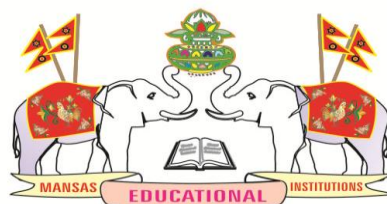


ACADEMIC REGULATIONS & CURRICULUM

**Applicable to the students admitted from the
Academic Year 2023-2024**



CHEMICAL ENGINEERING (B.Tech. Programme)



MAHARAJ VIJAYARAM GAJAPATHI RAJ COLLEGE OF ENGINEERING (Autonomous)

(Approved by AICTE, New Delhi, and permanently affiliated to JNTUGV,
Vizianagaram) Listed u/s 2(f) & 12(B) of UGC Act 1956.

Vijayaram Nagar Campus, Chintalavalasa, Vizianagaram-535005, Andhra Pradesh

The visionaries



Late Dr. P V G Raju

Raja Saheb of Vizianagaram
Founder Chairman-MANSAS
Ex-Minister for Education and Health, Govt. of AP
Ex Member of Parliament



Late Dr. P. Anand Gajapathi Raju
Ex-Chairman-MANSAS

Ex-Minister for Education and Health
Govt. of AP
Ex Member of Parliament



P. Ashok Gajapathi Raju
Chairman-MANSAS

Ex-Union Minister for Civil Aviation,
Govt. of India
Ex-Minister for Finance, Govt. of AP

DEPARTMENT OF CHEMICAL ENGINEERING
MVGR COLLEGE OF ENGINEERING (A)

Institute Vision

To create a learning environment and ecosystem that fosters continuous engagement in critical thinking, practical application and skill competence founded on relevant scientific principles to build a genre of engineers capable of effectively handling the challenges in industry, entrepreneurship, and sustainable society development.

Institute Mission

M1. Building strong academic staff

M2. Establishing clearly defined process and ensuring practice

M3. Development of curricula to bring industry and SDGs to classroom

Vision of the Department

To produce globally competent chemical engineers with a commitment to serve the society by continually work as an effective bridge between the aspirations of students for a fruitful professional career and industry's need for well-rounded chemical engineers with strong fundamentals and sound problem-solving skills.

Mission of the Department

Aspire to reach higher quality benchmarks in training students on all skills expected of a chemical engineering professional through a meticulously planned yet flexible learning process administered through the following:

M1. Design and develop curriculum for program of chemical engineering that adds value to student competencies abreast with changing industry needs.

M2. Impart students with knowledge of chemical engineering and use of modern tools and provide the best learning resources.

M3. Provide an enabling environment to equip students to serve the society as leading professionals, academicians, innovators and entrepreneurs.

M4. Promote and undertake academic research to address technical and societal challenges.

M5. Provide consulting services to the industry and create industry-academia synergy.

PEO'S:

PEO 1: DOMAIN KNOWLEDGE: Graduates will have the fundamental knowledge of mathematics, science, economics and computing and in-depth knowledge in chemical engineering concepts through theoretical, laboratory and project-based experience to design, develop and solve engineering problems.

PEO 2: EMPLOYMENT: Graduates will get employed in national and international; government and private organizations and will succeed in their chosen engineering careers through their skills, knowledge, personality and aptitude for innovation.

PEO 3: HIGHER STUDIES & LIFELONG LEARNING: Graduates will pursue advanced degrees in engineering and other fields; and will have skills of continued, independent and life-long learning to become experts in their profession by self-instilled passion and systematic approach.

PEO 4: PROFESSIONAL CITIZENSHIP: Graduates will organize and present information, write and speak well, work effectively with strong organizational skills in multidisciplinary teams on team-based engineering projects and practice ethics and have a sense of social responsibility.

PEO 5: MODERN TOOLS: Graduates will plan, design, execute, maintain and rehabilitate chemical engineering systems and solve chemical engineering problems using analytical methods or modern tools and techniques

POs and PSOs:

PO1: Engineering Knowledge: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization as specified in WK1 to WK4 respectively to develop to the solution of complex engineering problems.

PO2: Problem Analysis: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development. (WK1 to WK4)

PO3: Design/Development of Solutions: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with

consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required. (WK5)

PO4: Conduct Investigations of Complex Problems: Conduct investigations of complex

engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions. (WK8).

PO5: Engineering Tool Usage: Create, select and apply appropriate techniques, resources

and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems. (WK2 and WK6)

PO6: The Engineer and The World: Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment. (WK1, WK5, and WK7).

PO7: Ethics: Apply ethical principles and commit to professional ethics, human values, diversity and inclusion; adhere to national & international laws. (WK9)

PO8: Individual and Collaborative Team work: Function effectively as an individual, and as a member or leader in diverse/multi-disciplinary teams.

PO9: Communication: Communicate effectively and inclusively within the engineering community and society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations considering cultural, language, and learning differences

PO10: Project Management and Finance: Apply knowledge and understanding of engineering management principles and economic decision-making and apply these to one's own work, as a member and leader in a team, and to manage projects and in multidisciplinary environments.

PO11: Life-Long Learning: Recognize the need for, and have the preparation and ability for i) independent and life-long learning ii) adaptability to new and emerging technologies and iii) critical thinking in the broadest context of technological change. (WK8)

List of PSOs:

Chemical Engineering Graduates will be able to:

PSO1: An ability to solve chemical engineering problems using analytical methods and modern tools and techniques

PSO2: An ability to design, operate, maintain and troubleshoot chemical process equipment

Academic Regulations (R23) for B. Tech (Regular-Full time)

(Effective for the students admitted into I year from the Academic Year **2023-24** onwards)

1. Award of the Degree

(a) **Award of the B.Tech. Degree / B.Tech. Degree with a Minor if he/she fulfills the following:**

(i) Pursues a course of study for not less than four academic years and not more than eight academic years. However, for the students availing Gap year facility this period shall be extended by two years at the most and these two years would in addition to the maximum period permitted for graduation (Eight years).

(ii) Registers for 160 credits and secures all 160 credits.

(b) **Award of B.Tech. degree with Honors**

A student will be declared eligible for the award of the B.Tech. with Honors if he/she fulfills the following:

(i) Student secures additional 18 credits fulfilling all the requisites of B.Tech. program i.e., 160 credits.

(ii) Registering for Honors is optional.

(iii) Honors is to be completed simultaneously with B.Tech. programme.

Students, who fail to fulfill all the academic requirements for the award of the degree within eight academic years from the year of their admission, shall forfeit their seat in B.Tech. course and their admission stands cancelled. This clause shall be read along with clause 1 a) i).

2. Admissions

Admission to the B. Tech Program shall be made subject to the eligibility, qualifications and specialization prescribed by the A.P. State Government/University from time to time. Admissions shall be made either based on the merit rank obtained by the student in the common entrance examination conducted by the A.P. Government/University or any other order of merit approved by the A.P. Government/University, subject to reservations as prescribed by the Government/University from time to time.

3. Program related terms

Credit: A unit by which the course work is measured. It determines the number of hours of instruction required per week. One credit is equivalent to one hour of teaching (Lecture/Tutorial) or two hours of practical work/field work per week.

Credit definition:

1 Hr. Lecture (L) per week	1 credit
1 Hr. Tutorial (T) per week	1 credit
1 Hr. Practical (P) per week	0.5 credit
2 Hrs. Practical (Lab) per	1 credit

- a) **Academic Year:** Two consecutive (one odd + one even) semesters constitute one academic year.
- b) **Choice Based Credit System (CBCS):** The CBCS provides a choice for students to select from the prescribed courses.

4. Semester/Credits:

- A semester comprises 90 working days and an academic year is divided into two semesters.
- The summer term is for eight weeks during summer vacation. Internship/ apprenticeship / work-based vocational education and training can be carried out during the summer term, especially by students who wish to exit after two semesters or four semesters of study.
- Regular courses may also be offered during the summer on a fast-track mode to enable students to do additional courses or complete backlogs in coursework.
- The Universities/HEIs can decide on the courses to be offered in the summer term depending on the availability of faculty and the number of students.

5. Structure of the Undergraduate Programme

All courses offered for the undergraduate program (B. Tech.) are broadly classified as follows:

S.No.	Category	Breakup of Credits (Total 160)	Percentage of total credits	AICTE Recommendation (%)
1.	Humanities and Social Science	13	8 %	8 – 9%
2.	Basic Sciences (BS)	20	13 %	12 - 16%
3.	Engineering Sciences (ES)	23.5	14%	10 – 18%
4.	Professional Core (PC)	54.5	34 %	30 – 36%
5.	Electives – Professional (PE) & Open (OE); Domain Specific Skill Enhancement Courses (SEC)	33	21 %	19 - 23%
6.	Internships & Project work	16	10 %	8 – 11%
7.	Mandatory Courses (MC)	Non-credit	Non-credit	-

6. Course Classification:

All subjects/ courses offered for the undergraduate programme in Engineering & Technology (B.Tech. degree programs) are broadly classified as follows:

S.No.	Broad Course Classification	Course Category	Description
1.	Foundation Core Courses	Foundation courses	Includes Mathematics, Physics and Chemistry; fundamental engineering courses; humanities, social sciences and
2.	Core Courses	Professional Core Courses (PC)	Includes subjects related to the parent discipline /department / branch of Engineering
3.	Elective Courses	Professional Elective	Includes elective subjects related to the parent
		Open Elective Courses (OE)	Elective subjects which include interdisciplinary subjects or subjects in an area outside the
		Domain specific skill enhancement	interdisciplinary/job-oriented/domain courses which are relevant to the industry
4.	Project & Internships	Project	B.Tech. Project or Major Project
		Internships	Summer Internships – Community based and Industry Internships; Industry oriented Full Semester
5.	Audit Courses	Mandatory non-	Covering subjects of developing desired attitude

7. Programme Pattern

- Total duration of the B. Tech (Regular) Programme is four academic years.
- Each academic year of study is divided into two semesters.
- Minimum number of instruction days in each semester is 90 days.
- There shall be mandatory student induction program for fresher's, with three-week duration before the commencement of first semester. Physical activity, Creative Arts, Universal Human Values, Literary, Proficiency Modules, Lectures by Eminent People, Visits to local Areas, Familiarization to Dept./Branch & Innovations etc., are included as per the guidelines issued by AICTE.
- Health/wellness/yoga/sports and NSS /NSS /Scouts & Guides / Community service activities are made mandatory as credit courses for all the undergraduate students.
- Courses like Environmental Studies, Ethics and Human values are offered as non-credit mandatory courses for all the undergraduate students.
- Increased flexibility for students through an increase in the elective component of the curriculum, with 05 Professional Elective courses and 08 Open Elective courses.
- Professional Elective Courses, include the elective courses relevant to the chosen specialization/branch. Proper choice of professional elective courses can lead to students specializing in emerging areas within the chosen field of study.
- A total of 29 credits are offered in the curriculum as Extended Open Elective Cluster (EOEC). A student can complete the requirement for B.Tech. Degree with a Minor within the 160 credits by opting for the

courses offered through various verticals/tracks under Extended Open Elective Cluster (EOEC).

- x. While choosing the electives, students shall ensure that they do not opt for the courses with syllabus contents similar to courses already pursued.
- xi. A pool of interdisciplinary/job-oriented/domain skill courses which are relevant to the industry are integrated into the curriculum of all disciplines.
- xii. Students shall undergo summer internships, for a period of four week's duration at the end of second and third year of the programme. The internship at the end of second year shall be community oriented and industry internship at the end of third year.
- xiii. There shall also be internship in the final semester of the programme along with the project work.
- xiv. Undergraduate degree with Honors is introduced by the University for the students having good academic record.

8. Evaluation Process

The performance of a student in each semester shall be evaluated subject wise with a Maximum of 100 marks for theory and 100 marks for practical subject. Summer Internships shall be evaluated for 50 marks, Full Internship & Project work in final semester shall be evaluated for 200 marks, and mandatory courses with no credits shall be evaluated for 30 mid semester marks.

A student has to secure not less than 35% of marks in the end examination and a minimum of 40% of marks in the sum total of the mid semester and end examination marks taken together for the theory, practical, design, drawing subject or project etc. In case of a mandatory course, he/she should secure 40% of the total marks.

THEORY COUSES

Assessment Method	Marks
Continuous Internal	30
Semester End Examination	70
Total	100

- i. For theory subject, the distribution shall be 30 marks for Continuous Internal Assessment and 70 marks for the End-Examination.
- ii. For practical subject, the distribution shall be 30 marks for Internal Evaluation and 70 marks for Semester End Examination.
- iii. If any course contains two different branch subjects, the syllabus shall be written in two parts with 3 units each (Part-A and Part-B) and external examination question paper shall be set with two parts each for 35 marks.

a) Continuous Internal Evaluation

- i. For theory subjects, during the semester, there shall be two midterm examinations. Each midterm examination shall be evaluated for 30 marks of which 10 marks for objective paper (20 minute's duration), 15 marks for subjective paper (90 minutes duration) and 5 marks for assignment.
- ii. Objective paper shall contain for 05 short answer questions with 2 marks each. Subjective paper shall contain 3 either or type questions (totally six questions from 1 to 6) of which student has to answer one from each either-or type of questions. Each question carries 10 marks. The marks obtained in the subjective paper are condensed to 15 marks.

- iii. First midterm examination shall be conducted for I, II units of syllabus with one either or type question from each unit and third either or type question from both the units. The second midterm examination shall be conducted for III, IV and V units with one either or type question from each unit.
- iv. Final mid semester marks shall be arrived at by considering the marks secured by the student in both the mid examinations with 80% weightage given to the better mid exam and 20% to the other.

For Example:

Marks obtained in first mid: 25

Marks obtained in second mid: 20

Final mid semester Marks: $(25 \times 0.8) + (20 \times 0.2) = 24$

If the student is absent for any one midterm examination, the final mid semester marks shall be arrived at by considering 80% weightage to the marks secured by the student in the appeared examination and zero to the other. For Example:

Marks obtained in first mid: Absent

Marks obtained in second mid: 25

Final mid semester Marks: $(25 \times 0.8) + (0 \times 0.2) = 20$

b) End Examination Evaluation:

End examination of theory subjects shall have the following pattern:
There shall be 6 questions and all questions are compulsory.

- i. Question I shall contain 10 compulsory short answer questions for a total of 20 marks such that each question carries 2 marks.
- ii. There shall be 2 short answer questions from each unit.
- iii. In each of the questions from 2 to 6, there shall be either/or type questions of 10 marks each. Student shall answer any one of them.
- iv. The questions from 2 to 6 shall be set by covering one unit of the syllabus for each question.

End examination of theory subjects consisting of two parts of different subjects, *for example*: Basic Electrical & Electronics Engineering shall have the following pattern:

- i. Question paper shall be in two parts viz., Part A and Part B with equal weightage of 35 marks each.
- ii. In each part, question 1 shall contain 5 compulsory short answer questions for a total of 5 marks such that each question carries 1 mark.
- iii. In each part, questions from 2 to 4, there shall be either/or type questions of 10 marks each. Student shall answer any one of them.
- iv. The questions from 2 to 4 shall be set by covering one unit of the syllabus for each question.

PRACTICAL COURSES

Assessment Method	Marks
Continuous Internal	30
Semester End Examination	70
Total	100

- a) For practical courses, there shall be a continuous evaluation during the semester for 30 sessional marks and end examination shall be for 70 marks.
- b) Day-to-day work in the laboratory shall be evaluated for 15 marks by the concerned laboratory teacher based on the regularity/record/viva and 15 marks for the internal test.
- c) The end examination shall be evaluated for 70 marks, conducted by the concerned laboratory teacher and a senior expert in the subject from the same department.

Procedure	: 20 Marks
Experimental work & Results	: 30 marks
Viva voce	: 20 marks.

- d) In a practical subject consisting of two parts (Eg: Basic Electrical & Electronics Engineering Lab), the end examination shall be conducted for 70 marks as a single laboratory in 3 hours.

- e) Engineering Graphics evaluation

For the subject having design and/or drawing, such as Engineering Drawing, the distribution of marks shall be 30 for mid semester evaluation and 70 for end examination.

Assessment Method	Mark
Continuous Internal	30
Semester End	70
Total	100

Day-to-day work shall be evaluated for 15 marks by the concerned subject teacher based on the reports/submissions prepared in the class and 15 marks for the internal test.

The end examination pattern for Engineering Graphics, shall consist of 5 questions, either/or type, of 14 marks each. There shall be no objective type questions in the end examination.

9. a) NSS/NCC/SCOUTS & GUIDES/COMMUNITY SERVICE

General Guidelines:

1. Institutes must assign slots in the Timetable for the activities.
2. Institutes are required to provide instructor to mentor the students.

Evaluation Guidelines:

- Evaluated for a total of 100 marks.
- A student can select 6 activities of his/her choice with a minimum of 01 activity per unit. Each activity shall be evaluated by the concerned teacher for 15 marks, totaling to 90 marks.
- A student shall be evaluated by the concerned teacher for 10 marks by conducting viva voce on the subject.

b) HEALTH AND WELLNESS, YOGA AND SPORTS

General Guidelines:

1. Institutes must assign slots in the Timetable for the activities of Health/Sports/Yoga.
2. Institutes must provide field/facility and offer the minimum of five choices of as many as Games/Sports.
3. Institutes are required to provide sports instructor / yoga teacher to mentor the students.

Evaluation Guidelines:

- Evaluated for a total of 100 marks.
- A student can select 6 activities of his/her choice with a minimum of 01 activity per unit. Each activity shall be evaluated by the concerned teacher for 15 marks, totalling to 90 marks.
- A student shall be evaluated by the concerned teacher for 10 marks by conducting viva voce on the subject.

There shall be no external examination for mandatory courses with zero credits. However, attendance shall be considered while calculating aggregate attendance and student shall be declared to have passed the mandatory course only when he/she secures 40% or more in the internal examinations. In case, the student fails, a re-examination shall be conducted for failed candidates for 30 marks satisfying the conditions mentioned in item 1 & 2 of the regulations.

The laboratory records and mid semester test papers shall be preserved for a minimum of 1 year in the respective institutions and shall be produced to the Committees of the University as and when the same are asked for.

10. Community Project: There will be a summer break of 4 to 6 weeks at the end of each academic year to provide opportunity to students to engage in internships with industry/government agencies/NGO etc. These internships are intended to give exposure to the students through Community Projects and Mini Projects.

- A student shall identify and provide a solution to the problem relevant to society.
- A student shall engage at least 30 hours on community project. Community project shall be evaluated internally for 50 marks by Project Review Committee (PRC). PRC comprising of HoD, Two senior faculty and guide shall review the progress.
- There shall be no Continuous Assessment marks for these projects.
- A student shall secure minimum 40% of marks for successful completion. In case, if a student fails, he/she shall reappear as and when semester supplementary examinations are conducted by the Institution.

11. Mini Project:

- A student shall undergo internship (Physical/Virtual) for a period of 4 weeks and provide solution to the problem relevant to Industry/ Modern tool during the vacation after VI semester and submit comprehensive report/certificate (For virtual internship) issued by external agencies.

- The recommended Virtual Internships offered by external agencies/regulating bodies like AICTE/APSCE etc, conversions and appropriate grades/marks are to be approved by the BoS at the beginning of the semester.
- Mini project shall be evaluated internally for 50 marks by Project Review Committee (PRC). PRC shall prepare rubrics for assessment.

12. Skill Enhancement Course:

Skill Enhancement Course is assessed for 100 marks, of which, 30 marks for internal assessment and 70 marks for semester end examination.

Assessment Method	Marks
Continuous Internal	30
Semester End Examination	70
Total	100

Continuous Internal Assessment : (30 Marks)

Continuous assessment : 15 Marks

Internal test : 15 Marks

The end examination shall be evaluated for 70 marks, conducted by the concerned course teacher and a senior expert in the subject from the same department.

Procedure : 20 Marks
 Experimental work & Results : 30 marks
 Viva voce : 20 marks.

The student shall be given an option to choose either the skill courses being offered by the college or to choose a certificate course (Minimum 30 hours) being offered by industries / Professional bodies or any other accredited bodies. If a student chooses to take a Certificate Course offered by external agencies, the credits shall be awarded to the student upon producing the Course Completion Certificate from the agency. A committee shall be formed at the level of the college to evaluate the grades/marks given for a course by external agencies and convert to the equivalent marks/grades.

The recommended courses offered by external agencies, conversions and appropriate grades/marks are to be approved by the BoS at the beginning of the semester.

If a student prefers to take a certificate course offered by external agency and approved by BoS, the department shall mark attendance of the student for the remaining courses in that semester excluding the skill course in all the calculations of mandatory attendance requirements upon producing a valid certificate as approved by the BoS.

Evaluation pattern for Quantitative Problem Solving Techniques :

The Course is assessed for 100 marks, of which, 30 marks for internal assessment and 70 marks for semester end examination.

Assessment Method	Marks
Continuous Internal	30
Semester End Examination	70
Total	100

Continuous Internal Assessment : (30 Marks)

Continuous assessment : 15 Marks

Internal test : 15 Marks

The end examination shall be evaluated for 70 marks, conducted by the concerned course teacher and a senior expert in the subject from the same department.

Objective Test (MCQs, 50 Questions : 50 Marks

Each one mark)

Viva voce : 20 marks.

13. Main Project Work:

The 4th Year of study comprises only self-study courses giving opportunity to students to spend one full year as an intern at various organisations (government/private) in pursuance of his/her career aspiration. The student is also expected to complete the Main Project during this period. At the end of the year, the candidate shall submit the main project report and may also include a certificate of internship.

The project report shall be evaluated with an external examiner. The total marks for project work is **200 marks** and the distribution shall be **60 marks** for continuous assessment and **140 marks** for summative assessment. The supervisor assesses the student for 30 marks (Report: 20 marks, Seminar: 10 marks). At the end of the semester, all projects shall be showcased at the department for the benefit of all students and staff and the same is to be evaluated by the departmental Project Review Committee consisting of supervisor, a senior faculty and HOD for 30 marks. The external evaluation of Project Work is a Viva-Voce Examination conducted in the presence of internal examiner and external examiner and is evaluated for 140 marks.

The college shall facilitate and monitor the student main project/internship programs. Completion of the main project is mandatory. If any student fails to complete the main project, he/she will not be eligible for the award of degree. In such cases, the student shall repeat and complete the main project.

14. Massive Open Online Courses (MOOCs):

- It is recommended to register and complete minimum two courses through MOOCs approved by the BoS. A student can pursue courses other than core through MOOCs. A student is not permitted to register and pursue core courses through MOOCs.
- The student shall register for the (Minimum of 12 weeks) courses offered by SWAYAM/NPTEL as Program elective/Open elective with the approval of the BoS. The Head of the Department shall appoint one mentor for each MOOC. The student has to submit the pass certificate issued by SWAYAM/NPTEL after completion of the course.

- Students who have qualified in the proctored examinations conducted through MOOCs platform can apply for credit transfer as specified and are exempted from appearing internal as well as external examination (for the specified equivalent credit course only) conducted by the Institution.

Necessary amendments in rules and regulations regarding adoption of MOOC courses would be proposed from time to time.

15. Academic Bank of Credits (ABC)

The Institution is part of the Academic Bank of Credits (ABC) initiative to promote increased opportunity of mobility for a student (as per NEP 2020). As such,

- i. A student, upon joining the institution, will become part of the ABC.
- ii. All credits earned by the students in the institution as well as through MOOCs will be reflected in his/her account in the ABC
- iii. The student will be able to avail transfer of credits earned from other institutions to his account as per the regulations of UGC/AICTE/JNTUGV declared from time to time.

16. Guidelines for offering Honors

The objective of introducing B.Tech.(Honors) is to facilitate the students to choose additionally the specialized courses of their choice and build their competence in a specialized area in the UG level. The program is a best choice for academically excellent students having good academic record and interest towards higher studies and research.

- i. Honors is introduced in the curriculum of all B. Tech. programs offering a major degree and is applicable to all B.Tech (Regular and Lateral Entry) students admitted in Engineering & Technology.
- ii. A student shall earn additional 16 credits for award of B.Tech.(Honors) degree from same branch/department/discipline registered for major degree. This is in addition to the credits essential for obtaining the Undergraduate degree in Major Discipline.
- iii. A student is permitted to register for Honors and is allowed to take maximum of two subjects per semester pertaining to the Honors.
- iv. Separate class work and timetable of the courses offered under Honors program shall be arranged.
- v. Courses that are used to fulfill the student's primary major may not be double counted towards the Honors. Courses with content substantially equivalent to courses in the student's primary Major may not be counted towards the Honors.
- vi. Students can complete the courses offered under Honors either in the college or in online platforms like SWAYAM with a minimum duration of 16 weeks for a 4-credit course satisfying the criteria for credit mobility. If the courses under Honors are offered in conventional mode, then the teaching

- and evaluation procedure shall be similar to regular B. Tech courses.
- vii. A student registered for Honors shall pass in all subjects that constitute the requirement for the Honors degree program. No class/division (i.e., second class, first class and distinction, etc.) shall be awarded for Honors degree program.
 - viii. If a student drops or is terminated from the Honors program, the additional credits so far earned cannot be converted into open or core electives; they will remain extra. However, such students will receive a separate grade sheet mentioning the additional courses completed by them.
 - ix. The Honors will be mentioned in the degree certificate as Bachelor of Technology (Honors) in XYZ. For example, B.Tech. (Honors) in Mechanical Engineering.

Enrolment into Honors:

- i. Students of a Department/Discipline are eligible to opt for Honors program offered by the same Department/Discipline.
- ii. The enrolment of student into Honors is based on the CGPA obtained in the major degree program. CGPA shall be taken up to IV semester in case of regular and Lateral entry students. Students having 7 CGPA without any backlog subjects will be permitted to register for Honors.
- iii. Transfer of credits from Honors to regular B. Tech degree and vice-versa shall not be permitted.
- iv. Honors is to be completed simultaneously with a Major degree program.

Registration for Honors:

- i. The eligible and interested students shall apply through the HOD of his/her parent department. The whole process should be completed within one week before the start of every semester. Selected students shall be permitted to register the courses under Honors.
- ii. The selected students shall submit their willingness to the principal through his/her parent department offering Honors. The parent department shall maintain the record of student pursuing the Honors.
- iii. The students enrolled in the Honors courses will be monitored continuously. An advisor/mentor from parent department shall be assigned to a group of students to monitor the progress.
- iv. There is no fee for registration of subjects for Honors program offered in offline at the respective institutions.

17. Attendance Requirements:

- i. A student shall be eligible to appear for the University external examinations if he/she acquires a minimum 75% of attendance in aggregate of all the subjects.
- ii. Condonation of shortage of attendance in aggregate up to 10% (65% and above and below 75%) in each semester may be granted by the College Academic Committee.
- iii. Shortage of Attendance below 65% in aggregate shall in NO CASE be condoned.
- iv. Students whose shortage of attendance is not condoned in any semester are not eligible to take their end examination of that class and their registration shall stand cancelled.
- v. A student will not be promoted to the next semester unless he satisfies the attendance requirements of the present semester. They may seek

- readmission for that semester from the date of commencement of class work.
- vi. If the learning is carried out in blended mode (both offline & online), then the total attendance of the student shall be calculated considering the offline and online attendance of the student.
 - vii. For induction programme attendance shall be maintained as per AICTE norms.

18. Promotion Rules:

A student shall be promoted from IV semester to V semester if he fulfills the minimum attendance requirement (75%) and academic requirement of 40% of credits (any decimal fraction should be rounded off to lower digit) up to either III semester or IV semester from the following examinations irrespective of whether the candidate takes the examination or not.

- Two regular and Two supplementary examinations of I semester
- Two regular and One supplementary examinations of II semester
- One regular examination and One supplementary examination of III semester
- One regular examination of IV semester.

A student shall be promoted from VI semester to VII semester if he fulfills the minimum attendance requirement (75%) and academic requirement of 40% of credits (any decimal fraction should be rounded off to lower digit) up to either V Semester or VI semester from the following examinations irrespective of whether the candidate takes the examination or not.

- Three regular and Three supplementary examinations of I semester
- Three regular and Two supplementary examinations of II semester
- Two regular and Two supplementary examinations of III semester
- Two regular and One supplementary examinations of IV semester
- One regular and One supplementary examination of V semester
- One regular examination of VI semester.

19. Grading:

As a measure of the student's performance, a 10-point Absolute Grading System using the following Letter Grades and corresponding percentage of marks shall be followed:

After each course is evaluated for 100 marks, the marks obtained in each course will be converted to a corresponding letter grade as given below, depending on the range in which the marks obtained by the student fall.

Structure of Grading of Academic Performance

Range in which the marks in the subject fall	Grade	Grade points Assigned
90 & above	S (Superior)	10
80 - 89	A (Excellent)	9
70 - 79	B (Very Good)	8
60 - 69	C (Good)	7
50 - 59	D (Average)	6
40 - 49	E (Pass)	5
< 40	F (Fail)	0
Absent	Ab (Absent)	0

- i. A student obtaining Grade "F" or Grade "Ab" in a subject shall be considered failed and will be required to reappear for that subject when it is offered the next supplementary examination.
- ii. For non-credit audit courses, "Satisfactory" or "Unsatisfactory" shall be indicated instead of the letter grade and this will not be counted for the computation of SGPA/CGPA/Percentage.

Computation of Semester Grade Point Average (SGPA) and Cumulative Grade Point Average (CGPA):

The Semester Grade Point Average (SGPA) is the ratio of sum of the product of the number of credits with the grade points scored by a student in all the courses taken by a student and the sum of the number of credits of all the courses undergone by a student, i.e.,

$$SGPA = \frac{\sum (C_i \times G_i)}{\sum C_i}$$

where, C_i is the number of credits of the i th subject and G_i is the grade point scored by the student in the i th course.

The Cumulative Grade Point Average (CGPA) will be computed in the same manner considering all the courses undergone by a student over all the semesters of a program, i.e.,

$$CGPA = \frac{\sum (C_i \times S_i)}{\sum C_i}$$

where " S_i " is the SGPA of the i th semester and C_i is the total number of credits up to that semester.

Both SGPA and CGPA shall be rounded off to 2 decimal points and reported in the transcripts.

While computing the SGPA the subjects in which the student is awarded Zero grade points will also be included.

Grade Point: It is a numerical weight allotted to each letter grade on a 10-point scale. Letter Grade: It is an index of the performance of students in a said course. Grades are denoted by the letters S, A, B, C, D and F.

20. Award of Class:

After a student has satisfied the requirements prescribed for the completion of the program and is eligible for the award of B. Tech. Degree, he/she shall be placed in one of the following four classes:

Class Awarded	CGPA Secured
First Class with Distinction	≥ 7.5 (Without any supplementary)
First Class	$\geq 6.5 < 7.5$
Second Class	$\geq 5.5 < 6.5$
Pass Class	$\geq 5.0 < 5.5$

Note: * Students who have written supplementary examinations to fulfil the credit requirement will not be awarded First Class with Distinction. For such students the highest degree that is awarded will be First Class Only.

CGPA to Percentage conversion Formula – $(\text{CGPA} - 0.5) \times 10$

21. With-holding of Results

If the candidate has any dues not paid to the university or if any case of indiscipline or malpractice is pending against him/her, the result of the candidate shall be withheld in such cases.

22. Multiple Entry / Exit option

With NEP setting in, the theme is we will need to give different entry-exit options for students and a possibility to tailor a 4-year course or even a 3-year exit degree to suit their interests and requirements.

- Exit-Entry at each year of study through the entire 4-year duration.
- Possible multiple Degree Options with different Credit requirements that provide an option to a student to pick an option that best suits his/her interests and requirements.

Note: Four Year undergraduate program (FYUP) with or without Honors is the most recommended exit. But if for some unavoidable reasons, a student needs to exit at the end of Year I, Year II, Year III, the following would be the respective exit requirements with a tentative certificate/ diploma/ degree defined.

Year of Exit	Degree	Credits Required to be Earned During Course Work	Exit Extra Credits (Crash Course & Exam)	Total Credits
End of Year I	Office Tools Certificate (Or something equivalent as determined by Affiliating University)	40	6	46
End of Year II	Diploma in Discipline 1 (Or something equivalent as determined by Affiliating University)	88	8	96
End of Year III	Bachelor in Vocational Sciences in <u>Discipline 1</u> (Or something equivalent as determined by Affiliating University)	136	0	136
End of Year IV (Without Honors)	Bachelor of Technology in <u>Discipline 1</u> (Or something equivalent as determined by Affiliating University)	160	0	160

Year of Exit	Degree	Credits Required to be Earned During Course Work	Exit Extra Credits (Crash Course & Exam)	Total Credits
End of Year IV (With Honors)	Bachelor of Technology with Honors in <u>Discipline 1</u> (Or something equivalent as determined by Affiliating University)	176	0	176

Note: The exit extra credits at Year II and Year III would essentially come from critical courses as determined by BoS from the following semester.

(a) Exit Policy:

The students can choose to exit the four-year program at the end of first/second/third year.

- i) **UG Certificate in (Field of study/discipline)** - Program duration:
First Year (first two semesters) of the undergraduate program, 40 credits followed by an additional exit 6 credit bridge course. The 6 extra credits would be to make the certificate self-sufficient, with one 3-Credit Course on Taxation and one 3-Credit Course on Accounting that would help the candidates acquire job-ready competencies required to enter the workforce.
- ii) **UG Diploma (in Field of study/discipline)** - Program duration:
First two years (first four semesters) of the undergraduate program, 88 credits followed by an additional exit of 8-credit bridge course with 2 Integrated 4 Credit courses in Major with 3+1 Theory and Lab distribution administrated as a Crash course in 1 month which would help the candidates acquire job-ready competencies required to enter the workforce.
- iii) **Bachelor of Science (in Field of study/discipline) i.e., B.Sc. Engineering in (Field of study/discipline)**- Program duration:
First three years (first six semesters) of the undergraduate program, 120 credits.

(b) Entry Policy:

Modalities on multiple-entry by the student into the B.Tech. program will be provided in due course of time.

Note: The institution shall resolve any issues that may arise in the implementation of Multiple Entry and Exit policies from time to time and shall review the policies in the light of periodic changes brought by UGC, AICTE, State government and the affiliating univeristy.

23. Gap Year Concept:

Gap year concept for Student Entrepreneur in Residence is introduced and outstanding students who wish to pursue entrepreneurship / become entrepreneur are allowed to take a break of one year at any time after II year to pursue full-time entrepreneurship programme/to establish startups. This period may be extended to two years at the most and these two years would not be counted for the time for the maximum time for graduation. The principal of the respective college shall forward such proposals submitted by the students to the University. An evaluation committee constituted by the University shall evaluate the proposal submitted by the student and the committee shall decide whether to permit the student(s) to avail the Gap Year or not

24. Transitory Regulations

Discontinued, detained, or failed candidates are eligible for readmission as and when the semester is offered after fulfillment of academic regulations. Candidates who have been detained for want of attendance or not fulfilled academic requirements or who have failed after having undergone the course in earlier regulations or have discontinued and wish to continue the course are eligible for admission into the unfinished semester from the date of commencement of class work with the same or equivalent subjects as and when subjects are offered, subject to Section 2 and they will follow the academic regulations into which they are readmitted.

Candidates who are permitted to avail Gap Year shall be eligible for re-joining into the succeeding year of their B. Tech from the date of commencement of class work, subject to Section 2 and they will follow the academic regulations into which they are readmitted.

25. Minimum Instruction Days for a Semester:

The minimum instruction days including exams for each semester shall be 90 days.

26. Medium of Instruction:

The medium of instruction of the entire B.Tech undergraduate programme in Engineering & Technology (including examinations and project reports) will be in English only.

27. Student Transfers:

Student transfers shall be as per the guidelines issued by the Government of Andhra Pradesh and the Universities from time to time.

28. General Instructions:

- a. The academic regulations should be read as a whole for purpose of any interpretation.
- b. Malpractices rules-nature and punishments are appended.
- c. Where the words "he", "him", "his", occur in the regulations, they also include "she", "her", "hers", respectively.
- d. In the case of any doubt or ambiguity in the interpretation of the above rules, the decision of the Vice-Chancellor is final.
- e. The Universities may change or amend the academic regulations or syllabi at any time and the changes or amendments shall be made applicable to all the students on rolls with effect from the dates notified by the Universities.
- f. In the case of any doubt or ambiguity in the interpretation of the guidelines given, the decision of the Vice-Chancellor / Head of the institution is final.

Regulations for MALPRACTICES during the conduct of examinations

	Nature of Malpractices/Improper conduct	Punishment
1.a	If the candidate possesses or keeps accessible in examination hall, any paper, note book, programmable calculators, Cell phones, pager, palm computers or any other form of material concerned with or related to the subject of the examination (theory or practical) in which he is appearing but has not made use of (material shall include any marks on the body of the candidate which can be used as an aid in the subject of the examination) - FIRST TIME (whether copied or not)	Expulsion from the examination hall and cancellation of the performance in that subject only. • To keep the CC footage of the act as an evidence. • To obtain a statement from student and get it authorized by observer and Chief superintendent.
1.b	If the candidate possesses or keeps accessible in examination hall, any paper, note book, programmable calculators, Cell phones, pager, palm computers or any other form of material concerned with or related to the subject of the examination (theory or practical) in which he is appearing but has not made use of (material shall include any marks on the body of the candidate which can be used as an aid in the subject of the examination) - SECOND TIME (whether copied or not)	Expulsion from the examination hall and cancellation of the performance in that subject and all other subjects the candidate has already appeared including practical examinations, project work and shall not be permitted to appear for the remaining examinations of the subjects of that Semester/year. • To keep the CC footage of the act as an evidence. • To obtain a statement from student and get it authorized by observer and Chief superintendent.
1.c	If the candidate possesses or keeps accessible in examination hall, any paper, note book, programmable calculators, Cell phones, pager, palm computers or any other form of material concerned with or related to the subject of the examination (theory or practical) in which he is appearing but has not made use of (material shall include any marks on the body of the candidate which can be used as an aid in the subject of the examination) - REPITITION OF THE ABOVE ACT (After second time and whether copied or not)	Nature of punishment to be given for the improper conduct shall be as per the recommendations of the committee. • The committee comprising of Principal, Vice principal, Chief superintendent, Controller of Examinations and HoD to discuss and initiate the action to be taken and recommend. • To keep the CC footage of the act as evidence. • To obtain a statement from student and invigilator and authorized by Chief superintendent.
2.a.	If the candidate gives assistance or guidance or receives it from any other candidate orally or by any	Expulsion from the examination hall and cancellation of the performance in that subject only

	other body language methods.	of all the candidates involved. • To keep the CC footage of the act as an evidence.
2.b	If the candidate communicates through cell phones / through any other means with any candidate or persons in or outside the exam hall in respect of any matter. (i) If the communication is with the person(s) who belongs to our college. (ii) If the communication is with the person(s) outside the campus or people who are not related to our college.	Confiscation of the mobile or electronic gadgets involved and Expulsion from the examination hall and cancellation of the performance in that subject and all other subjects the candidate has already appeared including practical examinations, project work and shall not be permitted to appear for the remaining examinations of the subjects of that Semester/year. • To obtain all relevant proofs of evidence from the Mobile/ gadgets and handing over of the same to the candidate. • To keep the CC footage of the act as evidence. • To obtain a statement from student and invigilator and authorized by observer and Chief superintendent. Confiscation of the mobile or electronic gadgets involved and Expulsion from the examination hall and cancellation of the performance in that subject and all other subjects the candidate has already appeared including practical examinations, project work and shall not be permitted to appear for the remaining examinations of the subjects of that Semester/year. To obtain all relevant proofs of evidence from the Mobile/ gadgets and handing over of the same to the candidate. To keep the CC footage of the act as evidence. To obtain a statement from student and invigilator and authorized by observer and Chief superintendent. The person(s) involved should be handed over to the police and a case is registered against him.
3.	If the candidate impersonates any other candidate in connection with the examination.	The candidate who has impersonated shall be expelled from examination hall. The candidate is also debarred and forfeits the seat. The performance of the original candidate, who has been impersonated, shall be cancelled in all the subjects of the examination (including practical's and project work) already appeared and shall not

		be allowed to appear for examinations of the remaining subjects of that semester/year. The candidate is also debarred for two consecutive semesters from class work and all University examinations. The continuation of the course by the candidate is subject to the academic regulations in connection with forfeiture of seat. If the imposter is an outsider/candidate not on rolls, he will be handed over to the police and a case is registered against him. • To constitute a committee comprising of Principal, Vice principal, Chief superintendent, Observer, Controller of Examinations and HoD to discuss and initiate the above action with documented proofs. • To keep the CC footage of the act as an evidence. • To obtain a statement from student, invigilator, subject expert and authorized by observer and Chief superintendent.
4	If the candidate mishandles the Answer book or additional sheet or takes out or arranges to send out the question paper during the examination or answer book or additional sheet, during or after the examination. Also,if the answer script is mutilated / damaged disturbing the shape, of the script, answers, the bar code intentionally.	Expulsion from the examination hall and cancellation of performance in that subject and all the other subjects the candidate has already appeared including practical examinations and project work and shall not be permitted for the remaining examinations of the subjects of that semester. In addition to the above punishment, a committee shall be constituted and recommends appropriate punishment for the improper conduct. • To keep the CC footage of the act as an evidence. • To Obtain a statement from student and invigilator and authorized by observer and Chief superintendent.
5.	Uses objectionable, abusive or offensive language in the Examination hall.	Expulsion from the examination hall and cancellation of the performance in that subject only. • To Obtain a statement from student and invigilator and get it authorized by Observer and Chief superintendent.

6.	Refuses to obey the orders of the Chief Superintendent/ACE/ any officer on duty or misbehaves or creates disturbance of any kind in and around the examination hall or organizes a walk out or instigates others to walk out, or threatens the officer-in charge or any person on duty in or outside the examination hall of any injury to his person or to any of his relations whether by words, either spoken or written or by signs or by visible representation, assaults the officer-in-charge, or any person on duty in or outside the examination hall or any of his relations, or indulges in any other act of misconduct or mischief which result in damage to or destruction of property in the examination hall or any part of the College campus or engages in any other act which in the opinion of the officer on duty amounts to use of unfair means or misconduct or has the tendency to disrupt the orderly conduct of the examination.	In case of students of the college, they shall be expelled from examination halls and cancellation of their performance in that subject and all other subjects the candidate(s) has (have) already appeared and shall not be permitted to appear for the remaining examinations of the subjects of that semester. The candidates also are debarred and forfeit their seats. In case of outsiders, they will be handed over to the police and a police case is registered against them. • To constitute a committee comprising of Principal, Vice principal, Chief superintendent, Observer, Controller of Examinations and HoD to discuss and initiate the above action with documented proofs • To keep the CC footage of the act as an evidence. • To Obtain a statement from student and invigilator and authorized by observer and Chief superintendent.
7.	Leaves the exam hall taking away answer script or intentionally tears of the script or any part thereof inside or outside the examination hall.	Expulsion from the examination hall and cancellation of performance in that subject and all the other subjects the candidate has already appeared including practical examinations and project work and shall not be permitted for the remaining examinations of the subjects of that semester/year. The candidate is also debarred for two consecutive semesters from class work and all University examinations. The continuation of the course by the candidate is subject to the academic regulations in connection with forfeiture of seat. • To constitute a committee comprising of Principal, Vice principal, Chief superintendent, Observer, Controller of Examinations and HoD to discuss and initiate the above action. • To keep the CC footage of the act as an evidence. • To Obtain a statement from

		student and invigilator and authorized by observer and Chief superintendent.
8.	Possess any lethal weapon or firearm in the examination hall.	Expulsion from the examination hall and cancellation of the performance in that subject and all other subjects the candidate has already appeared including practical examinations and project work and shall not be permitted for the remaining examinations of the subjects of that semester/year. The candidate is also debarred and forfeits the seat. • To constitute a committee comprising of Principal, Vice principal, Chief superintendent, Observer, Controller of Examinations and HoD to discuss and initiate the above action with documented proofs • To keep the CC footage of the act as an evidence. • To obtain a statement from student and invigilator and authorized by observer and Chief superintendent. • The candidate shall be handed over to Police and register a case.
9.	If a student of the college, who is not a candidate for the particular examination or any person not connected with the college indulges in any malpractice or improper conduct mentioned in clause 6 to 8.	If the student belongs to our college: Expulsion from the examination hall and cancellation of the performance in that subject and all other subjects the candidate has already appeared including practical examinations and project work and shall not be permitted for the remaining examinations of the subjects of that semester. The candidate is also debarred and forfeits the seat. Person(s) who do not belong to the College will be handed over to police and, a police case will be registered against them. • To constitute a committee comprising of Principal, Vice principal, Chief superintendent, Observer, Controller of Examinations and HoD to discuss and initiate the above action. • To keep the CC footage of

		the act as an evidence. • To Obtain a statement from student and invigilator and authorized by observer and Chief Superintendent.
10	Comes in a drunken condition to the examination hall.	Expulsion from the examination hall and cancellation of the performance in that subject and all other subjects the candidate has already appeared including practical examinations and project work and shall not be permitted for the remaining examinations of the subjects of that semester. • To keep the CC footage of the act as an evidence(If any). • To obtain a statement from invigilator and any others as witness authorized by observer and Chief superintendent.
11	Copying detected on the basis of internal evidence, such as, during valuation or during special scrutiny.	Cancellation of the performance in that subject and all other subjects the candidate has appeared including practical examinations and project work of that semester/year examinations. • To Obtain a statement from Valuer / Chief Valuer authorized by Spot Coordinator and Controller of Examinations.

General :

- Wherever the words "he", "him", "his", occur in the regulations, they include "she", "her", "hers".
- The academic regulation should be read as a whole for the purpose of any interpretation.
- In the case of any doubt or ambiguity in the interpretation of the above rules, the decision of the Vice-Chancellor is final.
- The University may change or amend the academic regulations or syllabi at any time and the changes or amendments made shall be applicable to all the students with effect from the dates notified by the University.

* * *

RAGGING

Prohibition of Ragging in Educational Institutions A.P. Act 26 of 1997

- * Ragging within or outside any educational institution is **PROHIBITED**.
- * Ragging means doing an act which causes or likely to cause **INSULT** or **ANNOYANCE** or **FEAR** or **APPREHENSION** or **THREAT** or **INTIMIDATION** or **OUTRAGE OF MODESTY** or **INJURY** to a student.

Teasing
Embarrassing and
Humiliating



+ ₹ 1,000/-

Assaulting or using
criminal force or
criminal intimidation



+ ₹ 2,000/-

Wrongfully
restraining or confining
or causing hurt



+ ₹ 5,000/-

Causing grievous
hurt, kidnapping or
rape or committing
unnatural offence



+ ₹ 10,000/-

Causing death or
abetting suicide



+ ₹ 50,000/-

LET US MAKE MVGR A RAGGING FREE CAMPUS

Ragging



ABSOLUTELY NO TO RAGGING

1. Ragging is prohibited as per Act 26 of A.P. Legislative Assembly, 1997.
2. Ragging entails heavy fines and/or imprisonment.
3. Ragging invokes suspension and dismissal from the College.
4. Outsiders are prohibited from entering the College and Hostel without permission.
5. Girl students must be in their hostel rooms by 7.00 p.m.
6. All the students must carry their Identity Cards and show them when demanded
7. The Principal and the Wardens may visit the Hostels and inspect the rooms any time.

**ACADEMIC REGULATIONS (R23)
FOR B.TECH. (LATERAL ENTRY SCHEME)**

*(Effective for the students getting admitted into II year through Lateral Entry Scheme from the Academic Year **2024-2025** onwards)*

1. Award of the Degree

Award of the B.Tech. Degree / B.Tech. Degree with a Minor if he/she fulfils the following:

- i. Pursues a course of study for not less than three academic years and not more than six academic years. However, for the students availing Gap year facility this period shall be extended by two years at the most and these two years would in addition to the maximum period permitted for graduation (Six years).
- ii. Registers for 120 credits and secures all 120 credits.

2. Award of B.Tech. degree with Honors

A student will be declared eligible for the award of the B.Tech with Honors if he/she fulfils the following:

- i. Student secures additional 18 credits fulfilling all the requisites of a B.Tech. program i.e., 120 credits. (ii) Registering for Honors is optional.
- ii. Honors is to be completed simultaneously with B.Tech. programme.

Students, who fail to fulfil the requirement for the award of the degree within six consecutive academic years from the year of admission, shall forfeit their seat.

3. Minimum Academic Requirements

The following academic requirements have to be satisfied in addition to the requirements mentioned in item no.2

- i. A student shall be deemed to have satisfied the minimum academic requirements and earned the credits allotted to each theory, practical, design, drawing subject or project if he secures not less than 35% of marks in the end examination and a minimum of 40% of marks in the sum total of the mid semester evaluation and end examination taken together.
- ii. A student shall be promoted from VI semester to VII semester if he fulfills the minimum attendance requirement (75%) and academic requirement of 40% of credits (any decimal fraction should be rounded off to lower digit) up to either V Semester or VI semester from the following examinations irrespective of whether the candidate takes the examination or not.

- Three regular and Three supplementary examinations of I semester
 - Three regular and Two supplementary examinations of II semester
 - Two regular and Two supplementary examinations of III semester
 - Two regular and One supplementary examinations of IV semester
 - One regular and One supplementary examination of V semester
 - One regular examination of VI semester.
- iii. And in case if student is already detained for want of credits for particular academic year, the student may make up the credits through supplementary exams of the above exams before the commencement of IV year I semester class work of next year.

4. Course Pattern

- i. The entire course of study is three academic years on semester pattern.
 - ii. A student eligible to appear for the end examination in a subject but absent at it or has failed in the end examination may appear for that subject at the next supplementary examination offered.
 - iii. When a student is detained due to lack of credits/shortage of attendance the student may be re-admitted when the semester is offered after fulfilment of academic regulations, the student shall be in the academic regulations into which he/she is readmitted.
- 5.** All other regulations as applicable for B. Tech. Four-year degree course (Regular) will hold good for B. Tech. (Lateral Entry Scheme).

R23-MVGR
COURSE STRUCTURE AND CURRICULUM
B.TECH (Regular/Honors)-CHEMICAL ENGINEERING
(Applicable from the academic year 2023-24 onwards)

I Semester

S. No	Course Code	Course Title	L	T	P	Credits
1	R23MATT101	Linear Algebra and Calculus	3	0	0	3
2	R23CHYT101	Engineering Chemistry	3	0	0	3
3	R23EEET201	Basic Electrical and Electronics Engineering	3	0	0	3
4	R23CSET201	Introduction to Programming	3	0	0	3
5	R23MECD201	Engineering Graphics	1	0	4	3
6	R23CHYL101	Engineering Chemistry Lab	0	0	2	1
7	R23EEEL201	Electrical and Electronics Engineering Lab	0	0	3	1.5
8	R23CSEL201	Computer Programming Lab	0	0	3	1.5
9	R23HSSM802	NSS/NCC/Scouts & Guides/Community Service	0	0	1	0.5
Total Credits						19.5

Semester II

S. No	Course Code	Course Title	L	T	P	Credits
1	R23HSST001	Communicative English	2	0	0	2
2	R23MATT102	Differential Equations and Vector Calculus	3	0	0	3
3	R23PHYT101	Engineering Physics	3	0	0	3
4	R23CMET201	Basic Civil and Mechanical Engineering	3	0	0	3
5	R23CHET301	Introduction to Chemical Engineering	3	0	0	3
6	R23HSSL001	Communicative English Lab	0	0	2	1
7	R23PHYL101	Engineering Physics Lab	0	0	2	1
8	R23CHEL301	Elements of Chemical Engineering lab	0	0	3	1.5
9	R23MECW201	Engineering Workshop	0	0	3	1.5
10	R23CSEW201	IT workshop	0	0	2	1
11	R23HSSM801	Health and Wellness, Yoga and Sports	0	0	1	0.5
Total Credits						20.5

Semester III

S. No	Course Code	Course Title	L	T	P	Credits
1	R23MCHET002	Fluid Mechanics for Chemical Engineers	3	0	0	3
2	R23MCHET003	Chemical Process Calculations	3	0	0	3
3	R23MCHET004	Mechanical Unit Operations	3	0	0	3
4	R23MCHET005	Chemical Technology	3	0	0	3
5	R23MSCST001	Data Structures and Algorithms	3	0	0	3
6	R23MSCST011	Operating Systems	3	0	0	3
7	R23MCHEL001	Fluid Mechanics for Chemical Engineers Lab	0	0	3	2
8	R23MCHEL002	Mechanical Unit Operations Lab	0	0	3	2
9	R23MCSCSL001	Data Structures and Algorithms Lab	0	0	3	2
Total Credits						24

IV Semester

S. No	Course Code	Course Title	L	T	P	Credits
1	R23MCHET006	Process Heat Transfer	3	0	0	3
2	R23MCHET007	Chemical Engineering Thermodynamics	3	0	0	3
3	R23MCHET008	Chemical Reaction Engineering-I	3	0	0	3
4	R23MCHET009	Mass Transfer-I	3	0	0	3
5	R23MSCST007	Python Programming	3	0	0	3
6	R23MSCST010	Database Management Systems	3	0	0	3
7	R23MCHEL003	Process Heat Transfer Lab	0	0	3	2
8	R23MCHEL004	Chemical Reaction Engineering Lab	0	0	3	2
9	R23MCSCSL005	Python Programming Lab	0	0	3	2
10	R23MENGAT01	Ethics & Human Values	2	0	0	-
Total Credits						24

V Semester

S. No	Course Code	Course Title	L	T	P	Credits
1	R23MCHET010	Transport Phenomena	3	0	0	3
2	R23MCHET011	Chemical Reaction Engineering-II	3	0	0	3
3	R23MCHET012	Mass Transfer-II	3	0	0	3
4	R23MCHET013	Process Instrumentation	3	0	0	3
5	R23MCHETXXX	DSC-E1	3	0	0	3
6	R23MSCST005	Software Engineering	3	0	0	3
7	R23MCHEL005	Mass Transfer Lab	0	0	3	2
8	R23MSCSL003	Database Management Systems Lab	0	0	3	2
9	R23MCIVAT02	Environmental Studies	2	0	0	0
10	R23MCHEP001	Community Project	0	0	2	2
Total Credits						24

VI Semester

S. No	Course Code	Course Title	L	T	P	Credits
1	R23MCHET014	Process Modelling and Simulation	3	0	0	3
2	R23MCHET015	Process Dynamics and Control	3	0	0	3
3	R23MCHET016	Plant Design and Economics for Chemical Engineers	3	0	0	3
4	R23MCSCCT006	OOP with JAVA	3	0	0	3
5	R23MCHETXXX	DSC E2	3	0	0	3
6	R23MCHETXXX	DSC E3	3	0	0	3
7	R23MCHEL006	Process Control and Simulation Lab	0	0	3	2
8	R23MCSCCL004	OOP with JAVA Lab	0	0	3	2
9	R23MMATT007	Quantitative Problem Solving Techniques	2	0	0	2
Total Credits						24

VII Semester

S. No	Course Code	Course Title	L	T	P	Credits
1	R23MCHET017	Basic Environmental Engineering and Pollution Abatement (Self-Study/MOOCs)	3	0	0	3
2	R23MCHETXXX	DSC E4 (Self-Study/MOOCs)	3	0	0	3
3	R23MCHETXXX	DSC E5 (Self-Study/MOOCs)	3	0	0	3
4	R23MCHEP002	Mini Project	0	0	2	2
5	R23MCHEL007	Industrial Safety Training/Training in Pharmaceutical industries/ASPEN PLUS	0	0	3	2
Total						13

VIII Semester

S. No	Course Code	Course Title	L	T	P	Credits
1	R23MSCST007	Computer Networks	3	0	0	3
	R23MCSCST008	Artificial Intelligence: Principles and Techniques	3	0	0	
	R23MSCST009	OOAD and Design Patterns	3	0	0	
2	R23MCHEP003	Major-Dissertation/Academic Project-Major	0	0	16	8
Total Credits						11

B.Tech. (Regular/HONORS) Total Credits: 160

DEPARTMENT ELECTIVE COURSES

Specialization-1: Advanced Chemical Engineering

Type of Course	Course Code	Course Title	Semester
DSC-E1	R23MCHET021	Petroleum Refining	V
DSC-E2	R23MCHET022	Biochemical Engineering	VI
DSC-E3	R23MCHET023	Industrial Safety and Hazards Management	VI
DSC-E4	R23MCHET024	Physico-chemical processes for wastewater treatment	VII
DSC-E5	R23MCHET025	Renewable Energy Engineering: Solar, Wind and Biomass Energy Systems	VII

Specialization-2: Bioprocess Technologies

Course Code	Type of Course	Course Code	Semester
DSC-E1	R23MCHET026	Fluidization Engineering	V
DSC-E2	R23MCHET022	Biochemical Engineering	VI
DSC-E3	R23MCHET027	Chemical Process Utilities	VI
DSC-E4	R23MCHET028	Advanced Reaction Engineering	VII
DSC-E5	R23MCHET029	Chemical Process Intensification	VII

Computer Science Cluster(CSC)
(for MEC, ECE, EEE, CIV and CHE)
(Not for CSE/IT/CSIT/AIML/DS/ICB)

Type of Course	Course code	Course Title	Sem	Type of Course	Course Code	Course Title	Sem
EOEC-T1	R23MCSCST001	Data Structures & Algorithms	III	EOEC-L1	R23MCSCSL001	Data Structures & Algorithms Lab	III
EOEC-T2	R23MSCST011	Operating Systems	III	EOEC-L2	R23MSCSL005	Python Programming Lab	IV
EOEC-T3	R23MSCST007	Python Programming	IV	EOEC-L3	R23MCSCSL003	Database Management Systems Lab	V
EOEC-T4	R23MSCST010	Database Management Systems	IV	EOEC-L4	R23MCSCSL004	OOP with JAVA Lab	VI
EOEC-T5	R23MCSCST005	Software Engineering	V				
EOEC-T6	R23MCSCST006	OOP with JAVA	VI				
EOEC-E1 Selfstudy /Moocs	R23MCSCST007	Computer Networks	VIII				
	R23MCSCST008	Artificial Intelligence: Principles and Techniques					
	R23MCSCST009	OOAD and Design Patterns					

I Semester

R23MATT101	LINEAR ALGEBRA AND CALCULUS (Common to All Branches of Engineering)					
	Total Contact Hours	45 (L)	L	T	P	C
	Pre-requisite	Nil	3	0	0	3
Course Objective						
To equip the students with standard concepts and tools of mathematics to handle various real-world problems and their applications.						
Course Outcomes						
1	Solve system of equation by Direct and Indirect methods.					
2	Make use of Linear Algebra techniques to find higher powers and inverse of Matrices.					
3	Make use of Mean value theorems to deduce Mathematical identities.					
4	Use the concept of multivariable calculus to determine the maxima and minima of a multivariable function.					
5	Estimate areas and volumes with help of Multiple integrals.					
6	Formulate Mathematical models and estimate appropriate physical quantities.					
SYLLABUS						
Unit I	MATRICES					9 hr
Rank of a matrix by echelon form, normal form. Cauchy –Binet formulae (without proof). Inverse of Non-singular matrices by Gauss-Jordan method, System of linear equations: Solving system of Homogeneous and Non-Homogeneous equations by Gauss elimination method, Gauss Seidel Iteration Method.						
Unit II	LINEAR TRANSFORMATION AND ORTHOGONAL TRANSFORMATION					9 hr
Eigenvalues, Eigenvectors and their properties, Diagonalization of a matrix, Cayley-Hamilton Theorem (without proof), finding inverse and power of a matrix by Cayley-Hamilton Theorem, Quadratic forms and Nature of the Quadratic Forms, Reduction of Quadratic form to canonical forms by Orthogonal Transformation.						
Unit III	CALCULUS					9 hr
Mean Value Theorems: Rolle’s Theorem, Lagrange’s mean value theorem with their geometrical interpretation, Cauchy’s mean value theorem, Taylor’s and Maclaurin theorems with remainders (without proof), Problems and applications on the above theorems.						
Unit IV	PARTIAL DIFFERENTIATION AND APPLICATIONS (MULTI VARIABLE CALCULUS)					9 hr
Partial derivatives, total derivatives, chain rule, change of variables, Taylor’s and Maclaurin’s series expansion of functions of two variables, Jacobians, maxima and minima of functions of two variables, method of Lagrange multipliers.						
Unit V	MULTIPLE INTEGRALS (MULTI VARIABLE CALCULUS)					9 hr
Double integrals, triple integrals, change of order of integration, change of variables to polar, cylindrical and spherical coordinates. Finding areas (by double integrals) and volumes (by double integrals and triple integrals).						
LEARNING RESOURCES						
TEXT BOOKS:						
1	B.S. Grewal, <i>Higher Engineering Mathematics</i> , 44/e, Khanna Publishers, 2017.					
2	Erwin Kreyszig, <i>Advanced Engineering Mathematics</i> , 10/e, John Wiley & Sons, 2018.					

REFERENCE BOOKS:

1	R.K. Jain and S.R.K. Iyengar, <i>Advanced Engineering Mathematics</i> , 5/e, Alpha Science International Ltd., 2021 (9th reprint).
2	George B. Thomas, Maurice D. Weir and Joel Hass, <i>Thomas Calculus</i> , 14/e, Pearson Publishers, 2018.
3	Glyn James, <i>Advanced Modern Engineering Mathematics</i> , 5/e, Pearson publishers, 2018.
4	Michael Green berg, <i>Advanced Engineering Mathematics</i> , 9 th edition, Pearson edn.
5	K Das, Er. Rajnish Verma, <i>Higher Engineering Mathematics</i> , S. Chand, 2021.

Bloom's level - Units catchment articulation matrix

CO	Blooms Level	Unit I	Unit II	Unit III	Unit IV	Unit V
CO1	BL 3	X				
CO2	BL 3		X			
CO3	BL 3			X		
CO4	BL 3				X	
CO5	BL 3					X
CO6	BL 6	X	X	X	X	X

R23CHYT101	ENGINEERING CHEMISTRY (Common to Civil, Mechanical and Chemical Engineering)						
	Total Contact Hours	45 (L)	L	T	P	C	
	Pre-requisite	Nil	3	0	0	3	
Course Objective							
Students will get exposure, 1. To familiarize engineering chemistry and its applications 2. To impart the concept of soft and hard waters, softening methods of hard water 3. To train the students on the principles and applications of electrochemistry, polymers, surface chemistry, and cement.							
Course Outcomes							
1	The student will be able to suggest a suitable water treatment method for a given industrial application through assessing the quality of water.						
2	The student will be able to select a suitable energy storage device for a given application as well he/she will also design a suitable process for corrosion prevention in industry.						
3	The student will be able to recommend a suitable polymer/ plastic/ elastomer for a given industrial application. He /She will also assess the suitability of a given fuel.						
4	The student will be able to select a suitable composite/ refractory/ lubricant/ binding material for a given application.						
5	The student will be able to synthesize a suitable colloid or nanomaterial for a given application.						
6	The student will be able to synthesize a colloid/ nanomaterial/ polymer; recommend a suitable building material/composite/ refractory/ lubricant; select a suitable energy storage device and assess the quality of water for a given industrial application						
SYLLABUS							
Unit I	WATER TECHNOLOGY						9 hr
Soft and hardwater, Estimation of hardness of water by EDTA Method, Estimation of dissolved Oxygen - Boiler troubles –Priming, foaming, scale and sludge, Caustic embrittlement, Industrial water treatment – Specifications for drinking water, Bureau of Indian Standards(BIS) and World health organization(WHO) standards, Ion-exchange processes - desalination of brackish water, reverse osmosis (RO) and electrodialysis.							
Unit II	ELECTROCHEMISTRY AND APPLICATIONS						9 hr
Electrodes –electrochemical cell, Nernst equation, cell potential calculations. Primary cells – Zinc-air battery, Secondary cells – Nickel-Cadmium (NiCad),and lithium ion batteries- working principle of the batteries including cell reactions; Fuel cells-Basic Concepts, the principle and working of hydrogen-oxygen Fuel cell. Corrosion: Introduction to corrosion, electrochemical theory of corrosion, differential aeration cell corrosion, galvanic corrosion, metal oxide formation by dry electrochemical corrosion, Pilling Bedworth ratios and uses, Factors affecting the corrosion, cathodic and anodic protection, electroplating and electro less plating (Nickel and Copper).							
Unit III	POLYMERS AND FUEL CHEMISTRY						9 hr
Introduction to polymers , functionality of monomers, Mechanism of chain growth, step growth polymerization. Thermoplastics and Thermo-setting plastics:- Preparation, properties and applications of poly styrene. PVC Nylon 6,6 and Bakelite. Elastomers – Preparation, properties and applications of Buna S, Buna N, Thiokol rubbers. Fuels – Types of fuels, calorific value of fuels, numerical problems based on calorific value; Analysis of coal (Proximate and Ultimate analysis), Liquid Fuels							

refining of petroleum, Octane and Cetane number- alternative fuels- propane, methanol, ethanol and bio fuel-bio diesel.		
Unit IV	MODERN ENGINEERING MATERIALS	9 hr
Composites- Definition, Constituents, Classification- Particle, Fibre and Structural reinforced composites, properties and Engineering applications		
Refractories- Classification, Properties, Factors affecting the refractory materials and Applications.		
Lubricants- Classification, Functions of lubricants, Mechanism, Properties of lubricating oils – Viscosity, Viscosity Index, Flash point, Fire point, Cloud point, saponification and Applications.		
Building materials- Portland Cement, constituents, Setting and Hardening of cement.		
Unit V	SURFACE CHEMISTRY AND NANOMATERIALS	9 hr
Introduction to surface chemistry, colloids, nanometals and nanometal oxides, micelle formation, synthesis of colloids (Braggs Method), chemical and biological methods of preparation of nanometals and metal oxides, stabilization of colloids and nanomaterials by stabilizing agents, adsorption isotherm (Freundlich and Longmuir), BET equation (no derivation) applications of colloids and nanomaterials – catalysis, medicine, sensors, etc.		
LEARNING RESOURCES		
TEXT BOOKS:		
1	Jain and Jain, <i>Engineering Chemistry</i> , 16/e, Dhanpat Rai, 2013.	
2	Peter Atkins, Julio de Paula and James Keeler, <i>Atkins' Physical Chemistry</i> , 10/e, Oxford University Press, 2010.	
REFERENCE BOOKS:		
1	H.F.W. Taylor, <i>Cement Chemistry</i> , 2/e, Thomas Telford Publications, 1997.	
2	D.J. Shaw, <i>Introduction to Colloids and Surface Chemistry</i> , Butterworth-Heinemann, 1992.	
3	Textbook of <i>Polymer Science</i> , Fred W. Billmeyer Jr, 3rd Edition.	

Bloom's level - Units catchment articulation matrix

CO	Blooms Level	Unit I	Unit II	Unit III	Unit IV	Unit V
CO1	BL5	X				
CO2	BL5		X			
CO3	BL5			X		
CO4	BL5				X	
CO5	BL6					X
CO6	BL6	X	X	X	X	X

R23EET201	BASIC ELECTRICAL AND ELECTRONICS ENGINEERING (Common to All Branches of Engineering)						
	Total Contact Hours	48 (L)	L	T	P	C	
	Pre-requisite	Nil	3	0	0	3	
Course Objective							
Students will gain understanding of laws and principles of electrical and electronics engineering and able to apply this knowledge to build simple circuits in relevant fields.							
Course Outcomes: Student							
1	Will be able to apply the basic principles of electrical and circuits to solve DC and AC circuits.						
2	Will be able to analyze the construction and operation of various electrical machines and measuring instruments also select a machine for an application.						
3	Will be able to analyze power generation, electric safety measures and examine electrical power consumption and tariff.						
4	Will be able to appraiser a profound comprehension of semiconductor devices, basic electronic circuits, and instrumentation by examining the principles, characteristics, & application and analyze the block diagrams and interactions within electronic instrumentation systems.						
5	Will be able to design simple combinational and sequential circuits of digital electronics						
6	Will be able to combine the fundamental principles of electrical and electronics engineering to design & solve simple circuits and discuss power generation, control and safety.						
SYLLABUS							
Unit I	DC & AC CIRCUITS						8 hr
Electrical circuit elements (R), Ohm's Law and its limitations; KCL; KVL; Electrical circuit elements (L, C); Superposition theorem; A.C. Fundamentals; Voltage and current relationship with phasor diagrams in R, L, and C circuits; Concept of Impedance, Active power, reactive power, apparent power and power factor;							
Unit II	MACHINES AND MEASURING INSTRUMENTS						8 hr
Construction, principle and operation of & Applications - DC Motor; DC Generator; Single Phase Transformer; Three Phase Induction Motor; Construction, principle and operation of & Applications – Alternator; Construction and working principle of PMMC Instruments; MI Instruments; Wheatstone bridge;							
Unit III	ENERGY RESOURCES, ELECTRICITY BILL & SAFETY MEASURES						8 hr
Conventional and non-conventional energy resources, Layout and operation of various Power Generation systems - Hydel generation; Nuclear generation; Solar power generation.; Wind power generation. Power rating of household appliances, Definition of "unit" used for consumption of electrical energy; Two-part electricity tariff, calculation of electricity bill for domestic consumers; Working principle of Fuse and Miniature circuit breaker (MCB), merits and demerits; Earthing and types of earthing, Safety Precautions to avoid shock;							
Unit IV	SEMICONDUCTOR DEVICES						8 hr
Evolution of Electronics and Classification of Materials; PN Junction Diode and Characteristics; Zener Diode and Characteristics; Transistor (NPN and PNP) Operation; Transistor CB configuration; Transistor CE Configuration; Transistor CC Configuration; Small signal Transistor CE amplifier;							

Unit V	BASIC ELECTRONIC CIRCUITS AND INSTRUMENTATION	8 hr
Half Wave Rectifier; Full Wave Bridge Rectifier; Rectifiers with filters; Zener regulator; DC Power supply (RPS); Public Address System; Frequency response of CE amplifier; Electronic Instrumentation System;		
Unit VI	DIGITAL ELECTRONICS	8 hr
Number Systems; Binary Codes; Logic gates; Boolean Algebra; Half and Full adder; Flip Flops; Registers; Counters		
LEARNING RESOURCES		
TEXT BOOKS:		
1	D. C. Kulshreshtha, <i>Basic Electrical Engineering</i> , Tata McGraw Hill, 2019.	
2	P.V. Gupta, M.L. Soni, U.S. Bhatnagar and A. Chakrabarti, <i>Power System Engineering</i> , Dhanpat Rai & Co, 2013.	
3	R. S. Sedha, <i>A Textbook of Electronic Devices and Circuits</i> , S. Chand & Co, 2010.	
REFERENCE BOOKS:		
1	V.K. Mehtha, <i>Principles of Electrical and Electronics Engineering</i> , S.Chand Technical Publishers, 2020.	
2	S. K. Bhattacharya, <i>Basic Electrical and Electronics Engineering</i> , Person Publications, 2018.	
3	R. P. Jain, <i>Modern Digital Electronics</i> , Tata Mc Graw Hill, 2009.	
ONLINE COURSES		
1	https://nptel.ac.in/courses/108105053	
2	https://nptel.ac.in/courses/108108076	

Bloom's level - Units catchment articulation matrix

CO	Blooms Level	Unit I	Unit II	Unit III	Unit IV	Unit V	Unit VI
CO1	BL3	X	X				
CO2	BL3		X				
CO3	BL4			X			
CO4	BL4				X	X	
CO5	BL6						X
CO6	BL6	X	X	X	X	X	X

R23CSET201	INTRODUCTION TO PROGRAMMING (Common to All branches of Engineering)					
	Total Contact Hours	45 (L)	L	T	P	C
	Pre-requisite	NIL	3	0	0	3
Course Objective						
The course aims to equip students with advanced proficiency in C programming, fostering problem-solving skills and algorithmic design, while ensuring mastery in data manipulation, function implementation, and file handling techniques.						
Course Outcomes						
1	Students will develop essential problem-solving skills and ability to design efficient algorithms to address a wide range of challenges effectively.					
2	Students will formulate solutions by constructing well-organized and efficient C programs, effectively using data types, program flow, and loop structures with appropriate utilization of keywords, operators and identifiers.					
3	Students will have the ability to experiment on arrays, pointers, and dynamic memory allocation, effectively to develop strategies for manipulates data with precision and efficiency.					
4	Students will construct solutions by utilizing functions, string handling, applying variable scope and storage classes effectively, and implementing recursion through C programming principles.					
5	Students will create and develop skills in handling structures, unions, and self-referential structures, and demonstrate proficiency in file handling techniques for input and output operations in C.					
6	Students will develop and author comprehensive programming expertise in C, encompassing computer problem-solving skills, array and pointer manipulation, function implementation, string handling, and data structure utilization through file operations.					
SYLLABUS						
UNIT I	INTRODUCTION TO COMPUTER PROBLEM SOLVING					9 hr
Programs and Algorithms, Computer Problem Solving Requirements, Phases of Problem Solving, Problem. Solving Strategies, Top-Down Approach, Algorithm Designing, Program Verification, Improving Efficiency, Algorithm Analysis and Notations.						
UNIT II	INTRODUCTION TO C PROGRAMMING					9 hr
Introduction, Structure of a C Program. Comments, Keywords, Identifiers, Data Types, Variables, Constants, Input/output Statements. Operators, Type Conversion. Control Flow, Relational Expressions: Conditional Branching Statements: if, if-else, if-else—if, switch. Basic Loop Structures: while, do-while loops, for loop, nested loops, The Break and Continue Statements, goto statement.						
UNIT III	ARRAYS & POINTERS					9 hr
Introduction, Operations on Arrays, Arrays as Function Arguments, Two Dimensional Arrays, Multidimensional Arrays. Pointers: Concept of a Pointer, Declaring and Initializing Pointer Variables, Pointer Expressions and Address Arithmetic, Null Pointers, Generic Pointers, Pointers as Function Arguments, Pointers and Arrays, Pointer to Pointer, Dynamic Memory Allocation, Dangling Pointer, Command Line Arguments.						
UNIT IV	FUNCTIONS & STRINGS					9 hr
Introduction Function: Declaration, Function Definition, Function Call, Categories of Functions, Passing Parameters to Functions, Scope of Variables, Variable Storage Classes. Recursion. Strings: String Fundamentals, String Processing with and without Library Functions, Pointers and Strings.						
UNIT V	STRUCTURES & FILE HANDLING					9 hr
Structures, Unions, Bit Fields: Introduction, Nested Structures, Arrays of Structures, Structures and Functions, Self-Referential Structures, Unions, Enumerated Data Type —Enum variables, Using Typedef keyword, Bit Fields. Data						

Files: Introduction to Files, Using Files in C, Reading from Text Files, Writing to Text Files, Random File Access.	
LEARNING RESOURCES	
TEXT BOOKS:	
1	<i>A Structured Programming Approach Using C</i> , Forouzan, Gilberg, Cengage.
2	<i>How to solve it by Computer</i> , R. G. Dromey, and Pearson Education.
3	<i>Programming In C A-Practical Approach</i> . Ajay Mittal, Pearson
REFERENCE BOOKS:	
1	Byron Gottfried, <i>Schaum's Outline of Programming with C</i> , McGraw-Hill.
2	<i>Computer Programming</i> . Reema Thareja, Oxford University Press
3	<i>The C Programming Language</i> , Dennis Richie And Brian Kernighan, Pearson Education.
4	<i>Programming In C</i> , Ashok Kamthane, Second Edition, Pearson Publication.
5	<i>Let us C</i> , Yaswanth Kanetkar, 16th Edition, BPB Publication.
6	<i>Computing fundamentals and C Programming</i> , Balagurusamy, E., McGraw-Hill Education, 2008
WEB REFERENCES:	
1	http://www.c4learn.com/
2	http://www.geeksforgeeks.org/c/
3	http://nptel.ac.in/courses/122104019/
4	http://www.learn-c.org/
5	https://www.tutorialspoint.com/cprogramming/
ONLINE COURSES:	
1	https://mvqrce.codetantra.com

Bloom's level - Units catchment articulation matrix

CO	Blooms Level	Unit I	Unit II	Unit III	Unit IV	Unit V
CO1	BL3	X				
CO2	BL6		X			
CO3	BL3			X		
CO4	BL6				X	
CO5	BL6					X
CO6	BL6	X	X	X	X	X

R23MECD201	ENGINEERING GRAPHICS (Common to All Branches of Engineering)					
	Total Contact Hours	75 (15L + 60P)	L	T	P	C
	Pre-requisite	Nil	1	0	4	3
Course Objective: To enable the students with various concepts like dimensioning, conventions and standards related to Engineering Drawing						
Course Outcomes: On completion of the course, the student should be able to						
1	Apply the principles of curves, scales, orthographic and isometric projections. in engineering drawing (BL3).					
2	Interpret orthographic projections like front, top and side views related to points, lines, planes and solids.(BL5)					
3	Demonstrate the projection of solids in various positions in the first quadrant. (BL3)					
4	Examine the principles behind development of surfaces. (BL4)					
5	Develop orthographic and isometric projections of solids. (BL6)					
SYLLABUS						
Unit I	CURVES, SCALES AND POLYGONS					
Introduction: Lines, Lettering and Dimensioning, Geometrical Constructions and Constructing regular polygons by general methods. Curves: construction of ellipse, parabola and hyperbola by general, Cycloids, Involute, Normal and tangent to Curves. Scales: Plain scales, diagonal scales and vernier scales.						
Unit II	ORTHOGRAPHIC PROJECTIONS					
Orthographic Projections: Reference plane, importance of reference lines or Plane, Projections of a point situated in any one of the four quadrants. Projections of Straight Lines: Projections of straight lines parallel to both reference planes, perpendicular to one reference plane and parallel to other reference plane, inclined to one reference plane and parallel to the other reference plane. Projections of Straight Line Inclined to both the reference planes Projections of Planes: regular planes Perpendicular to both reference planes, parallel to one reference plane and inclined to the other reference plane; plane inclined to both the reference planes.						
Unit III	PROJECTIONS OF SOLIDS					
Projections of Solids: Types of solids: Polyhedra and Solids of revolution. Projections of solids in simple positions: Axis perpendicular to horizontal plane, Axis perpendicular to vertical plane and Axis parallel to both the reference planes, Projection of Solids with axis inclined to one reference plane and parallel to another plane.						
Unit IV	SECTIONS OF SOLIDS AND DEVELOPMENT OF SURFACES					
Sections of Solids: Perpendicular and inclined section planes, Sectional views and True shape of section, Sections of solids in simple position only. Development of Surfaces: Methods of Development: Parallel line development and radial line development. Development of a cube, prism, cylinder, pyramid and cone.						
Unit V	CONVERSIONS OF VIEWS					
Conversion of Views: Conversion of isometric views to orthographic views; Conversion of orthographic views to isometric views. Computer graphics: Creating 2D&3D drawings of objects including PCB and Transformations using AutoCAD						
LEARNING RESOURCES						
TEXT BOOKS:						
1	N. D. Bhatt, <i>Engineering Drawing</i> , Charotar Publishing House, 2016.					

REFERENCE BOOKS:	
1	K.L. Narayana and P. Kannaiah, <i>Engineering Drawing</i> , Tata McGraw Hill, Third Edition, 2013.
2	M.B.Shah and B.C. Rana, <i>Engineering Drawing</i> , Pearson Education Inc, 2009.
3	Dhananjay Jolhe, <i>Engineering Drawing with an Introduction to AutoCAD</i> , Tata McGraw Hill, 2017.
ADDITIONAL REFERENCE MATERIAL	
1	https://nitc.ac.in/imgserver/uploads/attachments/Ed__5c3343c5-c3f9-468a-b114-8f33556810b4_.pdf
ONLINE COURSES	
1	https://www.mygreatlearning.com/academy/learn-for-free/courses/engineering-graphics-drawing
2	https://onlinecourses.nptel.ac.in/noc21_me128/preview
3	https://www.udemy.com/course/engineering-drawing-graphics/

Bloom's level - Units catchment articulation matrix

CO	Blooms Level	Unit I	Unit II	Unit III	Unit IV	Unit V
CO1	BL3	X	X	X		
CO2	BL5	X	X	X		
CO3	BL3			X	X	X
CO4	BL4				X	X
CO5	BL6	X	X	X	X	X

R23CHYL101	ENGINEERING CHEMISTRY LAB (Common to Civil, Mechanical and Chemical Engineering)						
	Total Contact Hours	30 (P)	L	T	P	C	
	Pre-requisite	Nil	0	0	2	1	
Course Objective							
Verify the fundamental concepts with experiments							
Course Outcomes: At the end of the course, the student will be able to							
1	Determine the cell constant and conductance of solutions.						
2	Prepare advanced polymers and nanomaterials.						
3	Measure the strength of an acid present in secondary batteries.						
4	Understand, analyze and apply the principles of UV - Visible and IR spectroscopic techniques.						
5	Understand and determine the potentials using Potentiometry.						
List of Experiments							
1	Measurement of 10Dq by spectrophotometric method.						
2	Conductometric titration of strong acid vs. strong base.						
3	Conductometric titration of weak acid vs. strong base.						
4	Determination of cell constant and conductance of solutions.						
5	Potentiometry - determination of redox potentials and emfs.						
6	Determination of Strength of an acid in Pb-Acid battery.						
7	Preparation of a Bakelite.						
8	Verify Lambert-Beer's law.						
9	Wavelength measurement of sample through UV-Visible Spectroscopy.						
10	Identification of simple organic compounds by IR.						
11	Preparation of nanomaterials by precipitation method.						
12	Estimation of Ferrous Iron by Dichrometry.						
LEARNING RESOURCES							
TEXT BOOKS:							
1	Chemistry lab Manual. Prepared by Department of Chemistry, MVGR College of Engineering (A)						
REFERENCE BOOKS:							
1	J. Mendham, R. C. Denney, J. D. Barnes, and B. Sivasankar, <i>Vogel's textbook of quantitative chemical analysis</i> . New Delhi: Pearson, 2009.						
ADDITIONAL REFERENCE MATERIAL							
1	https://www.youtube.com/@spardhayavardhatheyvidya3470						

R23EEL201	ELECTRICAL AND ELECTRONICS ENGINEERING LAB (Common to All Branches of Engineering)					
	Total Contact Hours	45 (P)	L	T	P	C
	Pre-requisite	Nil	0	0	3	1.5
Course Objective						
To impart knowledge on design and practical verification basic electrical and electronic circuits and simple energy calculation.						
Course Outcomes: Student will be able to						
1	Design and analyze simple circuits to verify basic electrical laws and theorems.					
2	Design and analyze electrical circuits to measure resistance, power and energy consumption.					
3	Understand the voltage buildup procedure in DC shunt generator.					
4	Design simple electronic circuits to analyze the behavior of electronic components and verify their applications.					
5	Explain the operation of digital circuits.					
List of Experiments						
1	Verification of KCL and KVL					
2	Verification of Superposition theorem					
3	Measurement of Resistance using Wheat stone bridge					
4	Magnetization Characteristics of DC shunt Generator					
5	Measurement of Power and Power factor using Single-phase wattmeter					
6	Calculation of Electrical Energy for Domestic Premises					
7	Plot V-I characteristics of PN Junction diode A) Forward bias B) Reverse bias.					
8	Plot V – I characteristics of Zener Diode and its application as voltage Regulator.					
9	Implementation of half wave and full wave rectifiers					
10	Plot Input & Output characteristics of BJT in CE and CB configurations					
11	Verification of Truth Table of AND, OR, NOT, NAND, NOR, Ex-OR, Ex-NOR gates using ICs.					
12	Verification of Truth Tables of S-R, J-K& D flip flops using respective ICs.					
Additional experiments						
1	Measurement of Earth Resistance using Megger					
2	Frequency response of CE amplifier					
3	Simulation of RC coupled amplifier with the design supplied					
LEARNING RESOURCES						
TEXT BOOKS:						
1	D. C. Kulshreshtha, <i>Basic Electrical Engineering</i> , Tata McGraw Hill, 2019.					
2	P.V. Gupta, M.L. Soni, U.S. Bhatnagar and A. Chakrabarti, <i>Power System Engineering</i> , Dhanpat Rai & Co, 2013.					
3	R. S. Sedha, <i>A Textbook of Electronic Devices and Circuits</i> , S. Chand & Co, 2010.					
REFERENCE BOOKS:						
1	V.K. Mehtha, <i>Principles of Electrical and Electronics Engineering</i> , S.Chand Technical Publishers, 2020.					
2	S. K. Bhattacharya, <i>Basic Electrical and Electronics Engineering</i> , Person Publications, 2018.					
3	R. P. Jain, <i>Modern Digital Electronics</i> , Tata Mc Graw Hill, 2009					

ADDITIONAL REFERENCE MATERIAL

1	https://www.udemy.com/course/complete-course-on-electronic-devices-and-circuits/
2	http://nptel.iitm.ac.in/
3	http://www.learningware.in/

R23CSEL201	COMPUTER PROGRAMMING LAB (Common to all branches of Engineering)						
	Total Contact Hours	45 (P)	L	T	P	C	
	Pre-requisite	NIL	0	0	3	1.5	
Course Objective							
The course aims to give students hands – on experience and train them on the concepts of the C- programming language.							
Course Outcomes							
1	Read, understand, and trace the execution of programs written in C language.						
2	Select the right control structure for solving the problem.						
3	Develop C programs which utilize memory efficiently using programming constructs like pointers.						
4	Develop, Debug and Execute programs to demonstrate the applications of arrays, functions, basic concepts of pointers in C.						
LIST OF EXPERIMENTS							
1	WEEK 1: Familiarization with programming environment. i Basic Linux environment and its editors like Vi, Vim & Emacs, gedit etc. ii Exposure to Turbo C, gcc iii Writing simple programs using printf(), scanf()						
2	WEEK 2 Developing the algorithms/flowcharts for the following sample programs i Sum and average of 3 numbers ii Conversion of Fahrenheit to Celsius and vice versa iii Simple interest calculation						
3	WEEK 3 Simple computational problems using arithmetic expressions. i Finding the square root of a given number ii Finding compound interest iii Area of a triangle using heron’s formulae iv Distance travelled by an object						
4	WEEK 4: Simple computational problems using the operator’ precedence and associativity i Evaluate the following expressions. a. A+B*C+(D*E) + F*G b. A/B*C-B+A*D/3 c. A+++B---A d. J= (i++) + (++i) ii Find the maximum of three numbers using conditional operator iii Take marks of 5 subjects in integers, and find the total, average in float						
5	WEEK 5: Problems involving if-then-else structures.: i Write a C program to find the max and min of four numbers using if-else. ii Write a C program to generate electricity bill. iii Find the roots of the quadratic equation. iv Write a C program to simulate a calculator using switch case. v Write a C program to find the given year is a leap year or not.						
6	WEEK 6: Iterative problems: i Find the factorial of given number using any loop. ii Find the given number is a prime or not. iii Compute sine and cos series						

	- iv Checking a number palindrome - v Construct a pyramid of numbers.
7	WEEK 7: Array manipulation, linear search - i Find the min and max of a 1-D integer array. - ii Perform linear search on 1D array. - iii The reverse of a 1D integer array - iv Find 2's complement of the given binary number. - v Eliminate duplicate elements in an array
8	WEEK 8: Matrix problems, String operations, Bubble sort - i Addition of two matrices - ii Multiplication two matrices - iii Sort array elements using bubble sort - iv Concatenate two strings without built-in functions - v Reverse a string using built-in and without built-in string functions
9	WEEK 9: Pointers and structures, memory dereference. - i Write a C program to find the sum of a 1D array using malloc() - ii Write a C program to find the total, average of n students using structures - iii Enter n students data using calloc() and display failed students list - iv Read student name and marks from the command line and display the student details along with the total. - v Write a C program to implement realloc()
10	WEEK 10: - i Read and print a date using dd/mm/yyyy format using bit-fields and differentiate the same without using bit- fields - ii Create and display a singly linked list using self-referential structure. - iii Demonstrate the differences between structures and unions using a C program. - iv Write a C program to shift/rotate using bitfields. iv) Write a C program to copy one structure variable to another structure of the same type.
11	WEEK 11: Simple functions using call by value, solving differential equations using Eulers theorem. - i Write a C function to calculate NCR value. - ii Write a C function to find the length of a string. - iii Write a C function to transpose of a matrix. - iv Write a C function to demonstrate numerical integration of differential equations using Euler's method
12	WEEK 12: Recursive functions: - i Write a recursive function to generate Fibonacci series. - ii Write a recursive function to find the lcm of two numbers. - iii Write a recursive function to find the factorial of a number. - iv Write a C Program to implement Ackermann function using recursion. - v Write a recursive function to find the sum of series.
13	WEEK 13: Simple functions using Call by reference, Dangling pointers. - i Write a C program to swap two numbers using call by reference. - ii Demonstrate Dangling pointer problem using a C program. - iii Write a C program to copy one string into another using pointer. - iv Write a C program to find no of lowercase, uppercase, digits and other characters using pointers.
14	WEEK 14:

	File operations - i Write a C program to write and read text into a file. - ii Write a C program to write and read text into a binary file using fread() and fwrite() - iii Copy the contents of one file to another file. - iv Write a C program to merge two files into the third file using command-line arguments. - v Find no. of lines, words and characters in a file vi) Write a C program to print last n characters of a given file.
TEXT BOOKS:	
1	Ajay Mittal, <i>Programming in C: A practical approach</i> , Pearson.
2	Byron Gottfried, <i>Schaum's Outline of Programming with C</i> , McGraw Hill
REFERENCE BOOKS:	
1	Brian W. Kernighan and Dennis M. Ritchie, <i>The C Programming Language</i> , Prentice- Hall of India, 1988.
2	<i>C Programming, A Problem-Solving Approach</i> , Forouzan, Gilberg, Prasad, CENGAGE, 2011.
ONLINE COURSES:	
1	https://mvgrce.codetantra.com

R23HSSM802	NSS/NCC/SCOUTS & GUIDES/COMMUNITY SERVICE (Common to All Branches of Engineering)					
	Total Contact Hours	15 (P)	L	T	P	C
	Pre-requisite	Nil	0	0	1	0.5
Course Objective						
The objective of introducing this course is to impart discipline, character, fraternity, teamwork, social consciousness among the students and engaging them in selfless service.						
Course Outcomes						
1	Demonstrate the importance of discipline, character and service motto.					
2	Solve some societal issues by applying acquired knowledge, facts, and techniques.					
3	Explore human relationships by analyzing social problems.					
4	Develop service-oriented approach to extend their help for the fellow beings and downtrodden people.					
5	Develop leadership skills and civic responsibilities.					
SYLLABUS						
Unit I	General Orientation on NSS/NCC/ Scouts & Guides/Community Service activities, career guidance. Activities: i) Conducting –ice breaking sessions-expectations from the course-knowing personal talents and skills ii) Conducting orientations programs for the students –future plans-activities-releasing road map etc. iii) Displaying success stories-motivational biopics- award winning movies on societal issues etc. iv) Conducting talent show in singing patriotic songs-paintings- any other contribution.					5 hr
Unit II	NATURE & CARE Activities: i) Nature & Care Best out of waste competition. ii) Poster and signs making competition to spread environmental awareness. iii) Recycling and environmental pollution article writing competition. iv) Organizing Zero-waste day. v) Digital Environmental awareness activity via various social media platforms. vi) Virtual demonstration of different eco-friendly approaches for sustainable living. vii) Write a summary on any book related to environmental issues.					5 hr
Unit III	COMMUNITY SERVICE Activities: i) Community Service Conducting One Day Special Camp in a village contacting village-area leaders- Survey in the village, identification of problems- helping them to solve via media-authorities- experts-etc. 24 JNTUGV B. Tech. R23 Regulations ii) Conducting awareness programs on Health-related issues such as General Health, Mental health, Spiritual Health, HIV/AIDS, iii) Conducting consumer Awareness. Explaining various legal provisions etc. iv) Women Empowerment Programmes- Sexual Abuse, Adolescent Health and Population Education. v) Any other programmes in collaboration with local charities, NGOs etc.					5 hr

LEARNING RESOURCES	
REFERENCE BOOKS:	
1	Nirmalya Kumar Sinha & Surajit Majumder, <i>A Text Book of National Service Scheme Vol;.I</i> , Vidya Kutir Publication, 2021 (ISBN 978-81-952368-8-6)
2	Red Book - <i>National Cadet Corps – Standing Instructions Vol I & II</i> , Directorate General of NCC, Ministry of Defence, New Delhi
3	Davis M. L. and Cornwell D. A., <i>Introduction to Environmental Engineering</i> , McGraw Hill, New York 4/e 2008
4	Masters G. M., Joseph K. and Nagendran R. <i>Introduction to Environmental Engineering and Sciencell</i> , Pearson Education, New Delhi. 2/e 2007.
5	Ram Ahuja. <i>Social Problems in India</i> , Rawat Publications, New Delhi.

II Semester

R23HSST001	COMMUNICATIVE ENGLISH						
	(Common to All Branches of Engineering)						
	Total Contact Hours	30 (L)	L	T	P	C	
	Pre-requisite	Nil	2	0	0	2	
Course Objective							
The student will be able to apply the concepts of comprehension, Interpretation and structured presentation in varied contexts and demonstrate skilled communication.							
Course Outcomes							
1	Developing the ability to comprehend, analyze and elicit information.						
2	Demonstrating the skill of Structured thinking.						
3	Developing Competency to summarize and paraphrase content in different materials.						
4	Demonstrating the skill of constructive presentation.						
5	Building communicative competence.						
SYLLABUS							
Unit I	THEME: HUMAN VALUES Sample Text: <i>The Power of a Plate of Rice</i> (short story) by Ifeoma Okoye Supplementary Text: <i>The Lament</i> by Anton Chekov Listening: Identifying the topic, the context and specific pieces of information by listening to short audio texts and answering a series of questions. Speaking: Asking and answering general questions on familiar topics such as home, family, work, studies and interests; introducing oneself and others. Reading: Skimming to get the main idea of a text; scanning to look for specific pieces of information. Writing: Mechanics of Writing-Capitalization, Spellings, Punctuation-Parts of Sentences. (Remedial learning with additional resources.) Grammar: Parts of Speech, Basic Sentence Structures-forming questions. (Remedial learning with additional resources.) Vocabulary: Synonyms, Antonyms, Affixes (Prefixes/Suffixes), Root words						6 hr
Unit II	Theme: NATURE Sample Text: <i>Night of the Scorpion</i> (poem) by Nissim Ezekiel Supplementary Text: 'IF' by Rudyard Kipling Listening: Answering a series of questions after listening to audio texts. Speaking: Discussion in pairs/small groups on specific topics. Reading: Identifying sequence of ideas; recognizing verbal techniques that help to link the ideas in a paragraph together. Writing: Structure of a paragraph - Paragraph writing (specific topics) Grammar: Cohesive devices - linkers, use of articles and zero article prepositions. Vocabulary: Homonyms, Homophones, Homographs.						6 hr
Unit III	Lesson: BIOGRAPHY of Steve Jobs Supplementary Text: Biography of Tenzing Norgay Listening: Listening for global comprehension and summarizing. Speaking: Discussing specific topics in pairs or small groups and reporting what is discussed. Reading: Reading a text in detail by making basic inferences-recognizing and interpreting specific context clues; strategies to use text clues for comprehension.						6 hr

	Writing: Summarizing, Note-making, paraphrasing Grammar: Verbs - tenses; subject-verb agreement Vocabulary: Compound words, Collocations	
Unit IV	Lesson: INSPIRATION: The Toys of Peace by Saki Supplementary Text: <i>The Man Who Planted Trees</i> by Jean Giono Listening: Making predictions while listening to conversations/ transactional dialogues without video; listening with video. Speaking: Role plays for the practice of conversational English in academic contexts (formal and informal) - asking for and giving information/directions. Reading: Studying the use of graphic elements in texts to convey information, reveal trends/patterns/relationships, communicate processes or display complicated data. Writing: Letter Writing: Official Letters, Resumes. Grammar: Reporting verbs, Direct & Indirect speech, Active & Passive Voice. Vocabulary: Words often confused, Jargon.	6 hr
Unit V	Lesson: MOTIVATION: The Power of Intrapersonal Communication (An Essay) Listening: Identifying key terms, understanding concepts and answering a series of relevant questions that test comprehension. Speaking: Formal oral presentations Reading: Reading comprehension. Writing: Writing structured essays on specific topics. Grammar: Editing short texts –identifying and correcting common errors in grammar (articles, prepositions, tenses, subject-verb agreement) Vocabulary: Technical Jargon.	6 hr

LEARNING RESOURCES

TEXT BOOKS:

1	Pathfinder: <i>Communicative English for Undergraduate Students</i> , 1 st Edition, Orient Black Swan, 2023.
2	<i>Empowering English</i> by Cengage Publications, 2023.

REFERENCE BOOKS:

1	Dubey, Sham Ji & Co. <i>English for Engineers</i> , Vikas Publishers, 2020.
2	Bailey, Stephen. <i>Academic writing: A Handbook for International Students</i> . Routledge, 2014.
3	Murphy, Raymond. <i>English Grammar in Use</i> , Fourth Edition, Cambridge University Press, 2019.
4	Lewis, Norman. <i>Word Power Made Easy- The Complete Handbook for Building Superior Vocabulary</i> . Anchor, 2014.

WEB RESOURCES:

1. www.bbc.co.uk/learningenglish
2. <https://dictionary.cambridge.org/grammar/british-grammar/>
3. www.eslpod.com/index.html
4. <https://www.learngrammar.net/32>
5. <https://english4today.com/english-grammar-online-with-quizzes/>
6. <https://www.talkenglish.com/grammar/grammar.aspx>

Bloom's level - Units catchment articulation matrix

CO	Blooms Level	Unit I	Unit II	Unit III	Unit IV	Unit V
CO1	BL6	X	X	X	X	X
CO2	BL3		X			
CO3	BL6			X		
CO4	BL3	X	X	X	X	X
CO5	BL6	X	X	X	X	X

R23MATT102	DIFFERENTIAL EQUATIONS AND VECTOR CALCULUS (Common to All Branches of Engineering)						
	Total Contact Hours	45 (L)	L	T	P	C	
	Pre-requisite	Nil	3	0	0	3	
Course Objective							
1	To enlighten the learners in the concept of differential equations and multivariable calculus.						
2	To furnish the learners with basic concepts and techniques at plus two level to lead them in to advanced level by handling various real-world applications.						
Course Outcomes							
1	Solve first order differential equations and make use of them to deal with real word problems like law of cooling, growth, decay and electrical circuits.						
2	Solve the higher order differential equations to make use of them to deal with real word problems like LCR circuits and simple harmonic motion.						
3	Solve the partial differential equations by various methods.						
4	Interpret the physical meaning of different operators such as gradient, curl and divergence.						
5	Estimate the work done against a field, circulation and flux using vector calculus.						
6	Formulate Mathematical models and estimate appropriate physical quantities.						
SYLLABUS							
Unit I	DIFFERENTIAL EQUATIONS OF FIRST ORDER AND FIRST DEGREE						9 hr
Linear differential equations – Bernoulli's equations- Exact equations and equations reducible to exact form. Applications: Newton's Law of cooling – Law of natural growth and decay- Electrical circuits.							
Unit II	LINEAR DIFFERENTIAL EQUATIONS OF HIGHER ORDER (CONSTANT COEFFICIENTS)						9 hr
Definitions, homogenous and non-homogenous, complimentary function, general solution, particular integral, Wronskian, method of variation of parameters. Simultaneous linear equations, Applications to L-C-R Circuit problems and Simple Harmonic motion.							
Unit III	PARTIAL DIFFERENTIAL EQUATIONS						9 hr
Introduction and formation of Partial Differential Equations by elimination of arbitrary constants and arbitrary functions, solutions of first order linear equations using Lagrange's method. Homogeneous Linear Partial differential equations with constant coefficients.							
Unit IV	VECTOR DIFFERENTIATION						9 hr
Scalar and vector point functions, vector operator del, del applies to scalar point functions -Gradient, del applied to vector point functions - Divergence and Curl, vector identities.							
Unit V	VECTOR INTEGRATION						9 hr
Line integral – circulation - work done, surface integral - flux, Green's theorem in the plane (without proof), Stoke's theorem (without proof), volume integral, Divergence theorem (without proof) and applications of these theorems.							

LEARNING RESOURCES	
TEXT BOOKS:	
1	Erwin Kreyszig, <i>Advanced Engineering Mathematics</i> , 10/e, John Wiley & Sons, 2018.
2	B.S.Grewal, <i>Higher Engineering Mathematics</i> , 44/e, Khanna Publishers, 2017.
REFERENCE BOOKS:	
1	Dennis G.Zill and Warren S.Wright, <i>Advanced Engineering Mathematics</i> , Jones and Bartlett, 2018.
2	Michael Green Berg, <i>Advanced Engineering Mathematics</i> , 9 th edition, Pearson edn
3	George B.Thomas, Maurice D. Weir and Joel Hass, <i>Thomas Calculus</i> ,14/e, Pearson Publishers, 2018.
4	R. K. Jain and S. R. K. Iyengar, <i>Advanced Engineering Mathematics</i> , 5/e, Alpha Science International Ltd., 2021 (9th reprint).
5	B.V. Ramana, <i>Higher Engineering Mathematics</i> , Mc Graw Hill Education, 2017.

Bloom's level - Units catchment articulation matrix

CO	Blooms Level	Unit I	Unit II	Unit III	Unit IV	Unit V
CO1	BL 3	X				
CO2	BL 3		X			
CO3	BL 3			X		
CO4	BL 3				X	
CO5	BL 5					X
CO6	BL 6	X	X	X	X	X

R23PHYT101	ENGINEERING PHYSICS (Common to All Branches of Engineering)					
	Total Contact Hours	45 (L)	L	T	P	C
	Pre-requisite	Nil	3	0	0	3
Course Objective						
To bridge the gap between the Physics in school at 10+2 level and UG level engineering courses by identifying the importance of the optical phenomenon like interference, diffraction etc. Enlightening the periodic arrangement of atoms in crystalline solids and concepts of quantum mechanics, introduce novel concepts of dielectric and magnetic materials, physics of semiconductors.						
Course Outcomes						
1	Student will be able to analyze the intensity variation of light due to interference, diffraction and polarization					
2	Student will be able to investigate the crystallographic phase of the unknown specimen by using the X-ray diffraction method					
3	Student will be able to interpret the various polarization mechanisms and their frequency dependence in dielectrics; and choose a magnetic material for a given application based on the domain model.					
4	Student will be able to deduce the quantized facets for a free electron in a potential box, and extend the same to explain the electrical conductivity and Fermi energy of metals.					
5	Student will be able to classify the solids, analyze the semiconductor charge carrier concentrations, and identify the semiconductor type by using the Hall effect.					
6	Student will be able to elaborate the optical phenomena, crystallographic phase, magneto-dielectric physiognomies, quantum confinement effects, and the rudiments of semiconductor band model.					
SYLLABUS						
Unit I	WAVE OPTICS					9 hr
Interference: Introduction - Principle of superposition -Interference of light - Interference in thin films (Reflection Geometry) & applications - Colors in thin films- Newton's Rings- Determination of wavelength and refractive index. Diffraction: Introduction - Fresnel and Fraunhofer diffractions - Fraunhofer diffraction due to single slit, double slit & N-slits (Qualitative) – Diffraction Grating - Dispersive power and resolving power of Grating (Qualitative). Polarization: Introduction -Types of polarization - Polarization by reflection, refraction and Double refraction - Nicol's Prism -Half wave and Quarter wave plates.						
Unit II	CRYSTALLOGRAPHY AND X-RAY DIFFRACTION					9 hr
Crystallography: Space lattice, Basis, Unit Cell and lattice parameters – Bravais Lattices – crystal systems (3D) – coordination number - packing fraction of SC, BCC & FCC - Miller indices – separation between successive (hkl) planes. X-ray diffraction: Bragg's law - X-ray Diffractometer – crystal structure determination by Laue's and powder methods.						
Unit III	DIELECTRIC AND MAGNETIC MATERIALS					9 hr
Dielectric Materials: Introduction - Dielectric polarization - Dielectric polarizability, Susceptibility, Dielectric constant and Displacement Vector –Relation between the electric vectors - Types of polarizations- Electronic (Quantitative), Ionic (Quantitative) and Orientation polarizations (Qualitative) - Lorentz internal field - Clausius- Mossotti equation - complex dielectric constant – Frequency dependence of polarization – dielectric loss. Magnetic Materials: Introduction - Magnetic dipole moment - Magnetization-Magnetic susceptibility and permeability – Atomic origin of magnetism -Classification of magnetic materials: Dia, para, Ferro, anti-ferro& Ferri magnetic materials - Domain concept for Ferromagnetism & Domain walls						

(Qualitative) - Hysteresis - soft and hard magnetic materials.		
Unit IV	QUANTUM MECHANICS AND FREE ELECTRON THEORY	9 hr
Quantum Mechanics: Dual nature of matter – Heisenberg’s Uncertainty Principle – Significance and properties of wave function – Schrodinger’s time independent and dependent wave equations– Particle in a one-dimensional infinite potential well. Free Electron Theory: Classical free electron theory (Qualitative with discussion of merits and demerits) – Quantum free electron theory –electrical conductivity based on quantum free electron theory - Fermi-Dirac distribution - Density of states - Fermi energy.		
Unit V	SEMICONDUCTORS	9 hr
Semiconductors: Formation of energy bands – classification of crystalline solids - Intrinsic semiconductors: Density of charge carriers – Electrical conductivity – Fermi level – Extrinsic semiconductors: density of charge carriers – dependence of Fermi energy on carrier concentration and temperature - Drift and diffusion currents – Einstein’s equation - Hall effect and its applications.		
LEARNING RESOURCES		
TEXT BOOKS:		
1	M. N. Avadhanulu, P.G.Kshirsagar & TVS Arun Murthy, <i>A Text book of Engineering Physics</i> , 11 th Edition, S.Chand Publications, 2019.	
2	D.K.Bhattacharya and Poonam Tandon, <i>Engineering Physics</i> , 1 st Edition, Oxford press, 2015.	
REFERENCE BOOKS:		
1	B.K. Pandey and S. Chaturvedi, <i>Engineering Physics</i> , 2 nd Edition, Cengage Learning, 2021.	
2	Shatendra Sharma, Jyotsna Sharma, <i>Engineering Physics</i> , 1 st Edition, Pearson Education, 2018.	
3	Sanjay D. Jain, D. Sahasrabudhe and Girish, <i>Engineering Physics</i> , 1 st Edition, University Press, 2010.	
4	M.R. Srinivasan, <i>Engineering Physics</i> , 1 st Edition, New Age international publishers, 2009	
ONLINE COURSES:		
1	https://archive.nptel.ac.in/courses/122/107/122107035/	
2	https://www.youtube.com/watch?v=GQ5XpeS3e3U&list=PLLy_2iUCG87B_Tmfs0y2tR8GNIkyRIKpW	
3	https://archive.nptel.ac.in/courses/112/106/112106227/	
4	https://archive.nptel.ac.in/courses/115/101/115101107/	
5	https://archive.nptel.ac.in/courses/108/108/108108122/	

Bloom’s level - Units catchment articulation matrix

CO	Blooms Level	Unit-1	Unit-2	Unit-3	Unit-4	Unit-5
CO1	BL4	X				
CO2	BL5		X			
CO3	BL5			X		
CO4	BL4				X	
CO5	BL4					X
CO6	BL6	X	X	X	X	X

R23CMET201	BASIC CIVIL AND MECHANICAL ENGINEERING (Common to All branches of Engineering)					
	Total Contact Hours	48	L	T	P	C
	Pre-requisite	Nil	3	0	0	3
Course Objectives						
1	Get familiarized with the scope and importance of Civil and Mechanical Engineering in different sectors and industries.					
2	Introduce the preliminary concepts of Building Planning, Building Construction, Materials and the related tests.					
3	Provide preliminary knowledge of surveying and understand the importance of transportation and the water resources in terms of quantity and quality.					
4	Explain different engineering materials and manufacturing processes.					
5	Provide an overview of different thermal and mechanical systems; introduce basics of robotics and its applications.					
Course Outcomes						
1	Compile the role of a Civil Engineer in his multifaceted tasks and Discuss the principles of building planning and various construction aspects including materials					
2	Solve for areas of irregular boundaries by means of lengths and bearings and for reduced level of an object					
3	Elaborate the importance of Transportation in Nation's economy and the engineering measures related to highways in terms of geometrics and water resources and storage structures to appreciate the social responsibility of water conservation in terms of quality and quantity.					
4	Adapt and integrate the mechanical engineering technologies in various Industrial sectors, and choose appropriate engineering materials for engineering applications.					
5	Express the working of different manufacturing processes, refrigeration and air-conditioning cycles, IC engines, electric and hybrid vehicles.					
6	Express and write the working of power plants, mechanical power transmission systems, and different robotic configurations.					
SYLLABUS						
PART A: BASIC CIVIL ENGINEERING						
Unit I	BASICS OF CIVIL ENGINEERING					8 hr
Basics of Civil Engineering: Role of Civil Engineers in Society- Various Disciplines of Civil Engineering- Structural Engineering- Geo-Technical Engineering- Transportation Engineering - Hydraulics and Water Resources Engineering - Environmental Engineering-Scope of each discipline - Building Construction and Planning- Construction Materials-Cement - Aggregate - Bricks-Cement concrete- Steel-Tests on these materials. Factors to be considered in Building Planning- Nature of Buildings- Typical Layouts of a Residential Building- Industrial Building- Commercial Building like a Supermarket / Hotel / Theatre.						
Unit II	SURVEYING					8 hr
Surveying: Objectives of Surveying- Horizontal Measurements- Vertical Measurements- Angular Measurements- Levelling instruments used for levelling- Introduction to Bearings-Simple problems on levelling and bearings-Contour mapping.						

Unit III	TRANSPORTATION ENGINEERING, WATER RESOURCES AND ENVIRONMENTAL ENGINEERING	8 hr
Transportation Engineering, Water Resources and Environmental Engineering: Importance of Transportation in Nation's economic development- Types of Highway Pavements- Flexible Pavements and Rigid Pavements - Simple Differences - Basic geometric design elements of a highway- Camber- Stopping Sight Distance- Super elevation-Introduction.		
Water Resources and Environmental Engineering: Sources of water- Quality of water- Specifications and Tests- Introduction to Hydrology- Hydrograph –Rain water Harvesting- Rain water runoff- Water Storage Structures (Simple introduction to Dams and Reservoirs).		
PART B: BASICMECHANICAL ENGINEERING		
Unit IV	INTRODUCTION TO MECHANICAL ENGINEERING AND ENGINEERING MATERIALS	8 hr
Introduction to Mechanical Engineering: Role of Mechanical Engineering in Industries and Society- Technologies in different sectors such as Energy, Manufacturing, Automotive, Aerospace, and Marine sectors.		
Engineering Materials - Metals-Ferrous and Non-ferrous, Ceramics, Composites, Smart materials.		
Unit V	MANUFACTURING PROCESSES AND THERMAL ENGINEERING	8 hr
Manufacturing Processes: Principles of Casting, Forming, joining processes, Machining, Introduction to CNC machines, 3D printing, and Smart manufacturing.		
Thermal Engineering – working principle of Boilers, Otto cycle, Diesel cycle, Refrigeration and air-conditioning cycles, IC engines, 2-Stroke and 4-Stroke engines, SI/CI Engines, Components of Electric and Hybrid Vehicles.		
Unit VI	POWER PLANTS, MECHANICAL POWER TRANSMISSION AND INTRODUCTION TO ROBOTICS	8 hr
Power plants – working principle of Steam, Diesel, Hydro, Nuclear power plants.		
Mechanical Power Transmission - Belt Drives, Chain, Rope drives, Gear Drives and their applications.		
Introduction to Robotics - Joints & links, configurations, and applications of robotics.		
LEARNING RESOURCES		
TEXT BOOKS:		
1	M.S.Palanisamy, <i>Basic Civil Engineering</i> , Fourth Edition, Tata Mcgraw Hill publications (India) Pvt. Ltd, 2017.	
2	S.S. Bhavikatti, <i>Introduction to Civil Engineering</i> , First Edition, New Age International Publishers, 2022.	
3	Satheesh gopi, <i>Basic Civil Engineering</i> , First Edition, Pearson publications,2009.	
4	V.Ganesan, <i>Internal Combustion Engines</i> , 4th edition, Tata McGraw Hill publications Pvt. Ltd, 2017.	
5	S.S. Rattan, <i>Theory of Machines</i> , Fourth edition, McGraw Hill Education; 2017	
6	Jonathan Wicker and Kemper Lewis, <i>An introduction to Mechanical Engineering</i> , 3rd edition, Cengage learning India Pvt. Ltd, 2012.	
REFERENCE BOOKS:		
1	S.K. Duggal, <i>Surveying, Vol- I and Vol-II</i> , 4 th Edition, Tata McGraw Hill Publishers, 2017.	

2	Santhosh Kumar Garg, <i>Hydrology and Water Resources Engineering</i> , 23 rd Edition, Kahnna publishers, Delhi, 2016.
3	Santhosh Kumar Garg, <i>Irrigation Engineering and Hydraulic Structures</i> , 38 th Edition, Kahnna publishers, Delhi, 2023.
4	S K Khanna and C E G Justo and Veeraraghavan, <i>Highway Engineering</i> , 10 th Edition Nemchand Brothers Publications, 2019
5	Indian Standard Drinking water Specifications – IS 10500-2012
6	Appuu Kuttan KK, <i>Robotics, I.K. Volume-I</i> , International Publishing House Pvt. Ltd, 2013.
7	L. Jyothish Kumar, Pulak M Pandey, <i>3D printing & Additive Manufacturing Technology</i> , Springer publications, 2017.
8	Mahesh M Rathore, <i>Thermal Engineering</i> , Tata McGraw Hill publications (India) Pvt. Ltd, 2010.
ADDITIONAL REFERENCE MATERIAL	
1	Subramanian KP, <i>Highway, Railway, Airport and Harbour Engineering</i> , First Edition, Scitech Publications (India) Pvt. Limited, 2010.
2	M S Shetty, <i>Concrete Technology (Theory & Practice)</i> , Revised Edition, S Chand Publishers, 2006.
3	Dr. S.C. Rangwala, <i>Engineering Materials</i> , 3rd edition, Charotor Publishing House, 2018.
4	P. K. Nag, <i>Power Plant Engineering</i> , 4th edition, McGraw Hill Education, 2017.
5	James D. Halderman, Curt Ward, <i>Electric and Hybrid Electric Vehicles</i> , Pearson Education, 2023.
ONLINE COURSES	
1	https://archive.nptel.ac.in/noc/courses/noc22/SEM1/noc22-ce40/
2	https://www.udemy.com/course/surveying/
3	https://archive.nptel.ac.in/courses/112/103/112103316/
4	https://nptel.ac.in/courses/112107291

Bloom's level - Units catchment articulation matrix

CO	Blooms Level	Unit I	Unit II	Unit III	Unit IV	Unit V	Unit VI
CO1	6	X					
CO2	6		X				
CO3	6			X			
CO4	6				X		
CO5	6					X	
CO6	6						X

	INTRODUCTION TO CHEMICAL ENGINEERING						
R23CHET301	Total Contact Hours	45 (L)	L	T	P	C	
	Pre-requisite	Nil	3	0	0	3	
Course Objectives:							
Students will get familiarized with the scope and importance of Chemical Engineering in process industries and everyday life. They learn the fundamentals of Chemical Engineering such as unit operations and unit processes in Chemical industries.							
Course Outcomes							
Student will be able to,							
1	Appraise the role of Chemical Engineer in everyday life and distinguish between Unit Operations and Unit Processes (BL4)						
2	Illustrate different fluid flow models and select suitable fluid & solid handling machinery (BL3)						
3	Calculate the rate of heat transfer in heat exchange equipment (BL3)						
4	Outline various mass transfer operations and its applications (BL3)						
5	Estimate the reaction kinetics of homogeneous chemical reactions (BL5)						
6	Compile various Unit Operations and Unit Processes involved in a chemical process industry and develop material & energy balances (BL6)						
SYLLABUS							
Unit I	Basic Concepts and Introduction to Engineering Calculations						9 hr
Basic Concepts: Chemical Engineering in everyday, Applications of Chemical Engineering, Unit operations, Unit processes, Flow sheet types, Dimensionless quantities and its significance. Introduction to Engineering Calculations: material balance with chemical reaction, material balance without chemical reaction, energy balance, Chemical process plant –case study-1, Chemical process plant –case study-2.							
Unit II	Introduction to Mechanical operations and Fluid Flow						9 hr
Introduction to Mechanical operations: principles of Size reduction, types of crushers & grinders, filtration, transportation and storage of solids. Fluid Flow: Nature of the fluid, continuity equation, Bernoulli's equation, fluidization, fluid handling machinery, Relevance of mechanical unit operations and fluid mechanics in chemical engineering.							
Unit III	Introduction to Process Heat Transfer						9 hr
Introduction to Process Heat Transfer: conduction, convection, radiation, overall heat transfer coefficient, heat exchange equipment: flow arrangements, double pipe heat exchanger, shell and tube heat exchanger, evaporation, relevance of heat transfer in chemical engineering.							
Unit IV	Introduction to Mass transfer operations						9 hr
Introduction to Mass transfer operations: classification of mass transfer operations, molecular and bulk diffusion, choice of separation processes, basic principles and applications of absorption, distillation, adsorption, extraction and drying, relevance of mass transfer in chemical engineering.							
Unit V	Introduction to Reaction Engineering						9 hr
Introduction to Reaction Engineering: Classification of reactions, variables affecting the rate of reaction, rate equation, molecularity and order of reaction,							

elementary and non-elementary reaction, concentration and temperature dependency of reaction rate, types of reactors, relevance of reaction engineering in chemical engineering.

LEARNING RESOURCES

TEXT BOOKS:

1	S. K. Ghosal, S. K. Sanyal and S. Dutta, Introduction to Chemical Engineering, Fourth edition, Tata McGraw-Hill, 1993
2	S. Pushpavanam, Introduction to Chemical Engineering, First edition, PHI, 2012

REFERENCE BOOKS:

1	W.L. McCabe, J.C. Smith and Peter Harriott, Unit operations in Chemical Engineering, Seventh Edition, McGraw Hill, 2005
2	Incropera, Dewitt, Bergman and Lavine, Principles of Heat and Mass Transfer, Global Edition, Wiley India Edition, 2017
3	Richard M. Felder and Ronald W. Rousseau, Elementary Principles of Chemical Processes, Fourth edition, John Wiley & Sons, INC., 2018

Bloom's level - Units catchment articulation matrix

CO	Blooms Level	Unit I	Unit II	Unit III	Unit IV	Unit V
CO-1	BL4	X				
CO-2	BL3		X			
CO-3	BL3			X		
CO-4	BL3				X	
CO-5	BL5					X
CO-6	BL6	X	X	X	X	X

R23HSSL001	COMMUNICATIVE ENGLISH LAB (Common to All Branches of Engineering)					
	Total Contact Hours	30 (P)	L	T	P	C
	Pre-requisite	Nil	0	0	2	1
Course Objective						
The main objective of the course is to expose the students to a variety of self-instructional, learner friendly modes of language learning. The students will get trained in basic communication skills to become industry ready.						
Course Outcomes						
1	Demonstrate understanding of the different aspects of English language proficiency with emphasis on LSRW skills.					
2	Develop communication skills by exposing the student to various language learning activities.					
3	Analyze and apply techniques to comprehend information in audio/video material.					
4	Develop professionalism by facilitating debates and group discussions.					
5	Demonstrate effective presentation skills.					
List of Topics						
1	Communication Skills & JAM					
2	Articulation of sounds & Listening to comprehend information					
3	Role Play or Conversational Practice					
4	E-mail Writing					
5	Resume Writing, Cover letter writing					
6	Group Discussions-methods & practice					
7	Debates - Methods & Practice					
8	PPT Presentations/ Poster Presentation					
9	Interview skills					
LEARNING RESOURCES						
REFERENCE BOOKS:						
1	Raman Meenakshi, Sangeeta-Sharma, <i>Technical Communication</i> , Oxford Press, 2018.					
2	Taylor Grant, <i>English Conversation Practice</i> , Tata McGraw-Hill Education India, 2016.					
3	Hewing's, Martin, <i>Cambridge Academic English (B2)</i> , CUP, 2012.					
4	J. Sethi & P.V. Dhamija, <i>A Course in Phonetics and Spoken English</i> , (2nd Ed), Kindle, 2013.					
WEB RESOURCES						
1. www.esl-lab.com						
2. www.englishmedialab.com						
3. www.englishinteractive.net						
4. https://www.britishcouncil.in/english/online						
5. http://www.letstalkpodcast.com/						

R23PHYL101	ENGINEERING PHYSICS LAB (Common to All Branches of Engineering)							
	Total Contact Hours	30 (P)			L	T	P	C
	Pre-requisite	Higher Secondary School Physics			0	0	2	1
Course Objective								
To complement classroom learning with laboratory experiments. Calibration of instruments like travelling-microscope, spectrometer, etc. and to make precise measurements. Understand the physical principles involved in the conduct of experiment and measure the relevant experimental variables. Apply the analytical techniques and graphical analysis to experimental data and draw necessary conclusions. Prepare a concise and clear technical report to communicate his/her experimental understanding.								
Course Outcomes								
1	Student will be able to conduct experiments to reconnoitre the interference and diffraction patterns of light.							
2	Student will be able to find the signature variation of magnetic field due to current; and the hysteresis energy loss in a magnetic material.							
3	Student will be able to measure the physiognomies of the semiconductor devices like the energy band gap (E_g) and the temperature coefficient of resistance (α).							
4	Student will be able to observe the pendulum oscillations and determine the impelling parameters like rigidity modulus (η), acceleration due to gravity (g), etc.							
5	Student will be able to verify the laws of vibrations and determine the unknown fork frequency by forming standing waves on stretched strings.							
List of Experiments								
1	Determination of radius of curvature of a given plano-convex lens by Newton's rings.							
2	Determination of wavelengths of different spectral lines in mercury spectrum using diffraction grating in normal incidence configuration.							
3	Study the variation of B versus H by magnetizing the magnetic material (B-H curve).							
4	Determination of wavelength of Laser light using diffraction grating							
5	Determination of energy gap of a semiconductor using p-n junction diode							
6	Magnetic field along the axis of a current carrying circular coil by Stewart and Gee's Method							
7	Determination of temperature coefficients of a thermistor							
8	Determination of rigidity modulus of the material of the given wire using Torsional pendulum							
9	Determination of frequency of the electrically maintained tuning fork by Melde's experiment							
10	Sonometer: Verification of the laws of stretched string							
Additional experiments								
1	Determination of acceleration due to gravity and radius of Gyration by using a compound pendulum							
LEARNING RESOURCES								
TEXT BOOKS:								
1	S. Balasubramanian, M.N. Srinivasan, <i>A Textbook of Practical Physics</i> , S. Chand Publishers, 2017.							
REFERENCE BOOKS:								
1	C.S. Robinson and Dr. Ruby Das, <i>A Textbook of Engineering Physics Practical</i> , 1 st Edition Laxmi Publications Pvt. Ltd., 2016.							
ADDITIONAL REFERENCE MATERIAL								
1	www.vlab.co.in							

R23MECW201	ENGINEERING WORKSHOP (Common to All Branches of Engineering)					
	Total Contact Hours	45 (P)	L	T	P	C
	Pre-requisite	Nil	0	0	3	1.5
Course Objective						
Students will understand various engineering trades such as carpentry, tin smithy, foundry, fabrication, fitting and electrical house wiring skills and required safety practice required and address common trouble shooting in day- today practice.						
Course Outcomes						
1	Identify workshop tools and their operational capabilities.					
2	Practice on manufacturing of components using workshop trades including fitting, carpentry, foundry and welding.					
3	Apply concept of fitting and sheet metal understanding in various applications.					
4	Apply basic electrical engineering knowledge for House Wiring Practice.					
Syllabus						
1	Demonstration: Safety practices and precautions to be observed in workshop.					
2	Wood Working: Familiarity with different types of woods and tools used in wood working and make following joints. a) Half – Lap joint b) Mortise and Tenon joint c) Corner Dovetail joint or Bridle joint					
3	Sheet Metal Working: Familiarity with different types of tools used in sheet metal working, Developments of following sheet metal job from GI sheets. a)Tapered tray b) Conical funnel c) Elbow pipe d)Brazing					
4	Fitting: Familiarity with different types of tools used in fitting and do the following fitting exercises. a) V-fit b)Dovetail fit c) Semi-circular fit d) Bicycle tire puncture and change of two-wheeler tyre					
5	Electrical Wiring: Familiarity with different types of basic electrical circuits and make the following connections. a) Parallel and series b) Two-way switch c) Godown lighting d) Tube light e) Three phase motor f) Soldering of wires					
6	Foundry Trade: Demonstration and practice on Moulding tools and processes, Preparation of Green Sand Moulds for given Patterns.					
7	Welding Shop: Demonstration and practice on Arc Welding and Gas welding. Preparation of Lap joint and Butt joint.					
8	Plumbing: Demonstration and practice of Plumbing tools, Preparation of Pipe joints with coupling for same diameter and with reducer for different diameters.					
Additional Experiments						
1	Making of study lamp using combination of carpentry and house wiring trades.					
2	Frame making of dissemination using carpentry and welding.					
3	Electric Load calculation in a living room.					
4	Demonstration of connection in street lights using single control.					
LEARNING RESOURCES						
TEXT BOOKS:						
1	W. Felix, Basic Workshop Technology: Manufacturing Process, Independently Published, 2019.					
2	Bruce J. Black, Workshop Processes, Practices and Materials, Routledge publishers, 5th Edn. 2015.					
3	B.S. Raghuwanshi, Dhanpath Rai & Co., A Course in Workshop Technology					

	Vol I. & II, Dhanpat Rai& Co. 2015 & 2017.
REFERENCE BOOKS:	
1	S. K. Hajra Choudhury, <i>Elements of Workshop Technology, Vol. I.</i> 14th edition, Media Promoters and Publishers, Mumbai, 2007.
2	H. S. Bawa, <i>Workshop Practice</i> , Tata-McGraw Hill, 2004.
3	P.M.Soni & P.A.Upadhyay, <i>Wiring Estimating, Costing and Contracting</i> , Atul Prakashan, 2021-22.
ADDITIONAL REFERENCE MATERIAL:	
1	https://mrcet.com/downloads/hs/EWS-ITWS%20%20LAB%20MANUAL.pdf
2	https://sjce.ac.in/wp-content/uploads/2018/04/Workshop-Laboratory-Manual.pdf
3	https://manavrachna.edu.in/latest/virtual-lab-workshop-for-first-year-engineering-students-mru/

R23CSEW201	IT WORKSHOP					
	(Common to all branches of Engineering)					
	Total Contact Hours	30 (P)	L	T	P	C
	Pre-requisite	NIL	0	0	2	1
Course Objective						
To introduce the internal parts of a computer, peripherals, I/O ports, connecting cables , operating systems, Compression, Multimedia, Antivirus tools and Office Tools such as Word processors, spreadsheets, and Presentation tools.						
Course Outcomes						
1	Students will be able to analyze Hardware troubleshooting.					
2	Students will be able to identify Hardware components and inter dependencies.					
3	Students will be able to choose safeguard computer systems from viruses/worms.					
4	Students will be able to Create document and power point presentation.					
5	Students will be able to develop calculations using spreadsheets.					
List of Experiments						
1	Week-1: PC Hardware & Software Installation 1) Identify the peripherals of a computer, components in a CPU, and functions. Draw the block diagram of the CPU along with the configuration of each peripheral and submit to your instructor. 2) Every student should disassemble and assemble the PC back to working condition. Lab instructors should verify the work and follow it up with a Viva. Also, students must go through the video showing the PC assembling process. A video would be given as part of the course content.					
2	Week-2: 1) Students should install MS windows on their personal computer. The lab instructor should verify the installation and follow it with a Viva.					
3	Week-3: 1) Every student should install Linux on the computer. This computer should have Windows installed. The system should be configured as dual boot (VMWare) with Windows and Linux. Lab instructors should verify the installation and follow it up with a Viva. 2) Every student should install BOSS on the computer. The system should be configured as dual boot (VMWare) with Windows and BOSS. Lab instructors should verify the installation and follow it up with a Viva.					
4	Week-4: Internet & World Wide Web 1) Orientation & Connectivity Boot Camp: Students should connect to their Local Area Network and access the Internet. In the process, they configure the TCP/IP setting. Finally, students should demonstrate to the instructor how to access the websites and email. Without internet connectivity, instructors must simulate the WWW on the LAN. 2) Web Browsers, Surfing the Web: Students customize their web browsers with the LAN proxy settings, bookmarks, search toolbars, and pop-up blockers. Also, plug-ins like Macromedia Flash and JRE for applets should be configured.					
5	Week-5: 1) Search Engines & Netiquette: Students should know what search engines are and how to use the search engines. A few topics would be given to the students for which they need to search on					

	Google. This should be demonstrated to the instructors by the student. 2) Cyber Hygiene: Students would be exposed to the various threats on the internet and asked to configure their computers to be safe on the internet. They need to customize their browsers to block pop-ups, and block active X downloadsto avoid viruses and worms.
6	Week-6: LaTeX and WORD 1) Word Orientation: The mentor needs to give an overview of LaTeX and Microsoft (MS) Office or equivalent (FOSS) tool word: Importance of La TeX and MS office or equivalent(FOSS) tool Word as word Processors, Details of the four tasks and features that would be covered in each, Using LaTeX and word – Accessing, overview of toolbars, saving files, Usinghelp and resources, rulers, format painter in word. 2) Using LaTeX and Word to create a project certificate. Features to be covered:- Formatting Fonts in Word, Drop Cap in Word, Applying Text effects, Using Character Spacing,Borders, and Colors, Inserting Header and Footer, Using Date and Time options in LaTeX and Word.
7	Week-7: 1) Creating project abstract Features to be covered: Formatting Styles, Inserting table, Bullets and Numbering, Changing Text Direction, Cell alignment, Footnote, Hyperlink, Symbols, Spell Check, Track Changes. 2) Creating a Newsletter: Features to be covered:- Table of Contents, Newspaper columns, Images from files and clipart, Drawing toolbar and Word Art, Formatting Images, Textboxes, Paragraphs, and Mail Merge in word.
8	Week-8: EXCEL Excel Orientation: The mentor needs to tell the importance of the MS Office or equivalent (FOSS)tool Excel as a Spreadsheet tool give the details of the four tasks and features that would be covered in each. Using Excel – Accessing an overview oftoolbars, saving Excel files, Using helpand resources. 1) Creating a Scheduler - Features to be covered: Gridlines, Format Cells, Summation, auto-fill, Formatting Text. 2) Calculating GPA -. Features to be covered:- Cell Referencing, Formulae in Excel – average, std. deviation, Charts, Renaming and Inserting worksheets, Hyperlinking, Count function.
9	Week-9: 1) LOOKUP/LOOKUP : Split cells, freeze panes, group and outline, Sorting, Boolean and logical operators, Conditional formatting.
10	Week-10: POWERPOINT 1) Students will be working on essential PowerPoint utilities and tools which help them create introductory PowerPoint presentations. PPT Orientation, Slide Layouts, Inserting Text, Word Art, Formatting Text, Bullets and Numbering, Auto Shapes, Lines and Arrows in PowerPoint. 2) Interactive presentations - Hyperlinks, Inserting –Images, Clip Art, Audio, Video, Objects, Tables and Charts.
11	Week-11: 1) Master Layouts (slide, template, and notes), Types of views (basic, presentation, slide slotter, notes, etc), and Inserting – Background, textures, Design Templates, Hidden slides.

12	Week-12: AI TOOLS – Chat GPT 1) Prompt Engineering: Experiment with different prompts to see how the model responds. Try asking questions, starting conversations, or even providing incomplete sentences to see how the model completes them.. 2) Creative Writing: Use the model as a writing assistant. Provide the beginning of a story or a scene description, and let the model generate the rest of the content. This can be a funway to brainstorm creative ideas. 3) Language Translation: Experiment with translation tasks by providing a sentence in one language and asking the model to translate it into another language. Compare the output to see how accurate and fluent the translations are.
LEARNING RESOURCES	
TEXT BOOKS:	
1	Comdex Information Technology course tool kit, Vikas Gupta, WILEY Dream Tech, 2003
2	Introduction to Information Technology, ITL Education Solutions Limited, Pearson Education, 2012, 2nd edition
REFERENCE BOOKS:	
1	The Complete Computer Upgrade and Repair Book, Cheryl A Schmidt, WILEY Dream tech, 2013, 3rd edition
2	PC Hardware - A Handbook, Kate J. Chase, PHI (Microsoft)
3	LaTeX Companion, Leslie Lamport, PHI/Pearson

R23HSSM801	HEALTH AND WELLNESS, YOGA & SPORTS (Common to All Branches of Engineering)					
	Total Contact Hours	15 (P)	L	T	P	C
	Pre-requisite	Nil	0	0	1	0.5
Course Objective						
The main objective of introducing this course is to make the students maintain their mental and physical wellness by balancing emotions in their life. It mainly enhances the essential traits required for the development of the personality.						
Course Outcomes						
1	Demonstrate the importance of yoga and sports for Physical fitness and sound health.					
2	Demonstrate an understanding of health-related fitness components.					
3	Compare and contrast various activities that help enhance their health.					
4	Assess current personal fitness levels.					
5	Develop Positive Personality					
SYLLABUS						
Unit I	Concept of health and fitness, Nutrition and Balanced diet, basic concept of immunity Relationship between diet and fitness, Globalization and its impact on health, Body Mass Index (BMI) of all age groups. Activities: i) Organizing health awareness programmes in community ii) Preparation of health profile iii) Preparation of chart for balance diet for all age groups					5 hr
Unit II	Concept of yoga, need for and importance of yoga, origin and history of yoga in Indian context, classification of yoga, Physiological effects of Asanas- Pranayama and meditation, stress management and yoga, Mental health and yoga practice. Activities: Yoga practices – Asana, Kriya, Mudra, Bandha, Dhyana, Surya Namaskar					5 hr
Unit III	Concept of Sports and fitness, importance, fitness components, history of sports, Ancient and 49 Modern Olympics, Asian games and Commonwealth games. Activities: i) Participation in one major game and one individual sport viz., Athletics, Volleyball, Basketball, Handball, Football, Badminton, Kabaddi, Kho-kho, Table tennis, Cricket etc. Practicing general and specific warm up, aerobics ii) Practicing cardiorespiratory fitness, treadmill, run test, 9 min walk, skipping and running.					5 hr
LEARNING RESOURCES						
REFERENCE BOOKS:						
1	Gordon Edlin, Eric Golanty, <i>Health and Wellness</i> , 14th Edn. Jones & Bartlett Learning, 2022.					
2	T.K.V.Desikachar, <i>The Heart of Yoga: Developing a Personal Practice</i> , Inner Traditions,1999.					
3	Archie J.Bahm, <i>Yoga Sutras of Patanjali</i> , Jain Publishing Company, 1993.					
4	Wiseman, John Lofty, <i>SAS Survival Handbook: The Ultimate Guide to Surviving Anywhere</i> , Third Edition, William Morrow Paperbacks, 2014.					
5	Thomas Hanlon, <i>The Sports Rules Book/ Human Kinetics</i> , 3rd ed. Human Kinetics, Inc.2014.					

III Semester

R23MCHET002	FLUID MECHANICS FOR CHEMICAL ENGINEERS						
	Total Contact Hours	42 (L)	L	T	P	C	
	Pre-requisite	Nil	3	0	0	3	
Course Objectives:							
This course will prepare students to make them understand the various properties of fluids and their influence on fluid motion and analyse a variety of problems in fluid statics and dynamics.							
Course Outcomes: The student will be able to							
1	Interpret various fluid flow models and explain fluid statics & its applications. (BL-5)						
2	Explain macroscopic balances for mass, energy and momentum and assess major and minor losses associated to fluid flow in pipes (BL-5)						
3	Determine the pressure drop and energy requirement associated to incompressible and compressible fluid flow in pipes (BL-5)						
4	Estimate the pressure drop that occurs during fluid flow through packed beds and fluidized beds (BL-5)						
5	Select a suitable fluid transport machinery for a particular operation including flow measuring devices (BL-5)						
6	Discuss various fluid flow phenomena encountered in chemical engineering applications and determine pressure drop (BL-6)						
SYLLABUS							
Unit I	Fluid statics and Fluid flow phenomena						8 hr
Basics on dimensional Analysis, Nature of fluids, hydrostatic equilibrium, applications of fluid statics: U-Tube and Inclined Manometers. Fluid flow phenomena- Rheological properties of fluids, Turbulence, Boundary layers, wake formation.							
Unit II	Fluid Kinematics and Dynamics						8 hr
Basic equation of fluid flow –Mass balance in a flowing fluid- continuity, shell balance for mass flow, Differential momentum balance- Equation of motion, Macroscopic momentum balance, Bernoulli’s equation without friction, with friction and pump work, major and minor losses							
Unit III	Flow through pipes and channels						8 hr
Incompressible Newtonian /Non Newtonian Flow in pipes and channels- shear stress and skin friction in pipes, laminar flow & turbulent flow in pipes and channels. Flow of compressible fluids- Definitions and basic equations, Processes of compressible flow Isentropic flow through nozzles, adiabatic frictional flow & isothermal frictional flow.							
Unit IV	Flow past immersed objects						8 hr
Drag and Drag coefficient, stagnation point and stagnation pressure, flow through beds of solids, Motion of particles through fluids Fluidization: Conditions of fluidization, Types of fluidization, Minimum fluidization velocity & applications of fluidization.							
Unit V	Transportation of fluids						8 hr

Transportation fluids- Pipes and fittings, types of valves; Pumps: positive displacement pumps, and centrifugal pumps, NPSH, Fans, blowers, and compressors; Jet ejectors, Measurement of flowing fluids.	
LEARNING RESOURCES	
TEXT BOOKS:	
1	Unit Operations of Chemical Engineering by W.L.McCabe, J.C.Smith & Peter Harriot, McGraw-Hill, 6 th Ed, 2001
REFERENCE BOOKS:	
1	Transport processes and unit operations by Christie J. Geankoplis, PHI.
2	Introduction to Fluid mechanics by R.W. Fox, A.T.McDonald, P.J.Pritchard, JohnWileyand sons-6 th edition

Bloom's level and units catchment articulation matrix

CO	Blooms Level	UNIT I	UNIT II	UNIT III	UNIT IV	UNIT-V
CO1	BL5	X				
CO2	BL5		X			
CO3	BL5			X		
CO4	BL5				X	
CO5	BL5					X
CO6	BL6	X	X	X	X	X

R23MCHET003	CHEMICAL PROCESS CALCULATIONS						
	Total Contact Hours	42 (L)	L	T	P	C	
	Pre-requisite	Nil	3	0	0	3	
Course Objectives:							
This course will prepare students to make analysis of chemical processes through calculations, which need to be performed in the chemical processing operations. The students are introduced to the application of laws and also to formulate and solve material and energy balances in processes with and without chemical reactions.							
Course Outcomes							
Student will be able to,							
1	Determine degree of completion of a chemical reaction (BL-5)						
2	Evaluate how pressure and temperature changes influence gas volume in practical scenarios using gas laws. (BL-5)						
3	Formulate and solve the material balance calculations for processes with and without chemical reactions. (BL-6)						
4	Estimate the energy requirements for Physical and Chemical processes (BL-5)						
5	Determine equilibrium compositions in ideal solutions using Raoult's law and read humidity charts (BL-5)						
6	Perform material and energy calculations for any given Chemical process (BL-6)						
SYLLABUS							
Unit I	Fundamental concepts of Stoichiometry						8 hr
Mass and Volume relations in chemical reactions, Mole concept, Use of molal quantities, Excess reactants and degree of completion, Basis of calculations, Methods of expressing composition of mixtures and solutions. Density and specific gravity, Specific gravity scales.							
Unit II	Ideal Gases and Mixtures						8 hr
Kinetic Theory of gases, Application of ideal gas law, gage pressure, Dissociating gases, Mixtures of Ideal gases, Dalton's law, Amagat's law, Average molecular weight, density of gas mixtures, Composition of gases on dry and wet basis, Volume changes with change in compositions, Gases in chemical reactions.							
Unit III	Material balances						8 hr
Basic material balance principles, tie substance, Material balance calculations involving mixing, drying, evaporation, extraction, leaching, crystallization Material balance in processes involving chemical reactions, Recycle, bypass and purge calculations.							
Unit IV	Energy balances						8 hr
Energy balance -Thermophysics: Heat capacity of gases, liquids and solids, Kopp's rule, Heat of fusion and heat of vaporization, Trouton's rule, Kistyakowsky equation.							
Energy Balance-Thermochemistry: Heat effects accompanying chemical reactions, Standard heat of reaction, combustion and formation; Hess's law of constant heat summation, adiabatic flame temperature.							
Unit V	Vapor Pressure and Solutions-Humidity and Saturation						8 hr
Vapor Pressure and Solutions: Vapor pressure and boiling point, vapor pressure of solids, Effect of temperature on vapor pressure (Clausius-Clapeyron equation, Antoine equation), Vapor pressure plots. Vapor pressure of immiscible liquids, Vaporization with superheated steam, Ideal solutions, Raoult's law, Henry's law.							
Humidity and Saturation: Saturation, Partial saturation, Humidity, Percent humidity, Dew point, Wet bulb and dry bulb temperature, Enthalpy of humid air, Humidity charts, Adiabatic saturation.							

LEARNING RESOURCES	
TEXT BOOKS:	
1	Chemical Process principles, Part-1, Material and Energy balances by Hougen O.A, Watson K.M and Ragatz, R.A. 2 nd edition,2010.
2	Basic principles and calculations in Chemical Engineering by Himmelblau, 7 th edition,2009.
REFERENCE BOOKS:	
1	Stoichiometry by Bhatt and Vora, 4 th edition.
2	Stoichiometry and process calculations K.V.Narayanan and Lakshmikutty, 1 st edition.

Bloom's level and-Units catchment articulation matrix

CO	Blooms Level	UNIT I	UNIT II	UNIT III	UNIT IV	UNIT-V
CO1	BL5	X				
CO2	BL5		X			
CO3	BL6			X		
CO4	BL5				X	
CO5	BL5					X
CO6	BL6	X	X	X	X	X

R23MCHET004	MECHANICAL UNIT OPERATIONS						
	Total Contact Hours	42 (L)	L	T	P	C	
	Pre-requisite		3	0	0	3	
Course Objectives: This course aims to equip students with advanced skills in particle technology, mechanical separations, fluid dynamics, filtration, membranes, and agitation/mixing essential for chemical engineering applications.							
Course Outcomes: Student will be able to							
1	Determine specific property parameters of solids and Select suitable size reduction equipment for various applications. (BL-5)						
2	Analyze screen sizes, evaluate screen effectiveness, and understand magnetic and electrostatic separation principles and froth flotation processes. (BL-3)						
3	Differentiate gravity separation and centrifugal separation processes. (BL-4)						
4	To select a suitable type of filter for filtration of a slurry or a suspension. (BL-5)						
5	Master principles of liquid agitation (impeller types, power consumption) and solid mixing techniques (BL-5)						
6	Develop integrated knowledge of different mechanical unit operations for various particle handling systems (BL-6)						
SYLLABUS							
Unit I	Properties of Particulate Solids and Size reduction						8 hr
Particle shape, Significance of Particle size Analysis, Conveying of solids, Equipment for size reduction, Crushing laws, Crushers & Grinders, Ultra-fine grinders, Cutting machines and Open-closed circuit operation.							
Unit II	Mechanical Separations						8 hr
Screen Analysis, Ideal and actual screens, Capacity and effectiveness of screens, Screening equipment, Magnetic separation, Electrostatic separation, Jiggina and Heavy media separation, Froth floatation process.							
Unit III	Separations based on motion of particles through fluids						8 hr
Flow through beds of solids, Gravity sedimentation process, Equipment for sedimentation, Clarifiers and thickeners, Separations of solids from gases, Separations of solids from liquids, Centrifugal sedimentation, Centrifugal classifiers.							
Unit IV	Filtration						8 hr
Classification of Filtration, Principles of Cake Filtration, Industrial Filters, Rotary drum filter, Filter Aids, Principles of Centrifugal filtration, Types of Membranes, Membrane fouling.							
Unit V	Agitation and mixing of liquids						8 hr
Agitation of liquids, Power consumption in agitated vessels, Purpose of Agitation, Types of impellers, Measures for mixer performance, Mixers for Non-cohesive solids, Mixers for cohesive solids, Mixing index and mixing effectiveness.							
LEARNING RESOURCES							
TEXT BOOKS:							
1	Unit operations of Chemical Engineering, Warren,L., McCabe, Julian C.Smith, Peter Harriot, 7th Edition, McGraw Hill (2008).						
REFERENCE BOOKS:							
1	Chemical Engineering, vol.-II, J.H.Coulson and Richardson, 5th edition, Elsevier India (2006).						
2	Perry's Chemical Engineers Hand Book, Perry Rober H, 8th edition, McGraw Hill (2007).						
3	Mechanical Operations for Chemical Engineers, C. M. Narayana and B.C.Bhattacharyya, Khanna Publishers (1992).						

Bloom's level and-Units catchment articulation matrix

CO	Blooms Level	UNIT I	UNIT II	UNIT III	UNIT IV	UNIT-V
CO1	BL5	X				
CO2	BL3		X			
CO3	BL4			X		
CO4	BL5				X	
CO5	BL5					X
CO6	BL6	X	X	X	X	X

		CHEMICAL TECHNOLOGY				
R23MCHET005	Total Contact Hours	42 (L)	L	T	P	C
	Pre-requisite	Nil	3	0	0	3
Course Objectives:						
This course aims to equip students with the essential operational skills and technical knowledge required for the installation, monitoring, and maintenance of process instrumentation and control equipment in chemical plants.						
Course Outcomes						
After completing this course, the students will be able to,						
1	Understand and evaluate Soda ash, caustic soda, chlorine gas, and glass manufacturing processes. (BL-5)					
2	Understand and evaluate manufacturing processes for valuable chemicals in nitrogen industries. (BL-5)					
3	Understand and evaluate manufacturing processes of sulphur and paper industries (BL-5)					
4	Understand and evaluate process technologies in polymer industries. (BL-5)					
5	Understand and evaluate industrial process technology for extracting and refining vegetable oils, and manufacturing soaps, cements. (BL-5)					
6	Develop expertise in evaluating engineering problems in prominent inorganic and organic chemical industries. (BL-6)					
SYLLABUS						
Unit I	Chlor Alkali and Glass Industries					8 hr
Basic principles of Unit process and Unit operations in Chemical Industries, Manufacturing of Soda ash by Solvay process and Dual Process, Manufacturing of caustic soda and chlorine by Electrolytic Process, Manufacturing of Glass by Foucault and continuous sheet process, Properties & applications of special glasses, Major engineering problems of Solvay, Dual, Foucault and continuous sheet process						
Unit II	Fuel Gases, Cryogenics, Nitrogen & Fertilizer industries					8 hr
Manufacturing of producer gas, water gas and coke oven gas, Manufacturing of oxygen and nitrogen from Air liquefaction process, Hydrogen Production and Major engineering problems of production of Fuel and Industrial gases, Synthetic ammonia production, Urea Production, Production of Nitric acid and Ammonium nitrate, Production of Ammonium phosphate and complex fertilizers, Major engineering problems in Nitrogenous industries						
Unit III	Sulphur Industries, Industrial Chemicals, and Pulp & Paper Industry					8 hr
Extraction of sulphur by Frasch process, Manufacture of sulphuric acid by contact process, DCDA process. Production of Hydrochloric acid and Magnesium compounds, Major engineering problems in Sulfur industries, Production of sulphate and sulphite Pulp, Production of paper -wet process., Major engineering problems in pulp and paper industries						
Unit IV	Petrochemicals and Polymer industries					8 hr
Manufacture of phenols by Toluene oxidation process and Cumene Process, Manufacturing of Formaldehyde resin, Manufacturing of Poly Vinyl chloride, Manufacturing of phenol- formaldehyde resin, Manufacturing of SBR, Applications of Major Petrochemical and Polymer Chemicals, Major engineering problems in Petrochemical & Polymer Industries						
Unit V	Natural Products, Soaps & Detergents, Cement Manufacturing					8 hr
Extraction of vegetable oils and oil hydrogenation process, Soaps and Detergents: Definitions, continuous process for the production of fatty acids and soap, Production of detergents and glycerin, Major engineering problems in Oil, soap and detergent industries, Properties and uses of special types of cement,						

Manufacturing process of cement, Major engineering problems in Cement industries	
LEARNING RESOURCES	
TEXT BOOK:	
1	Shreeve's Chemical Process Industries edited by Austin, McGraw-Hill.5th ed.1985.
2	Dryden's Outlines of Chemical Technology, edited by M.Gopal Rao and M.Sittig, 2 nd ed. 1973.
REFERENCE BOOKS:	
1	Industrial Chemistry by B.K.Sharma.
2	Hand book of Industrial Chemistry Vol 1&II K.H.Davis& F.S. Berner Edited by S.C.Bhatia, CBS publishers.
3	Austin, G. T., Shreve's Chemical Process Industries, Tata – McGraw Hill Publishers,2012.

Bloom's level and-Units catchment articulation matrix

CO	Blooms L	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5
CO 1	BL 5	X				
CO 2	BL 5		X			
CO 3	BL 5			X		
CO 4	BL 5				X	
CO 5	BL 5					X
CO 6	BL 6	X	X	X	X	X

R23MCSC001		DATA STRUCTURES & ALGORITHMS (for MEC, ECE, EEE, CIV and CHE)					
		Total Contact Hours	42 (L)	L	T	P	C
		Pre-requisite	Basic Programming	3	0	0	3
Course Objective							
Students will get exposure to use data structures such as arrays, linked lists, stacks, queues, trees, graphs, hashing and will be able to select and implement the appropriate data structures to solve the given problem.							
Course Outcomes							
1	Will be able to apply various searching and sorting techniques and analyze their time complexities. (BL3)						
2	Will be able to apply Linked Lists and its variants and utilize them for various applications. (BL3)						
3	Will be able to compare arrays and Linked Lists and conclude which storage structure is appropriate for the given problem/data structure. (BL4)						
4	Will be able to develop novel solutions to small scale programming challenges involving data structures such as stacks, queues, trees and graphs.						
5	Will be able to recognize scenarios where hashing is advantageous, and design hash-based solutions for specific problems. (BL6)						
6	Will be able to collaborate in teams to design and implement innovative solutions by choosing and combining the appropriate data structure(s). (BL6)						
SYLLABUS							
Unit I		INTRODUCTION TO LINEAR DATA STRUCTURES					8 hr
Data Structures- Introduction, need for a data structure, Types of Data Structures; Overview of time and space complexity analysis, asymptotic notations; Recursion- Introduction, Types of recursions; Searching-Linear Search algorithm, Binary Search algorithm Sorting techniques- Bubble Sort, Selection Sort; Insertion Sort; Quick Sort; Merge Sort.							
Unit II		LINKED LISTS					8 hr
Introduction to Linked List, Variations/Types of Linked Lists, Applications; Single Linked List Operations: creation, insertion; Deletion, Traversal/Search; Circular Linked Lists-Insertion, Deletion, Traversal/Search. Double Linked Lists and Operations- Creation, Insertion; Deletion, Traversal/Search; Applications of Linked List-Representation of Sparse Matrix using Single Linked List, Representation of Polynomials using Single Linked List; Polynomial Operations (Addition) using Linked List.							
Unit III		STACKS AND QUEUES					8 hr
Introduction to Stack data structures, basic operation, implementation of Stack using array; Stack implementation using Linked Lists, advantages & disadvantages; Applications of Stack: Infix to postfix conversion; postfix expression evaluation, Factorial using Stack. Introduction to Queue data structures, basic operation, implementation of Queue using array; Queue operations implementation using Linked Lists; Circular Queues using Arrays; Double Ended Queues.							
Unit IV		TREE- BINARY TREE, BINARY SEARCH TREE, BALANCED TREE					8 hr
Tree - Introduction, Types of Trees; Binary Tree - Introduction, Properties, Various ways of representing Binary Tree in memory; Recursive Binary tree traversals, Construction of Binary tree given tree traversals (In-order, Pre-order & In-order, Post-order); Tree applications- Heap(Min/Max) Binary Search tree operations- Creation, Insertion; Deletion, Traversal/Search;							

Balanced Binary trees – Introduction, Operations on AVL Trees –Insertion; AVL Tree Deletion, Search.		
Unit V	GRAPHS AND HASHING	8 hr
Basic concepts, Representation of Graph using Adjacency Matrix and Adjacency List; Graph Traversals (BFS, DFS); minimum spanning tree using Prim's Algorithm; minimum spanning tree using Kruskal's algorithm Single Source Shortest Distance- Dijkstra's algorithm, transitive closure; Introduction to Hashing, Hash Functions; Collision Resolution Techniques: Open hashing -chaining, Open Addressing- linear probing; quadratic probing, double hashing.		
LEARNING RESOURCES		
TEXT BOOKS:		
1	Mark Allen Weiss, <i>Data Structures and algorithm analysis in C</i> , Pearson, 2nd Edition.	
2	Ellis Horowitz, Sartaj Sahni, Susan Anderson-Freed, <i>Fundamentals of data structures in C</i> , Silicon Press, 2008.	
3	Richard F, Gilberg , Forouzan, Cengage, <i>Data Structures</i> , 2/e.	
REFERENCE BOOKS:		
1	Algorithms and Data Structures: The Basic Toolbox by Kurt Mehlhorn and Peter Sanders.	
2	C Data Structures and Algorithms by Alfred V. Aho, Jeffrey D. Ullman, and John E. Hopcroft	
3	Problem Solving with Algorithms and Data Structures" by Brad Miller and David Ranum	
4	Introduction to Algorithms by Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, and Clifford Stein.	
5	Algorithms in C, Parts 1-5 (Bundle): Fundamentals, Data Structures, Sorting, Searching, and Graph Algorithms" by Robert Sedgewick	
ADDITIONAL REFERENCE MATERIAL		
1	https://www.javatpoint.com/data-structure-tutorial	
2	https://www.programiz.com/dsa	
3	https://www.cs.bham.ac.uk/~jxb/DSA/dsa.pdf	
ONLINE COURSES		
1	https://onlinecourses.nptel.ac.in/noc24_cs45/preview	
2	https://www.coursera.org/learn/data-structures	
3	https://www.coursera.org/specializations/boulder-data-structures-algorithms	

Bloom's level - Units catchment articulation matrix

CO	Blooms Level	Unit I	Unit II	Unit III	Unit IV	Unit V
CO1	BL3	X				
CO2	BL3		X			
CO3	BL4	X	X	X	X	X
CO4	BL6			X	X	X
CO5	BL6					X
CO6	BL6	X	X	X	X	X

R23MSCST011	OPERATING SYSTEMS (Common to all Branches)					
	Total Contact Hours	42 (L)	L	T	P	C
	Pre-requisite	-	3	0	0	3
Course Objective						
Students will gain a comprehensive understanding of operating systems, covering topics such as system architecture, functionalities, structures, processes, file systems, storage management, and advanced concepts like inter-process communication, multithreading, disk scheduling, and RAID, enabling them to grasp the fundamental principles and practical aspects of managing computer systems effectively.						
Course Outcomes						
1	Students will be able to analyze the diverse structures and functionalities of operating systems. (BL-4)					
2	Students will be able to design and make use of efficient process management strategies, employing system calls and various threading models to improve overall system responsiveness. (BL-6)					
3	Students will be able to analyze the system's performance and effectiveness by comparing different strategies for deadlock resolution and memory management. (BL-3)					
4	Students will be able to analyze the performance of virtual memory management techniques, including TLB, different page table structures, and page replacement algorithms. Examine system behavior to identify and understand the causes of thrashing and evaluate the effectiveness of various file management methods and directory structures. (BL-5)					
5	Students will be able to analyze the effectiveness of various file system structures and management techniques. Evaluate the efficiency of free space management techniques and disk scheduling algorithms. Examine RAID levels to assess their impact on disk and swap space management. (BL-5)					
6	Students will be able to adapt to build basic internals of operating system framework that integrates diverse OS concepts (process management strategies, efficient file system structures, and virtual memory management techniques), choose different approaches for inter-process communication to enhance system responsiveness and collaboration, and discuss various solutions for ensuring improved performance and reliability in storage systems. (BL-6)					
SYLLABUS						
Unit I	INTRODUCTION TO OS AND CONCEPTS OF PROCESS AND THREADING					8 hr
What Operating Systems do? Computer System architecture; OS Functionalities: Process Management, Memory Management, Storage Management, Protection and Security; Computing Environment: Traditional Computing, Client Server computing, Peer to Peer computing, web based computing, OS Services; System calls, Types of System calls; Operating System Structure: Simple, Layered, Microkernels, Modules; Introduction to Processes: Process, Process States, Process Control Block. Threads.; Operations On Processes: Process Creation, Process Termination (fork(),exec(),exit() system calls); Inter-Process communication: Shared memory, Message Passing;						
Unit II	PROCESS SCHEDULING AND SYNCHRONIZATION					8 hr
Multithreading Models: Overview, Benefits, Many to One, One to One, Many to Many. Process Scheduling: Scheduling queues, Schedulers, Context switch; Process Scheduling: Basic Concepts, CPU Scheduler, Preemptive Scheduling, Dispatcher, Scheduling Criteria; Scheduling Algorithms (Non-pre-emptive): FCFS, SJF; Scheduling Algorithms II(pre-emptive): Priority Scheduling, Round Robin; Multilevel Queue, Multilevel Queue feedback, Process Synchronization:						

Introduction to process synchronization. Producer Consumer Problem; Critical Section Problem, Peterson's Solution, Synchronization Hardware; Semaphore, Classical problems of synchronization: Bounded-buffer Problem, Readers Writers Problem; Dining Philosophers Problem, Monitors: Introduction, Usage;		
Unit III	DEADLOCKS AND MEMORY MANAGEMENT	8 hr
Deadlocks: Introduction, System Model, Deadlock Characterization; Methods for Handling Deadlocks Deadlock Prevention; Deadlock Avoidance (Part -1) Safe state, resource allocation graph algorithm; Deadlock Avoidance (Part -2) Banker's algorithm, Deadlock Detection single instance of each resource type; Deadlock Detection several instances of resource type and Recovery from Deadlocks; Memory Management, Address Binding, Logical vs Physical Address space; Swapping, Contiguous Memory; Paging (Basic Method);		
Unit IV	PAGING TECHNIQUES, PAGE REPLACEMENT AND ACCESSING FILES TECHNIQUES	8 hr
Hardware, TLB, Protection, Shared Pages,; Structure of the Page table, hierarchy, hashed,; Inverted page table, Segmentation; Virtual memory management, Demand paging; Page Replacement Algorithms: FIFO, Optimal page replacement; LRU Page replacement, Thrashing: causes of thrashing,; File concept, File Attributes, File operations, File types, File Structure; Access methods: Sequential Access, Direct Access, Directory Structure: Single level directory, Two level directory;		
Unit V	FILE ORGANIZATION AND DISK SCHEDULING TECHNIQUES	8 hr
Tree structured directories, Acyclic graph directories, File System Mounting File Sharing; File Protection: types of access, Access control, File allocation methods: Contiguous allocation,; File allocation methods: Linked allocation, Indexed allocation, Free space management: Bit vector, Linked list, Grouping,; Overview of Mass Storage Structure: Magnetic disks, Magnetic Tapes, Disk Structure; Disk Scheduling: FCFS,SSTF,SCAN,; CSCAN,LOOK,CLOOK; Disk Management, Swap Space Management; Raid Structure: Levels: 0-6, RAID levels 0+1;		
LEARNING RESOURCES		
TEXT BOOKS:		
1	"Operating System Concepts" by Abraham Silberschatz, Peter B. Galvin, and Greg Gagne.	
2	"Modern Operating Systems" by Andrew S. Tanenbaum.	
REFERENCE BOOKS:		
1	"Operating Systems: Internals and Design Principles" by William Stallings.	
ADDITIONAL REFERENCE MATERIAL		
1	"Operating Systems: Three Easy Pieces" by Remzi H. Arpaci-Dusseau and Andrea C. ArpaciDusseau (Free online book available at: http://pages.cs.wisc.edu/~remzi/OSTEP/)	
2	"Linux Kernel Development" by Robert Love.	
3	"File System Forensic Analysis" by Brian Carrier.	
ONLINE COURSES		
1	Coursera: "Operating Systems and System Programming" - Offered by Stanford University, this course covers fundamental concepts and principles of operating systems. https://www.coursera.org/specializations/codio-introduction-operating-systems	
2	edX: "Introduction to Operating Systems" - Provided by Georgia Institute of Technology, this course explores the design and implementation of modern operating systems. - Link: https://www.udacity.com/course/introduction-to-operating-systems--ud923	
3	MIT OpenCourseWare: "Operating System Engineering"	

	• A free online course from MIT, offering in-depth coverage of operating system design and implementation. Link: • https://ocw.mit.edu/courses/6-828-operating-system-engineering-fall-2012/
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Bloom's level - Units catchment articulation matrix

CO	Blooms Level	Unit I	Unit II	Unit III	Unit IV	Unit V
CO1	BL4	X				
CO2	BL6		X			
CO3	BL3			X		
CO4	BL5				X	
CO5	BL5					X
CO6	BL6	X	X	X	X	X

R23MCHEL001	FLUID MECHANICS FOR CHEMICAL ENGINEERS LAB					
	Total Contact Hours	42 (P)	L	T	P	C
	Pre-requisite	Nil	0	0	3	2
Course Objectives						
This lab enables the student to understand,						
1	Measurement of flow rates, velocity					
2	Fluid flow behavior, calculation of pressure losses during the fluid flow through closed conduits					
3	Calculation of pressure losses in pipe fittings					
4	The characteristics of the pumps					
5	The working of flow measurement devices					
6	Calculation of pressure losses during the fluid flow through packed beds					
7	How to handle and operate different types of Fluid handling equipment.					
Course Outcomes: Students will be able to,						
1	Determine velocity, volumetric flow rate and mass flow rate of fluids through conduits.(BL-5)					
2	Examine whether flow is laminar or turbulent and calculate pressure loss in straight pipes.(BL-4)					
3	Estimate pressure loss in fittings like bends, elbows, sudden contraction and sudden expansion.(BL-6)					
4	Interpret the performance of the pump through characteristic curves .(BL-5)					
5	Measure the fluid flow rates using flow measuring devices.(BL-5)					
6	Test different types of Fluid handling equipment.(BL-6)					
LIST OF EXPERIMENTS:						
1	Verification of Bernoulli equation					
2	Determination of friction factor for flow through straight pipes of different diameters and study of variation of friction factor with Reynolds number					
3	Determination friction losses in pipe fittings					
4	Determination of discharge coefficient for venturi meter					
5	Determination of discharge coefficient for orifice meter					
6	Determination of discharge coefficient in a V-notch					
7	Determination of viscosity of the fluid using stokes law.					
8	Determination of characteristic curves for centrifugal pumps.					
9	Determination of characteristic curves for Reciprocating pumps					
10	Pressure drop in a packed bed for different fluid velocities					
11	Determination of Pressure drop and bed porosity in a fluidized bed					
12	Calibration of Rotameter					
LEARNING RESOURCES						
TEXT BOOKS:						
1	Unit Operations of Chemical Engineering by W.L.McCabe, J.C.Smith& Peter Harriot, McGraw-Hill, 6 th Ed, 2001					
REFERENCE BOOKS:						
1	Transport processes and unit operations by Christie J. Geankoplis, PHI.					
2	Introduction to Fluid mechanics by R.W. Fox, A.T.McDonald, P.J.Pritchard, JohnWileyand sons-6 th edition					

R23MCHEL002		MECHANICAL UNIT OPERATIONS LAB					
		Total Contact Hours	42 (P)	L	T	P	C
		Pre-requisite	Nil	0	0	3	2
Course Objectives:							
1	Calculate avg. particle size of a given sample.						
2	Operate various size reduction mills and calculate energy requirements in these mills for a given size reduction ratio						
3	Estimate the capacity and efficiencies of various screens						
4	Evaluate the collection efficiency of cyclone separator						
5	Evaluate the operation of filtration techniques						
6	Determine percentage recovery of given feed using froth floatation						
7	Sort out the various ores using sedimentation techniques						
Course Outcomes							
After successful completion of this lab, the students able to:							
1	Calculate avg. particle size of a given sample. (Arithmetic mean diameter, Mass mean diameter, Volume mean diameter, Volume surface mean diameter, Surface area) (BL3)						
2	Operate various size reduction mills and calculate energy requirements in these mills for a given size reduction ratio (BL3)						
3	Estimate the capacity and effectiveness of various screens (BL5)						
4	Evaluate the collection efficiency of cyclone separator (BL5)						
5	Operate filter press and calculate the resistances of medium and cake (BL3)						
6	Determine percentage recovery of given feed using froth floatation (BL5)						
7	Sort out the various ores using sedimentation techniques (BL6)						
LIST OF EXPERIMENTS							
1. Sieve analysis of a given sample using Rotap sieve shaker 2. To calculate the effectiveness of a given screen for different capacities. 3. To crush the coal in a Primary Jaw Crusher (Blake Jaw Crusher) and determination of average product size and energy consumption for crushing. 4. To determine power consumption required for crushing of a given quantity of material using Roll crusher and compare with the values obtained from crushing laws. 5. To compare open circuit and closed circuit grinding by using Ball mill also to compare energy requirements for crushing in both the cases. 6. Determine particle size from batch sedimentation tests 7. To determine the specific cake resistance and filter medium resistance of slurry in a plate and frame filter press. 8. To study the effect of inlet gas velocity and particle size on collecting efficiency of a cyclone separator. 9. To calculate the percentage recovery of coal from coal-sand mixture using froth floatation cell 10. To grind the coal in attrition mill and determine the average product size and energy consumption for grinding. 11. To grind the coal in a hammer mill and determine the average product size and energy consumption for grinding.							
LEARNING RESOURCES							
TEXT BOOKS:							
1	Unit operations of Chemical Engineering, Warren, L., McCabe, Julian C. Smith, Peter Harriot, 7th Edition, McGraw Hill (2008).						
REFERENCE BOOKS:							
1	Chemical Engineering, vol.-II, J.H. Coulson and Richardson, 5th edition, Elsevier India (2006).						
2	Mechanical Operations for Chemical Engineers, C. M. Narayana and B.C. Bhattacharyya, Khanna Publishers (1992).						
3	Perry's Chemical Engineers Hand Book, Perry Rober H, 8 th edition, MGH'07						

R23MCSC001	DATA STRUCTURES & ALGORITHMS LAB (for MEC, ECE, EEE, CIV and CHE)					
	Total Contact Hours	42 (P)	L	T	P	C
	Pre-requisite	Basic Programming	0	0	3	2
Course Objective						
To get hands-on exposure to linear and non-linear data structures and to identify and apply the suitable data structures for the given real-world problem.						
Course Outcomes						
1	Student will be able to implement recursive algorithms and will be able to understand the role of linear data structures in organizing and accessing data efficiently using searching and sorting techniques.					
2	Student will be able to implement, and apply linked lists for dynamic data storage, demonstrating understanding of memory allocation.					
3	Student will be able to develop programs using stacks to handle recursive algorithms, manage program states, and solve related problems.					
4	Student will be able to apply queue-based algorithms for efficient task scheduling and breadth-first traversal in graphs and distinguish between linear queues and circular queues, and apply them appropriately.					
5	Student will be able to devise novel solutions to small scale programming challenges involving data structures such as stacks, queues, trees, graphs.					
6	Student will be able to recognize scenarios where hashing is advantageous, and design hash-based solutions for specific problems.					
LIST OF EXPERIMENTS						
1	WEEK 1 (SEARCH TECHNIQUES) - Write a C Program to search an element in the given list using Linear Search Technique. (using recursive and non-recursive functions) - Write a C Program to search an element in the given sorted list using Binary Search Technique. (using recursive and non-recursive functions)					
2	WEEK 2 (SORTING TECHNIQUES) - Write a C Program using recursive function to sort a given list of integers in ascending order using Bubble Sort Technique. - Write a C Program using recursive function to sort a given list of integers in ascending order using Quick Sort Technique. - Write a C Program using recursive function to sort a given list of integers in ascending order using Merge Sort Technique.					
3	WEEK 3 (LINKED LIST) Write a C Program to create a Single linked list and perform basic operations on Single Linked List.					
4	WEEK 4 (OTHER VARIANTS OF LINKED LIST) - Write a C Program to create a Circular linked list and perform basic operations. - Write a C Program to create a Double linked list and perform basic operations.					
5	WEEK 5 (STACKS & APPLICATIONS) - Write a C Program to implement Stack operations using arrays. - Write a C Program to implement Stack operations using linked list. - Write a C Program to implement Infix to postfix conversion using stacks. - Write a C Program to evaluate the Postfix Expression using stacks.					
6	WEEK 6 (QUEUES)					

	• Write a C Program to implement Queue operations using arrays. • Write a C Program to implement Queue operations using linked list • Write a C Program to implement Circular Queue operations.
7	WEEK 7 (BINARY TREE) • Write a C Program to implement Binary Tree Creation. • Write a C Program to implement Recursive Binary Tree Traversals.
8	WEEK 8 (BINARY SEARCH TREE(BST)) • Write a C Program to implement Binary Search Tree creation. • Write a C program to implement Insertion, Deletion, Search operations on Binary Search Tree.
9	WEEK 9 (GRAPHS & TRAVERSAL TECHNIQUES) • Write a C Program to create a Graph (using Adjacency Matrix or Adjacency List). • Write a C Program to implement Graph Traversals -Breadth First Search and Depth First Search.
10	WEEK 10 (GRAPH APPLICATIONS) • Write a C Program to implement Prim's & Kruskal's Algorithm for finding Minimum Cost Spanning Tree. • Write a C Program to implement Single Source Shortest Path -Dijkstra's Algorithm.
11	WEEK 11 (HEAPS) • Write a C Program to implement Binary Heap (Min Heap or Max Heap).
12	WEEK 12 (HASHING) • Write a C Program to implement Collision Resolution Techniques using Linear probing (Open Addressing) Technique using Division method as hash function.
LEARNING RESOURCES	
TEXT BOOKS:	
1	Mark Allen Weiss, <i>Data Structures and algorithm analysis in C</i> , Pearson, 2nd Edition.
2	Ellis Horowitz, Sartaj Sahni, Susan Anderson-Freed, <i>Fundamentals of data structures in C</i> , Silicon Press, 2008.
3	Richard F, Gilberg , Forouzan, Cengage, <i>Data Structures</i> , 2/e.
REFERENCE BOOKS:	
1	Algorithms and Data Structures: The Basic Toolbox by Kurt Mehlhorn and Peter Sanders.
2	C Data Structures and Algorithms by Alfred V. Aho, Jeffrey D. Ullman, and John E. Hopcroft
3	Problem Solving with Algorithms and Data Structures" by Brad Miller and David Ranum
4	Introduction to Algorithms by Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, and Clifford Stein.
5	Algorithms in C, Parts 1-5 (Bundle): Fundamentals, Data Structures, Sorting, Searching, and Graph Algorithms" by Robert Sedgewick
ADDITIONAL REFERENCE MATERIAL	
1	https://www.javatpoint.com/data-structure-tutorial
2	https://www.programiz.com/dsa
3	https://www.cs.bham.ac.uk/~jxb/DSA/dsa.pdf
ONLINE COURSES	
1	https://onlinecourses.nptel.ac.in/noc24_cs45/preview
2	https://www.coursera.org/learn/data-structures
3	https://www.coursera.org/specializations/boulder-data-structures-algorithms

IV Semester

R23MCHET006	PROCESS HEAT TRANSFER						
	Total Contact Hours	42 (L)	L	T	P	C	
	Pre-requisite	Fluid Mechanics	3	0	0	3	
Course Objectives:							
Heat transfer occurs in many unit operations across a variety of processes in the chemical, petrochemical, power, and pharmaceutical industries. Understanding the fundamentals that govern heat transfer is the key to designing equipment involving heat exchange. This course introduces students to the fundamental aspects and quantification of different modes of heat transport. The course aims to help students apply these fundamentals in typical engineering applications (such as heat exchangers, evaporators, boiling, and condensation), eventually leading to the design of relevant industrial units.							
Course Outcomes							
On completion of the course the students should be able to,							
1	Evaluate rate of heat transfer by conduction for one dimensional steady and transient heat flow through various geometries (BL-5)						
2	Evaluate the convective heat transfer coefficient for various flows in internal and external configurations without phase change (BL-5)						
3	Estimate condensation heat transfer coefficient-compare different regimes of pool boiling and evaluate the radiative heat exchange between different black and grey surfaces (BL-5)						
4	Evaluate heat exchanger performance using LMTD or ϵ -NTU methods (BL-5)						
5	Appraise the construction details-characteristics and maintenance of various types of heat exchangers and assess the performance of evaporators (BL-5)						
6	Design various process heat exchange equipment using the principles of heat transfer (BL-6)						
SYLLABUS							
Unit I	Heat transfer by Conduction						8 hr
Heat transfer by conduction in solids: Fourier's law, thermal conductivity, steady state heat conduction in plane & composite structures-wall; cylinder; spheres; Critical radius of insulation; Equation for one-dimensional unsteady state heat conduction-Lumped heat capacity systems.							
Unit II	Heat transfer by Convection without phase change						8 hr
Regimes of heat transfer in fluids, thermal boundary layer; heat transfer by forced convection in laminar flow; heat transfer by forced convection in turbulent flow; analogy between transfer of momentum and heat-Reynolds and Colburn analogies, Dimensionless numbers in heat transfer and their significance; Natural convection from vertical shapes and horizontal planes.							
Unit III	Heat transfer by Convection with phase change and Radiation heat transfer						8 hr
Heat transfer from condensing vapours-drop wise and film wise condensation; derivation and practical use of Nusselt equation; Heat transfer to boiling liquids, pool boiling of saturated liquid, maximum flux and critical temperature drop. Nature of thermal radiation, black body radiation, Laws of black body radiation; view factors; radiation between surfaces; radiation shields.							
Unit IV	Introduction to Heat Exchanger Design						8 hr
Double pipe heat exchanger, counter current and parallel current flows; overall heat transfer coefficient, fouling factors; logarithmic mean temperature difference (LMTD method); LMTD correction factor in multi pass heat exchangers; heat exchanger effectiveness (NTU method).							
Unit V	Heat exchange equipment and Evaporators						8 hr
Classification of Heat exchangers; Shell & tube heat exchangers and types; condensers, Reboilers, Plate & Frame heat exchangers, extended surface							

equipment; choice of tube-side fluid; factors affecting heat exchangers performance.	
Evaporators: Performance of tubular evaporators; area calculations for single effect evaporators; Multiple effect evaporators, methods of feeding.	
LEARNING RESOURCES	
TEXT BOOKS:	
1	W.L. McCabe, J. C. Smith & P. Harriot, <i>Unit Operations of Chemical Engineering</i> , 7 th ed., McGraw-Hill, 2005
2	J. P. Holman, <i>Heat Transfer</i> , 10 th ed., McGraw Hill, 2009
3	Y.V.C.Rao, <i>Heat Transfer</i> , University Press, 1 st ed., 2002
REFERENCE BOOKS:	
1	B. K. Dutta, <i>Heat Transfer Principles and Applications</i> , 2 nd ed., PHI, 2009
2	D.Q. Kern, <i>Process Heat Transfer</i> , 1 st ed., McGraw-Hill Publications, 1950
3	N. Ozisik, <i>Basic approach to Heat Transfer</i> , 1 st ed., McGraw-Hill, 1985
4	P. L. E. Sissom, <i>Schaum's Outlines of Heat Transfer</i> , 2 nd ed., McGraw-Hill publications, 2005
ONLINE RESOURCES	
1.	https://archive.nptel.ac.in/courses/103/105/103105140/
2.	https://archive.nptel.ac.in/courses/103/101/103101137/
3.	https://archive.nptel.ac.in/courses/103/103/103103031/

Bloom's level and units catchment articulation matrix

CO	Blooms Level	UNIT I	UNIT II	UNIT III	UNIT IV	UNIT-V
CO1	BL5	X				
CO2	BL5		X			
CO3	BL5			X		
CO4	BL5				X	
CO5	BL5					X
CO6	BL6	X	X	X	X	X

R23MCHET007	CHEMICAL ENGINEERING THERMODYNAMICS						
	Total Contact Hours	42 (L)	L	T	P	C	
	Pre-requisite	---	3	0	0	3	
Course Objectives:							
To introduce the principles of chemical engineering thermodynamics and illustrate their applications in the design of chemical process plants.							
Course Outcomes							
On completion of the course the students should be able to,							
1	Determine heat and work associated with a process by using 1st law of thermodynamics for a flow and non-flow process (BL 4)						
2	Determine whether a process takes place or not using second law of thermodynamics also demonstrating proficiency in applying property relations and Maxwell's equations (BL 4)						
3	Develop fundamental equations that govern the estimation of pure fluids properties and solution properties. (BL 5)						
4	Develop the Models for the excess Gibbs energy and equations for Property changes of mixing (BL5)						
5	Evaluate equilibrium conversion in reversible reactions at given pressure and temperature following rigorous thermodynamic method and Van't Hoff method and interpret the standard Gibb's energy change and the equilibrium constant (BL 5)						
6	Evaluate heat and work requirements in thermodynamic processes and Compute compositions of reacting systems in different phases at equilibrium. (BL6)						
SYLLABUS							
Unit I	First law of thermodynamics and Volumetric Properties of Pure Fluids						8 hr
First law of thermodynamics and Energy balance for closed systems, Equilibrium and Thermodynamic state, Reversibility, Mass and energy balance for open systems, Phase rule and its applications, PVT behaviour of pure substances, working equations for different thermodynamic process, Virial Equation of State and its applications, Cubic equation of state:Vander walls EOS, RK EOS. Theorem of corresponding states, Generalized correlation for gases and liquids.							
Unit II	Second law of thermodynamics and Thermodynamic Properties of Fluids						8 hr
Statements of the second law of thermodynamics, applications of second law to heat engines and heat pumps, Concept of Entropy and its calculation, Entropy balance for open systems, Entropy changes for an ideal gas, Third law of thermodynamics. Property relations for homogeneous phases, Maxwell relations, Enthalpy and Entropy as a function of T&P, Internal energy as a function of P, Internal energy as a function of T and V.							
Unit III	Solution Thermodynamics: Theory						8 hr
Concept of Residual properties, Calculation of residual properties from Virial EOS, Generalized property correlations for gases, Thermodynamic diagrams. Fundamental property relation, Chemical potential as a criterion for phase equilibrium, Partial properties, ideal gas mixtures Properties, Fugacity for pure species, Fugacity coefficient for species in solutions, Generalized correlations for Fugacity coefficient.							
Unit IV	Solution Thermodynamics: Applications						8 hr
The ideal solutions, Excess properties, The liquid phase properties from VLE data, Activity Coefficient, Excess Gibbs energy, Models for the excess Gibbs energy (Margules, Vanlaar, Wilson equations), Property changes of mixing.							
Unit V	Chemical Reaction Equilibria						8 hr

The reaction coordinate, application equilibrium criterion to chemical reactions, The standard Gibb's energy change and the equilibrium constant, effect of temperature on equilibrium constants, Relation of equilibrium constants to composition, equilibrium conversion for single reactions, Phase rule and Duhem's theorem for reacting systems

LEARNING RESOURCES

TEXT BOOK:

1	Introduction to chemical engineering thermodynamics by J.M. Smith, H.C. Van Ness and M.M. Abbott, 7th ed. McGraw Hill, 2005.
2	A Text book of chemical engineering thermodynamics by K.V. Narayanan. PHI, 2001.

REFERENCE BOOKS:

1	Chemical Engineering Thermodynamics, Rao Y.V.C., Universities Press (India) Pvt. Ltd., 1997
2	Chemical and Process Thermodynamics, BG Kyle, 3rd Edition, Phi Learning, 2008
3	Introductory Chemical Engineering Thermodynamics, J. Richard Elliott, Carl T. Lira, 2nd Edition, Prentice Hall, 2012
4	Koretsky, M.D., Engineering and Chemical Thermodynamics, 2 nd edition, John Wiley & Sons, 2004.

Bloom's level and units catchment articulation matrix

CO	Blooms Level	UNIT I	UNIT II	UNIT III	UNIT IV	UNIT-V
CO1	BL4	X				
CO2	BL4		X			
CO3	BL5			X		
CO4	BL5				X	
CO5	BL5					X
CO6	BL6	X	X	X	X	X

		CHEMICAL REACTION ENGINEERING-I				
R23MCHET008	Total Contact Hours	42 (L)	L	T	P	C
	Pre-requisite	Nil	3	0	0	3
Course Objectives:						
Provide knowledge of different types of reactions, reaction rate and its dependency on various parameters, Compare various reactors and choose right kind of reactor for single and multiple reactions.						
Course Outcomes						
After the completion of the course will be able to						
1	Estimate the reaction kinetics of homogeneous chemical reactions (BL-5)					
2	Analyze the batch reactor kinetic data of various types of reactions for both at constant volume and variable volume conditions. (BL-4)					
3	Compare the performance of various ideal reactors including multiple reactor systems and recycle reactors and develop skills to choose right kind of reactor. (BL-5)					
4	Design of suitable ideal reactors for multiple reactions. (BL-6)					
5	Analyze the effects of temperature and pressure on equilibrium constants and equilibrium conversions and predict the performance of non-isothermal reactors. (BL-4)					
6	Design of reactors for homogeneous isothermal and non-isothermal reactions (BL-6)					
SYLLABUS						
Unit I	Kinetics of Homogeneous Reactions					8 hr
Classification of reactions, Rate equations of elementary and non-elementary reactions, variables affecting the rate of reaction, reaction rate constant, reaction order and molecularity, Elementary and non-elementary reactions; Concentration dependent term of rate equation, Temperature dependent term of rate equation, Comparison of theories with Arrhenius law.						
Unit II	Interpretation of Batch reactor kinetic data					8 hr
Constant and variable volume reaction systems, integral and differential methods of kinetic analysis, half-lives, fractional life method – general procedure, irreversible unimolecular type first order, bimolecular type second order, and trimolecular type third order reactions, empirical reactions of nth order, zero-order reactions, overall order of irreversible reactions, Irreversible reactions in series and parallel, Analysis of total pressure data obtained in a constant-volume system, First and second order reversible reactions, reactions of shifting order						
Unit III	Introduction to Ideal reactors					8 hr
Introduction to ideal reactors – Characteristics and performance equations of ideal batch reactor, Steady-state mixed flow reactor, Steady-state plug flow reactors. Design for single reactions - Size comparison of single reactors, multiple reactor systems, Reactors in series, parallel and series-parallel combinations, Recycle reactor, Autocatalytic reactions.						
Unit IV	Design for multiple reactions					8 hr
Introduction to multiple reactions - Selectivity and Yield, qualitative discussion and quantitative treatment of product distribution and of reactor size for parallel reactions. Irreversible first order reactions in series, qualitative discussion and quantitative treatment of product distribution, quantitative treatment - plug flow						

or batch reactor, mixed flow reactor		
Unit V	Temperature and pressure effects	8 hr
Non-isothermal operation of reactors: Optimum temperature progression; Adiabatic and non- adiabatic batch, mixed flow and plug flow reactors; exothermic reactions in mixed flow reactors		
LEARNING RESOURCES		
TEXT BOOKS:		
1	O. Levenspiel, Chemical Reaction Engineering, 3rd ed. John Wiley & Sons, 2007.	
REFERENCE BOOKS:		
1	H. S. Fogler, Elements of Chemical Reaction Engineering, 4th ed., PHI, 2005.	
2	K.G. Denbigh, J.C.R Turner, Chemical Reactor Theory: An introduction, Cambridge University Press, 3rd Ed.,1984.	

Bloom's level and units catchment articulation matrix

CO	Blooms Level	UNIT I	UNIT II	UNIT III	UNIT IV	UNIT-V
CO1	BL5	X				
CO2	BL4		X			
CO3	BL5			X		
CO4	BL6				X	
CO5	BL4					X
CO6	BL6	X	X	X	X	X

R23MCHET009	MASS TRANSFER – 1						
	Total Contact Hours	42 (L)	L	T	P	C	
	Pre-requisite	Nil	3	0	0	3	
Course Objectives:							
1	To acquire basic understanding of engineering aspects of mass transfer operations to design a suitable equipment and to solve mass transfer operation problems						
Course Outcomes							
The student will be able to							
1	Evaluate the mechanism of mass transfer through various diffusional phenomena (BL-5)						
2	Analyse the theories of mass transfer to find the rate of diffusion through mass transfer coefficients (BL-4)						
3	Explain the importance of phase equilibrium to describe various separation processes using mass transfer (BL-5)						
4	Explain the basic principles of absorption and stripping and deal with the design calculations of equipment for gas absorption (BL-5)						
5	Recommend wide applications of distillation in separation of mixtures through its principles and design calculations (BL-5)						
6	Propose suitable mass transfer equipment for gas-liquid operations (BL-6)						
SYLLABUS							
Unit I	Molecular diffusion						8 hr
Introduction: Classification of Mass Transfer Operations, Methods of conducting the Mass Transfer Operations, Design Principles. Molecular diffusion: Fick's law, Molecular diffusion in gases, Molecular diffusion in liquids, Diffusion in solids, Fick's law for solids, unsteady state diffusion, Types of solid diffusion.							
Unit II	Mass Transfer Coefficients						8 hr
Mass transfer coefficients, Theories of Mass Transfer: Film Theory, Penetration Theory, Surface Renewal Theory, Combination of film-surface renewal theory, Surface stretch theory. Flow past solids: Boundary layers, Dimensionless groups in mass transfer, Mass and heat transfer analogies.							
Unit III	Interphase Mass Transfer						8 hr
Equilibrium, Diffusion between phases, Raoult's law, Henry's law, Mass transfer between two phases, Overall mass transfer coefficient, Material balances: Steady state co-current processes, Steady state counter-current processes, Stages, Cascades: Cross flow cascades, Counter-current cascades.							
Unit IV	Gas absorption						8 hr
Equilibrium solubility of gases in liquids, Ideal liquid solutions, Selection of solvent, Co-current flow, Counter-current flow, Determination of the number of stages in a tray tower, Height equivalent to theoretical plate (HETP), Tray efficiency. Gas dispersed: Bubble columns, Mechanically Agitated vessels, Tray towers. Liquid dispersed: Venturi scrubbers, Wetted wall towers, Spray towers, Packed towers.							
Unit V	Distillation						8 hr
Vapor-liquid equilibria, Relative volatility, Flash distillation, Simple distillation, Continuous rectification of binary mixtures, Condenser, Re-boiler, Enriching section, Exhausting section, McCabe-Thiele method, Ponchon Savarit method, Azeotropic distillation, Extractive distillation.							
LEARNING RESOURCES							
TEXT BOOKS:							
1	Principles of Mass Transfer and Separation Processes by Binay K. Dutta						
2	Mass Transfer Operations, R.E. Treybal, 3rd Edition., Mc Graw Hill, 1980						

REFERENCE BOOKS:

1	Unit Operations of Chemical Engineering, W.L.Mc Cabe, J.C.Smith & Peter Harriott, McGraw- Hill, 6th Edition, 2001.
2	Coulson and Richardson's Chemical engineering, Vol 1, Backhurst, J.R., Harker, Richardson, J.F., and Coulson, J.M., Butterworth-Heinemann, 1999
3	Coulson and Richardson's Chemical engineering, Vol 2, Richardson, J.F. & Harker, J.H. with Backhurst, J.R., Butterworth-Heinemann, 2002.

Bloom's level and units catchment articulation matrix

CO	Blooms Level	UNIT I	UNIT II	UNIT III	UNIT IV	UNIT-V
CO1	BL5	X				
CO2	BL4		X			
CO3	BL5			X		
CO4	BL5				X	
CO5	BL5					X
CO6	BL6	X	X	X	X	X

R23MSCST007	PYTHON PROGRAMMING (Common to all branches)						
	Total Contact Hours	42 (L)	L	T	P	C	
	Pre-requisite	Basic C Programming	3	0	0	3	
Course Objective							
Students will gain knowledge on the basic programming constructs of python language to develop both desktop and Graphical user applications.							
Course Outcomes							
1	Students will be able to apply the basic building blocks of python language.(BL3)						
2	Students will be able to distinguish between various conditional control statements and simplify the problems using functions.(BL4)						
3	Students will be able to experiment with various non-scalar data types.(BL3)						
4	Students will be able to examine the data using file operations and pandas library.(BL4)						
5	Students will be able to decide suitable widgets to implement Graphical User applications.(BL5)						
6	Students will be able to design and develop real time applications using Python Programming constructs and GUI tkinter module. (BL6)						
SYLLABUS							
Unit I	BASICS – DATA TYPES, OPERATORS, BUILT-IN MODULES						8 hr
Data Types, Escape Sequences, Variables and Basic Input/Output; Assignment Statements, Operators; Arithmetic Expressions, Operator precedence, Type Casting, Program Comments and Docstrings; Program Format and Structure, REPL, IDLE, Running a Script from a Terminal Command Prompt; Built-In Functions and Modules; User Defined modules creation and importing a user defined module; NumPy – Functions on 1D arrays, Functions on 2D arrays; Pandas Module-Creation of Series, DataFrames, indexing objects;							
Unit II	DECISION-MAKING STATEMENTS, LOOPS AND USER-DEFINED FUNCTIONS						8 hr
Conditional Statements; While loop, for loop; range () function, nested loops; While-else, For- else, break, continue, pass; Functions: Syntax and basics of function and usage; Passing Parameters, arguments in a function – Default, keyword, positional and Variable - length arguments; local and global scope of variable; return statement, recursive function, recursion vs iteration;							
Unit III	STRINGS, LISTS, TUPLES AND DICTIONARIES						8 hr
Strings- A String is a sequence, Strings are immutable, String slice, String methods; Membership and Identity operators, String search; List- Lists are mutable, List operations; Lambda functions, Map, filter and reduce; Tuples- Tuples are immutable, Tuple operations; Tuple as return values, List Comprehension, Comparison of Lists and tuples; Dictionaries – Dictionary Creation, operations, Looping through dictionaries; Dictionary Comprehension, Applying dictionary methods to counter objects, Reverse Lookup dictionary;							
Unit IV	FILES AND PANDAS						8 hr
Introduction to Files, modes, types of files, File handling functions: open(), close(), read(), readline(), readlines(); write(), writeline(), append(); seek(), tell(), flush(); file copy using shutil (), delete a file (os.remove ()); Pandas-DataFrame creation with dictionaries, list of dictionaries, dictionary of series, renaming columns and rows labels; Importing data from CSV to DataFrame (Pandas), Inspecting data in DataFrame (head (), tail (), info()), Statistical summary (describe ()); Slicing and Sorting in Pandas; Modifying Data Frames;							

Data Cleaning in Pandas;		
Unit V	TKINTER GUI, EVENT DRIVEN PROGRAMMING, WIDGETS	8 hr
The Behavior of Terminal-Based Programs and GUI-Based Programs, Label, Entry and Button widget; Tkinter Geometry methods (pack(), grid(), place()); Event-Driven Programming, Command Buttons and Responding to Events; CheckButton and Radiobutton widgets; Menu and Menu button widgets; Listbox and Scrollbar widgets; Messagebox and Toplevel widget; File Dialog widget;		
<u>LEARNING RESOURCES</u>		
TEXTBOOKS:		
1	Kenneth A. Lambert. -Fundamentals of Python: First ProgramsII, 2 nd Edition, Publisher: Cengage Learning	
2	Reema Thareja.-Python Programming using Problem Solving Approach	
3	R. Nageswara Rao, -Core Python Programming	
REFERENCE BOOKS:		
1	Wesley J. Chun. -Core Python Programming - Second EditionII, Prentice Hall	
2	John V Guttag. -Introduction to Computation and Programming Using PythonII, Prentice Hall of India	
ADDITIONAL REFERENCE MATERIAL		
ONLINE COURSES		
1	https://www.w3schools.com/python/	
2	https://www.tutorialspoint.com/python/index.htm	
3	https://docs.python.org/3/tutorial/	
4	https://www.pythontutorial.net/tkinter	
5	https://www.python-course.eu/python3_course.php	
6	https://www.geeksforgeeks.org/python-tkinter-tutorial/	
7	https://www.tutorialspoint.com/python/python_gui_programming.htm	
8	https://www.programiz.com/python-programming	

Bloom's level – Units catchment articulation matrix

CO	Blooms Level	Unit I	Unit II	Unit III	Unit IV	Unit V
CO1	BL3	X				
CO2	BL4		X			
CO3	BL3			X		
CO4	BL4				X	
CO5	BL5					X
CO6	BL6	X	X	X	X	X

R23MSCST010		DATABASE MANAGEMENT SYSTEMS (Common to all branches)					
		Total Contact Hours	42 (L)	L	T	P	C
		Pre-requisite	-	3	0	0	3
Course Objective							
Students will get Exposure on basics of designing relational Database without having any redundancy and also gain the knowledge on handling transaction data in concurrent way and recovering from the failures.							
Course Outcomes							
1	Students will be able to choose and appreciate the RDBMS over file system and also be able to apply the knowledge of ER Modeling design the database from the client requirements (BL-3)						
2	Students Will be able to analyze the SQL query pattern and classify the query patterns based on the client requirements (BL-4)						
3	Students will be able to Examine the database design and classify the different levels of dependencies using Normal Forms and students will be able to identify how triggers are useful in data auditing purpose. (BL-4)						
4	Students will be able to compare and choose different indexing mechanisms to store data in secondary storage devices as per the requirements. (BL-5)						
5	Students will be able to justify the importance of concurrency and recovery Management (BL-5)						
6	Students will be able to design the complete database without redundant storage and able to solve the user queries (BL-6)						
SYLLABUS							
Unit I	INTRODUCTION TO DATABASE MANAGEMENT SYSTEM, ER MODELING						8 hr
Need for DBMS, Advantages of DBMS over File Systems, Database applications; Database Users, Different Data Models; 3 Levels of Abstraction in DBMS (External, Conceptual & Physical Schema) and data independence, Database Management System Structure.; Introduction to ER Model, Entity, Entity Set, Attribute – Entity Vs Attribute; Relationship & Relationship Set – Entity Vs Relationship – Binary Relationship, Ternary Relationship; Introduction to Keys (Candidate Key, Primary Key, Super Key, Unique Key, Not Null Key) – Modeling Key Constraints; Modeling Weak Entities – Mapping concept of Weak Entities to Composite, Primary Key Concept, Referential Integrity Constraint (include cascaded operations of Delete & Update) ; Modeling Participation Constraints – Cardinality, Full participation & Partial, Modeling Class Hierarchies – Mapping concept of class Hierarchies to covering constraints, Modeling Aggregation – Ternary Vs Aggregation;							
Unit II	RELATIONAL ALGEBRA & RELATIONAL CALCULUS						8 hr
Introduction to Relational Model (Translating Entity Set & Relationship set into Tables) ; Introducing Basic operations on Relations: Selection and Projection , Cartesian product, examples; Introducing Basic operations on Relations : Joins, Set Operations and examples ; Introducing Basic operations on relations: Division & Renaming and example; Syntax & Semantics of Tuple Relational Calculus (notations used to represent a query using DRC); Syntax & Semantics of Domain Relational Calculus (notations used to represent a query using DRC); TRC, DRC Query representations using AND, OR, NOT OPERATORS; IMPLIES operator , Comparison between TRC and DRC;							

Unit III	SQL (STRUCTURED QUERY LANGUAGE)	8 hr
Basic Structure of SQL queries(Basic format of select query, DDL,DML commands) ; Integrity and Referential constraints (Includes syntax for all key constraints, Translating Constraints associated with ER into Tables); Additional Basic Operations(Arithmetic, logical, relational, pattern matching); Functions(String, Date, Numeric); Aggregate Functions, Clauses and Set Operations; Join Expressions; Nested Queries, Correlated Queries; Introduction to Views, Destroying/Altering/Updating of views, Handling Null values;		
Unit IV	NORMALIZATION	8 hr
FDs and Decomposition: Problems caused by redundancy, FD (definition), Armstrong 's axioms; FD identification from relations, Equivalence of two FD sets; Dependency preserving Decomposition, examples; Lossless join, verification, examples; Normal Forms: First normal form, partial dependency, Second normal Form; Transitive dependency, third normal form, Motivation for BCNF; BCNF, Multivalued dependency, Fourth normal form.; Triggers;		
Unit V	INDEXING, TRANSACTION MANAGEMENT, CONCURRENCY CONTROL & RECOVERY MANAGEMENT	8 hr
Types of indexes (Clustered index, un clustered index primary index, secondary index), Tree based index versus and Hash based index; ISAM, B+ Tree construction (Insertion and Deletion of nodes); Transaction concept, Transaction states, ACID properties of transaction; Transactions and Schedules, Concurrent executions of transactions (anomalies); Serializability, Testing for serializability,2PL; Strict 2PL, Deadlocks, timestamp based protocols; Recoverability, Introduction to Log based recovery, check pointing and shadow paging; ARIES algorithm;		
<u>LEARNING RESOURCES</u>		
TEXTBOOKS:		
1	Data base System Concepts, Silberschatz, Korth, McGraw hill, Sixth Edition. McGrawHill.	
2	Data base Management Systems, Raghurama Krishnan, Johannes Gehrke	
REFERENCE BOOKS:		
1	Fundamentals of Database Systems, Elmasri Navathe Pearson Education.	
2	An Introduction to Database systems, C.J. Date, A.Kannan, S.Swami Nadhan, Pearson, Eight Edition for UNIT III.	
ADDITIONAL REFERENCE MATERIAL		
1	https://docs.oracle.com/cd/B19306_01/server.102/b14200/toc.htm	
2	https://dev.mysql.com/doc/refman/8.0/en/select.html	

Bloom's level – Units catchment articulation matrix

CO	Blooms Level	Unit I	Unit II	Unit III	Unit IV	Unit V
CO1	BL3	X				
CO2	BL4		X	X		
CO3	BL4				X	
CO4	BL5					X
CO5	BL5					X
CO6	BL6	X	X	X	X	

R23MCHEL003		PROCESS HEAT TRANSFER LAB						
		Total Contact Hours	42 (P)		L	T	P	C
		Pre-requisite	Nil		0	0	3	2
Course Objectives:								
The student will get experimental exposure to calculate the thermal resistance, and calculation of heat transfer coefficients for both natural and forced convection scenarios. The course will impart practical understanding of common heat transfer equipment and apply the concepts of heat transfer, fluid dynamics to the design and operation of heat transfer experiments.								
Course Outcomes								
On completion of the lab the student should be able to:								
1	Apply Fourier's law of heat conduction in finding out the thermal conductivity of a given material (BL-3)							
2	Compare the heat transfer coefficients and rate of heat transfer between natural and forced convection mechanism (BL-5)							
3	Apply Stefan-Boltzmann's law to find out Stefan - Boltzmann constant & unknown body emissivity (BL-3)							
4	Identify different boiling regimes and evaluate the critical heat flux through pool boiling of water (BL-3)							
5	Evaluate effectiveness of co-current and counter current heat exchanger (BL-5)							
6	Develop skills in data collection, analysis and interpretation (BL-6)							
7	Discuss the results effectively in written and oral reports (BL-6)							
List of Experiments								
1.	Determination of overall heat transfer coefficient of composite wall							
2.	Determination of thermal conductivity of insulating powder							
3.	Determination of thermal conductivity of given metal rod							
4.	Determination of heat transfer coefficient in unsteady state heat transfer							
5.	Determination of heat transfer coefficient in natural convection							
6.	Determination of forced convective heat transfer coefficient for air flowing through a pipe							
7.	Determination of critical heat flux point for pool boiling of water							
8.	Determination of Stefan-Boltzmann constant for a given test body with black body							
9.	Determination of emissivity of a given plate at various temperatures							
10.	Determination of effectiveness and overall heat transfer coefficient in double pipe heat exchanger							
11.	Determination of efficiency and effectiveness of pin-fin							
12.	Heat transfer coefficient in drop wise & film type condensation							
LEARNING RESOURCES								
TEXT BOOKS:								
1	W.L. McCabe, J. C. Smith & P. Harriot, Unit Operations of Chemical Engineering, 7 th ed., McGraw-Hill, 2005							
2	B. K. Dutta, Heat Transfer Principles and Applications, 2 nd ed., PHI, 2009							
3	J. P. Holman, Heat Transfer, 10 th ed., McGraw Hill, 2009							
REFERENCE BOOKS:								
1	Y.V.C. Rao, Heat Transfer, University Press, 1 st ed., 2002							
2	D.Q. Kern, Process Heat Transfer, 1 st ed., McGraw-Hill Publications, 1950							
3	Dr. D.S. Kumar, Heat & Mass transfer, S.K. Kataria& Sons, 2013							

R23MCHEL004	CHEMICAL REACTION ENGINEERING LAB						
	Total Contact Hours	42 (P)	L	T	P	C	
	Pre-requisite	Nil	0	0	3	2	
Course Objectives:							
In this lab course, students will perform experiments related to chemical reactions, chemical reaction kinetics and basic operation of chemical reactors like CSTR, Batch, PFR reactors.							
Course Outcomes							
After successful completion of this lab, the students will be able to,							
1	Estimate reaction rate constant by applying Arrhenius theorem (BL-5)						
2	Analyse the concentration versus time data and determine the specific rate constant and the order of the reaction. (BL-4)						
3	Design and sizing of industrial scale reactor on the basis of kinetic data obtained at lab scale (BL-6)						
4	Determine RTD and model parameters in a PFR, Packed bed reactors (BL-5)						
5	Compare theoretical and experimental conversions in a CSTR and PFR and choose right kind of reactor for a single reaction (BL-4)						
6	Design lab equipment like CSTR, Batch, PFR reactors. (BL-6)						
LIST OF EXPERIMENTS							
1.	Determination of the order of a reaction using a batch reactor and analyzing the data by (a) differential method (b) integral method.						
2.	To determine the specific reaction rate constant of a reaction of a known order using a CSTR.						
3.	To determine the order of the reaction and the rate constant using a tubular reactor.						
4.	To study the effect of temperature on the reaction rate constant and to determine the activation energy of a reaction using (a) Batch reactor (b) CSTR (c) Plug flow reactor						
5.	To study the effect of residence time on conversion in a CSTR for a given reaction						
6.	To study the effect of residence time on conversion in a tubular reactor for a given reaction						
7.	To study the performance characteristics of combined flow reactors connected in series (PFR-MFR) and to determine the best reactor setup for a given reaction.						
8.	Determination of RTD and dispersion number for a packed-bed using tracer						
9.	Determination of RTD and dispersion number in a tubular reactor using a tracer.						
10.	Mass transfer with chemical reaction (solid-liquid system) – determination of mass transfer coefficient.						
11.	Mass transfer with chemical reaction (liquid-liquid system) – determination of mass transfer coefficient						
LEARNING RESOURCES							
TEXT/REFERENCE BOOKS:							
1	O. Levenspiel, Chemical Reaction Engineering, 3rd ed. John Wiley & Sons, 2007.						
REFERENCE BOOKS:							
1	H. S. Fogler, Elements of Chemical Reaction Engineering, 4th ed., PHI, 2005.						
2	K.G. Denbigh, J.C.R Turner, Chemical Reactor Theory: An introduction, Cambridge University Press, 3rd Ed.,1984						

R23MSCSL005	PYTHON PROGRAMMING LAB (Common to all branches)					
	Total Contact Hours	42 (P)	L	T	P	C
	Pre-requisite	C Programming	0	0	3	2
Course Objective						
Students will implement python programming constructs which are used to develop both desktop and graphical user applications.						
Course Outcomes						
1	Students will be able to apply the basic building blocks of python language like variables, operators and modules.					
2	Students will be able to apply conditional control statements and functions.					
3	Students will be able to apply various file operations and analyze the data using pandas library.					
4	Students will be able to choose and decide the suitable widgets to design and develop Graphical User Interface (GUI) applications.					
List of Experiments						
1	Week – 1: DATA TYPES, OPERATORS, BUILT-IN FUNCTIONS 1. Write a python script to illustrate data types (int, char, float, string). 2. Write a python program to perform the following expressions using operator precedence (1) 5+3*2 (2) 2*3**2 (3) 2**3**2 (4) (2**3)**2 3. Write a python program to illustrate type conversion functions 4. Write a python program to illustrate pi, sqrt, cos, sin functions of mathmodule					
2	Week – 2: PROGRAMS WITHOUT CONTROL STATEMENTS 1. Write a program to calculate simple interest 2. Write a python program to calculate compound interest 3. Write a python program to print ASCII value of a character 4. Write a python program to find the area of a circle 5. Write a python program to find the area of a triangle 6. Write a program to perform string concatenation					
3	Week – 3: PROGRAMS ON NUMPY MODULE 1. Write a program to work with 1D array operations including indexing and slicing. 2. Write a program to work with 2D array operations					
4	Week – 4: PROGRAMS ON CONTROL STATEMENTS 1. Write a python program find the power of a number without built-in functions. 2. Write a python program to count the number of even and odd numbers upto the given range. 3. Write a python program to print the multiplication table for a given number. 4. Write a python program to display minimum and maximum among three numbers.					
5	Week – 5: PROGRAMS ON FUNCTIONS 1. Write a python program to find if a number is prime or not with					

	and without recursion. 2. Write a python program to display Fibonacci series using iteration and recursion. 3. Write a python program to find the factorial of a number with and without recursion.
6	Week – 6: PROGRAMS ON STRINGS 1. Write a program to work with string built-in functions 2. Write a python program to determine number of times a given letter occurs in a string 3. Write a python program to check if a string is a palindrome or not. 4. Illustrate in operator and write a python program to count number of lowercase characters in a string. 5. Write a program to replace all the occurrences of letter 'a' with letter 'x' in a string.
7	Week – 7: PROGRAMS ON LISTS 1. Write a program to implement the following list functions a)len() b)extend() c)sort() d) append() e)insert() f)remove() 2. Write a program to pass list as an argument to a function 3. Write a python program to find the largest and smallest number in a list. 4. Write a python program to merge two lists and sort it. 5. Write a python program to remove the duplicate items from a list. 6. Write a python program to find sum of elements in a list
8	Week – 8: PROGRAMS ON TUPLES , DICTIONARIES 1. Write a program to create a list of tuples with the first element as the number and the second element as the square of the first element. 2. Write a python program that takes the list of tuples and sorts the list of tuples in increasing order by the last element in each tuple. 3. Write a program to implement the following dictionary methods a) keys() b) values() c)items() d) pop() e)delete() 4. Write a python program to add a key value pair to a dictionary and update the dictionary based on the key. 5. Write a Program to do a reverse dictionary lookup in python.
9	Week – 9: PROGRAMS ON FILES 1. Write a program to implement read(), readline(), readlines(), write(), writelines() methods on files. 2. Write a program to implement seek(), tell() and flush() methods with different arguments in a file. 3. Write a program to generate 20 random numbers in the range of 1 to100 and write to a file.
10	Week – 10: PROGRAMS ON PANDAS MODULE 1. Write a program to import data from CSV to DataFrame and inspect data in DataFrame using head(), tail (), info() and describe() functions in pandas. 2. Write a program to perform sorting and slicing operations in pandas. 3. Write a program to perform dataframe modification and data cleaning in pandas.
11	Week – 11: PROGRAMS ON GUI 1. Design and develop a GUI application to display -Hello World.

	2. Design and develop a GUI application using Label, Entry and Button widgets. 3. Design and develop a GUI application using Tkinter Geometry methods pack(),grid(), place(). 4. Design and develop a GUI application using CheckButton and Radiobutton widgets.
12	Week – 12: PROGRAM ON GUI CONTI... 1. Design and develop a GUI application using Menu and Menubutton widgets. 2. Design and develop a GUI application using Listbox and Scrollbar widgets. 3. Design and develop a GUI application using MessageBox and File Dialog widget
Demonstration experiments	
1	Demonstration of Python IDLE to implement solutions.
2	Demonstration on Colab notebook to read, access and display data from google drive.
3	Demonstration on jupyter notebook to link and access data.
<u>LEARNING RESOURCES</u>	
TEXTBOOKS:	
1	Kenneth A. Lambert. -Fundamentals of Python: First ProgramsII, 2 nd Edition, Publisher: Cengage Learning
2	Reema Thareja.-Python Programming using Problem Solving Approach
3	R. Nageswara Rao, -Core Python ProgrammingII
REFERENCE BOOKS:	
1	Wesley J. Chun. -Core Python Programming - Second EditionII, Prentice Hall
2	John V Guttag. -Introduction to Computation and Programming Using PythonII, Prentice Hall of India.
3	Python Practice Book Release 2014, Anand Chitipothu.
ADDITIONAL REFERENCE MATERIAL	
1	https://www.w3schools.com/python/
2	https://www.tutorialspoint.com/python/index.htm
3	https://docs.python.org/3/tutorial/
4	https://www.pythontutorial.net/tkinter
5	https://www.python-course.eu/python3_course.php
6	https://www.geeksforgeeks.org/python-tkinter-tutorial/
7	https://www.tutorialspoint.com/python/python_gui_programming.htm
8	https://www.programiz.com/python-programming

R23MENGAT01	ETHICS AND HUMAN VALUES					
	Total Contact Hours	28 (L)	L	T	P	C
	Pre-requisite		2	0	0	0
Course Objective						
The course creates awareness regarding the need for the development of a holistic perspective in understanding the nuances of personal, professional and social life. It enables the student to grasp the ethical principles that govern human existence.						
Course Outcomes						
After completing this course, the students will be able to						
1	Identify the relevance of the concepts of Self -Exploration and Natural Acceptance in day-to-day life to achieve continuous happiness and prosperity. (BL 3)					
2	Discuss the impact of trust and respect as foundational values in human relationships to achieve comprehensive human goals. (BL 3)					
3	Understand the relevance of ethical theories and their applications in societal living. (BL3)					
4	Understand the concept of ethics in engineering practice (BL 3)					
5	Discuss the purview of ethics in understanding global issues pertaining to different fields. (BL 3)					
SYLLABUS						
Unit I	UNDERSTANDING THE SELF					5 hr
Characteristics of Universal Human Values; Self-Exploration– Meaning and Process; Basic Human Aspirations – Meaning and Basic Requirements for fulfilment; Concept of Human Existence – Conscious and Material Entities; Difference between the Conscious and the Material Entities of Human Existence.						
Unit II	UNDERSTANDING THE FAMILY AND SOCIETY					5 hr
Understanding the importance of harmony in a family; Exploring value of feelings in relationships; Measures to ensure Harmony in the family. Understanding conflict (meaning, types); Dimensions of Human order for harmony in society – Physical, mental, social and spiritual; Universal values of justice, democracy, respect and gratitude.						
Unit III	ETHICAL THEORIES					6 hr
Professionalism and ethics; Ethical Theories: Golden mean theory, Rights-based theory, Duty-based theory, Utilitarian theory, Kohlberg’s Theory. Moral issues; Moral Dilemmas; Types of Inquiries – Normative, Conceptual, factual/descriptive.						
Unit IV	ETHICS AND ENGINEERING					6 hr
Engineering ethics - Social Experimentation; Safety Responsibility and Rights: Engineers as responsible Experimenters, Concept of Safety and Risk: Engineer’s Responsibility for Safety, Risk – Benefit Analysis. Case Studies: The challenger disaster, The Three Mile Island, Fukushima Nuclear Disaster, Bhopal Gas Tragedy, The Titan submersible disaster.						
Unit V	ETHICS AND GLOBAL ISSUES					6 hr
Ethics and Global Issues: Environmental ethics; computer ethics; Business Ethics; Corporate Social responsibility; Code of ethics.						
<u>LEARNING RESOURCES</u>						
TEXTBOOKS:						
1	R R Gaur, R Sangal, G P Bagaria, “A Foundation Course in Human Values and Professional Ethics” Excel Books, New Delhi, 2010.					
REFERENCE BOOKS:						
1	A.N. Tripathi, “Human Values”, 2nd Edition, New Age International Publishers, 2004.					
2	Charles D. Fleddermann, “Engineering Ethics”, Pearson Education / Prentice Hall, New Jersey, 2004.					

V Semester

R23MCHET010	TRANSPORT PHENOMENA						
	Total Contact Hours	42 (L)	L	T	P	C	
	Pre-requisite	Fluid Mechanics, Heat and Mass transfer	3	0	0	3	

Course Objectives:

Transport Phenomena covers momentum, mass, and energy transport, highlighting the analogies among them and their applications in chemical process engineering. The course introduces students to the systematic use of shell balances and equations of change, enabling them to analyze and solve a wide range of transport problems. By integrating theory with practical applications, it equips future engineers with the skills needed for effective process design and problem-solving.

Course Outcomes:

After completing this course, student will be able to

1	Analyze the fluid flow behavior predicted by various flow models and compare how transport properties change with temperature and pressure. (BL-4)
2	Analyze velocity profiles obtained from shell momentum balance for different flow geometries, and interpret the influence of geometry on flow behavior. (BL-4)
3	Analyze temperature profiles derived from shell energy balance, and explain how they vary across different heat transport problems. (BL-4)
4	Develop concentration profiles obtained from shell mass balance in mass transport problems, and derive the equations of change for mass, momentum, and heat transport. (BL-3)
5	Develop velocity, temperature, and concentration profiles from the equations of change for transport processes. (BL-3)
6	Formulate mathematical models for momentum, heat, and mass transport problems in process industries using transport phenomena principles. (BL-6)

SYLLABUS

Unit I	Transport properties – Flow models	8 hr
Analogy between the laws of Transport Phenomena; Flow models for Non-Newtonian fluids; Effect of Temperature and Pressure on Viscosity; Effect of Temperature and Pressure on Thermal conductivity; Effect of Temperature and Pressure on Diffusivity.		
Unit II	Shell Momentum balance	8 hr
Shell momentum balance and boundary conditions; Flow over an inclined plate (Flow of a falling film); Fluid flow between two parallel walls (narrow slit); Fluid flow through a circular tube; Flow of a Bingham plastic fluid through a circular tube.		
Unit III	Shell Energy balance	8 hr
Shell energy balances and boundary conditions; Heat conduction with an electrical heat source: Plane slab, Solid Cylinders, Solid Spheres; Heat conduction through plane walls with constant and variable thermal conductivity; Heat conduction with a viscous heat source; Heat conduction in a cooling fin.		
Unit IV	Shell Mass balance-Equations of change and applications	8 hr
Shell mass balance and boundary conditions; Diffusion through a Stagnant gas film; Diffusion with homogeneous Chemical reaction; Pore diffusion with Chemical reaction. Equations of change: Equation of continuity; Equation of motion; Equation of energy; Equation of continuity for binary mixtures; Application of equations of change: Heat conduction through plane structures without heat generation.		
Unit V	Applications of Equations of change	8 hr
Heat conduction through plane structures with heat generation; Flow over an		

inclined plate (Flow of a falling film); Flow between two parallel stationary plates; Flow through a circular tube; Flow through an annulus; Flow between rotating cylinders; Flow confined between two parallel plates with top plate moving (Simple Couette flow); Flow between two parallel plates with top plate moving (Couette flow).

LEARNING RESOURCES

TEXT BOOKS:

1	Transport Phenomena by Bird R.B., Stewart W.C., Lightfoot F.N., 2nd ed. John Wiley & Sons Inc, U.S.A, 1960.
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REFERENCE BOOKS:

1	Transport processes and unit operations by C.J. Geankoplis, PHI, 3rd ed. 1997.
2	Fundamentals of heat, momentum and mass transfer, Welty, Wicks and Wilson, John Wiley.

ONLINE RESOURCES

1.	https://nptel.ac.in/courses/103105128
2.	https://nptel.ac.in/courses/103108220

Bloom's level and-Units catchment articulation matrix

CO	Blooms Level	UNIT I	UNIT II	UNIT III	UNIT IV	UNIT-V
CO1	BL4	X				
CO2	BL4		X			
CO3	BL4			X		
CO4	BL3				X	
CO5	BL3					X
CO6	BL6	X	X	X	X	X

R23MCHET011		CHEMICAL REACTION ENGINEERING-II					
		Total Contact Hours	42 (L)	L	T	P	C
		Pre-requisite	Chemical Reaction Engineering-I	3	0	0	3
Course Objectives:							
Understand the basics of non-ideal flow and understand the concepts of Catalysis and Kinetics of heterogeneous catalytic reactions, concepts of pore diffusion resistance combined with surface kinetics and mechanism of Catalyst deactivation and identify the effects of temperature and pressure on equilibrium constants.							
Course Outcomes							
By the end of this course, student will be able to,							
1	Determine RTD and conversion in real reactors using zero parameter models. (BL-5)						
2	Compare the performance of single parameter models to predict the conversion in real reactor. (BL-5)						
3	Explain the concepts of Catalysis and synthesizing a rate law- mechanism and design of solid catalysed reactors for heterogeneous reactions. (BL-5)						
4	Explain the Performance equations for reactors containing porous catalyst particles. (BL-5)						
5	Determine the effect of catalyst deactivation for design of real solid catalysed reactions. (BL-5)						
6	Design of reactors for non-ideal reactions and heterogeneous catalytic reactions. (BL-6)						
SYLLABUS							
Unit I	Introduction to non-ideal flow						8 hr
Basics of non-ideal flow- E, the age distribution of fluid, the RTD, Conversion in Non-ideal flow reactors, Earliness of mixing, segregation and RTD- self-mixing of a single fluid, mixing of two miscible fluids.							
Unit II	Models of non-ideal flow						8 hr
The dispersion model-axial dispersion, correlations for axial dispersion, chemical reaction and dispersion, The tanks in series model- pulse response experiments and the RTD, chemical conversion. The convection model for laminar flow- the convective model and its RTD, chemical conversion in laminar flow reactors.							
Unit III	Catalysis						8 hr
Catalysis and Catalytic reactors- catalysts, steps in catalytic reactions, synthesizing a rate law, mechanism and rate limiting step. Heterogeneous reactions -Introduction. Solid catalyzed reactions- The rate equation for Surface Kinetics- Pore diffusion resistance combined with surface kinetics.							
Unit IV	Solid Catalyzed Reactions						8 hr
Solid Catalyzed Reactions-Performance equations for reactors containing porous catalyst particles, Experimental methods for finding rates.							
Unit V	Deactivating catalysis						8 hr
Deactivating catalysts, Mechanism of Catalyst De-activation, the rate and performance equations, the rate equation from experiment, determining the rate for independent deactivation, Effect of pore diffusion resistance on the kinetics of reactions with deactivating catalysts.							
LEARNING RESOURCES							
TEXT BOOKS:							
1	Chemical Reaction Engineering by Octave Levenspiel 3rd ed. Wiley Eastern Ltd.						
2	Elements of chemical reaction engineering by H.S. Fogler, 3rd ed. PHI, 1999.						

Bloom's level and units catchment articulation matrix

CO	Blooms Level	UNIT I	UNIT II	UNIT III	UNIT IV	UNIT-V
CO1	BL4	X				
CO2	BL4		X			
CO3	BL5			X		
CO4	BL5				X	
CO5	BL5					X
CO6	BL6	X	X	X	X	X

R23MCHET012	MASS TRANSFER –II						
	Total Contact Hours	42 (L)	L	T	P	C	
	Pre-requisite	Mass Transfer-I	3	0	0	3	
Course Objectives:							
Give an elaborative idea of separation techniques like extraction, leaching, adsorption, drying & crystallization and to understand the thrust of mass transfer operation's solutions & threshold limits of various processes involved.							
Course Outcomes							
The student will be able to							
1	Explain the liquid extraction process to separate the constituents and study the preliminary design of extraction equipment. (BL-5)						
2	Explain the separation of soluble constituents of a solid material using a suitable solvent by leaching operation. (BL-5)						
3	Evaluate the process design aspects of adsorption principles through adsorption isotherms and study fundamental design of equipment used. (BL-5)						
4	Estimate total time of drying and discuss the role of drying in product manufacturing in process industries. (BL-5)						
5	Conclude the importance of crystallization and select a suitable membrane separation process for different applications. (BL-5)						
6	Recommend the most important separation equipment in the process industries.(BL-6)						
SYLLABUS							
Unit I	LIQUID LIQUID EXTRACTION						8 hr
Liquid-liquid operations, fields of usefulness, liquid –liquid equilibrium, Equilateral triangular co-ordinates, choice of solvent, stage wise contact, multi stage cross current extraction, Multistage counter current without reflux. differential extractors (continuous contact), spray towers, packed towers, Mechanically agitated counter current extractors, centrifugal extractors, dilute solutions,							
Unit II	LEACHING						8 hr
Leaching: Fields of applications, Preparation of solid for leaching, Types of leaching, leaching equilibrium, single stage and multi stage leaching calculations, constant under flow conditions, Equipment for leaching operations.							
Unit III	ADSORPTION						8 hr
Types of adsorption, nature of adsorbents, adsorption equilibrium, single gases and vapors, adsorption hysteresis, effect of temperature, heat of adsorption, vapor and gases mixtures: one component adsorbed, effect of change of temperature or pressure. Freundlich equation, application of the Freundlich equation to single and multistage adsorption(cross current and counter. Fluidized and teeter beds, continuous contact steady state moving bed adsorbers, unsteady state –fixed bed adsorbers, chromatography, pressure swing adsorption, Ion – exchange techniques and applications, ion movement theory, ion exclusion.							
Unit IV	DRYING						8 hr
Drying: Equilibrium, definitions, drying conditions-rate of batch drying under constant drying conditions, Mechanisms of batch drying, drying time through							

circulation drying, Classification of drying operations: Batch and continuous drying equipment, Material and energy balances of continuous driers, rate of drying for continuous direct heat driers.			
Unit V	CRYSTALLIZATION & MEMBRANE SEPARATION PROCESSES		8 hr
Crystallization: Nucleation and crystal growth, controlled rate of crystals, crystallization equipment. Membrane separation processes: Basic principles of membrane separation, Brief introduction on reverse osmosis, nanofiltration, ultrafiltration, microfiltration, Pervaporation, dialysis, membrane extraction, electro dialysis; Types of synthetic membranes-micro porous, asymmetric, thin film composite, electrically charged and inorganic membranes, Membrane modules-industrial applications			
LEARNING RESOURCES			
TEXT/REFERENCE BOOKS:			
1	Mass transfer operations by R.E. Treybal, 3rd ed. McGraw Hill, 1980.		
2	Principles of Mass Transfer and Separation Processes by Binay K. Dutta		
REFERENCE BOOKS:			
1	Unit Operations of Chemical Engineering, W.L.Mc Cabe, J.C.Smith & Peter Harriott, McGraw- Hill, 6th Edition, 2001.		
2	Coulson and Richardson's Chemical engineering, Vol 1,Backhurst, J.R., Harker, Richardson, J.F., and Coulson, J.M., Butterworth-Heinemann, 1999		
3	Cussler E. L., Diffusion: Mass Transfer in fluid system, Cambridge University Press, 2009.		

Bloom's level and units catchment articulation matrix

CO	Blooms Level	UNIT I	UNIT II	UNIT III	UNIT IV	UNIT-V
CO1	BL5	X				
CO2	BL5		X			
CO3	BL5			X		
CO4	BL5				X	
CO5	BL5					X
CO6	BL6	X	X	X	X	X

R23MCHET013	PROCESS INSTRUMENTATION					
	Total Contact Hours	42 (L)	L	T	P	C
	Pre-requisite	Physics, Chemistry, thermodynamics	3	0	0	3
Course Objectives:						
This course aims to help students to learn the basic elements of an instrument and its static and dynamic characteristics, the various types of industrial instruments to measure pressure, temperature, composition, head, level, flow rate etc in various industries.						
Course Outcomes: The student will be able to						
1	Analyze instrumentation elements and characteristics for their industrial applications. (BL-4)					
2	Apply temperature measurement techniques for various industrial applications (BL-3)					
3	Recommend the various pressure and flow measurement systems for accurate monitoring. (BL-5)					
4	Evaluate methods for composition and level measurement to recommend optimal solutions. (BL-5)					
5	List advanced techniques for instrumentation and process analysis to enhance system performance. (BL-4)					
6	Elaborate and design comprehensive industrial instrumentation systems to enhance process efficiency and reliability. (BL-6)					
SYLLABUS						
Unit I	Introduction to Instrumentation					8 hr
Introduction about instruments: Elements of Instruments, Static and Dynamic Characteristics, Response of First Order Instruments. Expansion thermometers: Mercury-in-Glass Thermometer, Bimetallic Thermometer, Pressure Spring Thermometer, static accuracy and response of thermometers.						
Unit II	Temperature Measurement and Indicating Instruments					8 hr
Thermoelectric and resistance temperature measurement: Thermo electricity, Industrial thermocouples, thermocouple wires and wells, Thermal coefficient of resistance, industrial resistance thermometer bulbs and circuits. Radiation thermometers: Laws of radiation, Radiation receiving elements, radiation Thermometers, Photoelectric Pyrometers, Optical Pyrometers.						
Unit III	Pressure and Flow Measurement					8 hr
Pressure measurement: Liquid Column Manometers, Gauge Pressure Measuring Elements, Vacuum Measurement, Indicating Elements for Pressure Gauges, measurement of absolute pressure. Flow metering: Open channel meters, Area flow meters, viscosity measurements and quantity meters.						
Unit IV	Composition and Level Measurement					8 hr
Composition Analysis: Spectroscopic Analysis by absorption, emission and mass spectroscopy, Gas Chromatography, Refractometer. Measurement of head and level: Direct measurement of liquid level, Level Measurement in Open Vessels, Level Measurement in Pressure Vessels, Density Measurement.						
Unit V	Advanced Instrumentation Techniques					8 hr
Thermal Conductivity Measurement, small angle X-ray scattering (SAXS), X-ray diffraction (XRD), Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM), Atomic Force Microscopy (AFM), Scanning Tunneling Microscopy (STM) and Field Ion Microscopy (FIM).						

LEARNING RESOURCES	
TEXT BOOKS:	
1	Industrial instrumentation by Donald P.Eckman, Wiley eastern, 1950.
REFERENCE BOOKS:	
1	Principles of industrial instrumentation by Patra Nabis, TMH
2	Nanoscience and nanotechnology by BS Murthy, P Shankar, B Raj, BB Rath and James Murday, Universities Press,2013.
3	Instruments for measurements and control by Holbrock W.C. Van Nostrand East West.
4	Hand book Instrumentation, Considine, McGraw Hill.
5	Instrumentation for Process measurement and Control, Norman A. Anderson,3rd Edition, CRC press.

Bloom's level and units catchment articulation matrix

CO	Blooms Level	UNIT I	UNIT II	UNIT III	UNIT IV	UNIT-V
CO1	BL4	X				
CO2	BL3		X			
CO3	BL5			X		
CO4	BL5				X	
CO5	BL4					X
CO6	BL6	X	X	X	X	X

R23MCHET021 (DSC-E1)		PETROLEUM REFINING					
		Total Contact Hours	42 (L)	L	T	P	C
		Pre-requisite	Nil	3	0	0	3
Course Objectives: This course aims will help in understanding the science and engineering that sustenance the transformation of crude oil into fuels, petrochemicals, and countless other indispensable commodities.							
Course Outcomes: After completing this course, the students will be able to,							
1	Identify various ways of petroleum formation, refine crude oil, and understand their properties. (BL-3)						
2	Evaluate and test the properties of petroleum products. (BL-5)						
3	Distinguish between important petroleum operations involved in thermal and catalytic cracking processes. (BL-4)						
4	Differentiate and compare various aspects of petroleum fractionation. (BL-4)						
5	Evaluate the processing methods for gasoline, kerosene, and lubricants. (BL-5)						
6	Design an optimal process technology for transforming crude petroleum into refined products. (BL-6)						
SYLLABUS							
Unit I		Origin, Formation and Composition of Petroleum				8 hr	
Origin, formation and composition of petroleum: Origin and formation of petroleum, Reserves and deposits in world, Indian Petroleum Industry, Evaluation of petroleum.							
Unit II		Properties of petroleum				8 hr	
Past, present and future of petroleum refining, Characterization of petroleum & Petroleum products, Chemical Composition of Crude Petroleum. Thermal properties of petroleum fractions, important products of Petroleum, properties and test methods.							
Unit III		Thermal and Catalytic Processes				8 hr	
Thermal and catalytic processes: Cracking, catalytic cracking, catalytic reforming, Naphtha cracking, coking, Hydrogenation processes, Alkylation processes, Isomerization process.							
Unit IV		Fractionation of Petroleum				8 hr	
Fractionation of petroleum: Dehydration and desalting of crudes, heating of crude, pipe still heaters, distillation of petroleum, blending of gasoline.							
Unit V		Treatment Techniques				8 hr	
Treatment techniques: Fraction-impurities, treatment of gasoline, treatment of kerosene, treatment of lubes.							
LEARNING RESOURCES							
TEXT BOOKS:							
1	B.K.B Rao. "Modern Petroleum Refining Processes", 5 th Edition, Oxford and IBH Publishing, 2002.						
2	Nelson. W.L. "Petroleum refining Engineering", 4th Edition, Mc Graw Hill, New York, 1969.						
3	Mohamed A.Fahim, Taher A. Alsahhaf and Amal Elkilani, "Fundamentals of Petroleum Refining", Elsevier science, 2010.						
REFERENCE BOOKS:							
1	Hengstebeck R.J., "Petroleum Refining", McGraw Hill, New York 1959.						
2	Goldstine. R.F. "The Petroleum Chemicals Industry", Taylor and Francis, London, 1967.						

Bloom's level and-Units catchment articulation matrix

CO	Blooms L	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5
CO 1	BL 3	X				
CO 2	BL 5		X			
CO 3	BL 4			X		
CO 4	BL 4				X	
CO 5	BL 5					X
CO 6	BL 6	X	X	X	X	X

R23MCHET026 (DSC-E1)		FLUIDIZATION ENGINEERING					
		Total Contact Hours	42 (L)	L	T	P	C
		Pre-requisite	Basics of Fluid Mechanics, Heat Transfer, Mass Transfer and Reaction Engineering	3	0	0	3
Course Objectives:							
This course mainly covers the basic principles of fluidization phenomenon and introduces the fundamental and practical aspects of basic fluidization operations for industrial applications.							
Course Outcomes							
The student will be able to							
1	Explain the fluidization phenomena and analyze flow characteristics of various types of fluidization (BL-5)						
2	Determine pressure drop across the fluidized beds by analysing flow patterns and solid movement (BL-5)						
3	Classify various types of gas distributors for fluidized beds and determine effectiveness of gas mixing at the bottom region. (BL-4)						
4	Explain entrainment and attrition mechanisms and to estimate rate of mass transfer for the fluidized beds. (BL-5)						
5	Evaluate rate of heat transfer for the fluidized beds and design a suitable fluidized bed reactors. (BL-5)						
6	Recommend the most suitable fluidization techniques for the process industries.(BL-6)						
SYLLABUS							
Unit I	Introduction to Fluidization						8 hr
The phenomenon of fluidization; Advantages and disadvantages of fluidized beds; Industrial applications of fluidized beds; Classification of solids, Flow characteristics and its outline in the different types of fluidization.							
Unit II	Flow pattern of fluidization system						8 hr
Flow pattern and its transition, flow pattern map, Frictional pressure drop and its model to analyse. Solid movement, mixing, segregation and staging							
Unit III	Gas distribution in Fluidized beds						8 hr
Type of gas distributors in small and large scale industries, Design of distributor, Bubbling fluidized beds: Gas dispersion and gas interchange in bubbling beds, mixing characteristics							
Unit IV	Particle distribution and Mass Transfer phenomenon						8 hr
Entrainment and elutriation from fluidized beds, Attrition: Attrition mechanism and its analysis by model Mass transfer phenomena: Particle to gas mass transfer phenomena and its analysis by model in two e phase system.							
Unit V	Heat Transfer phenomena						8 hr
Heat transfer between fluidized beds and surfaces and modeling. Design of fluidized bed reactors: Design for physical operation, catalytic and non-catalytic system.							

LEARNING RESOURCES	
TEXT BOOKS:	
1	D. Kunii and O. Levenspiel, Fluidization Engineering, Butterworth, 1991.
2	D. Gidaspow, Multiphase flow and fluidization: continuum and kinetic theory description, Elsevier Science & Technology Books, 1993
REFERENCE BOOKS:	
1	L.G. Gibilaro, Fluidization-dynamics, Butterworth-Heinemann, 2001
2	S. K. Majumder, Hydrodynamics and Transport Processes of Inverse Bubbly Flow, 1st ed. Elsevier, Amsterdam (2016)

Bloom's level and units catchment articulation matrix

CO	Blooms Level	UNIT I	UNIT II	UNIT III	UNIT IV	UNIT-V
CO1	BL5	X				
CO2	BL5		X			
CO3	BL4			X		
CO4	BL5				X	
CO5	BL5					X
CO6	BL6	X	X	X	X	X

R23MSCST005	SOFTWARE ENGINEERING (Common to all Branches)					
	Total Contact Hours	42 (L)	L	T	P	C
	Prerequisite	None	3	0	0	3
Course Objective						
This course introduces students to fundamental Software Engineering principles, including software processes, requirements engineering, design, testing, quality assurance, and risk management.						
Course Outcomes						
After completing this course, the students will be able to						
1	Students will have the ability to apply the core concepts of software engineering, including the nature of software, layered technology, and common software myths, to analyze real-world software development scenarios. (BL-3)					
2	Students will have the ability to analyze various software process models to determine their suitability for different types of projects. (BL-4)					
3	Students will have the ability to apply requirements engineering techniques to elicit, document, and validate software requirements and utilize software design models (BL-3)					
4	Students will evaluate various software testing strategies, assess the effectiveness of black box and white box testing methods, and recommend improvements in testing strategies based on product metrics and testing outcomes to optimize software quality. (BL-5)					
5	Students will have the ability to analyze software project risks and develop strategies for risk mitigation and management (BL-6)					
6	Students will write the entire software engineering process, assess the effectiveness of each phase from requirements gathering to deployment, and recommend improvements for optimizing the overall workflow and activities involved in software engineering. (BL-6)					
SYLLABUS						
Unit I	INTRODUCTION TO SOFTWARE ENGINEERING					8 hr
The Nature Of Software; Software Engineering - A Layered Technology; Software Engineering Practice; Software Myths; A Generic Process Model, Software Process Framework; Process flow, Identifying Task set, Process pattern; Process Assessment and Improvement (SCAMPI, CMM-IPI, SPICE, ISO 9001:2000); The Capability Maturity Model Integration (CMMI);						
Unit II	PROCESS MODELS & SOFTWARE REQUIREMENTS					8 hr
The Waterfall Model, Incremental Process Models; Evolutionary Process Models: The Prototype Model, Spiral Model; Unified Process, Personal And Team Process Models; Agile Process Model; Feasibility Studies, User Requirements and System Requirements; Functional and Non - Functional Requirements; The software requirements document; Requirements engineering processes;						
Unit III	REQUIREMENTS ENGINEERING & DESIGN ENGINEERING					8 hr
Establishing The Groundwork, Requirements Elicitation; Requirement Analysis - DFD, Data Dictionaries; Developing Use Cases, Use Case Diagrams; Requirements Negotiation and Validation; Requirements Management; Preparation of SRS; Design Concepts - Abstraction, Architecture, Patterns, Separation of concerns and Modularity ;The Design Model - Data Design Elements, Architectural Elements-Interface, Component and Deployment design elements;						
Unit IV	TESTING STRATEGIES & METRICS					8 hr
A Strategic Approach to Software Testing, Test Strategies for Conventional Software - Unit and Integration Testing; Testing Strategies - Validation Testing, System Testing; Black Box Testing - Graph-Based Testing Methods; White box testing - Basis path testing; A Framework for Product Metrics - Measures, Metrics, and Indicators; Metrics for the Requirements Model - Function-Based Metrics; Metrics for the Design Model-						

Architectural Design Metrics and Metrics for Source Code; Metrics for Testing		
Unit V	QUALITY MANAGEMENT & RISK MANAGEMENT	8 hrs
Quality Management - Software Quality (McCall's software quality factors) ; Review Techniques - Informal and Formal Review Techniques; Software Quality Assurance Elements of SQA, SQA Tasks, Goals and Metrics; Statistical SQA, ISO 9000 Quality Standards; Reactive vs. Proactive Risk Strategies; Software Risks; Risk Identification; Risk Projection, Risk Refinement; RMMM Plan;		
<u>LEARNING RESOURCES</u>		
TEXTBOOKS:		
1	Software Engineering, A practitioner's Approach- Roger S. Pressman, 6th Edition, McGrawHill International Edition.	
2	Software Engineering- Sommerville, 7th edition, Pearson education.	
REFERENCE BOOKS:		
1	Software Engineering- K.K. Agarwal & Yogesh Singh, New Age International Publishers	
ADDITIONAL REFERENCE MATERIAL		
1	https://ocw.mit.edu/courses/16-355j-software-engineering-concepts-fall-2005/pages/lecture-notes/	
2		
ONLINE COURSES		
1	https://nptel.ac.in/courses/106101061	
2		

Bloom's level - Units catchment articulation matrix

CO	Blooms Level	Unit I	Unit II	Unit III	Unit IV	Unit V
CO1	BL3	X	X			
CO2	BL4		X			
CO3	BL3			X		
CO4	BL5				X	
CO5	BL6					X
CO6	BL6	X	X	X	X	X

LEARNING RESOURCES	
TEXT BOOKS:	
1	Principles of Mass Transfer and Separation Processes by Binay K. Dutta
2	Mass Transfer Operations, R.E. Treybal, 3rd Edition., Mc Graw Hill, 1980
REFERENCE BOOKS:	
1	Unit Operations of Chemical Engineering, W.L.Mc Cabe, J.C.Smith & Peter Harriott, McGraw- Hill, 6th Edition, 2001.
2	Coulson and Richardson's Chemical engineering, Vol 2, Richardson, J.F. & Harker, J.H. with Backhurst, J.R., Butterworth-Heinemann, 2002.

R23MSCSL003	DATABASE MANAGEMENT SYSTEMS LAB (Common to all branches)					
	Total Contact Hours	42 (P)	L	T	P	C
	Pre-requisite	-	0	0	3	2
Course Objective						
Students will gain exposure on ER model, R- Model to design the database, Data Retrieval using SQL and Procedural SQL. Students will be able to explore view level of data abstraction levels.						
Course Outcomes						
After completing this course, the students will be able to						
1	Students will be able to design the database for the given client requirements using ER- Model and also be able to convert the ER design to R model by covering all sorts of constraints					
2	Students will be able to retrieve the data for any given user constraints using SQL features group by, nested Queries and joins					
3	Students will be able to design the different views and also able to identify the execution differences between a query and query as a view.					
4	Students will be able to identify the importance of data and auditing.					
List of Experiments						
1,2	Designing of ER model for the given constraints					
3	Conversion of entities to relational tables with constraints using DDL statements (CREATE, ALTER, DROP)					
4	Conversion of relations to relational tables with referential integrity constraint (using ON DELETE CASCADE and ON UPDATE CASCADE) and DML operations (INSERT, DELETE, UPDATE)					
5	Querying the data using SELECT, WHERE, AND, BETWEEN, LIKE					
6	Applying string, number and date functions while querying the data					
7	Querying the data using set operations(UNION, UNION ALL, INRESECT, MINUS/EXCEPT) and GROUPBY, HAVING clauses					
8	Querying the data using Nested Queries (Correlated Queries- EXISTS, NOT EXISTS, independent queries- IN, NOT IN, ANY, ALL, =, > and <).					
9	Querying the data using JOINS and Handling NULL values using JOINS					
10	Designing views for different user perspectives (updatable views and non-updatable views),					
11	Designing of procedures and functions in PL/SQL					
12	Design of Triggers					
Additional experiments						
1	Sequence generation and its usage as primary key					
2	Verifying DCL-grant, revoke					
3	Verifying TCL commands- commit, roll back and save point.					
Demonstration experiments						
1	Case study - Library Management system					
2	Case study- E-commerce store management					
3	Case Study- Hospital management					
LEARNING RESOURCES						
TEXTBOOKS:						
1	Data base System Concepts, Silberschatz, Korth, McGraw hill, Sixth Edition. McGrawHill.					
2	Data base Management Systems, Raghurama Krishnan, Johannes Gehrke					
3	Learning SQL, Alan Beaulieu, O'Reilly Media, Inc., 3 rd Edition,					
ADDITIONAL REFERENCE MATERIAL						
1	https://docs.oracle.com/cd/B19306_01/server.102/b14200/toc.htm					
2	https://dev.mysql.com/doc/refman/8.0/en/select.html					

R23MCIVAT02	ENVIRONMENTAL STUDIES					
	Total Contact Hours	28 (L)	L	T	P	C
	Pre-requisite	NIL	2	0	0	0
Course Objective						
This course aims to impart a deep understanding of environmental processes, climate change, biodiversity, ecosystem functionality, and lifestyle impacts. Equipped with this knowledge, students will advocate for climate mitigation and combat climate change effectively.						
Course Outcomes: After completing this course, the students will be able to						
1	Develop comprehensive environmental management and conservation plans (BL6)					
2	Create programs for energy, water conservation, and waste reduction. (BL6)					
3	Formulate proposals for combating climate change (BL6)					
4	Develop models to study climate dynamics and impacts (BL6)					
5	Develop strategies to mitigate climate change impacts (BL6)					
SYLLABUS						
Unit I		INTRODUCTION TO ENVIRONMENTAL STUDIES				5 hr
Biodiversity and ecosystem functionality; Natural resources; Environmental pollution; Environmental episodes; Environmental legislation.						
Unit II		LIFE STYLE FOR ENVIRONMENT				5 hr
Sustainability Challenges; Save Energy; Save Water; Reduce waste; Healthy Lifestyles.						
Unit III		INTRODUCTION TO CLIMATE CHANGE				5 hr
Carbon cycle; Earth's Climate System; Weather and Climate; Understanding Microclimate; Policy initiatives to Combat Climate Change.						
Unit IV		SCIENCE BEHIND THE CLIMATE CHANGE – 1				5 hr
Greenhouse gas effect; Paleoclimate; Energy Balance; Water Cycle; Atmospheric motion.						
Unit V		SCIENCE BEHIND THE CLIMATE CHANGE – 2				5 hr
Ocean changes; Cryosphere dynamics; Volcanoes; Biosphere and climate regulation; Mitigation strategies.						
<u>LEARNING RESOURCES</u>						
TEXTBOOKS:						
1	E. Bharucha, <i>Textbook of Environmental Studies for Undergraduate Courses</i> , 2nd ed. Hyderabad, India: Universities Press, 2012.					
2	J.K. Arora, B.K. Tyagi, K.S. Bath, R. Bal, and S.S. Ladhar, <i>Activity Book on Climate Change</i> . Punjab State Council for Science & Technology, 2022.					
REFERENCE BOOKS:						
1	R. T. Wright and D. F. Boorse, <i>Environmental Science: Toward a Sustainable Future</i> , 13th ed. Boston, MA: Pearson, 2017.					
2	United Nations Development Programme, <i>Climate Box. An interactive learning toolkit on climate change</i> . New York, NY, 2018.					
ADDITIONAL REFERENCE MATERIAL						
1	https://missionlife-moefcc.nic.in/Download-Creatives-Save-Energy.php?id=MTE=					
ONLINE COURSES						
1	https://enterprise.edx.org/APSCHE/program/df4909e1-a837-4c49-b575-a909c3990bf8/progress					

Bloom's level - Units catchment articulation matrix

CO	Blooms Level	Unit I	Unit II	Unit III	Unit IV	Unit V
C01	BL6	X				
C02	BL6		X			
C03	BL6			X		
C04	BL6				X	
C05	BL6					X

VI Semester

R23MCHET014	PROCESS MODELING AND SIMULATION					
	Total Contact Hours	42 (L)	L	T	P	C
	Pre-requisite	Mathematics, Mass transfer, heat transfer and chemical reaction.	3	0	0	3
Course Objectives:						
This course aims to help students in applying fundamental laws in developing model equations, modeling and simulations of various chemical equipment's such as isothermal and non-isothermal CSTR, distillation column, batch reactor and also the application of numerical methods to solve various chemical engineering problems.						
Course Outcomes: The student will be able to						
1	Apply the component and energy balances to the chemical engineering problems (BL3)					
2	Analyze non isothermal CSTR (BL4)					
3	Model the distillation column and batch reactor (BL3)					
4	Solve chemical engineering problems using numerical methods (BL3)					
5	Evaluate chemical engineering problems using any modern tool (BL5)					
6	Develop models for various chemical operations and simulate (BL6)					
SYLLABUS						
Unit I	Mathematical models of Chemical Engineering systems					8 hr
Mathematical models for chemical engineering systems, Uses of mathematical models, principles of formulation, introduction to fundamental laws, transport equations, equation of state, Equilibrium, chemical kinetics.						
Unit II	Examples of mathematical models of Chemical Engineering systems					8 hr
Examples of mathematical models of chemical engineering systems, constant volume CSTRS, variable volume CSTR's, bubble point and dew point calculations, Gravity flow tanks, two heated tanks, gas phase pressurized CSTR, non-isothermal CSTR.						
Unit III	Examples of mathematical models of Chemical Engineering systems					8 hr
Examples of single component vaporizer, batch reactor, reactor with mass transfer, ideal binary distillation column, batch distillation with holdup, Interacting and non-interacting systems.						
Unit IV	Numerical methods for simulation					8 hr
Numerical methods for simulation 1: .Bisection, false position, Newton –Raphson method, Gauss elimination method, Gauss-Jordan and Gauss-Seidel's method. Numerical methods for simulation2: Euler method, Runge Kutta fourth order method, Computation of Eigenvalues and Eigen vectors, least square approximation of functions, linear regression, polynomial regression.						
Unit V	Simulation Examples					8 hr
Computer simulation examples-Gravity flow tank, three CSTRs in series, binary distillation column, batch reactor, Simulation of Non-isothermal CSTR, VLE dew point, bubble point calculations, heated tanks, counter current heat exchanger, Interacting and non-interacting systems.						
LEARNING RESOURCES						
TEXT BOOKS:						
1	W. L. Luyben, <i>Process modeling simulation and control for chemical</i>					

	<i>engineers</i> , 2nd Edition, McGraw Hill, 1990.
2	S. K. Gupta, <i>Numerical methods in engineering</i> , New Age international, 1995.
REFERENCE BOOKS:	
1	WF Ramirez, <i>Computational methods for process simulation</i> , Butterworth- Heinmann, 1998
2	Roger G.E. Franks, <i>Modeling and Simulation in Chemical Engineering</i> , Wiley-Interscience, 1972.

Bloom's level and-Units catchment articulation matrix

CO	Blooms Level	UNIT I	UNIT II	UNIT III	UNIT IV	UNIT-V
CO1	BL3	X				
CO2	BL4		X			
CO3	BL3			X		
CO4	BL3				X	
CO5	BL5					X
CO6	BL6	X	X	X	X	X

R23MCHET015	PROCESS DYNAMICS AND CONTROL					
	Total Contact Hours	42 (L)	L	T	P	C
	Pre-requisite	Laplace Transforms, Chemical Process Calculations	3	0	0	3
Course Objectives:						
The course aims to analyse the dynamic behavior of first and second order processes and various controllers and control systems used in chemical process industries to various forcing functions. The course introduces the stability of control system and tuning of controllers.						
Course Outcomes						
Student will be able,						
1	Model first order order systems and analyze the response to different forcing functions(BL-3)					
2	Model first second order systems and analyze the response to different forcing functions (BL-3)					
3	Analyze closed loop performance of a control system with different controllers (BL-4)					
4	Determine the stability analysis of a control system using Routh Test and Bode plots(BL-5)					
5	Estimate initial tuning parameters for P, PI, PID controllers using Z-N Method and Cohen & Coon (CC) methods(BL-5)					
6	Design and selection of controller for a process, Analyze the performance of multi loop control systems, and understand valve characteristics(BL-6)					
SYLLABUS						
Unit I	Response of first order systems					8 hr
Introduction to process dynamics and control. Response of First Order Systems. Physical examples of first order systems						
Unit II	Response of second order systems and Transportation lag					8 hr
Response of first order systems in series, Higher order systems: Second order and transportation lag						
Unit III	Controllers and Control systems					8 hr
Control systems, Controllers and final control elements Closed loop transfer functions, Transient response of simple control systems						
Unit IV	Stability and Control systems design by frequency response					8 hr
Stability, Introduction to frequency response, Control systems design by frequency response.						
Unit V	Advanced control strategies					8 hr
Controller tuning and process identification, Advanced control strategies: Cascade control, Feed forward control, ratio control, Control valves.						
LEARNING RESOURCES						
TEXT BOOK:						
1	Process systems analysis and control by D.R. Coughanowr, 3 rd. Mc Graw Hill 2009					
REFERENCE BOOKS:						
1	Chemical process control by G. Stephanopoulos, PHI, 1998					
2	Process Dynamics and Control, Dale Seaborg, Thomas F, Edgar, Duncan Mellichamp, 4 th edition, Wiley India pvt Ltd, 2016.					
3	Principles of process control, Patranabis, 3 rd edition, McGraw –Hill Education Pvt LTD, 2012.					
4	Industrial Process Control systems, 2 nd edition, Dale R, Patrick, Stephon, W.Fardo, CRC Press, 2009.					

5	Process control: Concepts, Dynamics and Control, S.K.Single, PHI Learning, 2009.
6	Process modeling simulation and control for chemical engineers by W. L. Luyben, McGraw Hill, 2nd Ed.,

Bloom's level and-Units catchment articulation matrix

CO	Blooms Level	UNIT I	UNIT II	UNIT III	UNIT IV	UNIT-V
CO1	BL3	X				
CO2	BL3		X			
CO3	BL4			X		
CO4	BL5				X	
CO5	BL5					X
CO6	BL6	X	X	X	X	X

R23MCHET016	PLANT DESIGN AND ECONOMICS FOR CHEMICAL ENGINEERS						
	Total Contact Hours	42 (L)	L	T	P	C	
	Pre-requisite	Nil	3	0	0	3	
Course Objectives:							
The course aims at cost components involved in estimation of Investment cost and product cost, concepts like interests, investments, taxes and insurance, depreciation, profitability, optimum design of operations in chemical plants.							
Course Outcomes							
Students will be able to:							
1	Understand the procedure involved in Process design development (BL-3)						
2	Estimate capital requirements for a process plant (BL-4)						
3	Evaluate interest cost and depreciation and understand how they affects the product cost. (BL-4)						
4	Analyze and Select the best investment among various alternatives available. (BL-5)						
5	Formulate optimization problem and solve it using graphical method / Analytical methods. (BL-5)						
6	Perform preliminary economic evaluation for a process. (BL-6)						
SYLLABUS							
Unit I	Process Design Development						8 hr
Introduction, Process Design development, Plant location, plant layout.							
Unit II	Cost estimation						8 hr
Cost estimation: Cash flow for industrial operations, factors effecting investment and production cost, capital investments, estimation of capital investments, cost indices, cost factors in capital investment, estimation of total product cost, production costs, fixed charges, plant overhead costs, financing.							
Unit III	Interest and Depreciation						8 hr
Interest and investment cost: types of interest, nominal and effective interest rates, continuous interest, present worth , annuities , capitalized costs Depreciation: Types of depreciation, services life, salvage value, present value, methods for determining depreciation, single unit and group depreciation.							
Unit IV	Profitability Analysis						8 hr
Profitability, alternative investments and replacements: profitability standards, discounted cash flow, capitalized cost, payout period or payout time, alternative investments and replacements							
Unit V	Optimum Design and Design Strategy						8 hr
Optimum Design and Design Strategy: Intangible and practical considerations, General procedure for determining optimum conditions, optimum production rates in plant operation, optimum conditions in cyclic operations, optimum economic pipe diameter, optimum flow rate of cooling water in condenser, optimum reflux ratio in distillation.							
LEARNING RESOURCES							
TEXT BOOKS:							
1	Plant Design and Economics for Chemical Engineering, 4 th ed., M.S. Peters and K.D. Timmerhaus, McGraw-Hill, 1991						
REFERENCE BOOKS:							
1	Process Engineering Economics, Schweyer						
2	S. M. Walas, Revised 2nd Edition, Butterworth-Heinemann, 2010.						

Bloom's level and-Units catchment articulation matrix

CO	Blooms Level	UNIT I	UNIT II	UNIT III	UNIT IV	UNIT-V
CO1	BL3	X				
CO2	BL4		X			
CO3	BL4			X		
CO4	BL5				X	
CO5	BL5					X
CO6	BL6	X	X	X	X	X

R23MCSCCT006	OOP WITH JAVA (for MEC, ECE, EEE, CIV and CHE)					
	Total Contact Hours	42 (L)	L	T	P	C
	Pre-requisite	Data Structures	3	0	0	3
Course Objective						
Students will have the ability to understand, design, integrate, and evaluate complex Java systems by combining object-oriented principles, multithreading, GUIs, exception handling, and collections to create efficient, scalable, and robust applications.						
Course Outcomes						
1	Students will be able to apply object-oriented concepts, Java programming constructs, and control structures. (BL3)					
2	Students will be able to analyze and implement constructors, access control, static and final keywords, nested classes, and string handling. (BL4)					
3	Students will be able to apply inheritance concepts, interfaces, access control, and Java standard libraries to develop modular and reusable Java programs. (BL3)					
4	Students will be able to Evaluate and design robust Java applications by implementing effective exception handling, thread lifecycle management, multithreading, synchronization, and custom exception handling to ensure performance, stability, and efficient concurrency. (BL5)					
5	Students will be able to apply the Delegation Event Model, AWT and Swing components, layout managers, and collections to create interactive Java applications with event handling and efficient data management. (BL3)					
6	Students will be able to design and implement advanced Java applications by integrating OOPS principles, inheritance, polymorphism, exception handling, multithreading, GUIs, and collections for efficient problem-solving. (BL6)					
SYLLABUS						
Unit I	BASICS OF JAVA					8 hr
Deficiencies with Structured Programming in C, History and Evolution of Java; OOP Principles - abstraction, encapsulation, inheritance and polymorphism; Java virtual machine, features of java, A First Simple Java Program(Command lines,scanner class) Compilation, execution, CLASS PATH; Data Types, Literals, Variables; Type Conversion, Operators, Precedence, Associativity; Control Statements – Selection; Control Statements - Iteration statements; Arrays (One Dimensional, Multi-Dimensional);						
Unit II	CLASS FUNDAMENTALS					8 hr
Class fundamentals, Declaring objects, Introducing Methods; Constructors, parameterized constructors; this keyword, garbage collection, returning objects, Access control; understanding static (static variable, static method, static block); final keyword, nested and inner classes; String Class, String Methods; String Buffer Class, Passing Arrays as parameters to methods; Method overloading, overloading constructors;						
Unit III	INHERITANCE, INTERFACES AND ABSTRACT CLASS					8 hr
Inheritance Basics – Base class, sub class, types of inheritance; Member Access, Method overriding; super keyword, Using final with inheritance; Abstract classes, Multiple inheritance issues; Interfaces – Defining an interface, implementing interfaces; Packages - Defining a Package, Finding Package with CLASSPATH, importing packages, Access Protection; Exploring java.util Package (Random, String Tokenizer, Scanner); Exploring java.io package (Byte and Character streams, File class);						

Unit IV	EXCEPTION HANDLING AND MULTITHREADING	8 hr
Exception Handling Fundamentals, Exception Types, Uncaught Exceptions; Using Try and Catch, Multiple Catch Clauses, Nested Try Statements; Throw, Throws and Finally; Handling of User Defined Exceptions; The Java Thread Model, Thread Life Cycle, Comparison of Thread and Process. The Main Thread; Creating a Thread: Implementing Runnable Interface, Extending Thread class; Creating Multiple Threads, isAlive () and join(); Synchronization (Keyword and Block), Thread Priorities;		
Unit V	EVENT HANDLING, AWT, SWING	8 hr
Delegation Event Model: Events, Event sources, Event Listeners; Event Classes, Event Listeners (Action Listener, Window Listener); Key Listener, keyboard events; Mouse Listeners, mouse events; AWT classes, AWT Controls (Button, Text Field, Label, Checkbox); Layout manager: BorderLayout, GridLayout, FlowLayout; Swings: JLabel, JButton, JTextField, JCheckbox; Collections: Array List, iterator;		
<u>LEARNING RESOURCES</u>		
TEXTBOOKS:		
1	Herbert Schildt, "Java The Complete Reference" 9 th Edition, Oracle Press	
2	Paul Deitel and Harvey Deitel, "Java How to Program", 11 th Edition, Pearson.	
REFERENCE BOOKS:		
1	Herbert Schildt, "Java: A Beginner's Guide", 9 th Edition, McGraw Hill, 2022	
2	Bruce Eckel, "Thinking in Java", 9 th Edition, Mind View, 2022.	
ADDITIONAL REFERENCE MATERIAL		
1	https://www.w3schools.com/java	
2	https://docs.oracle.com/javase/tutorial/	
3	https://www.geeksforgeeks.org/java/	
ONLINE COURSES		
1	https://www.udemy.com/courses/search/?q=java	
2	https://www.coursera.org/specializations/java-programming	

Bloom's level - Units catchment articulation matrix

CO	Blooms Level	Unit I	Unit II	Unit III	Unit IV	Unit V
CO1	BL3	X				
CO2	BL4		X			
CO3	BL3			X		
CO4	BL5				X	
CO5	BL3					X
CO6	BL6	X	X	X	X	X

	BIOCHEMICAL ENGINEERING					
R23MCHET022 (DSC-E2)	Total Contact Hours	42 (L)	L	T	P	C
	Pre-requisite	Mass Transfer, Chemical Reaction Engineering	3	0	0	3
Course Objectives:						
1	Differentiate the different types of microorganisms/biomolecules.					
2	Derive the kinetics of enzyme catalyzed reactions and the effect of various parameters on enzyme activity.					
3	Develop the kinetics of cell growth including substrate utilization and product formation.					
4	Develop the basic concepts of design and analysis of various types of bioreactors.					
5	Train on various downstream processing strategies for product recovery and purification					
Course Outcomes: After completing this course, the student will be able to						
1	Differentiate the different classes of biomolecules/microbes and their role in the bioprocess (BL-4)					
2	Develop the kinetics of enzyme catalyzed reactions and the effect of various parameters on enzyme activity (BL-6)					
3	Develop the kinetics of cell growth including substrate utilization and product formation. (BL-6)					
4	Design a bio-reactor for a given microbial/enzymatic process (BL-6)					
5	Develop strategies for the separation of bio products from the fermentation broths (BL-6)					
6	Develop a bioprocess for the production of important bio products (BL-6)					
SYLLABUS						
Unit I	Overview of microbiology and biochemistry of cells					8 hr
Fundamentals of Microbiology - Bacteria-Structure and functions, Fungi- Structure and functions, Algae- Structure and functions, Protozoa- Structure and functions Chemicals of life: Carbohydrates- types and functions, Proteins- types and functions; basic idea about primary, secondary and tertiary structure of proteins, protein denaturation. Lipids- classifications and functions. Nucleic acids- types and functions, Structure, chemistry, DNA, RNA.						
Unit II	The Kinetics of Enzyme-Catalyzed Reactions					8 hr
Enzymes – Classification and Properties of enzymes, The Enzyme-Substrate Complex and Enzyme Action, Michaelis-Menten Kinetics, Determination of Michaelis-Menten parameters, Substrate Activation and Inhibition, Other Influences of Enzyme Activity, Enzyme inhibition-Types of inhibition, Enzyme immobilization-different methods of immobilization.						
Unit III	Kinetics of Substrate Utilization, Product formation, and Biomass Production in Cell Cultures					8 hr
Production Media-Media preparation; different types of media, Sterilization-Sterilization of Air, media and equipment; batch and continuous sterilization, Biomass production in cell cultures, phases of microbial growth, Kinetics of balanced growth, Monod growth kinetics, Determination of kinetic parameters, Other Influences of Microbial growth rate.						
Unit IV	Design and analysis Bioreactors					8 hr
Batch reactor, Fed batch reactor, stirred tank reactor and stirred tank reactor with recycle of biomass, Plug flow reactor, Alternate Bioreactor Configurations, Aeration and Agitation, Oxygen requirement in fermentations, Determination of K _L a values.						
Unit V	Downstream processing (product recovery and purification)					8 hr
Recovery and purification of products, Cell disruption-mechanical methods, non-mechanical methods, Separation of insoluble Products-Filtration and						

centrifugation, Separation of soluble products (Liquid-liquid extractions, Distillation, Adsorption), Chromatographic Separation- Gas chromatography, Liquid chromatography, Final steps in purification – Crystallization and Drying.

LEARNING RESOURCES

TEXT BOOKS:

1	Biochemical Engineering Fundamentals, J.E.Bailey and D.F.Ollis, 2nd Edition, McGraw Hill, 1986.
2	Bioprocess Engineering, Michael L. Shuler and Fikret Kargi, 2nd Edition, Prentice Hall, 2002.

REFERENCE BOOKS:

1	Introduction to Biochemical Engineering, D.G.Rao, Tata McGraw-Hill, 2008.
2	Bioprocess Engineering principles, Pauline M. Doran, Academic Press, 2012.

Bloom's level and Units catchment articulation matrix

CO	Blooms Level	UNIT I	UNIT II	UNIT III	UNIT IV	UNIT-V
CO1	BL4	X				
CO2	BL3		X			
CO3	BL6			X		
CO4	BL6				X	
CO5	BL6					X
CO6	BL6	X	X	X	X	X

R23MCHET023 (DSC-E3)	INDUSTRIAL SAFETY AND HAZARDS MANAGEMENT						
	Total Contact Hours	40 (L)	L	T	P	C	
	Pre-requisite	Nil	3	0	0	3	
Course Objectives:							
This course aims to provide a strong foundation in process safety, focusing on accident prevention, risk management, and safety regulations. It covers toxicology, fire and explosion prevention, safety system design, including ventilation and sprinklers, and relief mechanisms. Students will also learn methods for identifying, evaluating, and managing hazards in chemical industries.							
Course Outcomes							
After completing this course, student will be able to							
1	Evaluate safety programs, engineering ethics, and accident statistics to evaluate risks and public perceptions. Examine toxicants and how they enter biological systems. (BL-3)						
2	Analyze toxin effects, elimination mechanisms, regulatory frameworks, and differentiate fires from explosions while assessing the fire triangle and flammability characteristics. (BL-4)						
3	Analyze MOC principles, ignition energy, and auto-ignition processes to assess explosion risks, evaluate inerting methods, and inspect explosion-proof equipment and instruments. (BL-4)						
4	Design ventilation systems, sprinkler systems, and relief mechanisms. Evaluate the location, types, and characteristics of relief systems in chemical industries to effectively manage safety scenarios. (BL-5)						
5	Apply data for sizing relief systems, conduct hazard checklists, surveys, and studies, and perform operability studies. Design and execute both informal and formal safety reviews to improve safety in industrial processes. (BL-5)						
6	Integrate process safety, toxicology, and hazard management to design effective safety programs, evaluate risks, and develop mitigation strategies. Apply engineering ethics, regulations, and hazard analysis to optimize safety systems and conduct comprehensive safety reviews in industrial scenarios. (BL-6)						
SYLLABUS							
Unit I	Safety Engineering: Ethics, Risk, and Human Impact						8 hr
Introduction to Safety program, Engineering ethics, Accident and Loss statistics, Acceptable risk, Public perception, Process Safety, What are Toxicants, How toxicants enter biological organisms							
Unit II	Industrial Toxicology and Fire Risk Management						8 hr
Effect of toxins on biological organisms, How toxicants are eliminated from biological organisms, Government regulations, Identification and Evaluation methodology for Toxins, Control mechanism of Toxins, The fire triangle, Distinction between fire and explosions, Flammability characteristics of liquids and vapors							
Unit III	Fire and Explosion Hazards: Mechanisms and Mitigation						8 hr
MOC (Minimum Oxygen Concentration), Ignition energy, Auto ignition and Auto oxidation, Adiabatic compression, Explosions, Inerting definition, Different ways of Inerting, Explosion proof equipment and Instruments							
Unit IV	Passive and Active Safety Measures in Industrial Processes						8 hr
Ventilations and Types of ventilations, Sprinkler systems, Design of Sprinkler systems, Relief Concepts, Definitions used within the chemical industry to describe various reliefs, Location of Reliefs in an industry, Relief Types and Characteristics, Relief Scenarios							
Unit V	Process Hazard Evaluation and Safety Review Methodologies						8 hr

Data for Sizing Reliefs, Relief Systems, Process Hazards Checklists, Hazards Surveys, Hazards Studies, Operability Studies, Safety Reviews: Informal and Formal Reviews	
LEARNING RESOURCES:	
TEXT BOOKS:	
1	D.A.Crowl & J.F.Louvar – Chemical Process Safety (Fundamentals with applications), Prentice Hall 1990.
2	Industrial Hygiene and Chemical Safety " to "R.E. Sanders - Chemical Process Safety, 3rd Edition, Elsevier Butterworth–Heinemann, 2005"
REFERENCE BOOKS:	
1	H.H.Fawcett and W.S.Wood –Safety and Accident Prevention in Chemical Operations, 2nd edition, John Wiley and sons, New York 1982
2	Coulson and Richardson's – Chemical engineering – R.K.Sinnot, Vol.6, Butterworth-Heinemann Limited 1996

Bloom's level – Units catchment articulation matrix

CO	Blooms Level	Unit I	Unit II	Unit III	Unit IV	Unit V
CO1	BL3	X				
CO2	BL4		X			
CO3	BL4			X		
CO4	BL5			X	X	
CO5	BL5		X			X
CO6	BL6	X	X	X	X	X

R23MCHET027 (DSC-E3)		CHEMICAL PROCESS UTILITIES					
		Total Contact Hours	42 (L)	L	T	P	C
		Pre-requisite	Chemical Engineering Thermodynamics, Chemical Technology, Heat Transfer	3	0	0	3
Course Objectives:							
1	Understand the fundamental principles of chemical process utilities, including energy perspectives, power cycles, and heat transfer utilities.						
2	Learn about water chemistry, inhibition, and water treatment in the context of boiler water treatment and steam generation.						
3	Familiarize yourself with the principles of air filtration, pneumatic conveying, and natural gas transmission.						
4	Comprehend the concept of heat transfer in cooling towers and their components, types, and applications.						
5	Understand the principles of refrigeration, refrigeration system components, and refrigeration cycles.						
6	Learn about refractories, thermodynamic principles, and corrosion in refractories.						
7	Apply mathematical principles to solve problems related to power cycles, heat transfer, and other chemical process utilities.						
Course Outcomes							
After completing this course, student will be able to							
1	Analyze the energy perspective of chemical process utilities and evaluate the efficiency of power cycles. (BL4)						
2	Analyze steam generation systems, including boiler water treatment and safety devices, to optimize efficiency and sustainability in industrial settings (BL4)						
3	Select and design appropriate air filtration and pneumatic conveying systems for various industrial applications. (BL3)						
4	Calculate heat transfer coefficients and design cooling towers for efficient heat transfer. (BL3)						
5	Evaluate the performance of refrigeration systems and recommend improvements. (BL5)						
6	Apply problem-solving skills to real-world scenarios in chemical process utilities, using mathematical principles and technical knowledge. (BL6)						
SYLLABUS							
Unit I	Energy and Heat Transfer Utilities						8 hr
Introduction to Chemical Process Utilities, Energy Perspective to the Utilities, Power Cycle, Fuel Analysis, Practice Problems related to Power Cycle and Fuel Analysis Heat transfer utilities, Plate and Frame Heat exchangers types, Heat transfer media and solar energy							
Unit II	Steam Generation and Water Treatment						8 hr
Water chemistry, Inhibition and water treatment, Boiler water treatment, Steam, Boilers, Industrial boiler types, Steam generation unit, Heaters, Attemperator and steam drum, Steam traps, Centralization and fuel selection, Economizer, super heaters, and safety devices, Insulation of steam generators							
Unit III	Air and Pneumatic Conveying Systems						8 hr
Air, Air filtration, and Pneumatic conveying, Introduction to Pneumatic conveying system, Conveying system types, Material properties and pipeline feeding devices, Gas solid flows, Design of pipelines, elements of pipeline design, Natural gas transmission							
Unit IV	Cooling Towers and Heat Transfer						8 hr
Cooling tower, Theory and some basic calculations, Concept of heat transfer in cooling tower and it's components, Types of cooling tower, Material of construction							

and applications of cooling tower, Control and maintenance in cooling towers, Pressure levels and terminology, Gauges for pressure measurement		
Unit V	Refrigeration and Insulation Materials	8 hr
Refrigerants and refrigeration, Introduction to refrigeration, Refrigeration system components and refrigeration cycle, Refractories, Thermodynamic principles and corrosion in refractories, Slag attack and kinds of refractories in uses, Heat transfer in insulation materials		
LEARNING RESOURCES		
TEXT BOOKS:		
1	Plant Utilities by Dr. Mujawar, Nirali Prakashan Publication.	
REFERENCE BOOKS:		
1	Plant Utilities by D.B. Dhone, Nirali Prakashan Publication.	
2	P.L.Balleney, Thermal Engineering, Khanna Publisher, New Delhi.	
3	Nordell,Eskel."Water Treatment for industrial and other uses" Reinhold Publishing Corporation, New York (1961).	

Bloom's level and Units catchment articulation matrix

CO	Blooms Level	UNIT I	UNIT II	UNIT III	UNIT IV	UNIT-V
CO1	BL4	X				
CO2	BL4		X			
CO3	BL3			X		
CO4	BL3				X	
CO5	BL5					X
CO6	BL6	X	X	X	X	X

R23MCHEL006	PROCESS CONTROL AND SIMULATION LABORATORY					
	Total Contact Hours	42 (P)	L	T	P	C
	Pre-requisite	Process modeling and simulation and Process Dynamics and control	0	0	3	2

Course Objectives

This lab enables the student to understand,

- | | |
|---|--|
| 1 | This course aims to train the students on evaluation of thermodynamic properties, dynamics of conventional processes using MATLAB or any modern tool and also on process instrumentation and controlling techniques. |
|---|--|

Course Outcomes: Students will be able to,

- | | |
|---|--|
| 1 | Apply the computer applications in chemical engineering design (BL3) |
| 2 | Evaluate the thermodynamic and transport properties (BL5) |
| 3 | Model the steady state design of conventional process and equipment's (BL3) |
| 4 | Utilize the instruments and learn its characteristics and control techniques (BL3) |
| 5 | Analyse the characteristics of control valves (BL4) |
| 6 | Develop and simulate the various unit operations/unit process using MATLAB (BL6) |

LIST OF EXPERIMENTS:

- | | |
|----|---|
| 1 | Gravity flow tank |
| 2 | Three CSTR's in series - open loop |
| 3 | Three CSTR's in series - closed loop |
| 4 | Non- interacting system - two tank liquid level |
| 5 | Interacting system - two tank liquid level |
| 6 | Bubble point calculations |
| 7 | Dew point calculations |
| 8 | To calibrate and study the response of mercury in glass thermometer for a step input and to estimate the time constant of the system. |
| 9 | To study the dynamic response of a U-tube manometer. |
| 10 | Experiments on Pneumatic control valve:
a. To determine the flow coefficient of a given control valve.
b. To study inherent characteristics of Control valve |
| 11 | Experiments on Temperature control system
a. Open loop response (manual control)
b. On/off controller
c. Proportional Controller
d. Proportional-Integral-Derivative Controller |

LEARNING RESOURCES

TEXT BOOKS:

- | | |
|---|---|
| 1 | W. L. Luyben, <i>Process modeling simulation and control for chemical engineers</i> , 2 nd Edition, McGraw Hill, 1990. |
| 2 | S.K. Gupta, <i>Numerical methods in engineering</i> , New Age international, 1995. |
| 3 | Process Systems Analysis and Control by D.R. Coughanowr, 2nd ed. McGraw Hill, 1991 |
| 4 | Industrial Instrumentation, Donald P.Eckman, CBS, 2004. |

REFERENCE BOOKS:

- | | |
|---|--|
| 1 | WF Ramirez, <i>Computational methods for process simulation</i> , 2 nd edition, Butterworth- Heinmann 1998. |
| 2 | Roger G.E. Franks, <i>Modeling and Simulation in Chemical Engineering</i> , Wiley-Interscience, 1972. |
| 3 | Instrumentation and Control Systems, K.Padmaraju, Y.J. Reddy, McGraw Hill Education, 2016. |
| 4 | Automatic Process Control, Donald P. Eckman, John wiley, Reprint 2011. |

R23MCSC004	OOP WITH JAVA LAB (for MEC, ECE, EEE, CIV and CHE)					
	Total Contact Hours	42 (P)	L	T	P	C
	Pre-requisite	-	0	0	3	2
Course Objective						
Students will have the ability to apply object-oriented programming concepts in Java to develop and implement modular and reusable software solutions.						
Course Outcomes						
1	Students will be able to implement object-oriented programming concepts such as classes, inheritance, polymorphism, and exception handling to build modular Java applications.					
2	Students will be able to examine and debug Java programs to identify and resolve logical errors, ensuring correctness and efficiency.					
3	Students will be able to assess the design and performance of Java applications, optimizing for scalability, maintainability, and resource management.					
4	Students will be able to design and develop advanced Java applications by integrating OOP principles, multithreading, GUIs, and data structures to solve real-world problems.					
List of Experiments						
1	Week 1: Introduction to Java and Structured Programming 1. Write a simple Java program that prints "Hello, World!" to the console. 2. Write a Java program that takes user input using the Scanner class. 3. Write a Java program to demonstrate all primitive data types. 4. Implement a Java program that converts a floating-point number to an integer. 5. Create a Java program that uses the final keyword to define constants.					
2	Week 2: Operators, Control Statements - Selection 1. Implement a Java program that uses arithmetic, relational, and logical operators. 2. Write a Java program to find the largest of three numbers using if-else statements. 3. Use the ternary operator to implement a simple conditional check.					
3	Week 3: Control Statements - Iteration 1. Write a Java program that prints all even numbers between 1 and 100 using a for loop. 2. Create a Java program that calculates the factorial of a given number using a while loop. 3. Write a JAVA program to display the Fibonacci sequence. 4. Implement a menu-driven program using a do-while loop.					
4	Week 4: Arrays 1. Write a Java program to reverse a one-dimensional array of integers. 2. Write a Java program to search for an element in an array. 3. Implement a Java program to find matrix multiplication using two-dimensional arrays.					
5	Week 5: Classes and Methods 1. Create a class with fields and methods, then instantiate and use it. 2. Implement a method to calculate the area of a rectangle (accepting length and width as parameters). 3. Create a program that returns the area of different shapes (circle, square, rectangle) using method overloading.					
6	Week 6: Constructors, this Keyword, and Garbage Collection 1. Implement a class with parameterized constructors and demonstrate object initialization. 2. Use 'this' keyword to resolve variable shadowing within methods and constructors.					

	3. Write a program that simulates garbage collection using System.gc() and observe the results.
7	Week 7: Inheritance and Polymorphism 1. Create a superclass and subclass to demonstrate basic inheritance. 2. Override a method in the subclass and call it from the main method. 3. Use the super keyword to call the parent class constructor and method.
8	Week 8: Abstract Classes and Interfaces 1. Write an abstract class with an abstract method and a concrete method. 2. Implement an interface and demonstrate how to implement it in a class. 3. Create a scenario where interfaces solve the multiple inheritance problem.
9	Week 9: Exception Handling 1. Write a program that demonstrates basic exception handling using try-catch blocks. 2. Implement a program that handles multiple exceptions using multiple catch clauses. 3. Create a custom exception class and use it to handle a specific error in a program.
10	Week 10: Multithreading 1. Implement a thread by extending the Thread class and demonstrate thread execution. 2. Create a program that demonstrates thread life cycle and state transitions. 3. Implement thread synchronization to avoid race conditions in a multi-threaded environment.
11	Week 11: Event Handling, AWT 1. Create a simple AWT program that displays a window with a button, text field, and label. 2. Implement mouse and keyboard event listeners in an AWT program.
12	Week 12: Swings 1. Create a Swing-based GUI with a JFrame, JButton, and JLabel, demonstrating layout managers like FlowLayout or BorderLayout. 2. Write a Java program that works as a simple calculator. Use a grid layout to arrange buttons for the digits and for the +, -, *, % operations. Add a text field to display the result.

LEARNING RESOURCES

TEXTBOOKS:

1	Herbert Schildt, "Java The Complete Reference" 9 th Edition, Oracle Press
2	Paul Deitel and Harvey Deitel, "Java How to Program", 11 th Edition, Pearson.

REFERENCE BOOKS:

1	Herbert Schildt, "Java: A Beginner's Guide", 9 th Edition, McGraw Hill, 2022
2	Bruce Eckel, "Thinking in Java", 9 th Edition, Mind View, 2022.

ADDITIONAL REFERENCE MATERIAL

1	https://www.w3schools.com/java
2	https://docs.oracle.com/javase/tutorial/
3	https://www.geeksforgeeks.org/java/
4	https://www.javatpoint.com/java-tutorial
5	https://www.udemy.com/courses/search/?q=java
6	https://www.coursera.org/specializations/java-programming
7	https://www.freecodecamp.org/news/tag/java/
8	https://www.tutorialspoint.com/java/index.htm

R23MMATT007	QUANTITATIVE PROBLEM-SOLVING TECHNIQUES						
	Total Contact Hours	28 (L)	L	T	P	C	
	Pre-requisite	NIL	2	0	0	2	
Course Objective							
The course aims to equip the students with standard concepts and techniques of arithmetic and logical thinking to handle various real-world problems and their applications.							
Course Outcomes: After completing this course, the students will be able to							
1	Enhance the aptitude and reasoning round clearing ability.						
2	Solve real-time problems for performing job functions easily.						
3	Improve individual decision-making abilities, how to think critically, and logically and analyze information as corporate company-based decisions.						
4	Acquire satisfactory competency in the use of VERBAL REASONING as well as LOGICAL REASONING.						
5	Develop knowledge, skills, and judgment around human communication that facilitate their ability to work collaboratively with others.						
SYLLABUS							
Unit I	ARITHMETIC ABILITY						5 hr
Number System and LCM & HCF; Ratio & Proportion; Percentages; Profit & Loss; Mixture and Allegation.							
Unit II	ALGEBRAIC ANALYSIS						5 hr
Quadratic & Linear eq's; Inequalities; Speed, Time and Distance; Time and Work; Simple Interest & Compound Interest.							
Unit III	ADVANCED MATHS						5 hr
Circles, lines, angles & Co-ordinate geometry; Triangles, quadrilaterals & polygons; Areas & perimeter-2D; Surface area & volumes-3D; Trigonometry.							
Unit IV	MODERN MATHS						5 hr
Probability; Permutation and Combination; Surds, indices & set theory; Functions; Logarithms.							
Unit V	DATA INTERPRETATION & ELEMENTARY STATISTICS						5 hr
Tables, charts & pie-diagrams; Venn diagrams; Data sufficiency; Mean, median & mode; Standard deviation ,variance & Case studies.							
LEARNING RESOURCES							
TEXTBOOKS:							
1	ARIHANT Publications - RAJESH VERMA Fast Track Objective Arithmetic (Revised Edition)						
2	MC GRAW HILL Education- ABHIJIT GUHA Quantitative aptitude (6th edition)						
3	ARIHANT Publications - B.S. SIJWALI & INDU SIJWALI Verbal, Non-verbal & Analytical reasoning						
4	ARIHANT SERIES - JAI KISHAN & PREM KISHAN Verbal, Non-verbal & Analytical reasoning						
5	R. S. Aggarwal - S. Chand Publications Quantitative Aptitude for Competitive Examinations						
REFERENCE BOOKS							
1	A sure shot guide to crack SSB: yes, you have it in you(Maj Gen VPS Bhakuni (author), vsm (author), kavita modi (author)) https://amzn.in/d/9qfy0of						
2	Excel in quantitative aptitude: chapter-wise maths 10 years previous solved papers (pyq) of ssc cgl, ibps po & clerk, sbi po, & rrb ntpc tier i & ii mathematics for ssc, banking, railways exams 2024 (arun						

	<u>sharma (author)) https://amzn.in/d/3otz5ui</u>
3	Ace Reasoning Ability For Banking And Insurance Book 2024 (Third English Edition)(<u>Adda247 Publications (Author))</u> <u>https://Amzn.In/D/4ammhvg</u>
4	Ultimate Guide To SSC CGL - Combined Graduate Level - Tier I & Tier II Exam With Previous Year Questions & 5 Online Practice Sets 9th Edition Combined Graduate Level Prelims & Mains Pyqs <u>https://Amzn.In/D/9iewmyc</u> (<u>Disha Experts (Author))</u>
5	Excel in quantitative aptitude: chapter-wise maths 10 years previous solved papers (pyq) of ssc cgl, ibps po & clerk, sbi po, & rrb ntpc tier i & ii mathematics for ssc, banking, railways exams 2024 (<u>arun sharma (author)) https://amzn.in/d/3otz5ui</u>
6	Quantitative Aptitude For CAT 2025 11th Edition (Latest) Quant CAT Preparation Exam Book With Solved Previous Years Papers (PYQ) McGraw Hill Edge Access: Mock Tests, Expert Sessions & Strategies (<u>Arun Sharma (Author)) https://Amzn.In/D/9OQMQBX</u>
7	Ace Reasoning Ability For Banking And Insurance Book 2024 (Third English Edition) (<u>Adda247 Publications (Author))</u> <u>https://Amzn.In/D/4ammhvg</u>

VII Semester

R23MCHET017	BASIC ENVIRONMENTAL ENGINEERING AND POLLUTION ABATEMENT (SELF STUDY / MOOCS COURSE)					
	Total Contact Hours	42 (L)	L	T	P	C
	Pre-requisite	Nil	3	0	0	3

Course Objectives:

The course deals with the fundamentals of environmental engineering and its application in pollution control. It is intended to impart the fundamental knowledge of environmental engineering along with the design aspect of some pollution control equipment.

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

1	Identify strategies to mitigate the risks associated with pollutants in the environment (BL3)
2	Analyze and evaluate the effectiveness of environmental standards, regulations, and sampling methods for assessing air, water, and industrial pollution. (BL4)
3	Classify latest treatment techniques of air pollution control (BL4)
4	Analyse various waste water treatment methods (BL4)
5	Apply appropriate technologies and schemes for managing solid, hazardous, and special category wastes. (BL3)
6	Develop integrated knowledge on various pollution control and its treatment methods (BL6)

SYLLABUS

Unit I	Ecological Principles and Environmental Concerns	8 hr
Introduction; Ecology, Environment, and Biodiversity; Ecosystem Services and its Risks; Pollution types and sources; Impact/consequences of pollutants; Transmission of pollutants in environment.		
Unit II	Environmental Quality and Regulations	8 hr
Ambient Air Quality and Standards; Water Quality and Standards; Industrial Pollution and Standards; Sampling and Characterization of Gas/Air/Emission; Sampling and Characterization of water/waste water; Characterization of solid wastes and soil; Environmental law and regulatory framework.		
Unit III	Pollution Prevention and Control	8 hr
Pollution Prevention Strategies and Processes; Pollution Prevention by using optimum water; Air pollution control methods and equipment.		
Unit IV	Water and Wastewater Treatment Technologies	8 hr
Treatment of surface and ground water for drinking water generation; Treatment of domestic and industrial waste water; Methods of primary treatments: screening, sedimentation, flotation, neutralization; Secondary treatment process; Secondary treatment equipment.		
Unit V	Solid Waste Management and Treatment	8 hr
Solid waste management schemes; Incineration, Gasification, Pyrolysis, Anaerobic digestion, Hazardous waste management, Management of special category wastes		
LEARNING RESOURCES		

TEXT BOOKS:

1	"Pollution Control Acts, Rules, Notification issued there under" CPCB, Ministry of Env. And Forest, G.O.I., 3 rd Ed.(2006)
2	Vallero D., "Fundamentals of Air Pollution", 4 th Ed. Academic Press.(2007

REFERENCE BOOKS:

1	Eckenfelder W. W., "Industrial water pollution Control", 2 nd Ed., McGraw Hill.(1999)
2	Kreith F. and Tchobanoglous G., "handbook of Solid waste Management", 2 nd Ed., McGraw Hill.(2002)
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", 4 th Ed., Tata McGraw Hill.(2003)
ONLINE RESOURCES	
1.	https://archive.nptel.ac.in/courses/103/107/103107215/

Bloom's level and-Units catchment articulation matrix

CO	Blooms Level	UNIT I	UNIT II	UNIT III	UNIT IV	UNIT-V
CO1	BL3	X				
CO2	BL4		X			
CO3	BL4			X		
CO4	BL4				X	
CO5	BL3					X
CO6	BL6	X	X	X	X	X

R23MCHET024 (DSC-E4)	PHYSICO-CHEMICAL PROCESSES FOR WASTEWATER TREATMENT (SELF STUDY / MOOCS COURSE)					
	Total Contact Hours	42 (L)	L	T	P	C
	Pre-requisite	MUO, Mass Transfer	3	0	0	3
Course Objectives:						
1	Develop a comprehensive understanding of the fundamental principles of physico-chemical processes used in wastewater treatment.					
2	Analyse and evaluate the role of various physico-chemical processes in achieving wastewater quality standards.					
3	Explore advanced and emerging physico-chemical techniques for the removal of contaminants from wastewater.					
4	Examine real-world industrial wastewater treatment scenarios and apply physico-chemical concepts to solve practical challenges.					
Course Outcomes: Upon successful completion of this course, students will be able to						
1	Evaluate the effectiveness of various physico-chemical treatment methods (e.g., coagulation, flocculation) for different types of wastewater. (BL-4)					
2	Analyse and explore the effectiveness of various physico-chemical treatment methods (e.g., Sedimentation, filtration, adsorption etc.) for different types of wastewater. (BL-5)					
3	Critically assess the performance and limitations of advanced treatment processes such as advanced oxidation processes (AOPs), electrochemical methods, and hybrid systems. (BL-5)					
4	Design a bio-reactor for a given microbial/enzymatic process (BL-6)					
5	Solve complex problems in industrial wastewater treatment by integrating physico-chemical and biological processes. (BL-6)					
6	Develop optimized treatment strategies incorporating physico-chemical processes to meet specific industrial or municipal wastewater treatment requirements. (BL-6)					
SYLLABUS						
Unit I	Pre-treatment & Physical treatment					8 hr
Introduction to Water Pollution and Control, Pre-treatment & Physical treatment: Flow equalization & Aeration, Principle of Coagulation and Flocculation – types of coagulants, coagulant aids, coagulation theory, and optimum dose of coagulant, design criteria.						
Unit II	Primary treatment					8 hr
Principles of sedimentation: Types of settling and settling equations, design criteria and design of settling tanks. Filtration: Theory, types, 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.						
Unit III	Advanced treatment					8 hr
Advanced water treatment: Ion exchange, electro-dialysis, Reverse Osmosis, Ultra filtration Advanced Oxidation Processes: Introduction, Photo-induced processes, Sono						

treatment, Electro-chemical Treatment.		
Unit IV	Chemical treatment	8 hr
Disinfection: different types, disinfectants, factors affecting disinfection, methods of disinfection, and chemistry of chlorination. Fluoridation and de-fluoridation - Principles and design.		
Unit V	Biological treatment and Industrial case studies	8 hr
Biological treatment processes, case studies on wastewater treatment in various chemical and allied industries like Pulp and paper mill wastes, Breweries and Distilleries waste, Sugar mill waste, Pharmaceutical waste, Refineries waste, Fertilizers waste etc.		
LEARNING RESOURCES		
TEXT BOOKS:		
1	Eckenfelder W.W., "Industrial Water Pollution Control", 2nd Ed., McGraw Hill, 1999.	
2	Metcalf & Eddy, George Tchobanoglous, H. David Stensel, and Franklin L. Burton, "Wastewater Engineering: Treatment and Resource Recovery" Tata McGraw-Hill, 2017.	
REFERENCE BOOKS:		
1	Arceivala S.J. and Asolekar S.R., "Wastewater Treatment for Pollution Control and Reuse", 3rd Ed., Tata McGraw Hill, 2007.	
2	S. Vigneswaran and C. Visvanathan, "Water Treatment Processes: Simple Options", CRC Press, 1995.	

Bloom's level and Units catchment articulation matrix

CO	Blooms Level	UNIT I	UNIT II	UNIT III	UNIT IV	UNIT-V
CO1	BL4	X				
CO2	BL3		X			
CO3	BL6			X		
CO4	BL6				X	
CO5	BL6					X
CO6	BL6	X	X	X	X	X

R23MCHET028 (DSC-E4)	ADVANCED REACTION ENGINEERING (SELF STUDY / MOOCS COURSE)					
	Total Contact Hours	42 (L)	L	T	P	C
	Pre-requisite	Chemical Reaction Engineering	3	0	0	3
Course Objectives:						
Advanced reaction engineering applies the basic concepts of reaction rate, stoichiometry and equilibrium to the design and analysis of chemical and biological reacting systems. The course is designed for graduate students with interests in the design and optimization of process reaction vessels in the chemicals/petrochemicals, biological/food as well as materials/minerals processing industries. The following core concepts are covered: analysis of complex industrial reaction kinetics, effect of micromixing on reactive systems, computational chemistry, non-isothermal reactor design, nonlinear analysis in reaction systems, catalytic processes, multiphase (gas-liquid-solid) reactors for single and multiple reactions, strategies for reactor optimization and case studies in industrial process reactor design and operation.						
Course Outcomes						
By the end of this course, student will be able to						
1	Analyze and predict the performance of various types of reactors. (BL-4)					
2	Analyze and predict the performance of various multi-phase reactors. (BL-4)					
3	Analyze the effects of temperature and pressure on equilibrium constants and equilibrium conversions of non-isothermal reactors. (BL-4)					
4	Explain the concepts of Catalysis and synthesizing a rate law- mechanism and design of solid catalyzed reactors for heterogeneous reactions. (BL-5)					
5	Determine the effect of catalyst deactivation for design of real solid catalysed reactions. (BL-5)					
6	Design of reactors for heterogeneous catalytic reactions and non-ideal reactions. (BL-6)					
SYLLABUS						
Unit I	Introduction to types of reactors					8 hr
Introduction of various reactors (BR, CSTR, PFR) Pressure drop in reactor design (PBR) Catalyst deactivation: types of deactivations, deactivation rate laws Temperature-time trajectories, Moving bed reactor (MBR), and straight-through transport reactor (STTR)						
Unit II	Multi-phase reactors					8 hr
Multi-phase reactors (Slurry reactor, Trickle bed reactor, Bioreactors) Bioreactors, Steady state non-isothermal reactor design: Energy Balance Multiple steady states.						
Unit III	Non ideal flow					8 hr
Non-ideal flow: RTD: Step/pulse input, Segregation model, Tank in series (TIS) model non-ideal flow: Various RTD Models: Dispersion model, the effect of dispersion on effluent concentration, Two-parameter model.						
Unit IV	Surface reaction mechanism and model studies					8 hr
Surface reaction mechanism and model studies: Langmuir-Hinshelwood reaction kinetics, Eley-Rideal reaction kinetics, LHHW model and parameter estimation, Mars-Van Krevlen model, and parameter estimation, Diffusion, and reaction: Internal effectiveness factor, Falsified-kinetics, Weisz-Prater criteria, Mear's criteria, temperature effect.						
Unit V	Collection and analysis of rate law data					8 hr
Collection and analysis of rate law data (ODE/Non-linear regression). Heterogeneous catalysis data analysis for reactor design (Numerical method,						

polynomial fit, integrating method, Non-linear regression).

LEARNING RESOURCES

TEXT BOOKS:

1	Chemical Reaction Engineering by Octave Levenspiel 3rd ed. Wiley Eastern Ltd.
2	Elements of chemical reaction engineering by H.S. Fogler, 3rd ed. PHI, 1999.
3.	Kulkarni Sulabha K., "Nanotechnology Principles and Practices", 3rd Ed., Capital Publishing Company, New Delhi, 2016.
4.	Banwell Colin N., and McCash Elaine M., "Fundamentals of Molecular Spectroscopy", 5th Ed., McGraw Hill Education (India) Pvt. Ltd, New Delhi, 2013
5.	Published articles from Journals on Catalysis, Reaction Engineering, Kinetics, and Material characterizations

Bloom's level and-Units catchment articulation matrix

CO	Blooms L	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5
CO 1	BL 4	X	X			
CO 2	BL 4		X	X		X
CO 3	BL 4			X	X	
CO 4	BL 5		X	X	X	
CO 5	BL 5	X			X	X
CO 6	BL 6	X	X	X	X	X

R23MCHET025 (DSC-E5)	RENEWABLE ENERGY ENGINEERING: SOLAR, WIND AND BIOMASS ENERGY SYSTEMS (SELF STUDY / MOOCS COURSE)						
	Total Contact Hours	42 (L)	L	T	P	C	
	Pre-requisite	None	3	0	0	3	
Course Objectives:							
1	Understand the fundamental principles of solar energy, including thermal applications, solar radiation, and energy storage systems.						
2	Learn about biomass energy conversion routes, including biochemical and thermochemical methods.						
3	Analyze the characteristics and properties of biomass and its structural components.						
4	Comprehend the principles of biogas production, gasification, and thermochemical conversion of biomass.						
5	Understand the basics of wind energy, including turbine types, characteristics, and power generation.						
6	Apply mathematical principles to solve problems related to solar, biomass, and wind energy systems.						
7	Evaluate the technical and economic feasibility of renewable energy systems for various applications.						
Course Outcomes							
After completing this course, student will be able to							
1	Design and optimize solar thermal systems, including non-concentrating and parabolic solar collectors. (BL6)						
2	Calculate biomass energy potential and evaluate different conversion routes for various biomass feedstocks. (BL3)						
3	Analyze the technical and economic feasibility of biogas production and gasification systems. (BL4)						
4	Apply knowledge of thermochemical conversion processes to design and optimize biomass-to-energy systems. (BL3)						
5	Evaluate the performance of wind turbines and calculate power generation from wind energy systems. (BL5)						
6	Integrate knowledge of solar, biomass, and wind energy systems to design and evaluate hybrid renewable energy systems for various applications. (BL6)						
SYLLABUS							
Unit I	Solar Energy Systems						8 hr
Solar Energy and Overview of Thermal Applications, Solar Radiation, Practice Problems, Non-Concentrating Solar Collectors Practice Problems, Parabolic Solar Collectors Practice Problems, Thermal Energy Storage Systems, Solar Energy Utilisation Methods							
Unit II	Biomass Energy Systems						8 hr
Classification of Energy Resources, Broad Classification and Compositional Analysis, Characteristics and Properties of Biomass, Properties and Structural Components of Biomass, Biomass Residues and Energy Conversion Routes							
Unit III	Biomass Conversion Technologies						8 hr
Utilisation of Biomass through Biochemical and Thermochemical Routes, Conversion Mechanism of Biomass to Biogas and Biogas and its Properties, Gasification of Biogas Plants, Practice Problems, Bioconversion of Substrates into Alcohol							
Unit IV	Thermochemical Conversion of Biomass						8 hr
Thermochemical Conversion, Combustion Processes, Thermochemical Conversion of Biomass to Solid, Liquid, and Gaseous Fuels, Gasification Processes, Practice Problems							
Unit V	Wind Energy Systems						8 hr

Turbine Terms, Types, and Theories, Characteristics and Power Generation from Wind Energy, Practice Problems	
LEARNING RESOURCES	
TEXT BOOKS:	
1	Khan B. H., Non-Conventional Energy Resources, 2 nd Edition, Tata McGraw-Hill Education Pvt. Ltd. 2009.
REFERENCE BOOKS:	
1	Sukhatme S. P., Nayak J. K., Solar Energy: Principles of thermal Collection and Storage, 3 rd Ed., Tata McGraw-Hill Education Pvt. Ltd 2008.
2	Twidell, J. and Tony W., Renewable Energy Resources, 2 nd Edition, Taylor & Francis 2006.
3	Prabir Basu, Biomass Gasification, Pyrolysis and Torrefaction, Academic Press, Elsevier, 2013.

Bloom's level and Units catchment articulation matrix

CO	Blooms Level	UNIT I	UNIT II	UNIT III	UNIT IV	UNIT-V
CO1	BL6	X				
CO2	BL3		X			
CO3	BL4			X		
CO4	BL3				X	
CO5	BL5					X
CO6	BL6	X	X	X	X	X

R23MCHET029 (DSC-E5)	CHEMICAL PROCESS INTENSIFICATION (SELF STUDY / MOOCS COURSE)					
	Total Contact Hours	42 (L)	L	T	P	C
	Pre-requisite	Mathematics, Mass transfer, heat transfer and chemical reaction	3	0	0	3
Course Objectives:						
This course aims to help students in applying the various techniques for process intensification and developing various models for RDC, counter-current multiphase flow in rotating systems , compact heat exchangers etc.						
Course Outcomes						
By the end of this course, student will be able to						
1	Apply the various techniques for process intensification (BL3)					
2	Develop model for thin film on rotating disc reactor (BL3)					
3	Model the counter-current multiphase flow in rotating systems (BL3)					
4	Construct compact heat exchangers (BL4)					
5	Recommend various micro reactors for heat, mass and mixing applications (BL5)					
6	Elaborate the importance of Process Intensification (BL6)					
SYLLABUS						
Unit I	Introduction to Process Intensification					8 hr
Definition of Process Intensification (PI). Benefits of PI. Techniques for PI application: active and passive techniques.						
Unit II	Spinning disc reactor (SDR)					8 hr
Spinning disc reactor (SDR): Operating principle and development of models for thin film flow on rotating disc. Examples of application of SDR to a range of processes.						
Unit III	Rotary packed bed (RPBs)					8 hr
Rotary packed bed (RPBs): Operating principle of rotating contactors. Development of models for counter-current multiphase flow in rotating systems. Examples of the application of multiphase contactors. Oscillatory baffled reactor (OBR): Description & operating principles. History. Explanation of niche applications. Design. Case studies.						
Unit IV	Compact heat exchangers (CHE)					8 hr
Compact heat exchangers (CHE): Definition of CHEs. Construction and main properties. Applications. Basic design procedures. Examples.						
Unit V	Micro-reactors					8 hr
Micro-reactors: Description and operating principles. Heat transfer, mass transfer and mixing applications.						
LEARNING RESOURCES						
TEXT BOOKS:						
1	David Reay, Colin Ramshaw and Adam Harvey, Process Intensification (Second Edition)					
2	Engineering for Efficiency, Sustainability and Flexibility, Elsevier publishers					
REFERENCE BOOKS:						
1.	Jirí Jaromír Klemeš, Petar Sabev Varbanov, Process Integration and Intensification, De Gruyter publishers 1st edition , 2014.					

Bloom's level and-Units catchment articulation matrix

CO	Blooms Level	UNIT I	UNIT II	UNIT III	UNIT IV	UNIT-V
CO1	BL3	X				
CO2	BL3		X			
CO3	BL3			X		
CO4	BL4				X	
CO5	BL5					X
CO6	BL6	X	X	X	X	X

R23MCHEL007	INDUSTRIAL SAFETY TRAINING (SKILL COURSE)						
	Total Contact Hours	42 (P)	L	T	P	C	
	Pre-requisite	Nil	0	0	3	2	

Course Objective: To equip students with the knowledge, skills, and mind-set necessary to create and maintain a safe and healthy work environment, thereby preventing workplace injuries, illnesses, and accidents, and fostering a culture of safety and well-being among employees.

Course Outcomes: At the end of the course, students shall be able to

1	Apply risk assessment techniques to identify workplace hazards and implement appropriate control measures. (BL-3)
2	Select and use personal protective equipment (PPE) effectively in various work environments. (BL-3)
3	Analyze emergency situations and develop comprehensive response plans, including conducting drills. (BL-4)
4	Assess ergonomic and physical risks in the workplace and implement injury prevention strategies. (BL-4)
5	Design and communicate safety programs that foster a strong safety culture through training and awareness.(BL-5)
6	Implement workplace wellness initiatives and high-risk protocols, including violence prevention and confined space safety. (BL-6)

SYLLABUS

1. Module 1: Introduction to Workplace Safety (2 hours)
 - Overview of workplace safety regulations and standards
 - Importance of safety culture
 - Key roles and responsibilities in safety management
2. Module 2: Hazard Identification Techniques (2 hours)
 - Methods for identifying workplace hazards
 - Hazard recognition training exercises
 - Practical examples and case studies
3. Module 3: Risk Assessment and Management (2 hours)
 - Understanding risk assessment methodologies
 - Prioritizing hazards based on severity and likelihood
 - Developing risk mitigation strategies
4. Module 4: Personal Protective Equipment (PPE) (2 hours)
 - Selection, proper use, and maintenance of PPE
 - Hands-on demonstration of different types of PPE
 - PPE fit testing and evaluation
5. Module 5: Hazard Control Measures (2 hours)
 - Implementing engineering controls, administrative controls, and PPE
 - Case studies on effective hazard control strategies
 - Continuous monitoring and improvement of controls
6. Module 6: Emergency Preparedness Planning (2 hours)
 - Developing comprehensive emergency response plans
 - Conducting hazard-specific emergency drills
 - Evaluating and improving emergency preparedness measures
7. Module 7: Chemical Safety and Hazardous Materials Management (2 hours)
 - Safe handling, storage, and disposal of hazardous chemicals
 - Understanding Safety Data Sheets (SDS)
 - Spill response and containment procedures
8. Module 8: Fire Safety and Prevention (2 hours)
 - Identifying fire hazards in the workplace
 - Fire prevention strategies and practices
 - Fire extinguisher training and hands-on exercises
9. Module 9: Electrical Safety (2 hours)
 - Recognizing electrical hazards and risks
 - Safe work practices around electrical equipment

- Lockout/tagout procedures and electrical safety controls
- 10.Module 10: Ergonomics and Injury Prevention (2 hours)
 - Identifying ergonomic risk factors in the workplace
 - Implementing ergonomic solutions and best practices
 - Strategies for preventing musculoskeletal injuries
- 11.Module 11: Safety Communication and Training (2 hours)
 - Effective safety communication strategies
 - Conducting safety meetings and toolbox talks
 - Developing engaging safety training programs and materials
- 12.Module 12: Building a Strong Safety Culture (2 hours)
 - Fostering employee involvement in safety initiatives
 - Recognizing and rewarding safety performance
 - Continuous improvement in safety practices and culture
- 13.Module 13: Workplace Violence Prevention (2 hours)
 - Understanding the risk factors for workplace violence
 - Implementing prevention strategies and security measures
 - Responding to incidents of workplace violence
- 14.Module 14: Confined Space Entry and Rescue (2 hours)
 - Identifying confined spaces and associated hazards
 - Developing confined space entry procedures and permits
 - Conducting confined space rescue drills and training
- 15.Module 15: Health and Wellness Promotion (2 hours)
 - Promoting employee health and wellness in the workplace
 - Strategies for managing stress and fatigue
 - Integrating health promotion into safety programs

LEARNING RESOURCES

TEXT BOOKS:

1	"Safety and Health for Engineers" by Roger L. Brauer.
2	"Introduction to Health and Safety at Work: The Handbook for the NEBOSH National General Certificate" by Phil Hughes and Ed Ferrett
3	"Industrial Hygiene Simplified: A Guide to Anticipation, Recognition, Evaluation, and Control of Workplace Hazards" by Frank R. Spellman and Nancy E. Whiting
4	"Safety Culture: An Innovative Leadership Approach" by James Roughton and James Mercurio.

1	J.H.Coulson and Richardson, <i>Chemical Engineering, vol.-II</i> , 5th edition, Elsevier India, 2006.
2	C. M. Narayana and B.C.Bhattacharyya, <i>Mechanical Operations for Chemical Engineers</i> , Khanna Publishers, 1992.
3	Perry Rober H, <i>Chemical Engineers Hand Book</i> , 8th edition, McGraw Hill, 2007.

R23MCHEL007	ASPEN PLUS (SKILL COURSE)					
	Total Contact Hours	42 (P)	L	T	P	C
	Pre-requisite		0	0	3	2
Course Objectives: To introduce students to use of ASPEN Plus software package for simulation, design and optimization and also analysing flow sheets.						
Course Outcomes: After successful completion of this lab, the students able to:						
1	Carry out thermodynamic property estimations using Aspen (BL-3)					
2	Simulate Mixer, splitter, pumps (BL-6)					
3	Simulate heat exchangers, reactors and distillation columns (BL-6)					
4	Apply sensitivity, design specification and case study tools in Aspen (BL-6)					
5	Carryout material and energy balance calculations using Aspen Plus tool (BL-6)					
6	Simulate chemical process plant and effect of process variables on the plant operation using Aspen Plus (BL-6)					
SYLLABUS						
Solve the following steady state simulation exercises using Aspen:						
1. Physical property estimations.						
2. Simulation of individual units like, mixers, splitters, heat exchangers, flash columns and reactors						
3. Simulation of heat exchangers						
4. Simulation of distillation columns.						
5. Mass and Energy balances using ASPEN PLUS						
6. Handling user specifications on output streams – Sensitivity and design Spec tools.						
7. Simulation of a Chemical process flow sheet.						
LEARNING RESOURCES						
TEXT BOOKS:						
1	Lab manuals / Exercise sheets					
2	A.K.Jana, Chemical Process Modelling and Computer Simulation, Prentice Hall India, 3rd Edition, 2018.					
3	Kamal I.M. Al-Malah, Aspen Plus: Chemical Engineering Applications, 2016, John Wiley & Sons Inc., USA.					

VIII Semester

R23MSCST007	COMPUTER NETWORKS (SELF STUDY / MOOCS COURSE) (Common to all Branches)					
	Total Contact Hours	42 (L)	L	T	P	C
	Pre-requisites	DLD, CAO	3	0	0	3
Course Objective						
Students will gain an ability to identify and design network architecture and apply the essence of various protocols.						
Course Outcomes						
1	Students will be able to analyse and apply key concepts of data communication, including network topologies, layering, and protocols; the OSI and TCP/IP reference models in order to design and evaluate efficient communication systems.					
2	Students will be able to describe, demonstrate, and analyse various data link layer techniques and apply this knowledge to design and evaluate reliable data communication systems					
3	Students will be able to identify, explain, and apply random access methods and assess their impact on the performance and evolution of network communication systems.					
4	Students will be able to describe, compare, and apply the roles of connecting devices (switches, hubs, routers, bridges, gateways), analyze and evaluate various routing algorithms and assess the effectiveness of flooding in network communication.					
5	Students will be able to compare , and apply the TCP and UDP datagram formats, congestion control techniques and flow control methods and their roles in Internet communication.					
6	Students will be able to design and evaluate efficient, reliable and effective network communication systems.					
SYLLABUS						
Unit I	OVERVIEW OF DATACOMMUNICATION AND NETWORKING					8 hr
Introduction to Data Communication; Network Topologies, Layering and Protocols; Reference-Model: OSI & TCP/IP Reference Model, Addressing; Physical Layer-Different types of Transmission Media-Guided; Different types of Transmission Media-Unguided; Multiplexing-TDM,FDM,WDM; Line Encoding (NRZ,NRZI,Manchester,AMI,4B/5B); Switching and Taxonomy: Circuit Switched, Packet Switched.						
Unit II	DATALINK LAYER : ERROR CONTROL & FLOW CONTROL					8 hr
Error Detection: CRC, Checksum; Error Correction: Hamming Distance, Linear Block Codes Framing: Bit and Byte Stuffing ; Flow Control: Noiseless-Simplest, Stop and Wait; Noisy: Stop and wait ARQ; Go Back N, Selective repeat; PPP, HDLC; Random Access: Aloha: Pure and Slotted;						
Unit III	DATALINK LAYER					8 hr
Random Access: CSMA, CSMA/CD; Random Access: CSMA/CA; Controlled Access-Reservation, Polling and Token passing; Channelization-FDMA; TDMA and CDMA; Standard Ethernet-MAC; Standard Ethernet-Physical Layer; Changes in the Standard- Fast Ethernet; Gigabit Ethernet,10 Gigabit Ethernet.						
Unit IV	NETWORK LAYER					8 hr
ConnectingDevices-Switches,Hubs,Routers,Bridges,Gateways;IPv4addressing-Classful,Classless; IPv4 Datagram Format,IPv6 Datagram Format; Address Mapping: ARP; RARP,BOOTP, DHCP; Routing: Routing table, Optimization, Distance Vector Routing ; Link State Routing, Path Vector Routing;						

Unit V	TRANSPORT LAYER AND APPLICATION LAYER	8 hr
TRANSPORT LAYER: TCP Datagram Format; UDP Datagram Format; Congestion Control: Data Traffic, Open Loop, Closed Loop; Quality of Service: Flow characteristics, Scheduling ; Flow Control: Leaky Bucket and Token Bucket;		
REMOTE LOGIN & APPLICATION LAYER: Telnet, Electronic Mail; DNS, Distribution of Name Space, DNS in the Internet; WWW and HTTP.		
LEARNING RESOURCES		
TEXTBOOKS:		
1	Data Communications and Networking, Behrouz Forouzan ,4 th Edition, McGrawHill.	
REFERENCE BOOKS:		
1	Computer Networks –Andrew S Tanenbaum,4 th Edition, Pearson Education/PHI.	
2	Computer Networking: <i>A Top Down Approach</i> -James F Kurose and Keith W Ross, 6 th Edition, Pearson Education.	
ADDITIONAL REFERENCE MATERIAL		
1	https://www.geeksforgeeks.org/computer-network-tutorials	
2	https://www.javatpoint.com/computer-network-tutorial	
3	https://www.tutorialspoint.com/data_communication_computer_network	
ONLINE COURSES		
1	https://onlinecourses.nptel.ac.in/noc22_cs19	
2	https://www.coursera.org/learn/illinois-tech-computer-networking	

Bloom's level - Units catchment articulation matrix

CO	Blooms Level	Unit I	Unit II	Unit III	Unit IV	Unit V
CO1	BL3	X				
CO2	BL4		X			
CO3	BL3			X		
CO4	BL5				X	
CO5	BL4					X
CO6	BL6	X	X	X	X	X

R23MCST008	ARTIFICIAL INTELLIGENCE: PRINCIPLES AND TECHNIQUES (SELF STUDY / MOOCS COURSE)					
	Total Contact Hours	42 (L)	L	T	P	C
	Pre-requisite	Data Structures	3	0	0	3
Course Objective This course aims to help students conversant with the theoretical concepts and algorithm approaches that can be applied to the design of AI applications and students will gain insights into foundational principles, algorithms, and theoretical frameworks underlying Machine Learning.						
Course Outcomes After completing this course, the students will be able to						
1	Apply AI Search Algorithms and Backtracking Techniques to Solve Constraint Satisfaction Problems and Design Adversarial Search Strategies in Real-World Scenarios. (BL3)					
2	Analyze and Compare the Applications and Limitations of Propositional Logic and First-Order Logic in Knowledge Representation and Reasoning. (BL4)					
3	Apply Machine Learning Techniques and Neural Network Models to Solve Real-World Problems Across Various Domains. (BL3)					
4	Analyze and Compare the Effectiveness of the Find-S and Candidate Elimination Algorithms in Designing a Learning System, Focusing on Version Spaces and Their Applications. (BL4)					
5	Evaluate the Effectiveness and Applicability of Decision Tree Learning and Single and Multi-Layer Perceptrons in Solving Classification Problems Across Various Domains. (BL5)					
6	Design and Develop an Integrated Intelligent System that Utilizes AI Search Algorithms, Knowledge Representation, and Machine Learning Techniques, Including Decision Trees and Neural Networks, to Solve Complex Real-World Problems. (BL6)					
SYLLABUS						
Unit I		INTRODUCTION TO ARTIFICIAL INTELLIGENCE				8 hrs
Introduction to Artificial Intelligence (AI), machine learning, deep learning, Types of AI, Advantages and Applications of AI; Agents in Artificial Intelligence, Types of agents; State Space Search: Uninformed search: (Iterative Deepening, Bidirectional search); Informed search: Best First Search; A* Algorithm; Hill Climbing Algorithms in Artificial Intelligence (Simple and Steepest Ascent); Constraint satisfaction problems (Constraint propagation: Arc Consistency), Backtracking Algorithm for CSP's; Knowledge-Based Agent (KBA): Architecture and Various level of KBA.						
Unit II		KNOWLEDGE REPRESENTATION AND REASONING				8 hrs
Knowledge representation (KR), Approaches to KR, Techniques of KR; Propositional Logic, Logical Connective and Equivalence; Rules of Inference; PEAS description of Wumpus world; First Order Logic in AI, Inference in First-Order Logic; Knowledge Engineering in First-order logic; Forward Chaining and backward chaining in AI; Reasoning in Artificial intelligence;						
Unit III		BASICS AND TYPES OF MACHINE LEARNING				8 hrs
Conceptual introduction to Machine Learning and Neural Networks: Biological Neural Networks and Artificial Neural Networks; Supervised Learning: (Linear and Non-Linear regression); Logistic Regression; Classification: Decision Tree and Support Vector Machines; Unsupervised Learning (clustering approach);						

Association; Semi-Supervised Learning; Reinforcement Learning		
Unit IV	MACHINE LEARNING TRAINING EXAMPLES	8 hrs
Well Posed Learning Problems, Designing A Learning System, Perspectives and Issues in Machine Learning; Introduction to Concept Learning: A Concept Learning as a Task; Concept Learning as Search; Find-S: Finding a Maximally Specific Hypothesis; Version Spaces Representation: The List-Then-Eliminate Algorithm, Compact Representation for Version Spaces; Candidate Elimination Algorithm and Example; Remarks on Version Spaces and Candidate-Elimination: Converge, Order of Training Examples, Usage of Partially Learned Concepts; Inductive Bias		
Unit V	DECISION TREE LEARNING AND SINGLE AND MULTI-LAYER PERCEPTRON	8 hrs
Introduction, Decision Tree Representation and Appropriate Problems for Decision Tree Learning;ID3 Algorithm: An Illustrative Example; Hypothesis Space Search and Inductive Bias in Decision Tree Learning; Neural Network Representation, Appropriate Problems for Neural Network Learning; Perceptrons - Representational Power of Perceptrons, The Perceptron Training Rule; Gradient Descent and The Delta Rule, Stochastic Approximation to Gradient Descent; Multilayer Networks and The Back Propagation Algorithm - A Differentiable Threshold Unit; The Back Propagation Algorithm		
<u>LEARNING RESOURCES</u>		
TEXTBOOKS:		
1	Tom M. Mitchell "Machine Learning", Indian Edition.	
2	Stuart J. Russell and Peter Norvig, "Artificial Intelligence A Modern Approach", Third Edition.	
3	Kevin Knight, Elaine Rich, B. Nair, "Artificial Intelligence", Tata McGraw-Hill Education, 3 rd Edition, 2010.	
REFERENCE BOOKS:		
1	Christopher M. Bishop, "Pattern recognition and machine learning", Springer,2007.	
2	Ethem Alpaydin, "Introduction to Machine Learning", PHI, Third edition, 2015.	
ADDITIONAL REFERENCE MATERIAL		
1	https://www.javatpoint.com/artificial-intelligence-ai/	
2	https://www.geeksforgeeks.org/machine-learning/	

Bloom's level - Units catchment articulation matrix

CO	Blooms Level	Unit I	Unit II	Unit III	Unit IV	Unit V
CO1	BL3	X				
CO2	BL4		X			
CO3	BL3			X		
CO4	BL4				X	
CO5	BL5					X
CO6	BL6	X	X	X	X	X

R23MSCST009	OOAD AND DESIGN PATTERNS (SELF STUDY / MOOCS COURSE) (Common to all Branches)					
	Total Contact Hours	42 (L)	L	T	P	C
	Prerequisite	Object Oriented Programming	3	0	0	3
Course Objectives						
1. Understand the importance and basic concepts of object oriented modeling, 2. Specify, analyze and design the requirements for a system and model the state of the set of objects and their implementation specifications. 3. Identify, Analyze the subsystems, various components and collaborate them interchangeably. 4. Describe the design patterns that are common in software applications 5. Design a module structure to solve a problem, and evaluate alternatives						
Course Outcomes						
On the successful completion of this course, Students will be able to						
1	Examine the Object Oriented Models required for Software development through use case driven approach (BL4)					
2	Categorize and model the structural and behavioural concepts of the software system. (BL4)					
3	Develop and explore the transformation of conceptual models into various scenarios and real time applications. (BL4)					
4	Construct a design consisting of a collection of modules using creational and structural design patterns. (BL5)					
5	Identify appropriate behavioral patterns to demonstrate the dynamic aspects of a given software model during execution. (BL5)					
6	Design a Small-Scale Application with Unified Models and Integrated Design Patterns. (BL6)					
SYLLABUS						
Unit I	INTRODUCTION TO UNIFIED MODELING LANGUAGE					8 hr
Introduction to UML, Importance of Modeling; Principles of Modeling; Object oriented modeling; Conceptual model of UML: Basic building blocks; Conceptual model of UML: Rules; Conceptual model of UML: Common Mechanisms; Architecture; Software Development life cycle						
Unit II	STRUCTURAL MODELING					8 hr
Basic Structural Modeling: Classes ; Relationships; Common Mechanisms; Diagrams; Advanced Structural Modeling: Advanced classes; Advanced Relationships; Interfaces, Types and Roles; Packages & Instances;						
Unit III	ARCHITECTURAL MODELING & UML 2.0					8 hr
Usecase Diagrams; Interactions : Sequence & Collaboration Diagrams; Activity Diagrams; State Diagrams; Component Diagrams; Deployment Diagrams; Updations in UML 2.0: Interaction overview diagram and Timing diagrams; Unified Process Models in Software Engineering;						
Unit IV	DESIGN PATTERNS-1					8 hr
Introduction to Design patterns; Creational Design Patterns : Factory Method & Abstract Factory; Builder; Prototype; Singleton; Case study on Creational Design Patterns ; Structural Patterns: Adapter ; Bridge;						
Unit V	DESIGN PATTERNS-2					8 hrs
Composite; FlyWeight; Case study on Structural Patterns; Behavioral Patterns: Chain of Responsibility; Iterator; Memento ; Observer ; Case study on Behavioral Patterns						

LEARNING RESOURCES	
TEXTBOOKS:	
1	Grady Booch, James Rumbaugh, Ivar Jacobson: The Unified Modeling Language User Guide, Pearson Education.
2	Design Patterns By Erich Gamma, Pearson Education.
3	Hans-Erik Eriksson, Magnus Penker, Brian Lyons, David Fado: UML 2 Toolkit, WILEY-Dreamtech India Pvt. Ltd.
REFERENCE BOOKS:	
1	https://www.ibm.com/developerworks/rational/library/769.html
2	https://www.visual-paradigm.com/tutorials/uml-class-diagram-in-diff-programming-languages.jsp
3	https://www.uml-diagrams.org/index-examples.html
4	https://www.tutorialspoint.com/design_pattern/
5	http://www.oodeesign.com/
6	https://praveenthomasln.wordpress.com/2012/03/03/interfaces-types-and-roles-s8-cs/
7	https://www.uml-diagrams.org/uml-25-diagrams.html
8	https://www.tutorialspoint.com/uml/uml_2_overview.htm#:~:text=UML%202.0%20offers%20four%20interaction,of%20interactions%20as%20interaction%20occurrences.
ONLINE COURSES	
1	NPTEL :: Computer Science and Engineering - NOC: Object-Oriented Analysis and Design
2	https://onlinecourses.nptel.ac.in/noc22_cs99/preview

Bloom's level - Units catchment articulation matrix

CO	Blooms Level	Unit I	Unit II	Unit III	Unit IV	Unit V
CO1	BL4	X				
CO2	BL4		X			
CO3	BL4			X		
CO4	BL5				X	
CO5	BL5					X
CO6	BL6	X	X	X	X	X