INSTITUTE OF CHEMICAL TECHNOLOGY
Ordinances, Regulations and Syllabi relating to the Degree of Bachelor of Chemical Engineering (B. Chem. Engg.)

1. Introduction

The Institute is revamping its academic structure. All the courses will be credit based and the evaluation will be grade based. Due to these academic reforms the Regulation R.9, passed by the Senate in its meeting held on 10th May 2007 stands repeal and is replaced by the new Regulation R.9.

Credit system is a systematic way of describing an educational programme by attaching credits to its components. The definition of credits may be based on different parameters, such as student workload, learning outcomes and contact hours. It is a student-centric system based on the **student workload** required to achieve the objectives of a programme. It should facilitate academic recognition of the courses and mobility of the students. Credits assignment is based on the principle that Credits can only be obtained after successful completion of the work required and appropriate assessment of the learning outcomes achieved. As per the AICTE norms 2L/week of lectures are 2 credits, while 2h/week of practicals/tutorials are1 credit. This may be taken as the basis.

Student workload consists of the time required to complete all prescribed learning activities such as attendance at lectures/practicals, seminars, projects, etc. Credits are allocated to all the educational components of a study programme and indicate the quantity of work each component requires to achieve its specific objectives.

Evaluation is an important component of any teaching-learning process. The Institute gives emphasis on continuous evaluation with considerable freedom to the teacher in deciding the mode of evaluation of the students. The performance of the student is documented by a **grade** at the end of the semester. The grading scale ranks the students on a statistical basis. Therefore, statistical data on student performance is a prerequisite for applying the grading system.

2. Course Credits

In general a certain quantum of work measured in terms of **credits** is laid down as the requirement for a particular degree. The student acquires credits by passing courses every semester, the amount of credit associated with a course being dependent upon the number of hours of instruction per week in that course.

There are mainly two types of courses in the Institute - lecture courses and laboratory courses. Lecture courses consist of lecture (L) and tutorial (T) hours. Laboratory courses consist of practical (P) hours. The credit (C) for a course is dependent on the number of hours of instruction per week in that course, as given below:

(1) 1h/week of lecture (L) or tutorial (T) = 1 credit
(2) 2h/week of Practicals (P) = 1 credit
(3) Credit (C) for a theory course = No. of hours of lectures per week + No. of hours of tutorials per week = L + T
(4) Credits (C) for a Laboratory course = ½ x No. of hours of laboratory course per week

Credits will be assigned to In-plant, Seminar, Projects and other mandatory course requirements also and these will be mentioned in the respective syllabi. There may be some non-credit requirements. A student is required to earn credits as mentioned in the syllabus.

3. Evaluation

3.1 The weight ages of different modes of assessments shall be as under.

	In-Semester evaluation		End-Semester-Exam	Components of continuous mode
	Continuous mode	Mid Semester-Exam		
Theory	30%	30%	40%	Quizzes, class tests (open or closed book), home assignments, group assignments, *viva-voce* assignments, discussions
Practicals	50%	-	50%	Attendance, *viva -voce*, journal,

				assignments, project, experiments, tests

3.2. In-Semester Evaluation:

(a) It is expected that the teacher would conduct at least two assessments under the continuous mode in a Semester.

(b) The teacher will announce at the beginning of the respective course the method of conducting the tests under the continuous mode and the assignment of marks

(c) In-semester performance of all students should be displayed and sent to the academic office by the teacher at least 15 days before the end-semester examination.

(d) For the theory courses, there will be one mid-semester test for each course to be held as per the schedule fixed in the Academic Calendar.

(e) For mid –semester examinations in theory papers, duration of examination will be 1 hour for 3 credit courses and 2 hours for 4 credit courses

3.3. End-Semester examination:

a) The semester end examination will cover the full syllabus of the course and will be conducted as per the Institutional time table at the end of each semester.
b) For end –semester examinations in theory papers, duration of examination will be 1 hour for 3 credit courses and 2 hours for 4 credit courses

3.4 Passes and Fail

(a) The candidates who obtain 40% and more marks of the total marks of a subject head shall be deemed to have **passed** the respective subject head.

(b) The candidates who obtain marks less than 40% of the total marks of a subject head shall be deemed to have **failed** in the respective subject head **(Grade FF).**

3.5 Grades:

(a) The performance of a student shall be documented by a **Letter grade.** Each letter grade has a **Grade point** associated with it. The Grades and Grade points shall be assigned to each head of passing and both will be indicated in the mark-list of the semester examination.

(c) The total marks (in-semester + end-semester) of a candidate in a subject head are converted into a letter grade, based on the relative (and some times the absolute) performance of the student.

Letter Grade	**Grade Point**
AA	10
AB	9
BB	8
BC	7
CC	6.5
CD	6
DD	5.5
EE	5

(d) For granting class a grade point of 6.0 and above will be considered equivalent to First class.

(c) The grades to be allotted in the case of students who fail or do not appear at the end-semester examination shall be as under.

Letter Grade	Grade Point	Explanation
FF	0	The candidate fails in subject head. The candidate will be allowed to take end-semester repeat or subsequent examinations as per rule.
XX		The candidate has not kept term for the subject head due to attendance less than requisite. Further see 3.5(g) below. In the above cases, the candidate has to repeat the respective course by paying the fees.
I	0	The candidate has kept term for the subject head, has taken all the internal examinations with satisfactory performance, but has failed to take the end-semester examination or repeat examination due to genuine reasons. The candidate will be allowed to take end-semester repeat or subsequent examinations as per rule.
FR	0	The candidate has exhausted all the permissible chances to clear the end-semester examinations. The candidate has to register for the respective semester again for all the subject heads or will be out of the respective degree course as per the rules.
DR	0	(i) The candidate hasn't participated in academic programme. (ii) The candidate has taken a drop for the subject head; - provided he/she intimates the same (i or ii) at least 7 days in advance of the commencement of the end-semester examination for the respective year.

(d) Grades **FF** and **I** are place-holders only and do not enter into CPI/SPI calculations directly. These grades get converted to one of the regular grades after the end-semester examination.

(e) A candidate with an **FR** grade is not eligible for any repeat examination in that course and has to re-register for that semester by paying the appropriate fees.

(f) **I** grade will not be continued beyond the permissible number of end-semester/repeat examinations [Refer to current Regulation R.9 (9) and R.9 (10)].In the six consecutive exams conducted by the institute, irrespective of whether the candidate fails to take any of these exams.

(g) **'XX' Grade:** The grade **XX** in a course is awarded if – (i) candidate does not maintain the minimum 75% attendance in the Lecture/Tutorial/Practical classes, (ii) candidate receives less than 20% of the combined marks assigned for continuous assessment and mid-semester examination, and (iii) candidate indulges in a misconduct/uses unfair means in the examination, assignments, etc., of a nature serious enough to invite disciplinary action in the opinion of the teacher.
(**Note:** Award of the **XX** grade in the case of g(iii) above shall be done by Disciplinary Action Committee (DAC)).

(h) The names/roll numbers of students to be awarded the **XX** grade should be communicated by the teacher to the Academic office as per academic calendar before the last date of submission of the application for end-semester examination.

3.6. Awarding the grades

The grading scale ranks the students on a statistical basis on the basis of the overall performance of the students of a given class in the given subject head. Therefore, statistical data on students' performance is a prerequisite for applying the grading system. While assigning grades in a given subject head, it is essential to know the **average marks (AM)** obtained by the students *who have passed the subject head* and the **highest marks (HM)** obtained in the *same subject head*.

3.6.1. If the **average marks (AM)** obtained by the students *who have passed the subject head* is <60%, the interval AM shall be awarded grade CC and the other grades shall be decided as follows:
(i) AA, AB, BB, and BC grades shall be decided between the AM and HM by dividing the range in equal intervals.
(ii) CD, DD and EE grades shall be decided between the AM and minimum marks required for passing the head (i.e. 40%) by dividing the range in equal intervals.

3.6.2. If the **average marks (AM)** obtained by the students *who have passed the subject head* is such that **60% ≤ AM < 70%,** the interval AM shall be awarded grade BC and the other grades shall be decided as follows:

(i) AA, AB, BB grades shall be decided between the AM and HM by dividing the range in equal intervals.

(ii) CC, CD, DD and EE grades shall be decided between the AM and minimum marks required for passing the head (i.e. 40%) by dividing the range in equal intervals.

3.6.3. If the **average marks (AM)** obtained by the students *who have passed the subject head* is **≥ 70%,** the interval AM shall be awarded grade BB and the other grades shall be decided as follows:

(i) AA and AB grades shall be decided between the AM and HM by dividing the range in equal intervals.

(ii) BC CC, CD, DD and EE grades shall be decided between the AM and minimum marks required for passing the head (i.e. 40%) by dividing the range in equal intervals.

4. SPI and CPI

(a) **Semester Performance Index (SPI):** The performance of a student in a semester is indicated by **Semester Performance Index (SPI),** which is a weighted average of the grade points obtained in all the courses taken by the student in the semester and scaled to a maximum of 10. (SPI is to be calculated upto two decimal places.)

A Semester Grade Point Average (SGPA) will be computed for each semester as follows:

$$\text{SGPA} = \frac{\left(\sum_{i=1}^{n} c_i g_i\right)}{\left(\sum_{i=1}^{n} c_i\right)}$$

Where

'n' is the number of subjects for the semester,

'c_i' is the number of credits allotted to a particular subject, and

'g_i' is the grade-points awarded to the student for the subject based on his performance as per the above table.

SGPA will be rounded off to the second place of decimal and recorded as such.

(b) **Cumulative Performance Index (CPI):** An up to date assessment of the overall performance of a student from the time he entered the Institute is obtained by calculating **Cumulative Performance Index (CPI)** of a student. The CPI is weighted average of the grade points obtained in all the courses registered by the student since he entered the Institute. CPI is also calculated at the end of every semester (upto two decimal places). .

Starting from the first semester at the end of each semester (S), a Cumulative Grade Point Average (CGPA) will be computed as follows:

$$\text{CGPA} = \frac{\left(\sum_{i=1}^{m} c_i g_i\right)}{\left(\sum_{i=1}^{m} c_i\right)}$$

Where

'm' is the total number of subjects from the first semester onwards up to and including the semester S,

'c_i' is the number of credits allotted to a particular subject, and

'g_i' is the grade-points awarded to the student for the subject based on his performance as per the above table.

CGPA will be rounded off to the second place of decimal and recorded as such.

(c) The CGPA, SGPA and the grades obtained in all the subjects in a semester will be communicated to every student at the end of every semester / beginning of the next semester.

(d) **When** a student gets the grade 'FF', or I' in any subject head during a semester, the SGPA and CGPA from that semester onwards will be tentatively calculated, taking only 'zero' grade point for each such 'FF' or 'I' grade. When the 'FF' grade(s) has / have been substituted by better grades after the repeat examination or subsequent semester examination, the SGPA and CGPA will be recomputed and recorded.

5. Repeat End-Semester Examination

5.1. For those candidates who fail in a subject head or are eligible for appearing at the repeat examination, **Repeat End-Semester Examination** will be conducted within one month from the declaration of the results of regular end-semester examination, as per **Regulation R.14**.

5.2. The marks obtained by candidates in the in-semester examinations (continuous assessment and periodic test) will be carried forward in such cases.

5.3. Grading the performance in the Repeat Examination: The grades will be assigned as per 3.5 and 3.6 above. However, for a candidate taking any repeat examination or subsequent regular semester examination or performance improvement examination shall be awarded **one grade lower** than that decided on the basis of the actual marks obtained; provided 'EE' grade obtained in such an examination shall remain 'EE'. For reference see the table below.

Grade obtained in repeat or subsequent end-semester examination	Grade to be assigned	Grade point
AA	AB	9.0
AB	BB	8.0
BB	BC	7.0
BC	CC	6.5
CC	CD	6.0
CD	DD	5.5
DD	EE	5.0
EE	EE	5.0

5.4. Revaluation of end-semester and repeat examination: Candidate's performance in these examinations will be displayed on proper notice board and after 3 days of such display the marks will be sent to the Academic Office. No revaluation of these examinations will be allowed.

6. Passing of a Semester examination

A candidate shall be declared as **'PASSED'** any semester examination if he/she has
(a) Cleared all heads of passing by securing grades EE or higher in all the heads;
(b) Passed all the heads of passing such as project, seminar, training, etc as per the rules;
(c) Satisfactorily completed all the mandatory requirements of the course;
(d) paid all the Institute dues;
(e) No case of indiscipline pending against him/her.

7. Eligibility for the Award of a Degree

A candidate shall be declared eligible for the award of a degree, if he/she has cleared all the semester examinations as given in (6) above.

8. Allowed to keep terms (ATKT)

8.1 A candidate who has I grade in one or more heads of passing of an odd semester of an academic year shall be allowed to keep terms for the respective even semester.

8.2. A candidate shall be allowed to keep terms for the subsequent academic year if he/she has FF or I grades in not more than two heads of passing from all the heads of passing of the two terms of the previous academic year taken together. Such a candidate shall be declared as **FAILED, ATKT**.

8.3. A candidate who has not cleared Semester-I and II as per clause 6 above shall not be eligible to register for semester-V and VI.

8.4. A candidate who has not cleared Semester-III and IV as per clause 6 above shall not eligible to register for semester-VII and VIII

9. Repeating a course

9.1 A student is required to repeat the course of a subject head under the following situations:
(a) A student who gets an **XX, FR, or DR** grade in a course; or
(b) A student has exhausted all permissible chances to clear the subject head.

9.2 A candidate from second, third and fourth years who remains absent for the regular end-semester examination of a semester and the corresponding repeat examination for **ALL SUBJECTS** shall have to take fresh admission for the corresponding year; unless the candidate has dropped out / terminated from the course.

9.3 If a candidate at the Second, Third or Fourth year fails to pass any semester examination in not more than 4 consecutive examinations, including the repeat examinations, from the date of registering for the respective year, the candidate shall have to take readmission for the corresponding year again in which the failure has occurred, provided the course is not changed.

10. Improvement of performance

A candidate will be allowed to appear at the **entire examination** after the regular end-semester examination as per the respective rules to improve the performance. In such a case if the result of the examination repeated –

1. Is better than the previous one, the previous result shall be declared null and void; and
2. Is worse than the previous one, the result of the subsequent examination shall not be declared.
3. However, awarding of final grade will be made under the provision of sub clause 5.3 above.

11. Exit rules for poorly performing students

A candidate shall be excluded from a course under the following conditions:

(a) If he/she fails to pass any semester examination of the any year of the course in not more than four consecutive attempts (Examination conducted by Institute) from the date of joining the course.

(b) If he/she does not keep two consecutive terms without giving any reasonable justification (as prescribed by the institute) for doing so.

(c) If a candidate fails to fulfill all the requirements of his/her respective degree within the prescribed period from the date of taking admission to the course, the candidate shall be excluded from the course.

12. Miscellaneous

(a) Although CPI will be given in the Semester grade report, the final degree certificate will not mention any **Class** whatsoever.

(b) Not withstanding anything said above if a course is revised /restructured then transient provisions applicable at the time of revision /restructuring shall be applicable.

Proposed Syllabus Details for B. Chemical Engineering Course

Semester I

No	Subjects	Hours/ Week	Total Marks*
1.	Inorganic Chemistry	2	50
2.	Organic Chemistry-I	3	100
3.	Applied Mathematics-I	2	100
4.	Applied Physics – I	3	100
	TOTAL:	10	350
5.	Engineering Graphics-I	6	100
6.	Physics Laboratory	3	50
7.	Inorganic Chemistry Laboratory	3	50
8.	Organic Chemistry Laboratory	3	50
	TOTAL:	15	250
9.	Tutorials: Inorganic Chemistry	1	
10.	Tutorials: Organic Chemistry-I	1	
11.	Tutorials: Appl. Physics – I	1	
12.	Tutorials: Appl. Maths – I	2	
		30	600

Semester II

No.	Subjects	Hours/ Week	Total Marks*
1.	Organic Chemistry-II	3	100
2.	Analytical Chemistry	2	50
3.	Material & Energy Balance Calculations	2	100
4.	Applied Mathematics-II	2	100
5.	Applied Physics – II	2	50
	TOTAL:	11	400
6.	Engineering Applications of Computers	3	50
7.	Organic Chemistry Laboratory	3	50
8.	Analytical Chemistry Laboratory	3	50
9.	Communication Skills	3	50
	TOTAL:	12	200
10.	Tutorials: Organic Chemistry-II	1	
11.	Tutorials: Analytical Chemistry	1	
12.	Tutorials: Appl. Physics – II	1	
13.	Tutorials: Appl. Maths – II	2	
14.	Tutorials: M. E. B. C.	2	
		30	600

Semester III

No.	Subjects	Hours/ week	Total Marks*
1.	Chem. Eng.Thermodynamics-I	2	50
2.	Momentum and Mass Transfer	3	100
3.	Biological Science	2	50
4.	Applied Mathematics-III	2	100
5.	Structural Mechanics	2	50
6.	Physical Chemistry	3	100
7.	Elective I (Chem./Phy./Maths/Gen Engg./Humanities)	2	50
	TOTAL:	16	500
8.	Physical Chemistry Laboratory	3	50
9.	Structural Mechanics Lab.	3	50
	TOTAL:	6	100
10.	Tutorials: Physical Chemistry	1	
11.	Tutorials: Momentum and Mass Transfer	1	
12.	Tutorials: C. E. T. – I	1	
13.	Tutorials: Applied Maths – III	2	
14.	Tutorials: Structural Mechanics	1	
15.	Tutorials: Elective – I	1	
16.	Tutorials: Biological Science	1	
		30	600

Semester IV

No.	Subjects	Hours/ week	Total Marks*
1.	Energy Engineering	3	100
2.	Electrical Engineering and Electronics	3	100
3.	Chemical Engineering Operations	2	100
4.	Applied Mathematics IV	2	100
5.	Chem. Eng. Thermodynamics-II	2	50
	TOTAL:	12	450
6.	Engineering Graphics -II	6	100
7.	Electrical Eng.& Electronics Laboratory	3	50
	TOTAL:	9	150
8.	Tutorials: Energy Engineering	1	
9.	Tutorials: Electrical Engg & Electronics	1	
10.	Tutorials: Chem Eng. Operations	2	
11.	Tutorials: Applied Maths – IV	2	
12.	Tutorials: C. E. T.– II	1	
		28	600

Semester V

No.	Subjects	Hours /week	Total Marks*
1.	Industrial & Engg. Chemistry	3	100
2.	Heat Transfer	2	50
3.	Chemical Reaction Eng.	2	100
4.	Separation Processes	2	50
5.	Biochemical Engineering	2	50
	TOTAL:	11	350
6.	Chem. Eng. Laboratory	6	100
7.	Process Simulation Lab – I	3	50
	TOTAL:	9	150
8.	Tutorials: Ind. & Eng. Chemistry	1	
9.	Tutorials: Heat Transfer	1	
10.	Tutorials: Chem. Reaction Engg.	2	
11.	Tutorials: Separation Processes	1	
12.	Tutorials: Biochem. Engg.	1	
		26	500

Semester VI

No.	Subjects	Hours /week	Total Marks*
1.	Materials Technology	2	50
2.	Multiphase Reaction Engineering	2	50
3.	Environmental Engg & Process Safety	2	100
4.	Instrumentation and Process Control	2	50
5.	Elective-II	2	50
	TOTAL:	10	300
6.	Chem. Eng. Laboratory	6	100
7.	Process Simulation Lab – II	3	50
8.	Equipment Design and Drawing-I	3	50
	TOTAL:	12	200
9.	Tutorials: Env. Eng.& Process Safety	1	
10.	Tutorials: Multiphase Reaction Eng.	1	
11.	Tutorials: Instru. & Process Control	1	
12.	Tutorials: Material Technology	1	
13.	Tutorials: Elective – II	1	
		27	500

Semester VII

No.	Subjects	Hours /week	Total Marks*
1.	Chem. Project Engg. & Economics	2	50
2.	Process Engineering	2	50
3.	Persp. of Society, Sci. & Tech.	2	50
4.	Elective – III	2	50
	TOTAL:	8	200
5.	Chem. Eng. Laboratory	6	100
6.	Process Simulation Laboratory– III	3	50
7.	Project 1: Seminar	3	50
8.	Project 2: Home Paper – I	3	50
9.	Project 3: In-Plant Training and Community Service	1	50
	TOTAL:	16	300
10.	Tutorials:Chem.Project Engg. Eco.	1	
11.	Tutorials: Process Engineering	1	
12.	Tutorials: Elective – III	1	
13.	Tutorials: PSST	1	
		28	500

Semester VIII

No.	Subjects	Hours /week	Total Marks*
1.	Industrial Psychology and Human Resource Management	2	50
2.	Industrial Management	2	100
3.	Design and Analysis of Experiments	2	50
4.	Elective – IV	2	50
	TOTAL:	8	250
5.	Equipment Design and Drawing	6	100
6.	Project 4: Home Paper - II	9	150
	TOTAL:	15	250
7.	Tutorials: Industrial Psychology and Human Resource Mgt.	1	
8.	Tutorials: Industrial Management	2	
9.	Tutorials: Design & Analysis of Expts.	1	
10.	Tutorials: Elective – IV	1	
		28	500

Detailed Contents of Syllabus

Semester – I

No	Subjects	Credits	Hrs/Week			Marks			
			L	T	P	Continuous Assessment	Periodic Test	Final Exam	Total
CHT 1121	Inorganic Chemistry	3	2	1	0	15	15	20	50
CHT 1131	Organic Chemistry-I	4	3	1	0	30	30	40	100
MAT 1101	Applied Mathematics-I	4	2	2	0	30	30	40	100
PYT 1101	Applied Physics – I	4	3	1	0	30	30	40	100
GEP 1101	Engineering Graphics-I	4	0	0	6	50	---	50	100
PYP 1102	Physics Laboratory	2	0	0	3	25	---	25	50
CHP 1122	Inorganic Chemistry Laboratory	2	0	0	3	25	---	25	50
CHP 1132	Organic Chemistry Laboratory – I	2	0	0	3	25	---	25	50
	TOTAL:	25	10	5	15				600

1. CHT 1121 – Inorganic Chemistry

Periodic Table, s,p,d and f elements and their general properties, correlations among various properties. 3

Main group Chemistry: Hydrogen, Chemistry of Group IA, II B and Group IIIB to VIIB elements and noble gases. 12

Chemical Bonding: Valence Bond theory and Molecular orbital theory 3

Coordination Chemistry: Nomenclature, Werner theory, VSEPR, crystal field theory, electronic and magnetic properties of the complexes. 12

Organometallics: Metal Ligand concept, , types of ligands, Effective atomic number rule reactions using organometallic compounds like addition, insertion, migration. Concepts of sigma bond and pi bond formation. Application of organometallic complexes in hydrogenation, hydroformylation, carbonylation etc. 15

Reference Books

Concise Inorganic Chemistry, J.D. Lee, Wiley India Edition

Basic Inroganic Chemistry, F.A. Cotton and G. Wilkinson, John Wiley and Sons

2. CHT 1131 – Organic Chemistry I

Nomenclature of organic compounds 5

Mechanisms of organic reactions: Types of Organic Reaction, Reactive intermediates; their generation, structure, stability and general reactions. 10

Stereochemistry: Elements of symmetry, stereochemistry of compounds containing one and two carbon atoms. Racemates and their resolution, conformation of cyclic and acyclic systems, E and Z isomers of olefins, Idea of asymmetric synthesis. 10

Chemistry of alkanes, cycloalkanes, alkenes and alkynes: Alkanes from petroleum, methods of synthesis. Properties, General reactions, oligomerization and polymerization of olefins, acidity of terminal alkynes, alkenes as fuels. 10

Aromaticity and Aromatic hydrocarbons: Huckel's theory of Aromaticity and monocyclic carbocyclic aromatic species, BTX, Aromatic hydrocarbons. Fridel-Craft alkylation. General reaction of aromatic hydrocarbons. 10

Aliphatic and aromatic halides: Methods of preparation, properties, General reactions, SN^1,SN^2 reactions, Aromatic nucleophilic reactions. 15

Reference Books:

Organic Chemistry, J. McMurry, Brooks/Cole

Organic Chemistry, T.W.G. Solomons, C.B. Fryhle, John Wiley and Sons Inc.,

Organic Chemistry, L.G. Wade Jr, Pearson Education

StereoChemistry of Carbon compounds, E.L. Eliel, Mcgraw-Hill

Organic Chemistry, Paula Y. Bruice, Pearson Education

3. MAT 1101 – Applied Mathematics-I

Rank of matrices, Solutions of system of linear equations (Gauss-elimination, LU-decomposition etc.)

Eigenvalues and Eigenvectors, Caley-Hamilton theorem: 6

Numerical methods for solution of linear and non-linear single and multiple algebraic equations. Solution of transcendental Equations, Newton's method, Fixed point iterative method etc. 6

Interpolation and extrapolation: interpolating polynomials for equal and non-equal spaced data (Forward, backward, central and spline) and their applications to numerical integration (trapezoidal rule, Simpson's Rule, Romberg Integration etc.) and numerical differentiations. 10

Probability of Statistics: Review of elementary probability theory, Random variables, Functions of random variables, probability distribution functions, expectation, moments and moment generating functions, Joint probability distributions, binomial, Poisson, and Normal distribution 12

Sampling distributions, Point and interval estimations, Statistical hypothesis tests, t-tests for one and two samples, F-test, χ^2-test, tests of hypothesis for proportion, Simple Applications; 10

Statistical Methods for Data Fitting: Linear, multi-linear, non-linear regression, ANOVA 6

Differential Calculus : Review and Concepts, Higher order differentiation and Leibnitz Rule for the derivative, Rolle's and Mean Value theorems, Taylor's and Maclaurin's theorems, Maxima/Minima, convexity of functions, Asymptotes, Radius of curvature; 10

Reference Books:

Advanced Engineering Mathematics, Erwin Kreyszig, John-Wiely.
Advanced Engineering Mathematics S. R. K. Iyengar, R. K. Jain, Narosa.
Introductory Methods Of Numerical Analysis, S. S. Sastry, PHI.
A First Course in Probability, Sheldon Ross, Pearson Prentice Hall.
Probability and Statistics in Engineering , W.W. Hines, D. C. Montgomery, D.M. Goldsman, John-Wiely

4. PYT 1101 – Applied Physics-I:

Thermal Physics 15

Temperature and the zeroth law of thermodynamics, heat conduction, first law of thermodynamics, kinetic theory of gases,

Maxwell-Boltzmann distribution, some aspects of non-ideal behaviour, entropy and second law of thermodynamics

Solid State Physics 6

Crystal Structure (6)

Crystal structure of solids, unit cell, space lattices and Bravais lattices, Miller indices, directions and crystallographic planes. Cubic crystals – SCC, BCC, FCC, Hexagonal crystals – HCP, atomic radius, packing fraction, ion-ligancy and critical ratio, Bragg's law, determination of crystal structure using Bragg spectrometer 15

Semiconductors (4)

Formation of energy bands in solids, concept of Fermi level, classification of solids – conductor, semiconductor and insulator. Intrinsic semiconductor, Effect of doping – extrinsic semiconductors. 8

Optics

Introduction,Diffraction – basic concepts, diffraction at a straight edge,diffraction at single and multiple slits, Resolving power – Rayleigh's criterion, resolving power of various optical components. 8

Ultrasonics

Generation of ultrasound – mechanical, electromechanical transducers, propagation of ultrasound, attenuation, velocity of ultrasound and parameters affecting it, measurement of velocity, cavitation, applications of ultrasound.

Optical Fibres 8

Introduction, optical fibre as a dielectric waveguide – total internal reflection, numerical aperture and various fibre

parameters, losses associated with optical fibres, step index and graded index fibres, applications of optical fibres.

Lasers and Microwaves

Introduction to interaction of radiation with matter, principles and working of a Laser– population inversion, pumping, various modes, threshold population inversion, types of Lasers – solid state, semiconductor, gas, applications of Lasers. Microwaves – production and applications.

Reference Books:

Physics: Vols. I and II – D. Halliday and R. Resnick, 2nd ed, 1962, Wiley Eastern.
Lectures on Physics: Vols. I, II and III – R. P. Feynman, R. B. Leighton and M. Sands, 1963, Narosa.
Concepts of Modern Physics – A. Beiser, 1969, McGraw-Hill.
Introduction to Modern Optics – G. R. Fowles, 2nd ed, 1975, Dover Publications.
A Course of Experiments with LASERs – R. S. Sirohi, 2nd ed, 1991, Wiley Eastern.

Optical Fibre Communication – G. Keiser, 3rd ed, 2000, McGraw-Hill.
Optoelectronics – J. Wilson and J. F. B. Hawkes, 2nd ed, 1992, Prentice-Hall India.
Ultrasonics: Methods and Applications – J. Blitz, 1971, Butterworth.
Applied Sonochemistry – T. J. Mason and J. P. Lorimer, 2002, Wiley VCH..

5. GEP 1101 – Engineering Graphics – I

Solid geometry projections of solids like prism, pyramids, cylinders and cones. Sections of solids. Developments of solids. Interpenetration of simple solids including cone and cylinder. Isometric scales and projections.
Machine drawing-Orthographic projections, First Angle and Third Angle method of projections. Conventions in dimensioning and in sections. Forms and proportions of screw threads, bolts, nuts, locking devices for nuts, studs, set-screws, hangers and brackets. Free hand sketches of the above parts

6. PYP 1102 – Physics Laboratory

Students will perform eight to ten experiments from selected topics in modern physics, heat and fluid mechanics

7. CHP 1122 – Inorganic Chemistry Laboratory

Volumetric Analysis : Preparation and Standardisation of Volumetric solutions. Acid base reactions, titrations of a mixture of (a) hydrochloric and acetic acid (b)Sulfuric and phosphoric acid (c) carbonate and bicarbonate. Oxidation - reduction titrations involving permanganate, dichromate, ceric sulfate, iodine (tri-iodide) potassium bromate. Precipitation titration : Mohr□s and Volhard□s titrations. Complexiметric titrations involving EDTA : Deterimination of hardness of water. Determination of Manganese in pyrolusite. Gravimetric analysis : Gravimetric determination of Fe, Ni, SO_4^{-2} and Cl^-. Analysis of a Fe-Ni alloy. Suitable number of experiments from the above list will be performed.

8. CHP 1132 – Organic Chemistry Laboratory – I

Identification of an organic compound through elemental analysis, group detection, physical constants (m.p and b.p) and derivatisation.
Estimation of selected organic compounds like: aniline/phenol, formaldehyde/acetone, glucose, glycerol. Neutral equivalents of acids and bases ,SAP value of an oil.

SEMESTER – II

No.	Subjects	Credits	Hrs/week			Marks			
			L	T	P	Continuous Assessment	Periodic Test	Final Exam	Total
CHT 1231	Organic Chemistry-II	4	3	1	0	30	30	40	100
CHT 1211	Analytical Chemistry	3	2	1	0	15	15	20	50
CET 1501	Material & Energy Balance Calculations	4	2	2	0	30	30	40	100
MAT 1102	Applied Mathematics-II	4	2	2	0	30	30	40	100
PYT 1103	Applied Physics – II	3	2	1	0	15	15	20	50
MAP 1201	Engineering Applications of Computers	2	0	0	3	25	---	25	50
CHP 1232	Organic Chemistry Laboratory – II	2	0	0	3	25	---	25	50
CHP 1222	Analytical Chemistry Laboratory	2	0	0	3	25	---	25	50
HUP 1101	Communication Skills	2	0	0	3	50	---	---	50
	Total	26	11	7	12				600

1. CHT 1231 – Organic Chemistry – II

Chemistry of Hydroxy derivatives of aliphatic and aromatic compounds:
Methods of preparation, Properties, General reaction, Acidity of phenol. 10

Aldehydes and ketones: Methods of preparation. Fridel-Craft acylations and related reactions, properties and reactivity, general reactions. 16

Carboxylic acids and their Derivatives: Carboxylic acids, esters, amides, acid chlorides and anhydrides Methods of preparation, Properties, Acidity of carboxylic acids, General reaction of their compounds. Interconversion. 10

Amines: Methods of preparation of primary, secondary and tertiary amines. .
properties, Basicities and general reactions. 7

Ethers, epoxides and sulphur acids: Methods of preparation, General reaction,
Acidity of sulphur acids. EO condensates. 5

Heterocyclic chemistry: Comparison with carbocyclic compounds, methods of
Preparation, Regenerated compounds Pyrrole, Furan, Thiophene, Pyridine,
Quinoline and Isoquinoline. Retrosynthetic approach, characteristic properties 12
and Reactions

Reference Books:

Organic Chemistry, J. McMurry, Brooks/Cole
Organic Chemistry, T.W.G. Solomons, C.B. Fryhle, John Wiley and Sons Inc.
Organic Chemistry, L.G. Wade Jr, Pearson Education
Organic Chemistry, Paula Y. Bruice, Pearson Education

2. CHT 1211 – Analytical Chemistry

Concept of quality: Definition of quality, quality control and assurance, TQM. Correlation between quality and analysis, steps and types of analysis, Stoichiometry and expression of concentration. 2
Theory of errors: Sources and classification of errors.
Statistical treatment of analytical data and presentation of results. 2
Sampling of solids, liquids and gases. 2
Evaluation and validation of analytical methods.
Good laboratory practices. 1
Fundamentals of chromatography, Chromatography methods: GLC, HPLC, TLC, HPTLC, ion chromatography, hyphenated techniques like GC-MS, LC-MS 6
Fundamentals of absorption / emission spectroscopy: Absorption of light, UV – Vis spectrophotometry, Beer-Lambert Law, characteristic bond frequencies. Energy levels in atoms and molecules. Principles of Atomic Absorption Spectroscopy (AAS), its application, features of the instrument. Principles of IR spectroscopy, application, and features of the instrument. 10
Diamagnetism and paramagnetism, nuclear spin, NMR spectroscopy, chemical shift, nuclear spin - spin coupling, EPR spectroscopy, Spectroscopy based on Scattering. 6
Fundamentals of Imaging Techniques: SEM TEM, 4
Electrochemical instruments, techniques and applications, controlled current and controlled potential principles, amplifiers, potentiostats, galvanostats, cyclic voltametry, chronoamperometry, chronopotentiometry, applications such as corrosion, electroplating, anodising, organic and inorganic electrosynthesis, fuel cells. 8
Thermal Methods : TGA, DTA, DSC 4

References:

Instrumental methods of Chemical Analysis, E.W. Ewing, McGraw Hill.
Instrumental Methods of Analysis, H.H. Willard, L.L. Merrit, J.A. Dean and F.A. Shette, Jr, CBS Publishers an Distributors, New Delhi.
New Instrumental Methods in Electrochemistry, P.D. Delaha
Instrumental methods of analysis, D.A. Scoog and D.M. Wes
Inorganic quantitative analysis, A.I. Vogel, Logmans ELBS.

3. CET 1501 – Material and Energy Balance Computations

Introduction to Chemical Engineering: Historical evolution of Chemical Engineering and Chemical Process Industries, Chemistry to Chemical Engineering 4
Revision of Units and Dimensions., Mathematical techniques, Introduction to use of calculators. 4
Mole concept, composition relationship and stoichiometry 2
Applications of Laws of Conservation of Mass and Energy to single and Multistage processes. 6
Behaviour of gases and vapors 4
Material balances for reacting systems. 8
Introduction to psychrometry humidity and air-conditioning calculations. 6
Calculation of X-Y diagrams based on Raoult's law. 4
Fuels and combustion. 6
Unsteady state material balances. 4
Material and energy balances for complete plants. 8
Material and energy balances using computers. 4

Reference Books:

Chemical Process Principles, Hougen O.A., Watson K. M.
Basic Principles and Calculations in Chemical Engineering, Himmelblau

Stoichiometry, Bhatt B.I. and Vora S.M.

4. MAT 1102 – Applied Mathematics – II

Functions of two or more variables, Limit and continuity, Partial differentiation, Total derivatives, Taylor's theorem for multivariable functions and its application to error calculations, Maxima/Minima, Jacobian. 10

Integral Calculus : Improper integrals, Beta and Gamma functions, Differentiation under the integral sign, Curve tracing, Application to length, Area, volumes, Surface of revolution, Moment of inertia, Centre of gravity 14

Differential Equations: Solution of Higher order ODE with constant and variable coefficients and its applications to boundary and initial value problems, Series solution of differential equations, Bessel functions, Legendre Polynomials, Error function, Solution by orthogonal set of functions. 12

Fourier Series and Fourier integrals, Fourier and Laplace Transforms and their applications to differential equation (both ODEs and PDEs) 14

Numerical methods for solution of ODEs (initial values and boundary values) using single step methods (RK, Euler's explicit and implicit methods). Multi-Step methods (predictor – corrector methods etc), Solution of Stiff ODEs, Adaptive step size, Shooting method , Solutions of Differential Algebraic Equations 10

Reference Books:

Advanced Engineering Mathematics, Erwin Kreyszig, John-Wiely
Advanced Engineering Mathematics S. R. K. Iyengar, R. K. Jain, Narosa.
Elements of *Applied Mathematics*. Volume 1, P.N.*Wartikar* and J.N.*Wartikar,* Pune Vidyarthi Graha.
Introductory Methods Of Numerical Analysis, S. S. Sastry, PHI.
Numerical Solution of differential Equations, M. K. Jain, Wiley Eastern.

5. PYT 1103 – Applied Physics – II

Quantum Mechanics 6

Introduction to quantum physics, blackbody radiation, explanation using the photon concept, photoelectric effect, Compton effect, de Broglie hypothesis, wave-particle duality, verification of matter waves, uncertainty principle, Schrodinger wave equation, Born's interpretation of the wavefunction, particle in a box, quantum harmonic oscillator, hydrogen atom (no detailed derivation)

Rheology 4

Introduction to rheology (8)

Basic concepts in fluid flow, importance of non-linearity, concepts of elasticity in solids and liquids, Hooke's law, Newton's law, scaling of time by means of Deborah number for characterisation of flow behaviour in melts and liquids, constitutive equations relating stress and deformation variables. 8

Melt Viscosity (6)

Concept of viscosity, variation of viscosity with different experimental conditions as shear rate, time of shearing, temperature and pressure, shear dependent viscosity , definition of Newtonian behaviour and Non-Newtonian behaviour, concepts of shear thinning and shear thickening.

Viscoelasticity (6) 6

Introduction to viscoelasticity, Maxwell and Kelvin models, relaxation models, relaxation spectrum, creep and creep recovery, complex modulus and complex viscosity.

Reference Books: 6

Solid State Physics – A. J. Dekker, 1957, MacMillan India.
Perspectives of Modern Physics – A. Beiser, 1969, McGraw-Hill.
Introduction to Rheology – H. A. Barnes, J. F. Hutton and K. Walters, 4th ed, 1996, Elsevier Science.
Physical Chemistry of Polymers – A. Tager, 2nd ed, 1978, Mir Publishers.
Viscoelastic Properties of Polymers – J. D. Ferry, 3rd ed, 1980,Wiley.

6. MAP 1201 – Engineering Applications of Computers

Computer Programming Languages : FORTRAN, C, C++, etc.
Softwares : Wordprocessing, Spreadsheets, Database, etc.
Softwares for Libraries etc.
Introduction to Computer Hardware, Architecture, Networking

7. CHP 1232 – Organic Chemistry Laboratory – II

Synthesis of several organic compounds such as acetanilide, m-dinitrobenzene, methyl salicylate, benzamide, o-chlorobenzoic acid, tribromophenol, p-nitrobenzoic acid, azo dye, etc. to demonstrate the various unit processes like oxidation ,reduction, alkylation chlorination, nitration ,etc. Seperation and purification of binary mixtures of the type : water soluble-water insoluble, both water soluble, liquid-liquid by distillation, dissociation –extraction ,crystalisation, etc.

8. CHP 1222 – Analytical Chemistry Laboratory

Students will perform eight to ten experiments based on topics that are covered in the theory

9. HUP 1101 – Communication Skills

Development of communication skills in oral as well as writing. The writing skills should emphasize technical report writing, scientific paper writing, letter drafting, etc. The oral communication skills should emphasize presentation skills. Use of audio-visual facilities like powerpoint, LCD. for making effective oral presentation. Group Discussions.

SEMESTER – III

No.	Subjects	Credits	Hrs /week			Marks			
			L	T	P	Continuous Assessment	Periodic Test	Final Exam	Total
CET 1301	Chem. Eng.Thermodynamics-I	3	2	1	0	15	15	20	50
CET 1101	Momentum and Mass Transfer	4	3	1	0	30	30	40	100
BST 1101	Biological Sciences	3	2	1	0	15	15	20	50
MAT 1104	Applied Mathematics-III	4	2	2	0	30	30	40	100
GET 1301	Structural Mechanics	3	2	1	0	15	15	20	50
CHT 1301	Physical Chemistry	4	3	1	0	30	30	40	100
CHT/PYT/MAT/GET/HUT	Elective I (Chem./Phy./Maths/Gen. Engg./Humanities)	3	2	1	0	15	15	20	50
CHP 1302	Physical Chemistry Laboratory	2	0	0	3	25	---	25	50
GEP 1302	Structural Mechanics Lab.	2	0	0	3	25	---	25	50
	Total	28	16	8	6				600

1. CET 1301 – Chem. Eng.Thermodynamics-I

Definition of terms and fundamental concepts (Thermodynamic properties, Phase rule, phase diagrams) 8
Pressure - volume - temperature relationships of pure fluids. 6
Calculations of enthalpy, entropy, free energy, from measurable properties 8
Thermodynamic properties of pure fluids, estimation of properties. 6
Calculation of Phase equilibrium using volumetric properties 4
Multi-component systems. Partial molal properties. Ideal gas mixtures and ideal solutions. 6
Concept of excess properties. Gibb's Duhem's equation. Thermodynamic consistency of vapour - liquid equilibrium data. 7

Reference Books:

Chemical Engineering Thermodynamics, Smith Van Ness
Chemical Engineering Thermodynamics, Daubert T.E.
Chemical Engineering Thermodynamics Balzhiser R.E
Chemical Engineering Thermodynamics Dodge B.F.
Chemical Engineering Thermodynamics Sandler S.I.
Molecular Thermodynamics of Fluid Phase Equilibria, Prausnitz J.M.
Properties of Gases and Liquids Reid R.C. and Sherwood T.K.

2. CET 1101 – Momentum and Mass Transfer

Fluid Statics and applications to engineering importance. 4
Equations of Continuity and Motion (Cartesian, cylindrical, and spherical coordinates) in laminar flows and its applications for the calculation of velocity profiles, shear stresses, power, etc. in various engineering applications. 10
Basics of Turbulent flows, equations of continuity and motion for turbulent flows: Reynolds averaging, Bossinesque hypothesis, Prandtl mixing length theory, Introduction to various types of turbulence models. Turbulent pipe flow, basis of Universal velocity profile and its use. Introduction to turbulent heat and mass transfer. 10
Boundary Layer Flows: Blasius equations and solution, Von-Karman integral equations and solutions, Boundary layer separation: skin and form drag. 4

Fundamentals of mass transfer: Molecular diffusion in fluids, mass transfer coefficients, and interface mass transfer, steady state theories of mass transfer, Whitman's two-film theory, and its variations. 8

Bernoulli's Equation and engineering applications, Pressure drop in pipes and Fittings, Piping design and fluid moving machinery such as pumps, blowers, compressors, vacuum systems, etc. 12

Particle Dynamics, Flow through Fixed and Fluidised Beds, 8

Gas – liquid Two phase flow: types of flow regimes, Regime maps, estimation of pressure drop and hold- 2

Blending: Theories of homogenisation, criteria for mixing, equipment and performance expressions of rate processes, mixing power estimation for impeller and liquid jets, impeller types and flow patterns 2

Reference Books:

Transport Phenomena, Bird R.B., Stewart W.E., Lightfoot E.N.

Transport Phenomena Brodkey R.S.

Momentum, Heat and Mass Transfer, Bennet and Myers

Fluid Mechanics, Kundu Pijush K.

Fluid Mechanics Subramanya K.

Fluid Dynamics Batchelor G.K

3. BST 1101 – Biological Sciences

Biological Macromolecules : structure and function of Carbohydrartes, Proteins, Nucleic Acids and Lipids Importance of stereo specificity of biological molecules 6

Cell Structure and Function: Prokaryote, eukaryote, archaebacteria, extremophiles, Structure and function of Microbial (bacteria, yeast, fungi, algae, virus), Plant and Animal cells and cellular organelles. Mitochondria, chloroplasts, cell membrane, cell wall, sub- cellular fractionation, Cell division-Mitosis, Meiosis 8

Microbiology: Microbial growth kinetics, growth of virus/phages, Microbial growth media, Approaches for sterilization and pasteurization 8

Biochemistry: metabolism – anabolism / catabolism, Primary and secondary metabolism, Central metabolic pathways (glycolysis, citric acid cycle, gluconeogenesis), Interconversion of metabolites, Regulation of metabolic pathways, Bioenergetics Photosynthesis, Bioinorganic chemistry-trace metals 11

Enzymology: Structure – function relations of enzymes; Classification, inhibition and regulation Enzyme purification and characterization, Coenzymes 6

Genetics: Nucleic acid metabolism (DNA RNA synthesis) and protein synthesis, Mendelian genetics, Bacterial genetics (transformation, transduction, conjugation), Induction/repression, Mutation 6

Reference Books:

Biochemistry, Lehninger

Microbiology Fundamentals and Applications, Purohit S.S.

4. MAT 1104 – Applied Mathematics-III

Numerical solution of Initial and Boundary Value Problems (ODEs) by finite difference methods (forward difference, backward difference, central differences), Matrix solution of ODEs (tri-diagonal matrix, Sparse solvers) 8

Solution of first order linear and non linear Partial Differential Equations, Classification of higher order PDEs, Solution by separation of variables with applications to: wave equation, time dependent conduction / diffusion, Difference methods for parabolic, elliptic and hyperbolic PDEs, Weighted Residual Methods for solution of ODEs, Finite Element methods for solution of second order PDEs 24

Complex Variables: Limit, continuity and derivative of complex functions, Regular functions, Cauchy Riemann equations, Complex integral and contour integrals, Cauchy theorems, Taylor's and Laurent's series, Contour integration by method of residues, Simple conformal mappings 16

Vector Calculus: Cauchy Schwarz inequality, triangle inequality, orthogonal projection, gradient, Curl, divergence operators, line and surface integrals, Greens theorem, Gauss divergence and Stokes theorem, and their application, tensor, co-variant and contra-variant and their transformations. 12

Reference Books:

Advanced Engineering Mathematics, Erwin Kreyszig, John-Wiely.

Advanced Engineering Mathematics S. R. K. Iyengar, R. K. Jain, Narosa.

Introductory Methods Of Numerical Analysis, S. S. Sastry, PHI.

Numerical Solution of differential Equations, M. K. Jain, Wiley Eastern.

Complex Analysis for Mathematics and Engineering**,** J. H. Mathews, R. W. Howell, Narosa.

Numerical Solution of Partial Differential Equations: Finite Difference Methods, G. D.Smith,, New York, NY: Clarendon Press.

5. GET 1301 – Structural Mechanics

Concepts of loads, supports and free body diagram. 3

Equilibrium of rigid bodies - Conditions of equilibrium. Determinant and inderterminant structures. Equilibrium of beams, frames problems on analysis of beams. 6

Concept of moment of Inertia (Second moment of area) its use. Parallel axis theorem. Problems of finding centroid and moment of Inertia of single figures composite figures, perpendicular axis theorem, Polar M.I. Radius of gyration. 8

Shear Force and Bending Moment - Basic concept, S.F. and B.M. diagram for cantilever, simply supported beams (with or without overhang). Problems with concentrated and U.D. loads. 6

Stresses and Strains - Tensile and compressive stresses, strains, modulus of elasticity, modulus of rigidity, bulk modulus. Relation between elastic constants. Lateral strain, Poisson's ratio, volumetric strain. Thermal stresses and strains. Problems based on stresses and strains. 8

Theory of Bending - Assumptions in derivation of basic equation, Basic equation, section modulus, bending stress distribution. 4

Problems on shear stress - Concept, Derivation of basic formula. Shear stress distribution for standard shapes. Problems of Shear stress distribution. 4

Slope and deflection of beams - Basic concept, standard cases of slope and deflection of cantilever and simply supported beams. Macaulay's method simple problems 6

Reference Books:

Engineering Mechanics Vol I Statics by B. N. Thadani Publisher Wenall Book Corporation
Mechanics of Materials by Ferdinand Beer and E. Russel Johnston Tata McGraw Hill Publishing Co. Ltd.
Fundamentals of applied Mechanics by Dadhe, Jamdar and Walavalkar Sarita Prakashan Pune
Engineering Mechanics by S. Timoshenko and D. H. Young McGraw Hill Publications
Strength of Materials by Ferdinand Singer and Andrew Pytel, Harper Colins Publishers India Pvt. Ltd
Introduction to Mechanics of Solids by Egor Popov, Prentice Hall of India Pvt. Ltd

6. CHT 1301 – Physical Chemistry

Structure - Property Relationship: Molecular interactions and bonds weaker than covalent bonds, e.g. hydrogen bond, dipole interaction, VDW forces etc., and their effects on various properties such as, refractive index, viscosity, surface tension, density, thermal conductivity, specific heat, diffusivity, melting point, boiling point, vapour pressure, heat of formation, latent heats of fusion and vaporisation, non-ideal behaviour in solutions, group contribution methods for estimation of these properties (including those of polymers and polymeric solution) 15

Elelctrochemistry: Theories of strong and weak electrolytes, activity coefficient, electrochemical cells and electrode potentials, batteries and fuel cells 10

Reaction dynamics and catalysis: Concept of reaction rates and extent of reaction, simple rate equations, correlation of reaction kinetics and mechanisms, theories of reaction rates, chain reactions, introduction to homogeneous and heterogeneous catalysis, concepts acid-base catalysis, kinetics of reactions on surfaces 15

Surface and interfacial Chemistry: Concept of surface/interfacial energy and surface/ interfacial tension. Thermodynamics of surfaces Gibbs adsorption equation and isotherms. Curved surfaces- Young, Laplace, Kelvin and Thompson equations contact angle and wetting phenomena, adhesion, cohesion, surface active agents: types and applications, surfactant aggregates, emulsions and microemulsions preparation, stability and applications 20

Reference Books:

Physical Chemistry, P.W. Atkins and J. D. Paula, 8th Edition, Oxford University Press.
Physical Chemistry, K.J. Laidler and J.M. Meiser, 2nd Edition, CBS Publishers
Physical Chemistry: A Molecular Approach, D.A. Mcquarrie and J.D. Simon
Chemical Kinetics and Catalysis, R.J. Masel, John Wiley and Sons1
Chemical Kinetics and Reaction dynamics, Paul H. Houston, McGraw Hill
Catalytic Chemistry, Bruce C Gates, John Wiley and Sons
Principles of Heterogeneous Catalysis, J.M. Thomas and W.J. Thomas, John Wiley and Sons.
Properties of Gases and Liquids Reid R.C. and Sherwood T.K.

7. CHT/PYT/MAT/GET/HUT – Elective I (Chem./Phy./Maths/Gen. Engg./Humanities)

Candidate will have to choose one of the elective subjects offered for that semester from the elective subjects from Chemistry / Physics / Mathematics / General Engineering / Huanities. A consolidated list of all the elective subjects is given at the end.

8. CHP 1302 – Physical Chemistry Laboratory

Measurements of Surface Tension by drop weight method, and torsion balance method-molecular weight determination of polymer by viscosity measurements-lowering of freezing point and elevation of boiling point method-heat of neutralisation and solution-verification of Ostwalds dilution law by conductivity measurements-specific rotation of cane sugar by polarimetry-percentage composition of mixture by refractive index measurement. Measurement of diffusivity in gas phase (acetone-air).

Hydrolysis of methyl acetate, relative strength of two acids-rate constant with varying concentration of ester-order of reaction between ($K_2S_2O_8$ + KI), ($KBrO_3$ + KI)-Saponification of ethyl acetate in presence of

base-adsorption of acid by charcoal-partition coefficient of I_2 in CCl_4 and benzoic acid in benzene-determination of energy of activation and other thermodynamic functions.

Determination of equivalent conductivity of strong electrolyte at infinite dilution, solubility of sparingly soluble salt by conductometric and potentiometric measurement. Conductometric titrations, determination of standard redox potential of Fe(II)/Fe(III) system, saponification of ethyl acetate by conductivity method, potentiometric titrations, evaluation of ΔH, ΔS, and ΔG for electrochemical reactions by e.m.f. measurements. Verification of Lambert Beers law, adsorption of a dye on solid surface by colorimetry.

Determination of transport number by Hittorff method and moving boundary method, Dissociation constant of acid by using pH meter. Determination of pKa of an acid. Determination of rate constant of inversion of cane sugar by polarimetry.

Study of rate of decomposition of H_2O_2 and Na_2O_2. Study of complex formation by distribution method. Determination of surface area by dynamic adsorption of N_2, decomposition of t-butanol by ion exchange resin catalyst, determination of solubility of gas in liquid, determination of vapour-liquid equilibrium and activity coefficients.

Suitable number of experiments from the above list will be performed.

9. GEP 1302 – Structural Mechanics Lab.

To determine Law of Machine for (Screw Jack / Single Purchase Crab, Double Purchase Crab, Differential wheel and axle).

To verify forces in single roof truss element.

To verify bending moment at various sections for Cantilever beam, Simply supported beam.

To verify reactions at the supports for simply supported and beam with overhang.

To verify basic Laws of concurrent co-planer forces.

To study the deflected shape of link and B.M. in equivalent simply supported beam.

To study graphical methods of analysis of forces.

To study the Universal testing machine and tests.

To study the torsion test and impact test.

Non-destructive testing: Smith Hammer test, Ultrasonic pulse velocity test

To study the carbonation of concrete

To study corrosion of re-inforcement.

To study properties of cement composites using various admixtures and additives

To study water and chloride penetration in cement composites

Suitable number of experiments from the above list will be performed

SEMESTER – IV

No.	Subjects	Credits	Hrs/week			Marks			
			L	T	P	Continuous Assessment	Periodic Test	Final Exam	Total
GET 1201	Energy Engineering	4	3	1	0	30	30	40	100
GET 1401	Electrical Engineering and Electronics	4	3	1	0	30	30	40	100
CET 1401	Chemical Engineering Operations	4	2	2	0	30	30	40	100
MAT 1105	Applied Mathematics IV	4	2	2	0	30	30	40	100
CET 1302	Chem. Eng. Thermodynamics-II	3	2	1	0	15	15	20	50
GEP 1102	Engineering Graphics -II	4	0	0	6	50	---	50	100
GEP 1402	Electrical Engineering and Electronics Laboratory	2	0	0	3	25	---	25	50
	Total	25	12	7	9				600

1. GET 1201 – Energy Engineering

Otto, Diesel, semi-diesel, and Brayton cycle. Representation of these on P-V and T-S diagrams. Calculations of work and power. 7

Pumps and Compressors: Types, constructional details 12

Vacuum Systems: Vacuum pumps, Ejectors: Types, constructional details 9

Steam Engineering, Study of the properties of steam high and low pressure boilers. Steam power plants, and power calculations using steam tables and Moellier Chart, types of steam turbines, gas turbines, Co-generation

of steam and electricity 10
Refrigeration Cycles: types of refrigerants, refrigeration systems 4
Energy conservation strategies in the above systems 2
Transmissions: Types of drives, group and individual drives, their merits and demerits. Belts, chain and gear drives. Calculations of pulley sizes and gear trains for speed reduction. 8
Study of bearings: (Journal, ball and roller bearings), stuffing box, keys and bolts, mechanical seals and their types. 4
Bearing to withstand end thrust. Shafts and couplings. 4

Reference Books:

Thermodynamics, P. K. Nag
Heat Engines, P. L. Ballany
Heat Engines, Vasnandani
Heat Engines, Wrangham
I.C. Engines, Morse
Heat Engines, Patel and Karamchandani
Refrigeration, C. P. Arora
Theory of Machines, Beevan
Theory of Machines, Ballany

2. GET 1401 – Electrical Engineering and Electronics

Electrical Engineering:

Steady state and transient response of RC, RL and RLC circuits 4
Three phase system of emfs and currents, Star and Delta connections, 4
Three phase power measurement.
Single phase transformers, Principle of working, regulation. 6
A.C.Motors: Working Principles of synchronous and induction motors, 8
their characteristics and starting methods.
Electrical Tariff 4
Power factor improvement. 6

Electonics:

Functional Characteristics of Diode, rectifiers 4
Characteristics of transistors and transistor amplifiers 6
Cathode ray oscilloscope. 2
Digital circuits. 4
Introduction to thyristors. 6
Introduction to (Operational amplifiers) and their applications. 6

Reference books:

Electrical Technology by B.L.Theraja, A.K.Theraja vol I,II,IV
Electronic devices and circuits by Allen Mottershed
Electrical Machines by Nagrath, Kothari
Electronic devices and circuits by Boylstead, Nashelsky
Digital Electronics by Millman, Tob

3. CET 1401 – Chemical Engineering Operations

Absorption: Solubility, choice of solvent, concept of rate approach and stagewise approach, countercurrent and co-current multistage operations, dilute and concentrated systems, process design of absorption equipments, performance evaluation of absorbers. Plate and packed columns, packing characteristics / selection. 8

Distillation : Fundamentals of vapours - liquid equilibrium, Henry's, Raoult's and Dalton's laws; boiling point and dew point curves, X - Y and T-X-Y diagram, partial vaporisation / condensation, performance evaluation of distillation columns including reboilers and condensers Flash; differential and steam distillation, staged calculation using McCabe -Thiele method. Batch distillation - Binary systems, constant product / constant reflux operation. Advanced topics in batch distillation. Distillation: Staged calculations using enthalpy - concentration diagram, multicomponent distillation

Design aspects of packed columns: sizing, packing selection, design of other internals, efficiency calculations,

Design aspects of tray columns: regime of operation in tray towers, sizing of tray towers, efficiency and entrainment calculations 8

Drying : Wet bulb, dry bulb and adiabatic saturation temperatures, humidity, drying mechanism, drying rate curves, estimation of drying time and process design of dryers e.g. spray, rotary, tunnel, tray, fluid bed and thin film, performance evaluation of dryers 6

Evaporation: Theory of boiling and evaporation, nucleate and film boiling, B.P. rise, expressions for heat transfer coefficients, types of evaporators, multiple effect evaporations and steam economy. Performance evaluation of evaporators 6

Humidification/Dehumidification and Cooling Tower: Definitions, usage of psychometric chart, temp/humidity, enthalpy/humidity chart, air conditioning, method of changing humidity and equipments, cooling tower process design, counter-current, co-current and cross current, mass and heat balances in bulk and interfaces, estimation of air quality, performance evaluation of cooling towers. 8

Filtration and Centrifugation : Mechanism of filtration, basic equation, constant volume, constant pressure filtration, rate expressions with cake and filter cloth resistances, compressible and incompressible cakes, process design of filtration equipments and their performance evaluation, plate and frame, Nutsch, rotary, vacuum. Theory of centrifugal separation, design equations, centrifuge types, and performance evaluation. 6

Leaching: Solid-liquid extraction: Solid - liquid equilibria, efficiency, performance evaluation 3

Size reduction of solids, energy for size reduction, Kick's, Bond's and Rittinger's law, work index, particle size distributions, crushing equipment, their working and energy requirements e.g. Jaw crusher, hammer mill, ball mill, pulverisers, micronizers 8

Types of classifiers, sieving operations, types of sieving (dry, wet, vibro), magnetic separators, and froth flotation. 7

Reference Books:

Unit Operations of Chemical Engineering, McCabe W. L., Smith J.C., Harriot P.
Chemical Engineering vol. 1 - 7 Coulson Richardson
Principles of Mass Transfer and Separation Processes, Dutta, B.K.
Fundamentals of Modelling and Separation Processes, Holland C.D.
Fundamentals of Multicomponent Distillation, Holland C.D.
Distillation, Kister H.Z.
Mass Transfer Operations, Treybal R.E.
Mass Transfer Sherwood T.K.
Separation Processes, King J. C.

4. MAT 1105 – Applied Mathematics IV

Introduction to Optimization 4
Classical Optimization Techniques 6
Linear Programming: Simplex Method, Revised Simplex Method,
Other Advanced Methods 6
Non-Linear Programming 16
Geometric Programming, 4
Dynamic Programming, 4
Integer Programming, 4
Stochastic Programming, 4
Genetic Algorithms, Simulated annealing, 6
Neural network based methods, etc. 6

Reference Books:

Engineering Optimization: theory and practices, S.S. Rao, New Age International Pvt. Ltd.
Optimization of Chemical Processes, T.F. Edger & D.M. Himmelblau, McGraw- Hill.
Optimization: Theory and practices, M. C. Joshi, Kannan M. Moudgalya, Narosa
Optimization for Engineering Design, K. Deb, Prentice Hall, India
Artificial Neural Network –A comprehensive Foundation, Simon Haykin, Pearson Education.
Elements of artificial neural networks with selected applications in chemical engineering, and chemical & biological sciences, Sanjeev S Tambe**;** B D Kulkarni**;** Pradeep B Deshpande**,** Louisville, KY, USA
Handbook of genetic Algorithm, L. Davis, New York Van Nostrand Reinhold
Genetic Algorithm+Data Structure=Evolution Programme, Z. Michaleuwicz, Springer-Verlag
Foundations of Genetic Algorithms, R. K. Belew and M. D. Vose, San Francisco, CA: Morgan Kaufmann
Genetic Algorithms in Search, Optimization, and Machine Learning, David E. Goldberg, Addison-Wesley

5. CET 1302 – Chem. Eng. Thermodynamics-II

General equations of equilibrium. Vapor - liquid equilibrium in miscible Binary and multicomponent systems. 4
Models for liquid phase. Prediction and correlation of activity coefficients. 8
Calculations of flash, isobaric X-Y diagrams. Modified Raoults Law 4
Group contribution methods for activity coefficients. 4
Azeotropy. 2
Vapor - liquid equilibria in systems with partially miscible liquid phase. Liquid - liquid equilibria. 5

Solubility of gases in non-polar and polar liquids, and aqueous solutions. Effect of temperature, pressure on solubility of gases. 3
Solubility of solids in liquids. 2
Chemical reaction equilibria in homogeneous and heterogeneous systems. 7
Methods for equilibria in complex multireacton systems. 6

Reference Books:

Chemical Engineering Thermodynamics Sandler S.I.
Molecular Thermodynamics of Fluid Phase Equilibria, Prausnitz J.M.
Chemical Engineering Thermodynamics, Smith Van Ness
Chemical Engineering Thermodynamics, Daubert T.E.
Chemical Engineering Thermodynamics Balzhiser R.E
Chemical Engineering Thermodynamics Dodge B.F.
Properties of Gases and Liquids Reid R.C. and Sherwood T.K.

6. GEP 1102 – Engineering Graphics -II

Use of AUTOCAD or similar softwares for Engineering Graphics
Bearing, shaft and shaft couplings, keys, cotters, pin. Pulleys, stuffing boxes, cottered joints and knuckle joints. Various flanges and pipe connections. Valves, cocks, traps. Fixed and flexible joints. Expansion joints and bellows. Different types welded joints.

7. GEP 1402 – Electrical Engineering and Electronics Laboratory

Suitable no. of experiments out of the following will be conducted :

Electrical Engineering :

Study of RLC circuits
Load test on transformer
Load test on induction motor
Study of 3 phase circuits with (a) Star connected load (b) Delta connected load

Electronics :

Study of C.R.O. and its applications.
Study of half wave, full wave and bridge rectifier circuits
and study of their input and output wave on C.R.O.
Study of input and output characteristics of a transistor.
Study of various logic gates and their application in logic circuits.
Study of UJT and UJT relaxation oscillator.
Study of operational amplifier circuits

SEMESTER – V

No.	Subjects	Credits	Hrs /week			Marks			
			L	T	P	Continuous Assessment	Periodic Test	Final Exam	Total
CET 1502	Industrial & Engineering Chemistry	4	3	1	0	30	30	40	100
CET 1102	Heat Transfer	3	2	1	0	15	15	20	50
CET 1201	Chemical Reaction Engineering	4	2	2	0	30	30	40	100
CET 1402	Separation Processes	3	2	1	0	15	15	20	50
CET 1202	Biochemical Engineering	3	2	1	0	15	15	20	50
CEP 1701	Chem. Eng. Laboratory	4	0	0	6	50	---	50	100
CEP 1702	Process Simulation Lab – I	2	0	0	3	25	---	25	50
	Total	23	11	6	9				500

1. CET 1502 – Industrial & Engineering Chemistry

Overview of Indian Chemical Industry 2

ORGANIC CHEMICALS

Petroleum refining and cracking operations. 6

Process Engineering aspects of manufacture of :

Syn-gas, H_2 and methanol. 2

Methanol / Ethanol based organic Chemicals (formaldehyde, acetaldehyde, acetic acid etc.) 6

Petrochemicals: (Ethylene oxide / Ethylene glycol, Vinyl chloride, α-Olefins, vinyl acetate, 2 Ethylhexanol, acrylic acid, acrylonitrile, Cumene, Phenol, nitrobenzene, aniline, LAB, Phthalic anhydride, PTA) 12

Polymers: (polyethylene / polypropylene, polyamide, PVC, polystyrene, polyester) 4

INORGANIC CHEMICALS

Process Engineering Aspects of manufacture of:

inorganic acids (sulphuric acid, nitric acid, phosphoric acid), chlor-alkali (Chlorine, caustic soda, soda ash), 14

Fertilizers (ammonia, urea, phosphates) 6

FUELS 8

Classification, sampling, analysis, and selection of coal. Carbonisation and complete gasification of coal. Fuel oil specifications. Combustion of solid, liquid, and gaseous fuels.

Reference Books:

Encyclopedia of Chemical Technology, Kirk Othmer

Ulmann's encyclopedia of Industrial Chemistry

Industrial Organic Chemistry, Weissermel

From Hydrocarbons to Petrochemicals, Hatch L.F. and Matar S.

Chemical Process Industries, Shreve B, Austin

Chemical Process Technology, Moulijn, M. and van Dippen.

2. CET 1102 – Heat Transfer

Steady state and unsteady state conduction, Fourier's law, Concepts of resistance to heat transfer and the heat transfer coefficient. Heat transfer in Cartesian, cylindrical and spherical coordinate systems, Insulation, critical radius. 4

Convective heat transfer in laminar and turbulent boundary layers. Theories of heat transfer and analogy between momentum and heat transfer. Heat transfer by natural convection. 4

Heat transfer in laminar and turbulent flow in circular pipes: Double pipe heat exchangers: Concurrent, counter-current and cross flows, mean temperature difference, NTU – epsilon method for exchanger evaluation. 4

Shell and tube heat exchangers: Basic construction and features, TEMA exchanger types, their nomenclature, choice of exchanger type, correction to mean temperature difference due to cross flow, multipass exchangers.

Design methods for shell and tube heat exchangers such as Kern Method, Bell – Delaware method 10

Finned tube exchangers, air-cooled cross flow exchangers and their process design aspects 4

Compact Exchangers: Plate, Plate fin, Spiral, etc.: Construction, features, advantages, limitations and their process design aspects 2

Condensation of vapours: theoretical prediction of heat transfer coefficients, practical aspects, horizontal versus vertical condensation outside tubes, condensation inside tubes, Process Design aspects of total condensers, condensers with de-superheating and subcooling, condensers of multicomponent mixture, condensation of vapours in presence of non-condensables. 6

Heat transfer to boiling liquids: Process design aspects of evaporators, natural and forced circulation reboilers 4

Heat transfer in agitated vessels: coils, jackets, limpet coils, calculation of heat transfer coefficients, heating and cooling times, applications to batch reactors and batch processes 4

Basics of Radiative heat transfer and application to Furnace Design 3

Reference Books:

Fluid Dynamics and Heat Transfer Knudsen and Katz

Process Heat Transfer, Kern D.Q.

Heat Exchangers, Kakac S., Bergles A.E., Mayinger F.

Process Heat Transfer, G. Hewitt

3. CET 1201 – Chemical Reaction Engineering

Kinetics of homogeneous reactions, Interpretation of batch reactor data, Single ideal reactors, Design for single and multiple reactions, Temperature and pressure effects, 20

Non ideal flow, Micro and macromixing of fluids. 10

Non-Catalytic Fluid-particle reactions, 10

Homogeneous and Heterogeneous Catalysis, Kinetics of Solid Catalyzed Reactions. Design of gas – solid catalytic reactors 20

Reference Books:

Chemical Reaction Engineering, O. Levenspiel

Chemical Engineering Kinetics Smith J.M.

Elements of Chemical Reaction Engineering, Scott Foggler

Chemical Reactor Analysis and Design, Froment G.F., Bischoff K.B.

4. CET 1402 – Separation Processes

Liquid-Liquid Extraction Solvent selections, ternary liquid equilibria, staged calculations, spray columns, packed, and plate columns, multistage extraction columns, mixer - settlers, analysis on solvent - free basis. Performance evaluation of extractors 12

Adsorptive Separations and Ion Exchange: Adsorption isotherms, industrial adsorbents with their characteristics, breakthrough curve, adsorption columns 12

Membrane Separation Processes: Fundamentals, gas separations, Microfiltration, ultrafiltration, Reverse osmosis, nanofiltration, pervaporation, membrane modules, design of membrane systems 11

Crystallisation: Theory of solubility and crystallisation, phase diagram (temp/solubility relationship), population balance analysis, method of moments for rate expressions for, volume, area and length growth, CSD distribution, MSMPR operation, evaporative and cooling (rate expressions) , most dominant size, ideal classified bed, melt crystallisation, process design of crystallisers and their operation 10

Reference Books:

Unit Operations of Chemical Engineering, McCabe W. L., Smith J.C., Harriot P.
Chemical Engineering vol. 1 - 7 Coulson Richardson
Principles of Mass Transfer and Separation Processes, Dutta, B.K.
Fundamentals of Modelling and Separation Processes, Holland C.D.
Mass Transfer Operations, Treybal R.E.
Adsorption Technology, Slejko,
Mass Transfer Sherwood T.K.
Separation Processes, King J. C.
Transport Mechanisms in Membrane Separation Processes, Bitter J. G. A.
Membrane Technology and Applications, Baker R.
Membrane Processes, Rautenbach R., Albreacht R.
Membrane Separations Technology, Hoffman E. J.
Synthetic Membrane Processes: fundamentals and water applications, Belfort G.

5. CET 1202 – Biochemical Engineering:

Introduction to Biotechnology: Role of chemical engineers in biotechnology 2

Enzymology: Structure function relations of enzymes; Classification, Enzyme kinetics, inhibition and regulation Mechanism of Enzyme action, Enzyme purification and characterization, Coenzymes 8

Basic of Genetic Engineering and Tissue Culture : Recombinant DNA technology Gene cloning, Plant and animal cell cultures for the production of biochemicals, monoclonal antibodies 8

Enzyme Technology and Bioprocess Development: Enzymes as industrial catalysts; Immobilized enzymes, and cells. 6

Biochemical process development and bioreactors using biological catalysts, Analytical applications, medical applications, Integration of downstream processing with bioprocessing 4

Kinetics of microbial growth, models and simulations, Batch and continuous culture, Mixed microbial culture , Transport phenomena in bioreactions and bioreactors 8

Fundamentals of fermentation-submerged fermentation, Fermenter design and basic biochemical engineering aspects of fermentation

Reactor design for biochemical reactions and scale up, Process Design for bioproducts, Bioreactor design, Scale up of bioreactions/reactors, 9

Reference Books:

Biochemical Engineering Fundamentals, Bailey and Olis
Biotransformations and Bioprocesses, Doble,Anilkumar and Gaikar, Marcel Dekker

6. CEP 1701 – Chem. Eng. Laboratory

Flow through pipes, coils and fittings. Flow meters, orifice, venturi, rotameter and turbine meter. Flow through packed beds. Two phase flow. Compressors, blowers and pumps. Sedimentation. Fluidization. Solid-liquid separation. Mixing. Heat transfer in shell and tube, and plate heat exchangers. Heat transfer in packed and fluidized beds. Evaporators. Unsteady state heat transfer.

Suitable number of experiments from the above list will be performed

7. CEP 1702 – Process Simulation Lab – I

Several Examples from Chemical Engineering fields to be solved using self-developed programmes. The examples include, simulation of reactors with multiple reactions (heat and material balances), conduction / diffusion, stagewise calculations for unit operations, dynamics of linear and non-linear systems, simulation of heat transfer equipment, optimisation of equipment, process and plant. Computational fluid dynamics. Use of design softwares.

SEMESTER – VI

No.	Subjects	Credits	Hrs/week			Marks			
			L	T	P	Continuous Assessment	Periodic Test	Final Exam	Total
CET 1601	Materials Technology	3	2	1	0	15	15	20	50
CET 1203	Multiphase Reaction Engineering	3	2	1	0	15	15	20	50
CET 1503	Environmental Engineering and Process Safety	4	2	2	0	30	30	40	100
CET 1703	Instrumentation and Process Control	3	2	1	0	15	15	20	50
CET	Elective-II	3	2	1	0	15	15	20	50
CEP 1704	Chem. Eng. Laboratory	4	0	0	6	50	---	50	100
CEP 1705	Process Simulation Lab – II	2	0	0	3	25	---	25	50
GEP 1103	Equipment Design and Drawing-I	2	0	0	3	25	---	25	50
	Total	24	10	6	12				500

1. CET 1601 – Materials Technology

Engineering Materials: Classification, study of ferrous and non ferrous materials 3
Phase diagrams of steel, brass and cupronickel and the applications of phase diagrams 5
Modification and control of material properties 6
Non metallic materials: Thermo settings and thermoplastics 4
Inorganic materials , composite materials and smart materials 4
Corrosion Engineering: Elctrochemical principles, different types of corrosion, mechanisms of corrosion control and prevention, preventive coatings. Corrosion behavior of important alloys such as stainless steels,brass etc. 10
Theory of failure: Crystal defects, plastic deformation. Types of mechanical failure, fracture , fatigue and creep 9
Criteria for selection of materials in chemical process industry 4

Reference Books:

Material Science and Engineering Metallurgy, Agrawal B. K.
Materials Science and Engineering, Raghavan V.
Materials Science and Engineering, Van Vlack L.H.
Engineering Materials and Applications, Flin R.A., Trojan P.K.

2. CET 1203 – Multiphase Reaction Engineering

Mass transfer with Chemical Reaction in Fluid – Fluid systems. 7
Model contactors, pilot plants, and collection of scale-up data 8
Classification of multiphase reactors, qualitative description, examples of industrial importance. 6
Hydrodynamics, scale-up, process design and performance of the following major classes of multiphase reactors, case studies and problems:
(a) Bubble columns, packed bubble columns, sectionalised bubble columns, plate columns, internal loop and external loop air-lift reactors, jet loop fixed beds, static mixers 6
(b) Solid-Liquid and Gas – Solid fluidised Beds and solid-gas transport reactors, 6
(c) Stirred tank reactors. 12

Reference Books:

Heterogeneous Reactions vol. I and II, Doraiswamy L.K., Sharma M.M.
Fluid Mixing and Gas Dispersion in Stirred Reactors, Tatterson G. B.
Bubble Columnn Reactors, Deckwer W.D.
Fluidisation, Kunni D. and Levenspiel O.
Gas Liquid Reactions, Danckwerts P.V.
Fluidisation, Davidson J.F., Harrison D.
Random Packings and Packed Tower Design, Strigel R.F.

3. CET 1503 – Environmental Engineering and Process Safety

Air- Pollution: Definitions of concentration of pollutants, classification of pollutants, primary and secondary pollutants with examples, sources of pollutants (gaseous and particulate). Natural Processes and

Anthrapogenic processes, quantities, (SO_2, NO_X, CO, CO_2, O_3 etc.), behaviour of pollutants and atmospheric chemical reactions, photochemical smog 4

Meteorological Aspects: Lapse rates and stability of atmosphere (e.g. adiabatic, dry, wet, environmental), inversion (subsidence, radiational and Advectic with examples), Plume behaviours, examples.

Atmospheric Dispersion: Atmospheric turbulence, surface topography, models of dispersion and stack height calculations. 6

Sampling and measurements of Pollutants 2

Air-Pollution control: SO_X, NO_X emissions and their control, Particulate matter control 6

Water- Pollution: Water quality standards, discharge standards, types of pollutants, physical, biological, and chemical examination techniques. 4

Coagulation and flocculation, filtration (sand, gravity, fluidized sand etc.), clarification (clarifier design, Lamella clarifier etc.) 2

Biological treatment: Design procedures, HRT, CRT, SVI, MLSS etc., Activated Sludge Process, trickling filters, types of aerators and their efficiency of oxygen transfer. 10

Tertiary Treatment Processes: Membrane processes, Adsorption and ion exchange, Root-Zone, chlorination, ozonation 6

Chemical treatment: Chemical oxidation, wet air oxidation, incineration. 2

Treatment of solid and hazardous wastes: Toxics, nuclear, land fill. 2

Introduction to SHE analysis, Life cycle analysis (LCA), ISO 14000, Environmental Audit/ Statutory Regulations. 4

Industrial hygiene and safety aspects related to toxicity, noise, pressure, temperature, vibrations, radiations, etc. Explosions including dust, vapour cloud, and mist explosions. 2

Hazard identification, assessment and safety audit including ETA, FTA and Dow fire and explosion index. HAZOP, HAZAN and consequence analysis. 4

Safety aspects related to (i) transport handling and storage of flammable liquids and gases and toxic materials (ii) Process equipment including piping (fire, static electricity, pressure, temperature, etc.) Safety aspects at process development and design stage. Reliability engineering. Hazard mitigation systems Emergency planning. Case studies. 6

Reference Books:

Wastewater Engineering, Metcalf and Eddy
Industrial and Pollution Engineering, Cavaseno, VinCene N.T.
Environmental Pollution Control Engineering, Rao C.S.
Environmental Engineering, Peavy H. S.
Chemical Process Safety Fundamentals and Applications, Crawl D.A., Louver J.F.
Schaum series

4. CET 1703 – Instrumentation and Process Control

Principles of measurement, principles of transductions., Measurement of pressure; Temperature Level and flow measuring devices, composition measurements, selection of sensors, Electrical/Electronic/PLC control systems 4

Introduction to system dynamics, concept of dynamic response, linear systems, First, second and higher order system, systems with dead time definition of terms such as transfer function, time constant, gain of the process with practical examples. Response of the process to standard inputs. 8

Introduction to process control: set point, disturbance, closed loop and open loop control, feedback and feed forward configurations, types of controllers, Poles and zeros of the transfer functions. The effects of controller action on process response: offset, closed-loop gain, controller gain effect of controller parameters. Stability Analysis 10

Design of controllers using criteria such as quarter decay, ISE, IAE, ITAE 2

Design of controllers using open loop response, Zigler-Nichols approach, experimental determination of process model. 6

Introduction of frequency response technique, 2

Design of controllers using frequency response technique, analysis of the systems for stability, Bode and Nyquist stability criterion. 4

Multiple loop control systems, cascade control design, ratio control, feed forward control designs 2

Introduction to multivariable control system, identification of interaction, design of controllers in interactions, elimination of interactions 4

Control strategies for common industrial processes such distillation, heat exchangers, etc. Control strategies for Batch processes 3

Reference Books:

Chemical Process Control An Introduction to Theory and Practice, Stephanopolous G.

Instrumentation in Process Industries, Liptak B.G.
Process Control Systems Shinsky F.G.
Process Systems Analysis and Control, Coughanour and Koppel
Process Modelling, Simulation, and Control for Chemical Engineers, Luyben
Principles and Practice of Automatic Process Control, Smith C.A., Corripio A.B.

5. CET – Elective-II

Candidate will have to choose one of the elective subjects offered for that semester from the elective subjects. A consolidated list of all the elective subjects is given at the end.

6. CEP 1704 – Chem. Eng. Laboratory

Diffusion. Absorption in a packed column. Adsorption isotherms. Drying characteristics. Differential and steam distillation. Homogeneous kinetics. Kinetics of polymerisation, performance of ideal and non-ideal reactors. Characteristics of control valves. Controller calibration. Vapour-liquid and liquid-liquid equilibrium studies. Calorific values of solid and gaseous fuels. Properties of liquid fuels. Proximate analysis of coal. Study of spray nozzles, impellers, tower packings, dryers, filters, evaporators. Demonstration of some phenomena, particularly in mixing, fluid mechanics, etc.
Suitable number of experiments from the above list will be performed.

7. CEP 1705 – Process Simulation Lab – II

Several Examples from Chemical Engineering fields to be solved using self-developed programmes. The examples include, simulation of reactors with multiple reactions (heat and material balances), conduction / diffusion, stagewise calculations for unit operations, dynamics of linear and non-linear systems, simulation of heat transfer equipment, optimisation of equipment, process and plant. Computational fluid dynamics. Use of design softwares.

8. GEP 1103 – Equipment Design and Drawing-I

Introduction to various codes used in CPI (Chemical Process Industry) and their application.
Basic Engineering design approach and selection of internal and external pressure vessels components such as shell, end-closures, dished ends, flat ends, flanges, gaskets nozzles and manholes, etc.
Design of storage tanks for liquid and liquefied gases. Concept of site fabricated tanks. Non destructive testing sonication, radiography and dye test for lead bonds vessel.

Drawing :

Fabrication drawings of pressure vessel component such as end-closure, nozzles, flanges, etc.
Storage vessel details with bottom layout and shell layout.

Reference Books:

Process Equipment Design, Joshi M.V.

SEMESTER – VII

No.	Subjects	Credits	Hrs/week			Marks			
			L	T	P	Continuous Assessment	Periodic Test	Final Exam	Total
CET 1504	Chemical Project Engg. & Economics	3	2	1	0	15	15	20	50
CET 1505	Process Engineering	3	2	1	0	15	15	20	50
HUT 1102	Perspectives of Society, Sci. & Tech.	3	2	1	0	15	15	20	50
CET	Elective – III	3	2	1	0	15	15	20	50
CEP 1706	Chem. Eng. Laboratory	4	0	0	6	50	---	50	100
CEP 1707	Process Simulation Laboratory – III	2	0	0	3	25	---	25	50
CEP 1708	Project 1: Seminar	3	0	0	3	---	---	30 (Report) 20(Presentation)	50
CEP 1709	Project 2: Home Paper – I	3	0	0	3	30 (submissions) 20(Presentation)	---	---	50
CEP 1710	Project 3: In-Plant Training Evaluation and Community Service	2	0	0	2			30 (Report) 20(Presentation)	50
	Total	26	8	4	17				500

1. CET 1504 – Chemical Project Engg. & Economics

Meaning of Project Engineering, various stages of project implementation
Relationship between price of a product and project cost and cost of production, EVA analysis 10
Elements of cost of production, monitoring of the same in a plant, Meaning of Administrative expenses, sales expenses etc.
Introduction to various components of project cost and their estimation. Introduction to concept of Inflation, location index and their use in estimating plant and machinery cost. Various cost indices, Relationship between cost and capacity. 4
Project financing: debt: Equity ratio, Promoters' contribution, Shareholders' contribution, source of finance, time value of money
Concept of interest, selection of various alternative equipment or system based on this concept. Indian norms, EMI calculations.
Depreciation concept, Indian norms and their utility in estimate of working results of project. 8
Working capital concept and its relevance to project.
Estimate of working results of proposed project. Capacity utilization, Gross profit, operating profit, profit before tax, Corporate tax, dividend, Net cash accruals.
Project evaluation: Cumulative cash flow analysis Break-Even analysis, incremental analysis, various ratios analysis, Discounted cash flow analysis. 4
Process Selection, Site Selection, Feasibility Report
Project: Conception to Commissioning: milestones
Project execution as conglomeration of technical and non-technical activities, contractual details
Contract: Meaning, contents, Types of contract 8
Reading of Balance Sheets and evaluation of Techno-commercial Project Reports 3
PERT, CPM, bar charts and network diagrams 8

Reference Books:

Chemical Project Economics, Mahajani V. V. and Mokashi S M.
Plant Design and Economics for Chemical Engineers, Peters M.S., Timmerhaus K.D.
Process Plant and Equipment Cost Estimation, Kharbanda O.P.

2. CET 1505 – Process Engineering

Development of a preliminary Process System: Modular approach: Unit Process based Process evaluation and selection with special reference to eco-friendly technologies. 8
Process Engineering aspects of low and medium volume chemicals including process development. 8
Concept of dedicated and multiproduct plant facilities 4
Development and evaluation of alternative flow sheets; efficient utilisation of energy; heat exchange networks. 8
Preparation of Conceptual process and instrumentation diagrams. . 4
Preparation of process specifications for typical equipment. 4
Process Utilities in process industries: Steam, heat transfer fluids, cooling water, chilled water, glycol, etc. 4
Safety aspects pertaining to the design of chemical plants. 5

Reference Books:

Industrial Chemical Process Design, D. L. Erwine
Laboratory Chemical Process Development, Anderson N.
Organic Unit Processes, Groggins
Chemical Process Engineering: Design and Economics, Silla H.
Handbook of Chemical Process Development, Chandalia S. B.
Conceptual Chemical Plant Design, Douglas J. M.

3. HUT 1102 – Perspectives of Society, Science & Technology

Age of modern Science, Technology, and their integration. Evolution of Engineering. 3
Characteristics of society, technology, science and engineering and their interactions. 3
Recent developments in technology (chemical, biotechnology energy, telecommunications, etc.) and their influence on society 7
Value system and Ethics in the profession of Technology, Science and Engineering. 4
Problems before the World and India. Various approaches in solving them. 4
Industrial disasters and their effect on science and technology and society 8
Environmental degradation, global warming and their effect on science and technology and society 8
IPR issues and their relevance to science and technology and society 5
Some aspects of future of Society, Technology, Science and Engineering. 3

Reference Books:

Environmental perspectives of chemical industry: socio economic and technological imperatives, Chandalia, S.B., Rajagopal R.

4. CET Elective – III

Candidate will have to choose one of the elective subjects offered for that semester from the elective subjects. A consolidated list of all the elective subjects is given at the end.

5. CEP 1706 – Chem. Eng. Laboratory

Absorption with and without chemical reactions in packed, plate and bubble columns. Distillation in packed and/or plate column. Humidification towers. Spray, packed and mechanically agitated extraction columns. Solid dissolution with or without chemical reaction; Sublimation of solids. Absorption/ion exchange in fixed beds. Separation by membranes. Residence time distribution in tubes and coils. Kinetics of solid catalysed liquid phase reactions. Mixing studies. Flow of non-Newtonian fluids. Analogy between momentum, heat and mass transfer. Dynamics of feedback control systems. Level and pH control. Demonstration of some important phenomena in Chemical Engineering, notably coalescence, foaming, internal circulations in drops and bubbles, two and three phase fluidization, aggregative and particulate fluidization, mixing, crystallization etc.

Suitable number of experiments from the above list will be performed

6. CEP 1707 – Process Simulation Laboratory – III

Several Examples from Chemical Engineering fields to be solved using self-developed programmes. The examples include, simulation of reactors with multiple reactions (heat and material balances), conduction / diffusion, stagewise calculations for unit operations, dynamics of linear and non-linear systems, simulation of heat transfer equipment, optimisation of equipment, process and plant. Computational fluid dynamics. Use of design softwares.

7. CEP 1708 – Project 1: Seminar

Students will be required to prepare a critical review of selected topics in Chemical Engineering and allied subjects and submit in the form of a standard typed report.

Typically, the report should contain and will be evaluated based on the following points:

(i) Introduction: 2 pages maximum,

(ii) Exhaustive review of literature (including figures): 10 – 12 pages: 50% weightage

(iii) Critical analysis of the literature and comments on the analysis (including figures): 10 – 12 pages: 50% weightage. The critical analysis of literature should include the following points: are the papers technically correct?; are assumptions reasonable; is the reasoning logical? If you think it is not, specify what you think is incorrect and suggest the correct approach. Are the methods used in the literature appropriate? Are there any internal contradictions or computational errors and are there any loopholes in the observations? If so, please explain. Critical analysis of papers should also contain quantitative comparison of observations, results and conclusion amongst the various papers.

Each student will also be required to make an oral presentation of the review. Weightage would be 40% for the presentation and 60% for the report. Additional details are given at the end.

8. CEP 1709 – Project 2: Home Paper - I

Every student will be required to solve a problem on design, which will set by one or more of the teachers in the institution. The design will have to be submitted in the form of a standard typed report. Every student will be orally examined. The student will be assessed based on the progress made during the semester. There would be two submissions: (i) Process selection and PFD, (ii) Material and Energy Balance. The submissions will be presented to a panel of faculty members / examiners

There will be a weightage of 60% for the submissions and 40% for the presentation.

Additional details are given at the end.

9. CEP 1710 – Project 3: In-Plant Training Evaluation and Community Service

In-Plant Training Evaluation:

At the end of Semester – VI students will have to spend 6 – 8 weeks in a Chemical plant. They will be required to submit a written report on their In-plant training. The report should consist of

(i) Major products of the company, (ii)Plant description, (iii) General plant layout, (iv)Processes for Major Products (no confidential proprietary information may be included), (v)Chemistry of processes studied (in case of chemical manufacture) based on Journal papers, Patents, Books, etc.,(vi)Safety and Health (Material Safety Data Sheets, Safety Policy), (vii)Environmental Protection (measures used and general description of the processes and facilities used), (viii)Standards and compliance thereof (ISO 9000, ISO 14000, OHSAS 18000, etc.), (ix)Three Major Equipment – description with sketch (no detailed drawing to be given: just a sketch with major dimensions, nozzle location and dimensions thereof), (x)Heat Exchangers: total number and types, Pumps and Compressors: total number and types, (xi)Improvements proposed by the student, for example, Power savings for pumps, blowers, compressors, etc. Cycle time reduction in case of batch processes, Waste heat recovery, Waste solvent recovery, Product quality improvement, Any project assigned to you by the company (title, a short description, results and conclusions: all in less than 500 words)

Students will present their work before a panel of teachers in the Institute. The report would carry 50%

weightage and the presentation would carry 50% weightage

Community Service:

Introductory lectures / Project identification / including preliminary and finalization visits**.** This will involve faculty lecture, debate, interaction with students, group / individual projects.

(A) Community Teaching: Municipal and under-privileged aided schools in the areas of Basic Sciences, Elementary and Basic Mathematics, English Speaking

(B) Community Field Work: Project Implementation: Project could be in Science of hygiene, Teaching, Fabrication, Construction, social and science awareness, Technology implementation, energy conservation etc.

(C) Submission of work report

Students will present their work before a panel of teachers in the Institute. The report would carry 50% weightage and the presentation would carry 50% weightage

SEMESTER – VIII

No.	Subjects	Credits	Hrs /week			Marks			
			L	T	P	Continuous Assessment	Periodic Test	Final Exam	Total
HUT 1103	Industrial Psychology and Human Resource Management	3	2	1	0	15	15	20	50
HUT 1104	Industrial Management	4	2	2	0	30	30	40	100
MAT 1106	Design & Analysis of Experiments	3	2	1	0	15	15	20	50
CET	Elective – IV	3	2	1	0	15	15	20	50
GEP 1104	Equipment Design and Drawing	4	0	0	6	50	---	50	100
CEP 1711	Project 4: Home Paper – II	9	0	0	9	50		30(Report) 70(Viva-Voce)	150
	Total	26	8	5	15				500

1. HUT 1103 – Industrial Psychology and Human Resource Management

Introduction & Overview of the Course	2
Changes/Challenges in HRM	2
Management Theories	6
Research Methodology & Statistical Tools	2
Management of Change	5
Organizational Culture & Climate	2
Knowledge Productivity	2
New Leadership	2
Motivation Theories	3
Talent Management	3
Training & Development	2
Performance Management	2
Selection & Recruitment	2
Compensation	2
Unions	2
Entrepreneurship	2
Business Communication & Soft Skills	2
Counseling & Coaching	2

Reference Books:

Personality and Organization., Argyris C.
New Patterns of Management, Likert R.
The Principles of Scientific Management, Taylor F. W.
The Human Side of Enterprise, McGregor, D.
The Ultimate Advantage: Creating the High-Involvement Organization, Lawler, E.E.
Competitive Advantage through People, Pfeffer, J.
Organizational Capability, Ulrich, D and Lake, D.
The Essence of Leadership, Locke, Edwin A.
Handbook of Leadership: A Survey of Theory and Resarch, Bass, B. M.
The Competent Manager, Boyatzis, R. E.
Charismatic Leadership: The Elusive Factor in Organizational Effectiveness, Conger, Jay A.

Pygmalion in Management, Eden, D.
Organization Development, French & Bell
Practicing Organization Development: A Guide for Consultants, W. Rothwell, R. Sullivan, G. McLean
An Experiential Approach to Organization Development, Harvey and Brown
Organisational Behaviour, Robbins S.
Organizational Behaviour, Luthans F.
Organizational Behavior, Schermerhorn, Hunt, Osborn
Management of Organizational Behavior, Hersey, Blanchard, Johnson
Essentials of Organizational Behavior, S. Robbins
A Primer on Organizational Behavior, Bowditch and Buono
Managing Human Resources, Bach, S. 2005
Human Resource Management: A Contemporary Approach, Claydon, T and J. BeardwellFolger, R. and R.
Organisational Justice and Human Resource Management, Cropanzano,.
Foundation of Behavioral Research, Kerlinger, F.N.

2. HUT 1104 – Industrial Management

1. Introduction: Principles of Management, Evolution, Planning, Motivating, Controlling 6

2. Organisational Process and Behaviour :
Introduction and Meaning of Organisation, Organisation as a process, Span of Control, Authority, Responsibility and Accountability, Delegation of authority, Decentralisation of authority, Enhancing Managerial Effectiveness through self and others, Individual Personality & Behaviour, Perception, Attitudes, Values and Aptitude, Frustration, Conflict, Organisational structure, Organisational culture, Organisational transformation, Organisational Effectiveness and Assessment 16

3. **Operations Management:**
Production Management – Modern Approach,
Manufacturing / Operations Strategy – Principles & concept, Operations as competitive weapon -- Investment strategy, Capacity strategy, Quality strategy, Technology strategy, Customer focus strategy, Facility location strategy, Product flexibility strategy, Short delivery process strategy, Quick time delivery strategy), Concepts of Productivity, its Measurement & Improvement, Lean Manufacturing, Value Engineering, Business Process Reengineering,
World Class Manufacturing (WCM) - Principles & concepts, Systems, Processes & tools in WCM, Kanban, JIT, Waste identification & elimination, Poka Yoke system, EHSS management in WCM, HR Dimensions in WCM, WCM in reference to Indian industry and Indian scenario, Maintenance practices 15

4. **Financial Management:** Investment decisions, Linking investment to Product Life Cycle, Investment risk analysis and risk control / mitigation, Balance sheet evaluation, Financial ratios & their evaluation / significance, Cost control by variable analysis 6

5. Quality Management: Quality – concept / meaning, Modern approach to Quality Management, QA versus QC, Deming's 14 points of QM, TQM Principles & implementation, ISO 9001 – 2000 and other ISO 9000 quality standards, Quality By Design (QBD) 8

6. **Technology Management:** Strategies & their applications in industry, Business specifications versus Technical specifications, Intellectual Property Rights (IPR), Introduction to Strategic Innovation 4

7. Others: Marketing management, Brand management, Supply chain management 5

Reference Books:
Industrial Management – I, Jhamb L. C. and Jhamb S.
Industrial Management, Spriegel U.S.
Production & Operations Management – An Applied Modern Approach, Joseph S. Martinich
Operations Management for Competitive Advantage, Richard B. Chase, F. Robert Jacobs, Nicholas Acquilano
Competitive Manufacturing Management Continuous Improvement, Lean Manufacturing & Customer-focused Quality, John M. Nicholas
World Class Manufacturing - A strategic Perspective, B.S. Sahay, K.B.C. Saxena, Ashish Kumar
Quality Planning and Analysis, Juran and Gryna
Management Finance, Varanasay Murthy
Corporate Finance Management, Varanasay Murthy
Financial Management, Prasanna Chandra
Financial Management, R. M. Srivastava
Financial Management, Kuchhal S. C.
Quality Planning and Analysis, Juran
Essentials of Management,Koontz
Principles of Marketing, Kotler

3. MAT 1106 – Design and Analysis of Experiments

Overview of statistical analysis of data, Statistical inference. Tests of significance. Regression analysis. Analysis of variance. 4
Quality control acceptance sampling. 2
Statistical design of experiments. Factorial design. Evolutionary Operation (EvOp) techniques, 12
Response Surface Methodology (RSM), Principal Component Analysis 12

Reference Books:

Response Surface Methodology: Process and Product Optimization using designed experiments, Myers R. H., Montgomery D.C.
Design and Analysis of Experiments, Montgomery D. C.
Introduction to Statistical Quality Control, Montgomery D. C.
Design of experiments in Chemical Engineering, Lazic Z.
The Theory of the design of experiments, Cox D. R.

4. CET – Elective – IV

Candidate will have to choose one of the elective subjects offered for that semester from the elective subjects. A consolidated list of all the elective subjects is given at the end.

5. GEP 1104 – Equipment Design and Drawing – II

Mechanical specification of rotary machinery such as pumps, compressors, blowers, centrifuges, etc. Design of lined vessels.
Mechanical Design of and fabrication drawings of agitated vessels, with internal pressure, Jackets, simple limpet coil, etc. Shell and tube heat exchangers, Plate and packed towers with internals.
Supports .ladders etc. for the above equipment.
Specification sheets for Centrifugal, Soren and reciprocating Compressors, Blowers, Centrifuges, Pumps, gas, steam condensing and extraction turbines.

Drawing :

Fabrication drawings of selected process equipment such as reaction vessels, and heat exchanges, distillation column details, evaporator, piping drawings.
Drafting of Engineering flow sheets and P and I diagrams.

Reference Books:

Process Equipment Design, Joshi M.V.

6. CEP 1711 – Project 4: Home Paper - II

There would be two submissions: (iii) Process Design, (iv) P&ID, Mechanical design, Costing, feasibility. The submissions will be presented to a panel of faculty members / examiners. The submissions would be given a weightage of 50 marks. There will be a weightage of 60% for the submissions and 40% for the presentation.
Final report of the home paper would be given a weightage of 30 marks.
There will be a viva-voce after the submission of the report. The weightage for the viva-voce would be 70 marks.
Additional details are given at the end.

Additional Details for Project 1: Seminar

(These details are subject to change from time to time with permission from Dept Syllabus Committee)

1. The Seminar work is concerned with a detailed and critical review of an area of interest to Chemical Engineering. Typically, the report should contain and will be evaluated based on the following points:
   (i) Introduction: 2 pages maximum,
   (ii) Exhaustive review of literature (including figures): 10 – 12 pages: 50% weightage
   (iii) Critical analysis of the literature and comments on the analysis (including figures): 10 – 12 pages: 50% weightage. The critical analysis of literature should include the following points: are the papers technically correct?; are assumptions reasonable; is the reasoning logical? If you think it is not, specify what you think is incorrect and suggest the correct approach. Are the methods used in the literature appropriate? Are there any internal contradictions or computational errors and are there any loopholes in the observations? If so, please explain. Critical analysis of papers should also contain quantitative comparison of observations, results and conclusion amongst the various papers.
2. One typed copy of the report on thesis size bond paper (297 mm x 210 mm) is to be submitted to Coordinator on **time to be deciced by coordinator.** The detailed time-table for the presentation would be communicated later.
3. The report should be prepared using the Times Roman font (size 12) using 1 1/2 spacing leaving 1 inch margin on all sides producing approximately 29 lines per page. The report should be typed on one side of the paper and need not be bound in a hard cover binding. Figures and tables should be shown as a part of the running text. Each figure should be drawn inside a rectangular box of 12 cm width and 10 cm height. The figures must be sufficiently clear and hand drawn figures will be acceptable. Particular care must be taken if a figure is photocopied from source. Each figure must have a sequence number and caption below. Each table must have a sequence number and title at the top.
4. Name of the student, title of the problem and year of examination must be indicated on the top cover. THE NAME OF THE SUPERVISOR (ONLY INITIALS) MUST APPEAR ON THE BOTTOM RIGHT CORNER OF THE TOP COVER.

5. The report must be precise. All important aspects of the topic should be considered and reported. **The total number of pages, including tables, figures and references should not exceed 30.** Chapters or subsections need not be started on new pages, while getting the report typed.
6. Typographical errors in the report must be corrected by the student. The student will be discredited for any omission in the report. All the symbols used in the text should be arranged in an alphabetical order and given separately after conclusions.
7. The list of references should be arranged in alphabetical order of the names of authors. In the text the reference should be cited with author's name and year. (author - date style) For example:

(i) The flow pattern in gas-liquid-solid fluidized bed has been reported in the published literature (Murooka et.al., 1982).

OR

(ii) Murooka et.al. (1982) have measured flow patterns in gas-liquid-solid fluidized beds. The title of the article should also be included. The references must be given in the following standard format.

(a) Format for listing references of articles from periodicals: Murooka S., Uchida K. and Kato Y., Recirculation Turbulent Flow of Liquid in Gas- Liquid-Solid Fluidised Bed", J. Chem.Engg. Japan, 15, 29-34 (1982).

(b) Format for listing references of Books:
Constant R.F.,"Crystallization, Academic Press, New York, pp. 89-90, 1968.

(c) Format for listing Thesis:
Niranjan K., "Hydrodynamic and Mass Transfer Characteristics of Packed Columns", Ph.D.(Tech.) Thesis, University of Mumbai, 1983.

(d) Format for listing references of Patents in Chemical Abstracts:
Cananaush R.M., U.S.Patent 2,647,141, Cf. C.A. 48, 82636 (1954).

(e) Format for listing Handbooks, Tables, Symposia etc.:
Kumar R and Kuloor N.R., "Formation of Drops and Bubbles", in Advances in Chemical Engineering, Vol.8, T.B. Drew et.al. (Eds.) New York, Academic Press, pp.256-364 (1970).

(f) Format for listing Private Communications and other categories:
Sharma, M.M., Private Communication (1984).

8. Consistency of units should be maintained in the written report. SI systems should be used. [For SI system - Ref: Ind. Chem. Engr., XXIV(1), 32, 3 (1983)]. Units used in the literature (if not SI) should be correctly converted.
9. The time allotted for the oral presentation of seminar is 20 minutes: additional 10 minutes are provided for questions and answers.
10. The programme of presentation will be communicated later.
11. INCOMPLETE AND CARELESSLY WRITTEN REPORT IS LIABLE TO BE REJECTED.
12. The last date for submission will NOT be extended on any grounds whatsoever.
13. There must not be any acknowledgment about the guidance by the faculty in the Seminar.
14. The Seminar will be evaluated on the basis of i) rational approach to the problem. ii) correctness and completeness of the written text and iii) performance in the oral presentation.
15. Do not copy word to word from published articles. Use your own language. Do not use flowery language at all.

Additional Details for Project 2 and Project 4: Home Paper

(These details are subject to change from time to time with permission from Dept. Syllabus Committee)

1.Two typed and bound copies of the Home Paper of about 100-150 pages in answer to the assignment must be submitted to the Head of Chemical Engineering Department for notified faculty members on _____ **(Date to be decided by the coordinator)**. The soft copy in word format must be submitted to the Incharge. The Home Paper must be typed only on one side of the paper of the size approx. 21 cm x 29.5 cm (or A4) with diagrams etc. in convenient size. The name of the student, the title of the problem and the year of examination must be indicated on the top cover and also on the side in an abbreviated form. ONLY initials of the supervisor should appear at the bottom of top cover.

2. Incomplete or careless work will not be accepted. The report must be free from typographical and grammatical mistakes.

3. The Home Paper document is deemed to be a preliminary (pre-preliminary) Techno-Economic Feasibility Report. It may be for a Battery limit (B/L) plant or for a Grass roots project. Students are expected to use their judgment in sizing various units from first principles in case adequate data / info is not available. The supervisor is expected to guide student but the student has to defend his project. While process design should be done for all major equipment the detailed process designing should be done for two equipments. The detailed mechanical design should be done for one equipment. The detailed design will have equipment data sheet prepared for the same. For the rest of equipments a separate list is prepared with equipment identification number and "Four Line" specifications, adequate enough to estimate cost. The choice of the units to be designed in detail should be decided in consultation with the faculty members supervising the Home Paper.

4. It is desired that the candidate should include following topics/aspects in this report.

4.1 Introduction

4.2 Executive Summary

4.3 Process Selection: Must include literature survey, competing processes in brief and justification for the chosen process.

The selected process should be described in details. The process description should include the equipment number given in the PFD. For example," the crude product is pumped from a day tank (V1001) to a feed pre heater (E1003) and then to the distillation column (D1001)."

4.4 Site Selection: Justify the site location with points relevant to the site.

4.5 Process Design:

4.5.1 Design basis.: For a continuous plant 8000 hrs are considered in a year for production purpose. For example, Plant capacity 100,000 TPA means 12.5 T / hr.
For a batch process 300 days are considered in a year.

4.5.2 Material and Energy Balance: Material balances must show total and component input and output quantities. Properties for all the substances used in the Energy Balance must be presented in a tabular form. Energy conservation (ENCON) philosophy should be adopted in the design.

4.5.3 Process Design of an Equipment:

- Design basis be stated.
- If computer programme is developed it should be included as an Annexure.
- All calculations with formulae should be clearly exhibited. At the end nomenclature should be included.
- Standard Engineering Practices be followed.
- Selection of material of construction (MOC) with references should be included.
- Process Design Data Sheet should be given

4.5.4 Detailed Design of an Equipment:

- Detailed design should be as per standard engineering practices. Use Indian Standards, ASME, TEMA standards.
- Various nozzles should be clearly identified with sizes.
- The equipment drawing showing elevation (sectional) and plan should be drawn. All nozzles should be shown properly.
- P & ID (Piping & Instrumentation Diagram) around this equipment should be shown separately.

4.5.5 The rest of equipment should be listed separately with " four line" specifications.

4.6 Outside Battery Limit (OSBL) Facilities

Utilities are generally modular in nature. Therefore give 4 line specifications. For example, Boiler: Fuel used, capacity (T/ hr) and pressure.

These are bought out items from the vendor

Storage : Any special storage requirement of the ware house. For example, temperature control, humidity control etc.

Effluent treatment Plant: Present estimate of effluents generated. Suggest treatment facility w.r.t. your project and the site.

4.7 Material Safety Data Sheet (MSDS) : Salient features, not exceeding two pages be presented for major chemicals in the project as Annexure

4.8 Lay Outs:

Plant Layout : Block or major equipment layout for the B/L Plant should be Presented.

Project Layout : Block Layout w.r.t. project should be presented.

4.9 Project Economics:

Present estimates of:

4.9.1 Plant & Machinery

4.9.2 Project cost

4.9.3 Gross Cost of Production for 10 years

4.9.4 Project Financing

4.9.5 Estimate of working results

4.9.6 Project Profitability (Viability) Analysis.

4.10 Conclusions

4.11 References

4.12 DRAWINGS

I. Process Flow Diagram (PFD)

Must include the equipment no., legend of description of each equipment no. At the bottom present a table giving each stream number with component and material balance with temperature and pressure. Process lines of the main flow must be bold and utilities light.

II Piping & Instrumentation Diagram

For the equipment whose detailed design has been performed.

III Detailed Drawing of an Equipment you have designed totally

The equipment drawing showing elevation (sectional) and plan should be drawn. All nozzles should be shown properly.

5. Metric or S. I. units must be used.

6. Industrial establishment must not be approached for getting any information regarding design data or technology without the prior permission of the HOD.

7. The literature survey should be critical and the references should be cited in the text as per guidelines issued for "Seminar" assignment.

8. The Home Papers will be evaluated on the basis of continuous evaluation by the supervisor and on the basis of:

(i) Rational approach to the problem,
(ii) Accuracy, correctness and soundness of calculations and conclusions,
(iii) Clarity of presentation and perspectives and
(iv) Performance in the oral examination.

9. There will be an Internal Assessment of the Home Paper depending on stage wise completion. The total internal assessment is of 50 marks out of 150 marks for the Home paper. Marks are reserved for the timely submission of stage wise activity. **The part wise submission will be checked by the supervisor and returned to the student within a week period.** The student should incorporate the corrections in the final copy.

10 The Home Paper activity should be completed as per the following stages:

Stage No.	Activity	Date	Time
1 2	Literature Survey , Process & site selection block diagram, Kinetics & thermodynamic feasibility Material & Energy Balance		
3 4	Detailed design of the equipment P & I diagram, controls, safety costing, references, fabrication drawing		

The typed report of the completed stage wise activity should be submitted to the undersigned as mentioned above. The full report should be submitted to the Head, Chemical Engineering Department as mentioned earlier.

11. Along with the Seminar presentation, an oral presentation is to be made on the Literature Survey and Process Selection, for which schedule will be given separately.

ELECTIVE SUBJECTS

The elective subjects may be added from time to time with prior approval from UGPC/Senate.

1. **PYT 1104E – Molecular Quantum Mechanics (Applied Physics Department)**

Revision of Basic Concepts

Schrodinger equation for the hydrogen atom, solution in terms of radial and angular wavefunctions, significance of quantum numbers, atomic spectra.

The quantum harmonic oscillator, eigenvalues and eigenfunctions (no detailed derivation), significance of 'zero-point' energy.

Origin of Molecular Spectra

Analysis of diatomic molecule as a rigid rotator, rotational and vibrational energy levels of a simple diatomic molecule.

Approximation methods in Quantum Mechanics

Brief introduction to perturbation theory with simple examples, variational theorem, analysis of helium atom as an example.

Molecular Quantum Mechanics

Molecular orbital and valence bond theories for diatomic molecules, Born-Oppenheimer approximation, LCAO method in H_2^+ ion and H_2 molecule, valence bond method

2. **PYT 1105E – Statistical Mechanics (Applied Physics Department)**

Basic Statistical Approach to a System

Applicability of the statistical approach to a system, equilibrium and fluctuations, irreversibility and approach to equilibrium, counting of system states – macrostates and microstates, equiprobability postulate, concept of statistical ensemble, number of accessible states of a system, phase space.

Ensemble approach to Thermodynamics of Physical Systems

Isolated system – microcanonical ensemble, system in contact with a heat reservoir, canonical ensemble, Maxwell-Boltzmann distribution as an example, mean values in a canonical ensemble, partition function for a canonical ensemble, relation to thermodynamics.

Generalised Interactions

Grand canonical ensemble, systems with variable number of particles, chemical potential, partition function for a grand canonical ensemble, relation to thermodynamic variables.

Applications to Multi-phase Systems

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

3. **CHT 1403E – Advanced Spectroscopy (Applied Chemistry Department)**

UV-VIS spectroscopy - Woodward rules, aromatic and heterocyclic compounds
IR spectroscopy: FT technique, group frequencies, vibrational coupling. NIR spectroscopy. New applications
Raman spectroscopy: Stokes, anti-Stokes and Releigh scattering, rotational and vibrational transitions. Raman vs IR.
NMR spectroscopy: Pulse technique, FID, and FT. Relaxation and saturation phenomena, quadrupole relaxation, isotopomers.
H1 NMR: Chemical shifts and factors affecting the same, spin-spin coupling of different systens, different spin systems, coupling constants.
Simplification of complex spectra: Double resonance and decoupling, lanthanide shift reagents, INDOR technique.
C13 NMR: Basics, doble resonance,
2D NMR: H1-H1- COSY, H1-C13 HETCOR- APT and DEPT, C13-C13 connecticity: INADEQUATE
F19 and P31 NMR
Through space interactions: NOE and NOESY
Solid state NMR and MAS.
Mass spectrometry: Basics, EI and CI techniques. Isotopic abundance, fragmentation, rearrengment of ions, Maclaferty rearrangement, retrodiels-alder reaction.
Hyphenated techniques: GC-MS, LC-MS, LC-MS-MS, GC-IR, GC-AIS, GC-NMR, LC-NMR
ESR spectroscopy: Theory, experimental technique, Hyperfine splitting
Mossbaur spectroscopy
Structure elucidation using combined stereoscopic methods
Emission: Flame photometry, ICP, Ark-Spark spectra, Phosphorescence, XRF

4. **CHT 1205E – Organometallic Chemsitry (Applied Chemistry Department)**

Nature of C-M bond: Metal-carbon bond with main group and transition elements.
Factors controlling metal-carbon bond formation. Methods of M-C bond formation. Nomenclature and heptacity. Electron counting and 16 and 18 electron rules - applications and exceptions. Stability. Stereochemical nonrigidity in organometallic compounds.
Structure and bonding of metal alkyls and aryls. Complexes with CO and related ligands, olefins, acetylenes and related unsaturated molecules. Organic transition metal complexes as protective and stabilizing groups for double bond, triple bond, propyl cation and short lives species. Complexes with cyclopentadiene and arenes and other CnHn sandwich and half-sandwich complexes. Hydride, dinitrogen and dihydrogen complexes
Bimetallic and cluster complexes: Structure and applications in catalysis
Basic organometallic reactions: Ligand substitution, oxidative reactions, migratory reactions, migratory insertion, extrusion, oxidative addition, reductive elimination, reductive elimination –mechanism and stereochemistry.
Nucleophilic regents with C-M bond: Li, Mg, Al, Ti and Ce alkyls; Organicuprates, organic zinc reagents
Alkyne complexes: Pauson Khand reaction. The use of stoichiometric transition metal complexes in the synthesis of complexes organic molecules - enantioselective synthesis via organometallic compounds.
Organo silicon compounds, boranes, carboranes and, metallocarboranes, organo platinum complexes, metallocenes
Importance of organometallic compounds in Biological systems

5. **CHT 1206E – Green Chemistry & Catalysis (Applied Chemistry Department)**

Concept of Green Chemistry: Twelve principles of green chemistry, E factor, Waste management
Types of catalysis: Homogeneous and Heterogeneous catalysis. Catalytic cycles
Organometallic compounds used as catalysts: Pd, Rh, and Ru in C-C bond formation. Catalytic properties of mononuclear compounds
Homogeneous catalysis: Hydrogenation, hydroformylation, hydrocyanation, Hydrosilylation, Wilkinson catalysts, Chiral ligands and chiral induction, Ziegler-Natta catalysts
Mercuration and oxymercuration
Organopalladium catalysts: Suzuki coupling, Heck coupling and related cross coupling reactions.
Alkene oligomerization and metathesis.
Catalytic oxidations and reductions: Epoxidation, dihydroxylations.
including carbonylation, decarbonylation, olefin isomerization, arylation
Important catalytic reactions: Monsanto acetic acid process, Wacker process, Heck reaction.

6. **CHT 1303 – Theoretical and Computational Chemistry (Applied Chemistry Department)**

Basics: Wave character and wave functions, De Broglie equation, normalization and orthogonalization, Quantum mechanical operators, Schrodinger equation, particle in an infinite square well potential, quantum mechanical harmonic oscillator, angular momentum operator and rigid rotor, Born Oppenheimer approximation, potential energy surfaces, self consistent field wave functions,

Computauional methods: Molecular mechanics, MO theory, semi empirical and ab initio methods, SCF theory, Hartree Fock method, DFT.

7. **MAT 1107E – Momentum, Heat and Mass Transfer (Applied Mathematics Department)**

Derivation of equation of momentum, energy, mass transfer in curvilinear coordinate system, constitutive equation (Newtonian & Non Newtonian fluids), Flow in some simple cases - Flow between two concentric cylinders, flow between two concentric rotating cylinders, hydrodynamics of bearings lubrication, steady flow around a sphere (theory of very slow motion).

Singular perturbation theory, derivation of bounder layer equations (using singular perturbation theory), similar and non similar solutions for some forced, mixed and natural convection problems (using bounder layer theory) .

Flow stability, theory of ordinary diffusion in liquids, diffusion with homogenous chemical reaction, diffusion into a falling liquids films (forced convection mass transfer).

8. **MAT 1108E – Turbulent Flow and CFD (Applied Mathematics Department)**

Derivation of equations of momentum and energy for turbulent flows. Modelling of turbulent flows: kinetic energy, algebraic stress model, Low Reynolds number model, LES model etc.

Turbulent boundary layer flows and similar solutions

Grid generation

Use of Control volume method, Methods of lines, Finite difference, Finite element and various algorithms (SIMPLE, SIMPLER & SIMPLEC etc) to solve the momentum, energy and mass transfer equations for simulation of some practical problems (Simulation of stirred vessel, Natural convection flow inside a closed chamber etc)

9. **GET 1303E – Advanced Strength of Materials (General Engineering Department)**

Analysis of Trusses - Condition for perfect truss, redundancy, stable, unstable truss. Analysis of truss by method of joints, method of sections.

Torsion of a circular shaft - concept, basic derivation, shear stress distribution, simple problem.

Short and Long columns (Struts) - Basic concept, crippling load, end conditions. Euler's and Rankine's approach (without derivations)

Thick and Thin cylinders - concept of radial, longitudinal stresses, behaviour of thin cylinders. Problems on thin cylindrical and spherical shells. Behaviour of thick cylinders (theory only).

Advance stresses and strains – Representation of stress and strain at a point, Stress stain relationship, plane stress and plane strain. Transformation of stresses and its importance, Principal stresses and strains, maximum shearing stress, Mohr's circle its use and construction.

Basics of Engineering Design - Steps in the engineering design, Importance of analysis, 1-D, 2-D and 3-D analysis and interpretation of results. Design philosophies, factor of safety, Force displacement relationship, Strain deformation relationship, Introduction to finite element packages. Computer aided analysis and design.

Composite Materials – Types of composite materials, fillers for composites, polymer composites, fibres and matrix for a composite material, Types of fibres, their properties, woven and non woven fibres, manufacturing of polymer composite materials. Mechanics of composite materials, Properties and testing of composite materials, Uses of composite materials.

Advance materials for industrial applications - Advances in materials, Materials used for coatings, anticorrosive coatings, special purpose floorings, water proofing compounds, Various polymers and epoxies used for industrial applications. Different types of performance enhancing and special purpose construction chemicals. Plasticizers and super-plasticizers, air entraining agents, accelerators and retarders, viscosity modifying agents, corrosion inhibitors.

10. **HUT 1105E – Industrial Economics (Humanities)**

Nature and Significance of Economics

Demand and supply / elasticity of demand and supply, price determination, demand forecasting

theory of firm : (A) financial aspects : cost analysis, revenue structure, conditions for profit maximisation, different market structures (B) technical aspects : factors of production, role of entrepreneur, laws of return, returns to scale.

Money market and capital market, evolution of money and banking, foreign exchange and currency de-valuation.

Budget, taxation, public expenditure, borrowing and deficit financing

Development issues and economic planning in India, Role of public sector / liberalisation / privatisation / globalization

11. **CET 1506E – Engineering Aspects of Manufacturers of Organic Chemicals (Chemical Engineering**

Department)

Special features of process parameters and reactors used for typical organic processes such as hydrogenation, oxidation, alkylation, nitration, sulphonation etc. Different strategies of conducting reactions. Introduction to a few name reactions such as Friedel Crafts reactions, Sandmeyers reaction, Darzens condensation, etc. Typical reaction schemes for the synthesis of medium and low volume chemicals, with an emphasis on the alternative flow sheets of the entire process.

12. **CET 1204E – Electrochemical Engineering (Chemical Engineering Department)**

Introduction to eletrochemical engineering. Theoretical aspects and special features of electrochemical process. Role of mass transfer in a variety of electrochemical processes. Some aspects of electrochemical reactor design. Scale-up and optimization of reactors.

13. **CET 1712E – Mathematical Methods in Chemical Engineering (Chemical Engineering Department)**

Classification of problems in Chemical Engineering. Typical problems from heat transfer, catalysis, mass transfer with chemical reaction, dynamics of process equipments, etc. Numerical evaluation of Laplace Transforms.

Separation of variables, Eigen values, Collocation Techniques.

14. **CET 1713E – Statistical Methods in Engineering (Chemical Engineering Department)**

Continuous and discrete probability distributions, normal, chi-square, gamma, Poisson distributions. Applications. t-Tests, F-Test, Homogeneity tests, Quality Control. Acceptance sampling Linear regression and lack of fit Contingency tables.

15. **CET 1103E – Heat Transfer Equipment Design (Chemical Engineering Department)**

Classification of Heat Transfer Equipment, direct, indirect, boiling, fired, Fluidised, geometry, construction.

Thermal design methods of heat exchangers : survey, capital NTU, LMTD concept, temperature approach, etc.

Shell and Tube heat exchangers : thermal, mechanical design, hydraulic design and equations, introduction to codes and standards

Extended surface heat exchanger design : plates, plate fins, effectiveness factor.

Heat transfer equipment with phase change, two phase flow maps, and design of equipments for heat transfer and pressure drop.

Fluidised bed and direct heat exchangers design methodology.

Synthesis of optimal heat exchanger networks.

Worked Examples

16. **CET 1205E – Mixing (Chemical Engineering Department)**

Examples of industrial importance

Flow pattern, power consumption, classification of impellers, internals

Mechanism of mixing, Blending in viscous and turbulent system, Suspension of solid particles, Heat transfer, Gas-liquid dispersion, Liquid-liquid dispersions, Three phase dispersions, Solid-solid mixing, emulsions, pastes, Mass transfer at gas-liquid, liquid-liquid, solid-solid and solid-liquid interface

Process design and scale-up considerations case studies

17. **CET 1507E – Petroleum Reservoir Engineering (Chemical Engineering Department)**

Energy sources, world scenario, oil pricing, Genesis of petroleum and migration, Composition of petroleum and its classification, Petroleum reservoirs, Exploration and drilling technology, Well logging and well completion, Core analysis, Capillarity and wettability, Models of pore structure and multiphase flow , Well stimulation and production strategy, Well pressure behaviour, Gas reservoir engineering, Fluid displacement and frontal displacement; Buckley-Leverett theory, Material balance, Decline curve analysis, Well patterns and displacement efficiencies, Primary recovery, Gravity drainage, Waterflooding , Mechanisms of microscopic and macroscopic flow, Transportation of oil and gas, Production rate, reservoir life, Heavy oil and tar sand technologies, Residual oil determination, Computer modelling of reservoirs, Tertiary recovery methods

18. **CET 1508 – Enhanced Oil Recovery (Chemical Engineering Department)**

Residual oil and tracer studies, Defining enhanced oil recovery, Basic equations for fluid flow in porous media, Petrophysics and petrochemistry, Phase behaviour and fluid properties, Efficiency of waterflooding , Pore level mechanisms, Mobility control , capillary number, bond number correlations, Heterogeneity of pore structure and reservoirs, Thermal methods , Steam stimulation, steam flooding and hot water drive, Combustion- forward and reverse, Ancillaries in thermal methods, Miscible flooding, Surfactant flooding, Microemulsion flooding, Foam flooding, Polymer flooding, Micellar-polymer flooding, Alkaline flooding, Carbon dioxide flooding, Inert gas injection, Reactive gas injection, Microbial recovery

19. **CET 1104E – Flow Though Porous Media (Chemical Engineering Department)**

Relevance of pore structure in science and technology, Examples from oil reservoirs, catalysis, soil science, membranes, aquifers, foods, polymers, biology, etc., Pore structures and their determination, Capillarity and wettability, Models of pore structure, Wettability and flow histories, Single phase flow, Multiphase flow,

Percolation processes and network models, Fractal models, Simulations of macroscopic properties, Pore level mechanisms of flow, Diffusion and dispersion in porous media, Membrane transport, Analysis of trickle and packed beds, Ultrafiltration, Models of catalyst poisoning and deactivation, Geostatistics

20. **CET 1509E – Refinery Science and Engineering (Chemical Engineering Department)**
Terminology, Origin, Kerogen, Occurrence, Recovery, Classification, Composition, Evaluation, Fractionation, Identification, Asphaltic constituents, Refining chemistry, Refining distillation, Thermal cracking, Catalytic cracking, Hydroprocessing, Reforming, Treatment processes, Gas cleaning, Products, Petrochemicals

21. **CET 1206E – Fundamentals of Catalytic Science and Engineering (Chemical Engineering Department)**
Relevance and examples, Atom economy and green chemistry concepts, Homogenous and heterogeneous catalysis, Fundamentals of homogeneous catalysis and mechanisms and kinetics, Fundamentals of adsorption, isotherms, energetics, structural and dynamic considerations, Mechanisms, models and kinetics of surface reactions, Fractal models, Determination of surface structure though modern methods , Significance of Pore structure and models, Solid and surface chemistry of catalysis, Quantum mechanical, molecular mechanical and hybrid models, Catalyst design through artificial intelligence and computer modelling, Poisoning, promotion, deactivation and selectivity , Catalytic process engineering , Measurement of catalytic rates and kinetic parameters, Types of reactors

22. **CET 1207E – Homogeneous Catalysis (Chemical Engineering Department)**
Examples, Single phase and multiphase catalytic reactions, Acid--base catalysis, Transition metal catalysis, Bio-catalysis : Microbes and enzymes, Phase transfer catalysis, Micellar catalysis, Microemulsion catalysis, Electron transfer catalysis, Heteropoly acid catalysis, Homogeneous polymer catalysis, Heterogenisation of homogeneous catalysts, Catalysis by microwaves and ultrasound, Catalyst recovery and reuse

23. **CET 1208E – Catalytic Green Science and Technology (Chemical Engineering Department)**
Green synthesis and heterogeneous catalysis, Metal and supported metal catalysis, metal-support interaction, Metal oxides and determination of acidity and basicity, Nature and type of supports , Solid acid catalysis, Solid base catalysis, Catalyst design, preparation and activation, Clay and modified clays, Ion exchange resins, Zeolites and zeotypes , Heteropoly acids, Inorganic-organic catalysts, Immobilised enzymes, zeozymes, complexes, Electrochemical catalysis, Photocatalysis, Microwave catalysis, Ultrasound catalysis, Synergistic catalysis, Important examples from, Refinery industry -FCC, reforming, platforming, hydroforming, polymerisation, alkylation, isomerisation; hydrodesulfurisation, hydronitrogenation, Pharmaceutical and fine chemical industry, Dyestuff and intermediate industries, Perfume and flavour industry, Polymer industry, Textile industry, Paint industry, Edible oil industry, Food industry, Waste water treatment, Catalysis for auto-exhaust pollution abatement, DeNox, DeSOx technologies

24. **CET 1602E – Colloid and Interfacial Science (Chemical Engineering Department)**
Capillarity: Definition, Existence of surface tension/surface free energy, Laplace equation, Young Equation, Capillarity rise phenomena, Measurement of surface tension, Contact angle Wetting characteristics

Surface Thermodynamics : Surface thermodynamic properties, Kelvin Eqn. Gibbs eqn, Surface Excess, Monolayer phase

Adsorption: Localised vs Mobile adsorption, Adsorption isotherms Langmuir, Freundlich, BET etc., - Potential theory, Adsorption from solution, Electrical Diffuse Double layer theory, Debye Huckel theory scaled particle theory, Stern layer, Surfactant adsorption

Micelles: Classes of surfactants, synthesis of surfactants, Micelle structures, Determination of HLB, Models for micelle formation, Swollen micelles, Hydrotropy

Solubilization in micelles :Location of solubilizate in micelles, Measurement of solubilization, Spectroscopic methods:NMR, Fluorescence, IR etc, Detergency, selective solubilization

Emulsions :Micro and macro emulsions, Stability of emulsions (Mechanical vs. thermodynamic), Bancroft rule, deemulsification, HLB for emulsion, multiple emulsions, applications

Foams: Gibbs triangle, Film elasticity, drainage of films, Foam, defoaming, applications of foams

25. **CET 1603E – Interfacial Science and Engineering (Chemical Engineering Department)**
Definitions: Chemical and physical properties of interfaces, Introduction to surface mechanisms and thermodynamics, capillarity, meniscus shapes, contact angle, surface tension and its measurement, Laplace Equation, Young's equation, Kelvin Equation, Gibbs equation, equilibrium criteria, dividing surface, monolayers and films, mobile and fixed interfaces Interfacial areas and degrees of wetting, aerosols, liquid-liquid and particulate dispersions, Bubbles,and drops aphrons.

Microphases: Definitions and dynamics, Micelle formation surfactants CMC, structures of micelles,swollen micelle and microemulsions models, phase diagrams, Macroemulsions, Mechanical vs thermodynamic stability, HLB, Bancroft rule and other systems, Foams Colloids, Film elasticity, drainage, association, Langmuir-Blodgets film production. Experimental techniques of measurement of relevant properties: surface tension, solubilization, thermodynamic properties, spectroscopic techniques

Rheological aspects of two phase (involving microphases) flow and transport, visco-elasticity of surfactant

solutions.

Solubilization and catalysis by microphases: Models, theories and data, surface potential and equations of state, double layer theory, layer Debye Huckel theory, Thermodynamics of solubilization, Hydrotropy

Emulsification and Demulsification, foam breakage, theories of coalescence, and agglomeration, Brownian motion, shear and other models.

Applications: Adsorption, foam fractionation, froth floatation Enhanced oil recovery, Novel separation processes, Coagulation, Flocculation, Microelectronics, surface vapour deposition, other applications with techniques

Monte Carlo simulation for molecular dynamics of structures, graphics software for structural display., Diffusion on the surface and in microphases.

26. **CET 1403E – Adsorptive Separations (Chemical Engineering Department)**

Separation Processes: overview, alternative separation techniques, Mass separating agents

Adsorbents: Molecular sieves activate carbon,zeolites alumina, silica ion exchangers, Polymeric adsorbents

Physical and Reactive adsorption: Selectivity engineering in catalysis, Gaseous and liquid adsorption, Thermodynamics of adsorption, Statistical thermodynamics of adsorption phenomena, Surface excess, theories of adsorption. Separations: Bulk separation, purifications, Concentration and recovery from dilute solutions: metals, organic chemicals, microelectronics

Design of adsorbers: Gaseous and liquid phase adsorption

Theoretical analysis of diffusion in relation to adsorption in micropores

Chromatographic separations: Bulk chemicals separations, Purification, refining operations, Biochemical applications

Novel separation techniques using adsorbents, Industrial examples

27. **CET 1209E – Advanced Biochemical Engineering (Chemical Engineering Department)**

Biotechnology, Biochemistry and microbiology, Enzymatic reactions, cell culturing

Enzyme engineering, enzyme modifications, stability, reactivity and selectivity considerations

Genetics and Genetic engineering, DNA recombinant technology, Hybridoma technology, single cell proteins, gene manufacturing

Fermentation and design of fermenters with modified organisms

Bioprocess simulations, molecular modelling for protein synthesis and drug design, protein engineering

Applications in fermentation industry, pharmaceutical industry, medical field such as gene therapy, Biomedical engineering

Bioreactor design, Scale up of bioreactions/reactors, Downstream processing in biochemical industry

Organic synthesis using enzymes

28. **CET 1404E – Downstream Processing in Biochemical Industry (Chemical Engineering Department)**

Separation processes in biochemical industry, Separation processes for bulk chemicals and proteins, special needs, Unit operations on biochemical industry, such as filtration, centrifugation, heat and mass transfer , Solvent extraction: liquid-liquid extractions, phase diagrams, thermodynamics of liquid-liquid extraction, physical vs reactive extraction, liquid ion exchangers, design of extractors, two phase flow in extractors, modelling and simulation of extractors, Aqueous two phase extraction, affinity partitioning, dye ligand partitioning, Reverse micellar extraction of proteins and enzymes, Adsorption: physical and chemical adsorption, theories of adsorption, ion exchange resins and polymeric adsorbents, adsorption of small molecular weight bioproducts such primary and secondary metabolic products of cells, Protein purifications, precipitation, affinity precipitation, adsorptive and chromatographic separations of proteins, design of adsorption columns, Methods of operation., Gel permeation chromatography, metal ligand chromatography, dye ligand chromatography, affinity chromatography, expanded bed chromatography,

Applications in biochemical industry.

29. **CET 1405E – Advanced Separation Processes**

Membrane Processes : Principles of various membrane processes like Reverse Osmosis, pervaporation, gas separation and electro-dialysis. Design equations and module design. Concentration polarization.

Adsorption and Ion Exchange Processes : Adsorption and ion exchange equilibria. Various isotherms. Contact filtration, design of fixed bed adsorber including breakthrough cuurve.

Chromatographic Separations : Principles of chromatographic separation, criteria for effective separation, supports and methodology and process design.

Separation of Racemic Mixtures : Principles of racemic modification and their application in separation of racemic mixtures with specific examples.

Dissocaition Extraction, Reactive Extraction

30. **CET 1210E – Introduction to Polymer Engineering (Chemical Engineering Department)**

Introduction to Polymers : Classification based on application and history, Natural and synthetic polymers and types e.g. fibres, rubbers, adhesives, resins, plastics, etc.

Classification based on properties/structures : Thermoplastic, thermosetting, crystalline, amorphous, molecular weights status, transitions, glass transition temperature

Polymer formation/modification : Functionality and reactions, chain, ionic, condensation, co-ordination, complex polymerisation, Kinetic schemes, Orders of reactions, Cross-linking, Co-polymerisation, Heat effects
Polymerisation Processes and methods of manufacture : Bulk, Solution, Suspension and emulsion polymerisation with examples, polystyrene, polyethylene/propylene, styrene-Butadiene, poly urethane, Epoxy, PET, Kinetics, reaction rates, diffusional limitations, Biodegradable polymers.

31. **CET 1604E – Polymer Processing (Chemical Engineering Department)**

Plastic Technology : Moulding, (injection, blow) extrusion, cold-not and vacuum forming multipolymer systems. Equipments design and operating conditions

Fibre Technology : Textile processing, fibre spinning and after treatment. Equipments design and operating conditions

Elastomer Technology : Vulcanisation, Reinforcement compounding

Equipments- design & operating conditions, environmental impact

Recycle of polymers : Reprocessing techniques and limitations

Selection of polymers : domestic & engineering usage

Rheological and mechanical measurements concept of solution viscosity

32. **CET 1211E – Polymer Reactor Engineering (Chemical Engineering Department)**

Kinetic modelling, concept of reactor design, optimisation and control of polymerisation process, isolation and separation of monomers/catalyst/by products etc for Bulk polymerisation, Solution polymerisation, Emulsion polymerisation, suspension polymerisation with case studies
Kinetic modelling of co-polymerisation processes.

33. **CET 1605E – Advanced topics in Polymer Chemistry/Physics Characterisation/Analysis of Polymers (Chemical Engineering Department)**

Structure/property relationship : Morphology & Cristallinity Mechanical and Chemical properties
Structure/Rheology relationships

Rheology, elasticity, Viscoelasticity, yield and fracture chemical resistance

Properties of commercial polymers. PE, PP, Acrylic, amides & peptides phenolic & Urethane resins

Role of Additives : Type of additives and their role in altering the properties

Polymer composites : Carbon filled, fibre filled etc. Reinforced polymers

Analysis of polymer solubility, thermodynamics and phase equilibrium of polymer solutions, End group analysis, Colligative property measurement, Light scattering, Solution viscosity and molecular size and wt distribution. Spectroscopic methods, microscopy, thermal analysis.
Selection of polymers, domestic and engineering usage.

34. **CET 1510E – Fuels Engineering (Chemical Engineering Department)**

Classification of fuels : G/L/S

Automotive Fuels Bharat Standards II III & IV

Gaseous Fuels:

Natural Gas: Processing for pipe line specs
CO_2/H_2S/COS Removal
Gas dehydration
Gas compression for pipe line transport

Coal bed methane, Bio Gas (methane)

CNG : As auto fuel, Compression, CNG stations

LNG : Liquefaction of NG JT effect, closed & open cycle , Storage of LNG, Transportation of LNG, vessels / truck, terminal, Gasification of LNG to NG for pipeline transport

Liquid Fuels:

- Refinery sources, Reforming for fuels
- LPG : Domestic and Auto LPG Storage and handling,
- Manufacture and Storage (Partly in I&EC) Petrol, Diesel, Aviation Turbine Fuel, HSD, LDO. Furnace oil, Fuel oil, LSHS.
- Biofuels : bioethanol, biodiesel

Solid Fuels : Characterization

- Coal
- Biomass
- Residue from Refinery
- Plastic waste
- Municipal domestic waste

Combustion of Fuels :

- Basic equation, air requirement norms for excess air.
- Heating value : GHV/LHV Calculations for mixture of components
- Wobbe number for Gaseous Fuels definition and significance.
- Burners : Gas/Liquid/Hydrogen
- Flue gas composition, Dew point calculations
- Treatment of flue gas to meet local standards,Carbon Credit

Gasification of i) Coal, Indian Coal
ii) Biomass
iii)Refinery Heavy Residue

Power generation, combined cycle, cogeneration

35. **CET 1511E – Plant Utilities (Chemical Engineering Department)**

Role of Process Utilities in process industries. Impact on Project economics
Water, its characteristics and its conditioning and treatment for process industries e.g. boiler feed water, cooling water. Recycling aspects of water from blow downs.
Application of steam systems in chemical process plants, design of efficient steam heating systems, condensate utilization, flash steam, steam traps.
Characteristics properties, classification, selection and industrial applications
Characteristics of air and air receivers, instrument air. Inert gas generation
Vacuum system engineering.
Electrical Power : HT/LT
Area classification,
Motors/drives selection accordingly.
Single line diagram.
Emergency Drives Identification
Emergency power. Inverters, DG sets. Etc.
Estimation of utilities
Utilities Audit

36. **CET 1512E – Project Management: Case Study Approach (Chemical Engineering Department)**

Project: meaning, Different types, why to manage, cost overruns centres, various stages of project execution : conception to commissioning.
Project execution as conglomeration of technical and non technical activities.
Detailed Engineering activities.
Pre project execution main clearances and documents
Project team : Role of each member. Importance
Project site : Data required with significance.
Project contracts. Types and contents.
Project execution
Project cost control.
Bar charts and Network diagram.
Project commissioning: mechanical and process.

37. **CET 1606E – Advanced Materials (Chemical Engineering Department)**

Nanostructured Materials: Metal nano particles, their structure and properties
Carbon nano tubes: manufacture, properties and applications.
Nano materials in catalysis.
Composite Materials: Polymer composites, metal-metal composites, polymer-metal composites, metal- ceramic composites.
Superconducting Materials: Principles of superconductivity, properties, advantages and limitations of superconductors. Applications superconductors
Smart Materials: Shape memory alloys, Auxetic materials and Biomimmicking materials. Stimulii for sensors and actuators.

38. **CET 1513E – Process Systems Engineering (Chemical Engineering Department)**

Introduction to Systems Engineering: Systems and their origin, examples of problems in Systems Engineering
Foundations of Systems Engineering: Scope and Formulation of Engineering Problems, Goals, Objectives, Specifications and Constraints, Types of Models; Hierarchical decomposition of systems, Types of Problems: Forward solution and inversion of models
Structural Analysis of Systems: Graphs and digraphs: Representation of systems, Partitioning and Precedence Ordering of systems, Structural analysis of modeling equations, Structural controllability and observability of

systems, Applications to engineering problems
Steady State Analysis of Systems: Formulating steady-state models and simulations, Degrees of freedom and design specifications, The Sequential-Modular Strategy, The Equation-Oriented Strategy, Applications to engineering problems
Optimization of Systems: Theory and Algorithms: Basic concepts and definitions, Linear programming, Unconstrained nonlinear optimization, Nonlinear Programming, Combinatorial optimization, Applications to engineering problems
Simulation of Dynamic Systems: Basic concepts: Systems described by ODEs and DAEs, Formulating dynamic simulations; consistent initialization, Numerical integration of ODEs and DAEs, Modeling-simulation of hybrid Discrete/Continuous systems, Applications to engineering systems
Model-Based Process Control: The nature of feedback control, The concept of model-based control systems, Design and analysis of model-based control systems applications

39. **CET 1106 – CFD applications in chemical processes (Chemical Engineering Department)**
Derivation of equations of momentum and energy for turbulent flows.
Finite volume technique
One dimensional heat conduction and flow
Grid generation
Space and time discretization
Pressure velocity coupling (simple, simpler & SIMPLEC)
OpenFOAM software, simulation of pipe flow, backward step, flow past cylinder
Commercial software, simulation of pipe flow, backward step, flow past cylinder, stirred vessel, bubble column, cyclone separator, spray dryer etc.
Suggested Books:
Versteeg and malalasekera, "An introduction to computational fluid dynamics. The finite volume method", (2007)
Patankar S., "Numerical heat transfer and fluid flow", (1980)

40. **CET 1407 – Process Design of Heat and Mass Transfer Equipment**
(3 Credits: 2 Lectures + 1 Tutorial – 3 hours per week, 45 hrs total)
Advanced Process design aspects of various process equipments will be considered through several case studies; and will cover: hydrodynamic characteristics, heat and mass transfer characteristics, selection criteria, etc. The topics will include some of the following equipment (but not limited to):
(1) Equipment for heat transfer: plate heat exchangers, plate fin exchangers, finned tube exchangers, thermo-siphon reboilers, evaporators, condensers, etc.
(2) Equipment for Unit operations: plate and packed columns, spray towers, etc.
(3) Equipment for Multiphase reactions: Stirred tanks, gas inducing reactors, bubble columns / modified bubble columns, air-lift reactors, packed and plate columns, trickle bed reactors, ejectors, etc.

41. **CET 1408 Advanced Membrane Separations**
Introduction : classification and definitions
Membrane Processes and their applications: Microfiltration, Ultrafiltration and micelle-enhanced ultrafiltration, Nanofiltration, Reverse osmosis, Dialysis, piezodialysis, electrodialysis, Pervaporation and membrane distillation, Gas permeation,Liquid membranes, Ion exchange membranes
Transport mechanisms, and mathematical modelling
Membranes: Design of membranes, Characterization
Polarisation and fouling: Polarisation phenomena and fouling concentration polarization, Characteristic flux behaviour in pressure driven membrane operation, Membrane fouling, Methods to reduce fouling
Process design: modules and configurations: Capillary, hollow fibre, tubular, Plate and frame, Spiral wound
Membrane reactors and their applications in biotechnology
Text books:
Mulder, M.H.V. Membrane Separations, Springer.
Philip, R., Wankat, C. Rate-Based Separations, Springer.
Reference books:
Nunes, S.P., Peinemann, K.V. Membrane Technology in the Chemical Industry, Wiley.
Rautanbach and R. Albrecht, Membrane Processes, Wiley.
Crespo, J.G., Bodekes, K.W. Membrane Processes in Separation and Purification, Kluwer Academic Publications.
Geankoplis, C.J. Transport Processes and Unit Operations, Prentice-Hall.

42. **CET 1607 Biomaterials: Biodegradable Materials for Biomedical Applications**
Introduction of Biomaterials
Biomaterials Surfaces: Structure and Properties, Surface Energy

Adsorption and Reconstruction at Surfaces,
Protein-Surface Interactions
Proteins: Structure, Properties, Functions, Protein Adsorption: Complex Phenomena, Measurement
Cell-Surface Interactions: Host Response to Biomaterials: Cell adhesion mechanism, coagulation cascade, immune response
Surface Characterization: AES, XPS, AFM, Contact Angle
Quantifying Cell Behavior: Cell Culture, Cellular Assays
Biosensors and Diagnostic devices
Drug Delivery: Controlled Release, Diffusion Controlled and Membrane based devices, Mechanical Pumps
Biomaterial for Organ Replacement
Mechanical Properties, Bone Substitutes
Introduction of Tissue Engineering: Cell, Scaffold design, Artificial liver, pancreas, cartilage
Regulatory overview
Text Books:
Ratner, Buddy D., et al. Biomaterials Science: An Introduction to Materials in Medicine. 2nd ed. Burlington, MA: Academic Press, 2004. ISBN: 9780125824637.