Asymptotic or Internal Stability of Nonlinear Systems.

Lyapunov Function, Lyapunov Theorem for LTI Systems. Feedback and Input-output Linearization of Nonlinear Systems - Relative Degree, Exact Linearization via State Feedback, Nonlinear Coordinates Transformation and State Feedback, The State-space Exact Linearization Problem for SISO Systems. Exact and Input-output Linearization. Exact Linearization via State Feedback.

Reading:

1. K.M. Hangos, J. Bokor, G. Szederkényi, Analysis and Control of Nonlinear Process Systems, Springer, 2004.
2. Jean-Jacques E Slotine, Weiping Li, Applied Nonlinear Control, Prentice-hall, 1991.
3. Daizhan Cheng Xiaoming Hu Tielong Shen, Analysis and Design of Nonlinear Control Systems, Springer, 2010.
4. Michael Baldea, Prodromos Daoutidis, Dynamics and Nonlinear Control of Integrated Process Systems, Cambridge University Press, 2012.
5. H. K. Khalil, Nonlinear Systems, 3rd Edition, Englewood Cliffs, NJ: Prentice Hall, 2001.
6. B. Wayne Bequette, Process Dynamics: Modeling, Analysis and Simulation, Prentice Hall, 1998.

CH5262	SOFT-COMPUTING TECHNIQUES	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Understand the concept of neural networks
CO2	Use neural networks to control the process plants
CO3	Develop fuzzy logic based controllers for different processes
CO4	Combine fuzzy logic with neural networks for plant control
CO5	Design controllers using genetic algorithms

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	2	2	1	-	-	-	1
CO2	3	2	2	1	-	-	-	1
CO3	3	2	2	1	-	-	-	1
CO4	3	2	2	1	-	-	-	1
CO5	3	2	2	1	-	-	-	1

Detailed syllabus

Introduction to Neural Networks: Artificial Neural Networks: Basic properties of Neurons, Neuron Models, Feed forward networks. Computational complexity of ANNs.

Neural Networks Based Control: ANN based control: Introduction: Representation and identification, modeling the plant, control structures – supervised control, Model reference control, Internal model control, Predictive control: Examples – Inferential estimation of viscosity an chemical process, Auto – turning feedback control, industrial distillation tower.

Introduction to Fuzzy Logic: Fuzzy Controllers: Preliminaries – Fuzzy sets and Basic notions – Fuzzy relation calculations – Fuzzy members – Indices of Fuzziness – comparison of Fuzzy quantities – Methods of determination of membership functions.

Fuzzy Logic Based Control: Fuzzy Controllers: Preliminaries – Fuzzy sets in commercial products – basic construction of fuzzy controller – Analysis of static properties of fuzzy controller – Analysis of dynamic properties of fuzzy controller – simulation studies – case studies – fuzzy control for smart cars.

Neuro – Fuzzy and Fuzzy – Neural Controllers: Neuro – fuzzy systems: A unified approximate reasoning approach – Construction of role bases by self-learning: System structure and learning.

Introduction to Genetic algorithms. Controller design using genetic algorithms.

Reading:

1. Bose and Liang, Artificial Neural Networks, Tata McGraw Hill, 1996.
2. Huaguang Zhang, Derong Liu, Fuzzy Modeling and Fuzzy Control, Birkhauser Publishers, 2006.
3. Kosco B, Neural Networks and Fuzzy Systems: A Dynamic Approach to Machine Intelligence, Prentice Hall of India, New Delhi, 1992.
4. Lakshmi C. Jain, N. M. Martin, Fusion of Neural Networks, Fuzzy Systems and Genetic Algorithms: Industrial Applications, CRC Press, 1998.
5. Muhammet Ünal, AyçaAk, VedatTopuz, Hasan Erdal, Optimization of PID Controllers using Ant colony and Genetic Algorithms, Springer, 2013.
6. S. N. Sivanandam and S. N. Deepa, Principles of Soft Computing, John Wiley & Sons, 2007.

CH5141	SEMINAR I	PCC	0– 0 – 0	1 Credit

Pre-requisites: None

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

CO1	Communicate with group of people on different topics
CO2	Prepare a seminar report that includes consolidated information on a topic

Mapping of course outcomes with program outcomes

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO1	-	-	-	-	3	-	-	-
CO2	2	1	1	2	-	2	2	3

Detailed syllabus

Any topic of relevance to chemical and allied engineering and science.

CH5191	SEMINAR II	PCC	0– 0 – 0	1 Credits

Pre-requisites: None

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

CO1	Communicate with group of people on different topics
CO2	Prepare a seminar report that includes consolidated information on a topic

Mapping of course outcomes with program outcomes

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO1	-	-	-	-	3	-	-	-
CO2	2	1	1	2	-	2	2	3

Detailed syllabus

Any topic of relevance to chemical and allied engineering and science.

CH6142	COMPREHENSIVE VIVA-VOCE	PCC	2 Credits

Pre-requisites: None

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

CO1	Demonstrate an understanding of advanced topics.
CO2	Explain the principles, phenomena and their applications.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	2	1	1	2	1	1	2
CO2	3	2	2	1	3	2	1	2

Detailed syllabus

Chemical Engineering courses of I year.

CH6149	DISSERTATION PART-A	6 Credits

Pre-requisites: None

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

CO1	Identify the problem based on literature survey
CO2	Formulate the problem
CO3	Identify the methods or techniques required for the solution
CO4	Develop the solution methodology

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	1	1	2	2	2	2	3	3
CO2	3	1	2	2	2	3	3	1
CO3	2	3	2	2	2	1	1	1
CO4	2	3	2	2	2	3	3	3

CH6199	DISSERTATION PART-B	12 Credits

Pre-requisites: CH6149 Dissertation Part-A

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

CO1	Implement the methods/techniques identified in dissertation part-A
CO2	Analyze and interpret the results obtained
CO3	Compare the results obtained with literature.
CO4	Demonstrate the original contribution to knowledge

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	3	2	2	2	3	3	2
CO2	3	3	2	2	2	3	3	2
CO3	3	3	2	2	2	3	3	3
CO4	3	3	2	2	2	3	3	3