COURSE STRUCTURE, SYLLABUS AND REGULATIONS

2017

CSR/04/17 dated 8.2.2017

(1st and 2nd semester is common for all departments under the Faculty of Engineering & Technology, University of Calcutta)

(10+2+4) B. TECH PROGRAMME IN CHEMICAL ENGINEERING

DEPARTMENT OF CHEMICAL ENGINEERING

UNIVERSITY OF CALCUTTA

UNIVERSITY OF CALCUTTA

Faculty of Engineering and Technology

4 year B.Tech. Course

Course Structure for 1st SEMESTER

Serial No.	Name	Code	Credit	Weekly Load			Total Load
				L	T	P	
1	Communicative English	HU101	03	2	1	0	03
2	Physics-I	PH102	03	2	1	0	03
3	Chemistry-I	CH103	03	2	1	0	03
4	Engineering Mathematics-I	MA104	03	2	1	0	03
5	Electrical Technology	EE105	03	2	1	0	03
6	Computer Programming and Data Structure	CS106	03	2	1	0	03
7	Language Lab	HU107	02	0	0	3	03
8	Physics-I Lab	PH108	02	0	0	3	03
9	Chemistry-I Lab	CH109	02	0	0	3	03
10	Electrical Technology Lab	EE110	02	0	0	3	03
11	Computer Lab	CS111	02	0	0	3	03
	TOTAL		28	12	6	15	33

Course Structure for 2nd SEMESTER

Serial No.	Name	Code	Credit	Weekly Load			Total Load
				L	T	P	
1	Sociology	HU201	03	2	1	0	03
2	Physics-II	PH202	03	2	1	0	03
3	Chemistry-II	CH203	03	2	1	0	03
4	Engineering Mathematics-II	MA204	03	2	1	0	03
5	Basic Electronics	ET205	03	2	1	0	03
6	Engineering Mechanics	ME206	03	2	1	0	03
7	Physics-II Lab	PH207	02	0	1	3	03
8	Chemistry-II Lab	CH208	02	0	0	3	03
9	Electronics Lab	ET209	02	0	0	3	03
10	Workshop Practice	ME210	02	0	0	3	03
11	Engineering Drawing	ME211	02	0	0	3	03
	TOTAL		28	14	4	15	33

Curriculum of 4 year B. Tech. programme in Chemical Engineering – Departmental papers

3rd Semester:

A. THEORY						
Serial Number	**Subject**	**Contact Hours/Week**				**Credit Points**
		L	**T**	**P**	**Total**	
1.	Fluid Mechanics (ChE-301)	2	1	0	3	3
2.	Process Heat Transfer-I (ChE-302)	2	1	0	3	3
3.	Introduction to Chemical Engineering (ChE-303)	2	1	0	3	3
4.	Energy Resources and Utilization (ChE-304)	2	1	0	3	3
5.	Chemical Engineering Mathematics-I (ChE-305)	2	1	0	3	2
6.	Strength of Material (ChE-306)	2	1	0	3	2
Total of Theory					**18**	**16**

B. PRACTICAL						
Serial Number	**Subject**	**Contact Hours/Week**				**Credit Points**
		L	**T**	**P**	**Total**	
7.	Computer Programming-I (FORTRAN) (ChE-307)	0	0	3	3	2
8.	Instrumental Method of Analysis (ChE-308)	0	0	3	3	2
9.	Fuel Technology laboratory (ChE-309)	0	0	3	3	2
10.	Workshop Practice-II (ChE-310)	0	0	3	3	0 (A)
11.	Engineering Drawing (ChE-311)	0	0	3	3	0 (A)
Total of Practical					**15/9**	**6**
Total of Semester					**33/27**	**22**

4th Semester:

A. THEORY						
Serial Number	**Subject**	**Contact Hours/Week**				**Credit Points**
		L	**T**	**P**	**Total**	
1.	Transport Phenomena-I (ChE-401)	2	1	0	3	3
2.	Process Heat Transfer-II (ChE-402)	2	1	0	3	3
3.	Mechanical Operations (ChE-403)	2	1	0	3	3
4.	Chemical Technology (ChE-404)	2	1	0	3	3
5.	Chemical Engineering Mathematics-II (ChE-405)	2	1	0	3	3
6.	Process Calculation (ChE-406)	2	1	0	3	3
Total of Theory					**18**	**18**

B. PRACTICAL						
Serial Number	**Subject**	**Contact Hours/Week**				**Credit Points**
		L	**T**	**P**	**Total**	
7.	Fluid Mechanics laboratory (ChE-407)	0	0	3	3	2
8.	Heat Transfer laboratory (ChE-408)	0	0	3	3	2
9.	AUTOCAD drawing (ChE-409)	0	0	3	3	2
10.	Seminar-I (ChE-410)	0	0	3	3	2
Total of Practical					**12**	**8**
Total of Semester					**30**	**26**

5th Semester:

A. THEORY						
Serial Number	**Subject**	**Contact Hours/Week**				**Credit Points**
		L	**T**	**P**	**Total**	
1.	Numerical Methods in Chemical Engineering (ChE-501)	2	1	0	3	2
2.	Material Science (ChE-502)	2	1	0	3	2
3.	Separation Process-I (ChE-503)	2	1	0	3	3
4.	Machine Design (ChE-504)	2	1	0	3	3
5.	Reaction Engineering-I (ChE-505)	2	1	0	3	3
6.	Engineering Thermodynamics (ChE-506)	2	1	0	3	3
Total of Theory					**18**	**16**

B. PRACTICAL						
Serial Number	**Subject**	**Contact Hours/Week**				**Credit Points**
		L	**T**	**P**	**Total**	
7.	Mechanical Operations laboratory (ChE-507)	0	0	3	3	2
8.	Machine Drawing (ChE-508)	0	0	3	3	2
Total of Practical					**6**	**4**
Total of Semester					**24**	**20**

6th Semester:

A. THEORY						
Serial Number	**Subject**	**Contact Hours/Week**				**Credit Points**
		L	**T**	**P**	**Total**	
1.	Separation Process-II (ChE-601)	2	1	0	3	3
2.	Process Control (ChE-602)	2	1	0	3	3
3.	Process Instrumentation (ChE-603)	2	1	0	3	3
4.	Chemical Engineering Thermodynamics (ChE-604)	2	1	0	3	3
5.	Reaction Engineering-II (ChE-605)	2	1	0	3	3
Total of Theory					**15**	**15**

B. PRACTICAL						
Serial Number	**Subject**	**Contact Hours/Week**				**Credit Points**
		L	**T**	**P**	**Total**	
6.	Mass Transfer laboratory (ChE-606)	0	0	3	3	2
7.	Thermodynamics and Reaction Engineering laboratory (ChE-607)	0	0	3	3	2
8.	Process Control and Instrumentation laboratory (ChE-608)	0	0	3	3	2
9.	Process Equipment Design and Drawing-I (ChE-609)	0	0	3	3	2
Total of Practical					**12**	**8**
Total of Semester					**27**	**23**

7th Semester:

A. THEORY						
Serial Number	**Subject**	**Contact Hours/Week**				**Credit Points**
		L	**T**	**P**	**Total**	
1.	Modern Separation Techniques (ChE-701)	2	1	0	3	3
2.	Industrial Economics & Management (ChE-702)	2	1	0	3	3
3.	Environmental Engineering and Process Plant Safety (ChE-703)	2	1	0	3	3
4.	Project Engineering (ChE-704)	2	1	0	3	3
5.	Transport Phenomena-II (ChE-705)	2	1	0	3	3
6.	Modeling Simulation and Optimization (ChE-706)	2	1	0	3	3
Total of Theory					**18**	**18**

B. PRACTICAL						
Serial Number	**Subject**	**Contact Hours/Week**				**Credit Points**
		L	**T**	**P**	**Total**	
7.	Project Work (ChE-707)	0	0	3	3	3
8.	In-Plant training (ChE-708)	0	0	3	3	2
9.	Process Equipment Design and Drawing-II (ChE-709)	0	0	3	3	2
Total of Practical					**9**	**7**
Total of Semester					**27**	**25**

8th Semester:

A. THEORY						
Serial Number	**Subject**	**Contact Hours/Week**				**Credit Points**
		L	**T**	**P**	**Total**	
1.	Polymer Engineering (ChE-801)	2	1	0	3	3
2.	Process Plant Simulation (ChE-802)	2	1	0	3	3
3.	Biotechnology (ChE-803)	2	1	0	3	3
4.	Nanotechnology (ChE-804)	2	1	0	3	2
Total of Theory					**12**	**11**

B. PRACTICAL						
Serial Number	**Subject**	**Contact Hours/Week**				**Credit Points**
		L	**T**	**P**	**Total**	
5.	Process Plant Simulation (ChE-805)	0	0	3	3	2
6.	Project Work (ChE-806)	0	0	3	3	3
7.	General Viva Voce (ChE-807)	0	0	3	3	2
Total of Practical					**9**	**7**
Total of Semester					**21**	**18**

UNIVERSITY OF CALCUTTA
Faculty of Engineering & Technology

A. Regulation for 4-year 8-semester B. Tech. course
(with effect from the academic year 2015 – 2016)

<table>
<tr><td>01</td><td colspan="2">The Faculty of Engineering and Technology, University of Calcutta shall provide instructions leading towards the 4-year, 8-semester B. Tech. degree in different Engineering/ Technology courses as mentioned below:

1. Chemical Engineering
2. Chemical Technology
3. Computer Science and Engineering
4. Electrical Engineering
5. Electronics and Communication Engineering
6. Information Technology
7. Instrumentation Engineering
8. Jute and Fibre Technology
9. Optics and Optoelectronics Engineering
10. Polymer Science and Technology

Each of the courses is of four (4) years duration comprised of eight (8) Semesters, each Semester being of six (6) months' duration.</td></tr>
<tr><td>02</td><td colspan="2">Eligibility for Admission</td></tr>
<tr><td></td><td>(a)</td><td>Category-1: For admission into the FIRST YEAR of 4-Year B.Tech. course in any stream, the candidates must have passed Class XII Examinations in the system of 10+2 under West Bengal Council of Higher Secondary Education or equivalent with Physics, Chemistry, Mathematics securing an average of at least 60% marks (or equivalent grade) in these subjects and cleared West Bengal JEE. The minimum requirement of marks will however not be applicable for admission to Jute and Fibre Technology.</td></tr>
</table>

	(b)	Category-2: For admission of the B.Sc. (Hons.) qualified students into the SECOND YEAR of all B.Tech. courses **except the Jute and Fibre Technology course**, the candidates must have passed B.Sc. Honours with the subjects specified for different courses as given below. The selection will be strictly based on merit as adopted and invoked time to time by University of Calcutta. **Chemical Engineering**: BSc Honours in Chemistry **Chemical Technology**: BSc Honours in Chemistry **Computer Science and Engineering**: BSc Honours in Physics/ Computer Science/Mathematics/ Statistics **Electrical Engineering**: BSc Honours in Physics **Electronics and Communication Engineering:** BSc Honours in Physics/Electronics **Information Technology:** BSc Honours in Computer Science/Physics/Electronics **Instrumentation Engineering**: BSc Honours in Physics **Optics & Optoelectronics Engineering**: B.Sc. Honours in Physics/Electronics **Polymer Science and Technology**: BSc Honours in Chemistry The 'Category-2' students (except Jute & Fiber Tech. course)' must have to attend and pass 'Workshop' and 'Engineering Drawing' subjects additionally arranged in the THIRD/FOURTH Semester curriculum. However, no credit points will be awarded and will not be included for SGPA calculation. In the main mark sheet, mention will be made (at the bottom) that he/she has qualified 'Workshop/Drawing' with grade ----. The course of study for students admitted in the 2nd year will be of 6 Semesters (starting from third Semester) in three academic years. <u>Special Note</u>**: A certain percentage of seats in 4-year B.Tech. course will be set aside for entry of B.Sc. (Hons) qualified students in the second year. This percentage is 50% for the academic year 2015-16, and will be reduced in successive years as may be decided from time to time, but will never be below 20%. This provision, however, will not be applicable for admission to Jute and Fibre Technology.**
	(c)	Category-3: **Jute and Fibre Technology:** For admission into the SECOND YEAR of B.Tech. course in Jute and Fibre Technology, the candidates should qualify JELET for lateral entry, and should have any one of the following degrees: BSc with Physics/Chemistry/Mathematics, BSc in Textile and Clothing/ B.FAD OR Diploma in Mechanical Engineering/ Electrical Engineering/ Chemical Engineering/ Computer Engineering/Ceramic Engineering / Electronics/ Textile Technology/ Handloom Technology/ Apparel and Fashion Technology; Post BSc 2-year PG Diploma in Jute Technology and Management. The course of study for students admitted in the 2nd year will be of 6 Semesters (starting from third Semester) in three academic years.
	(d)	Any seat(s) remaining vacant at the end of Second Semester will be filled up by Category-2 candidates except for Jute and Fibre Technology (who might consider JELET qualified candidates).
03	The award of the said B. Tech. Degrees will be conferred to students who are successful in all of the eight	

	(8) / six (6) Semester examinations.	
04	**Attendance:** A student must attend 75% of the theoretical and laboratory/ practical classes separately in order to appear at Semester examinations.	
05	**Credit based Evaluation**	

(a) The credit based examination system will be followed for all Semester examinations. Each course shall have a certain number of credits assigned to it depending upon the academic load of the course assessed on the basis of *weekly contact hours* of lecture, tutorial and laboratory classes, assignments or field study and/or self study.

Generally, each course shall have an integer number of credits reflecting its weight. The number of credits of a course in a semester shall ordinarily be calculated as under:

(i) Lecture (L)/Tutorial (T): One lecture hour per week shall normally be assigned one credit. One hour of tutorial per week shall be assigned one credit. For determining the credits of a theory course, lectures and tutorials shall be added.

(ii) Practical (P): Three laboratory hours per week shall be assigned two (2) credits. Courses other than Lectures/Tutorials shall be treated as practical courses.

The course credits for each course shall be given as L-T-P. For example, 3-1-0 will mean that it is a lecture based course and has 3 lectures, 1 tutorial, and no practical assigned to it. Similarly, a course with 0-0-3 means that it is a practical course with 3 hours of practical work. Credits will be assigned to seminar, dissertation, project etc. under the practical component.

The 4-year course in any field of study will have subjects covering a total of 190 credits. The Semester wise credit points in various Departments may vary except the first two Semesters which are common to all disciplines (each Semester having a total of 28 credit points).

All examinations on theoretical papers will be on 100 marks while the laboratory/practical papers will carry 50 marks. Credit points of theoretical and practical papers including project work, design, General Viva Voce, plant training, seminar presentation etc. offered by various Departments will be given in Course Structures separately. There will be two components of examinations of theoretical papers: i) Sessional assessment 30% i.e. 30 marks ii) End Semester examination 70% i.e. 70 marks.

(b) The Sessional assessment components of theory papers are:

Serial No	Type of evaluation	Marks
01	Sessional Assessments through Class Test/ Assignments	20
02	Active participation in routine classes	05
03	Overall conduct, attendance, manners, skills etc.	05

(c) Evaluation in Laboratory/ practical papers:

Serial No	Type of evaluation	Marks
01	Report and results	20
02	Viva	20
03	Overall conduct, attendance, discipline, manners, skills etc.	10

	(e)	**Eligibility of success/failure in a Semester Examination:** (i) A student has to secure at least 50% marks i.e. Grade-D in all subjects individually in order to ***pass the examination.*** (ii) If a student fails in some subjects having total credits more than 8, he/she will have to repeat the whole Semester and will not be allowed to continue his studies to the next Semester classes. The student will eventually face a year loss. (iii) If a student fails in some subjects amounting 8 credits or less in a Semester but earns rest of the credits, he/she will be allowed to continue to the next Semester, ***provided that total of such backlog credits within the entire course period of eight semesters is 24 or less***. [Example: In the *first and second* Semesters, one has to earn at least 28 - 8= 20 credits; this may vary in other Semesters] (iv) Supplementary examinations of all papers of present Semester will be arranged soon after the publication of results of regular examinations of the present Semester. If the candidate fails to clear the supplementary paper(s), he / she will get another chance to clear the same in the corresponding semester in the next academic session. (v) **Special supplementary examinations** will be arranged only for *Semester 8* just after the declaration of results of *8^{th} Semester.* (vi) **Additional Semester Examination:** A student who does not appear in some or all the examinations in a Semester on medical grounds or for representing the University in sports, cultural activities, NSS or any other reason considered valid under exceptional circumstances may apply for supplementary examinations to the Vice Chancellor through Head of the Department. These cases will be considered by the university authority and decision will be taken by the Syndicate. (vii) 'Category 1' students will have to utilize all the allowed chances (to pass back papers) **within six years** (i.e. 12 consecutive Semesters) to acquire 190 credits in 8 Semesters. Similarly, 'Category 2' students including lateral entry students of Jute and Fibre Technology will have to utilize all the allowed chances (to pass back papers) within **five years** (i.e. 10 consecutive Semesters) to acquire 134 credits in 6 Semesters. (viii) Eligibility for a Degree: The total credits for all the engineering courses are 190 for a 4-year course. Thus, a student ('Category 1') who could earn 190 credits in 8-Semester course would be eligible for a B.Tech. degree in above mentioned courses. 'Category 2' candidates, however will have to earn a total of 134 credits for the same B.Tech. Degree in 6 (six) Semesters starting from THIRD Semester. (ix) A student failing in any subject should apply to the Secretary, UCSTA through respective Head of the Department for appearing at the supplementary examinations within 07 days of the publication of results.

06

(a) On the basis of total marks (TA+CT+ESE) secured in each paper, **Grade (G)** and **Grade Point (GP)** shall be awarded to a student.

The equivalence between grades, grade points and the percentage marks is given by:

Percentage (%) of marks	**Grade (G)**	**Grade Point (GP)**
≥ 90	Ex	10
89 – 80	A	9
79 - 70	B	8
69 - 60	C	7
59 - 50	D	6
< 50	F	0

(b) Each paper shall carry **Credit (C)** according to the number of hours allotted per week and as indicated in the following table:

Paper/subject	No. of hours/week	Credit (C) assigned
Theoretical	1	1
Tutorial	1	1*
Practical	1	(2/3)*

*: For fractional credit, calculation is to be made by rounding off.

(c) The course structure and the credits assigned to each semester of each course are provided by individual Departments.

(d) The performance of a candidate in n^{th} Semester examination, who earns all the credits of that semester, will be assessed by the '**Semester Grade Point Average' (SGPA), 'S_n'** to be computed as:

$$SGPA\ [S_n\ ] = \frac{\sum_k [C_k\ GP_k]}{\sum_k C_k}$$

where 'k' denotes the number of papers in a particular semester

and $\sum_k C_k$ denotes the total credits of a particular semester and GP_k is the grade point of k^{th} paper.

(e) On completion of the B.Tech. course, the overall performance of a candidate will be assessed by the '**Cumulative Grade Point Average' (CGPA)** to be computed as:

$$CGPA = \frac{\sum_n [C_n\ S_n]}{\sum_n C_n}$$

where, $C_n = \sum_k C_k$ and $\sum_n C_n$ denotes total credits of all the semesters i.e. 190 credits for category-1 and 134 credits for category-2 and 3.

(f) Each theory and each practical paper will be assessed by internal examiner(s). Design, Project, seminar and General Viva Voce examinations will be assessed by a board consisting of at least two (2) internal examiners and at least one (1) external examiner.

07 Candidates appearing in a semester examination shall join classes in the next semester immediately, wherever applicable, after completion of the examination.

08 If a candidate is unable to appear at any of the theory or practical examination(s), he/she will earn zero (0) credit in that paper(s).

09 The CU syndicate shall publish a list of successful candidates of the B. Tech. examination for each of the Semester examinations.

10 At the end of each Semester examination, a Grade-Sheet showing the Semester performance (Semester Grade Sheet) indicated by **SGPA** will be issued to the students. However, SGPA will not be calculated for those candidates who fail to earn all the credits in that Semester.
The Semester Grade Sheet should have the following basic information: The merit list will be prepared on the basis of the total marks obtained.

11 (a) A consolidated Grade-Sheet, showing the overall performance in the B. Tech course indicated by **CGPA**, will be issued only to those successful students who have earned 190 credits for Category-1 and 134 credits for category-2 and 3 in the B. Tech. courses.
The consolidated grade sheet shall consist of two components. The first component will have the information of the final Semester as follows:

Paper	Details of courses	Full Marks	Marks obtained	Credit obtained	Grade	Grade Point	SGPA	Remarks

The second component will have a **summary** of all the semesters having the following basic information:

Semester	Total credit	Credit obtained	SGPA	Full marks	Marks obtained	Cumulative statement	
						Total credit	
						CGPA	
						Full marks (Total)	
						Marks obtained	
						Result	#

The hash (#) in the last row of last column will contain the information regarding the final achievement of the candidate in all the examinations. This box will contain only one (1) of the following three (3) information: '1st Class' / '2nd Class' / 'Failed'.

(b) Candidates securing CGPA at least 7.5 in B. Tech. Examination shall be placed in the First Class and those securing 6.0 or more but less than 7.5 shall be placed in the 'Second Class'. Candidates securing CGPA less than 6.0 shall be declared 'Failed'.

12 The Degree of **"Bachelor of Engineering/Technology"** under the seal of the University shall be awarded to a successful candidate mentioning the grade and class he/she has obtained. The format will be as follows:

UNIVERSITY OF CALCUTTA
LOGO

It is hereby certified that after satisfying all the conditions prescribed by the University

------------*(Name)* Was on the ---th day of ----(month), -----(year)
Duly admitted to the Degree of
Bachelor of ---------- Engineering/Technology
In the ---- Class

Vice Chancellor
Senate House

Additional Regulations of 4 year B. Tech. programme in Chemical Engineering for Departmental papers

Each theoretical paper is of one hundred (100) marks – 70 marks for end-semester examination (of 3 hour duration) and 30 marks for continuous sessional evaluation.

There will be at least two (2) paper-setters (internal) for each theoretical paper for end semester examination and the answer scripts will be examined by at least two examiners (internal). Each paper shall consist of 4 compulsory sections, each dedicated to individual module of respective syllabus. There will be no external paper setter or external examiner for theoretical papers. Theoretical papers will be moderated by a board of moderators consisting of at least 4 departmental faculty members including HOD as the chairman of the Board of moderators.

Examination of Practical Papers (excluding Audit Courses, Seminar, Project Work, In-Plant Training, General Viva-Voce) will be conducted jointly by at least two (2) internal examiners and one (1) external examiner. Examination of Audit Courses (ChE-310 and ChE-311) will be conducted by at least Three (3) internal examiners including HOD (Chairman of the Board).

Seminar (ChE-410)- A candidate shall deliver lecture in an open seminar on a pre-assigned topic during the semester and submit a term-paper (3 copies) which will be assessed by a board consisting of at least 3 internal examiners including the teachers(s) in–charge and HOD (Chairman of the Board). Assessment of the candidates shall be on the basis of the term-paper submitted and performance at the seminar.

Project Work (Thesis-I) (ChE-707) and Thesis-II (ChE-806)- A research problem shall be assigned to a candidate during semester VI. He/She shall work on the assigned problem under the supervision of a teacher in the department in semester VII and semester VIII.

For (ChE-707), two type-written and bound copies of an interim progress on the research problem shall be submitted by the candidate at least 15 days before the commencement of B. Tech. seventh semester examination. Examination of Project Work (Thesis-I) shall be conducted by a number of panels of examiners (internal), duly constituted by the departmental committee. The interim project evaluation is to be done by the supervisor (50%) and the panel excluding the supervisor (50%).

For (ChE-806), two type-written and bound copies of final report on the research problem shall be submitted by the candidate at least 15 days before the commencement of B. Tech. eighth semester examination. Examination of Project Work (Thesis-II) shall be conducted by a number of panels of examiners (internal and external), duly constituted by the departmental committee. The final project evaluation is to be done by the supervisor (50%) and the panel excluding the supervisor (50%).

For In-Plant Training (ChE-708), the candidates shall submit two type-written and bound copies of report with certificate from respective training providers on his/her four to six week In-Plant Training, within one month from date of return from training. Each candidate has to deliver an open presentation based on their training within 15 days from the date of submission of report. A Board consisting of examiners, including teacher(s) in–charge of plant training, one external examiner and HOD as the Chairman of the Board, will jointly conduct the viva-voce examination. The evaluation will be based on report, presentation and viva-voce.

For General viva-voce (ChE-807): Examination shall be conducted by two panels, each consisting of at least one external examiner and three internal examiners.

B. Tech 1st Semester syllabus

A. THEORY

Course HU101- Communicative English

i)Developing Listening Comprehension through Language Lab Device

ii)Conversational Practice , Classroom presentation

iii)Group Discussion , Comprehension from selected stories

iv)Correction of errors, Vocabulary, Grammer: Sentence Structures and Transformation; Active & Passive Voice; Direct & Indirect Narration

Course PH102- Physics-I

i)Viscosity, electricity, surface tension

i)Vectors in particle mechanics: Unit vectors in spherical and cylindrical polar coordinates, Conservative vector fields and their potential functions - gravitational and electrostatic examples, Gradient of a scalar field, Equipotentials, States of equilibrium, Work and Energy, Conservation of energy, Motion in a central field and conservation of angular momentum.

ii) Simple harmonic motion: Composition of simple harmonic motion, Forced vibration and resonance, Wave equation in one dimension and travelling wave solution, Standing waves, Wave velocity and group velocity.

iii)Wave Optics : Diffraction- Fresnel and Fraunhofer class, theory of plane transmission grating, missing orders, resolving power. Polarization – Double refraction, ordinary and extra ordinary rays, polaroids, linearly, circularly and elliptically polarized light, half wave and quarter wave plates.

Fiber Optics : Core and cladding, step index and graded index fibers, acceptance angle, numerical aperture, losses, applications.

iv)Acoustics: Propagation of sound waves, acoustics of buildings

Course CH103- Chemistry-I

Chemical Bonding :Valence bond theory, Molecular orbital theory, characteristics of different bonds

Structure and Reactivity of Organic Molecules : Electronic influencing effects, aromaticity, elementary idea of stereochemistry, mechanisms of some selected organic reactions.

Coordination Chemistry : Coordination numbers, Chelate effect, Coordination complexes and application, Bio-inorganic chemistry : Metal ions in Biological systems., environmental aspects of Metals, NOx, CO, CO2.

Organic Reaction Mechanism : Mechanisms of selected organic, bio-organic, polymerization and catalytic reactions.

Stereochemistry of Carbon Compounds : Selected Organic Compounds : Natural products and Biomolecules (Amino acids/nucleic acids/proteins).

Course MA104- Engineering Mathematics-I

Differential calculus: Differential, Successive differentiation, Leibnitz Rule. Rolles Theorem. L'Hospital's Rule. Taylor's theorem with Lagrange's and Cauchy's forms of remainders, Taylor's and Maclaurin's series, expansion of functions, curvature, asymptotes. Maxima and minima of functions of a single variable Curvature, concavity. Convexity, Points of inflexion.

Partial derivatives, differentials and total derivatives of composite functions. Euler's theorem on homogeneous functions. Taylor's theorem for a function of two variables. Maxima and minima of a function of several variables. Lagrange's method of undetermined multipliers.

Infinite Series : Geometric series, Comparison test, p-series, D'Alembert's Ratio Test, Cauchy's Root Test, Rabbe's test, Gauss' test, Power series, radius of convergence.

Int. Calculus: Properties of definite integrals. Quadrature, Rectification, Numerical integration by Trapezoidal Rule and Simpson's Rule. Double integral, change of order of integration, change of variables, determination of area, volume, moment of inertia, centroid.

Vector calculus: Brief review of vector algebra, scalar and vector triple products, Directional derivatives, gradient, divergence, curl, statements of Gauss's theorem, Green's theorem, Stokes' theorem, examples.

Course EE105- Electrical Technology

D.C. Circuits: Kirchhoff's laws, Maxwell's loop current method, star-delta transformation. Network theorems – Superposition theorem, Thevenin's theorem, Norton's theorem, Maximum power transfer theorem.

Magnetic Circuit: MMF, Flux ,Reluctance. B-H Loop. Hysteresis and Eddy current loss. Magnetic circuit analysis with air gap.

A.C. Fundamentals : Sinusoidal quantities, phase & phase difference, average & RMS values, form factor & peak factor, concept of Sinusoids, impedance & admittance, power & power factor,

A.C. Circuits: Series and parallel R-L-C Circuits, Form Factor, Peak. Factor. Phasor concept of Sinusoids. Impedance and Admittance. Power, Power Factor, V A, V AR.
Balanced 3-phase: 3-phase AC balanced circuits. Phase-sequence, Star and Delta connections.

Power Measurement: Wattmeter circuit connection. Power Measurment by two wattmeter methods in 3phase system.

DC Machines: Construction and general principle of operation. Generator EMF Equation. Field connection ,shunt series and compound. Generator characteristics. Motor-equation and general operation. starting and speed control, torque -speed curve. 1-PhaseTransformer: Construction. EMF equation. Phasor diagram. Equivalent circuits. Losses and Efficiency. Open circuit and Short circuit test.

3-Phase Induction Machine: Types of induction machines. Rotating magnetic field, slip ,torque equation, torquespeed curve.DOL starting and reduced voltage starting.

Course CS106- Computer Programming and Data Structure

Introduction to digital computers; introduction to programming – variables, assignments; expressions; input/output; conditionals and branching; iteration; functions; recursion; arrays; introduction to pointers; structures; introduction to data-procedure encapsulation; dynamic allocation; linked structures; introduction to data structures – stacks and queues; time and space requirements.

B. PRACTICAL

Language Lab- HU107

i)Honing 'Listening Skill' and its sub skills through Language Lab Audio device;
ii)Honing 'Speaking Skill' and its sub skills
iii)Linguistic/Paralinguistic features (Pronunciation/Phonetics/Voice modulation/
Stress/ Intonation/ Pitch &Accent) of connected speech
iv)Introducing 'Group Discussion' through audio –Visual input and acquainting them with key
strategies for success
v)Honing 'Conversation Skill' using Language Lab Audio –Visual input; Conversational Practice Sessions
'Group Discussion' through audio –Visual input and acquainting them with key strategies for success;
vi)G D Practice Sessions for helping them internalize basic Principles (turn- taking, creative intervention, by using correct body language, courtesies & other soft skills) of GD;
vii)Honing 'Reading Skills' and its sub skills using Visual / Graphics/Diagrams /Chart Display/Technical/Non Technical Passages;

viii)Learning Global / Contextual / Inferential Comprehension

Physics-I Lab PH108
Determination of:
i)Modulus of elasticity
ii)Coefficient of viscosity by Stoke's law
iii)Refractive index of transparent liquid by travelling microscope
iv)Moment of inertia
v)Surface tension of a liquid
vi)Coefficient of friction

Chemistry-I Lab PH109
1. Titrations: acid-base, redox, complexometric, conductometric
2. To determine calcium and magnesium hardness of a given water sample separately.
3. To determine the value of the rate constant for the hydrolysis of ethyl acetate catalyzed by hydrochloric acid.
4. Determination of partition coefficient of acetic acid between n-butanol and water
5. Determination of dissolved oxygen present in a given water sample.
6. To determine chloride ion in a given water sample by Argentometric method

Electrical Engineering Lab- EE110
i)Familiarization experiments(Variac,Potential divider, MCV.MIV,MCA,MIA &Wattmeter)
ii)Study of AC series R-L-C series circuit
iii) Characteristics of Tungsten and Carbon filament lamps
iv)No load test on Single phase Transformer
v)Experiments on DC circuits and DC machines
v)Calibration of voltmeter, ammeter and energy meter
vii)Experiments on magnetic circuit principles

Computer Lab- CS111
i)Introduction to: LAN, Server-Client, Microsoft Windows and Linux Platforms, Common OS Commands, Editor, Compiler.
ii) Expression evaluation
iii) Conditionals and branching
iv)Iteration
v)Functions
vi)Recursion
vii) Arrays
viii)Structures
ix) Linked lists
x) Data structures

B. Tech 2nd Semester syllabus

A. THEORY

Course HU201-Sociology
i)Sociology: Nature and scope of Sociology - Sociology and other Social Sciences - Sociological Perspectives and explanation of Social issues
ii) Society and Technology: Impact of Technology on the Society - A case study

iii)Social Stratification: Systems of Social Stratification - determinants of Social Stratification - Functionalist, Conflict and Elitist perspectives on Social Stratification
iv)Work: Meaning and experience of work: Post industrial society- Post-Fordism and the Flexible Firm
v)Development - Conceptions of and approaches to development - The Roles of State and the Market in the Development
vi) Globalization: The concept of globalization - globalization and the nation state - Development and globalization in post colonial times.
vii) Industrial Policy and Technological change in India - The nature and Role of the State in India
viii)Technology Transfer: The Concept and Types of Technology Transfer-Dynamics of Technology Transfer
ixTechnology Assessment: The Concept - Steps involved in Technology Assessment 10. Environment: Sociological Perspectives on Environment - Environmental Tradition and values in ancient India 11.The Development of Management: Scientific Management - Organic Organization - Net Work organization - Post modern Organization - Debureaucratization - Transformation of Management 12. Technological Problems and the Modern Society: Selected Case Studies - Electric Power Crisis, Industrial and/or Environmental Disaster, or Nuclear Accident.

Course PH202- Physics-II

i)Nuclear Physics : Q-value, exoergic and endoergic reaction, threshold energy for endoergic reaction, packing fraction and binding energy, semi empirical mass formula, principle of reactors(qualitative)

ii) Kinetic theory of gases: Expression for pressure, Significance of temperature, Deduction of gas laws, Qualitative idea of (i) Maxwell's velocity distribution. (ii) degrees of freedom and equipartition of energy, Specific heat of gases at constant volume and constant pressure.

iii)Thermodynamics: Carnot cycle, principle of steam engine and refrigeration, entropy, enthalpy, free energy, conduction of heat.

iv)Quantum Mechanics: Planck's radiation law, Compton effect, wavelength shift and recoil of electrons; de Broglie hypothesis, Schrodinger time dependent and time independent equation, application to free particle and particle in a box.

Course CH203- Chemistry-II

Polymeric Materials: Elementary ideas of Polymer chemistry, thermosetting and thermoplastics, Nylon 6, Nylon 66, polyester, SBR, biopolymers, proteins.

Analytical chemistry: Principles of spectroscopic techniques in Chemistry, Experimental methods of structure determination using UV-VIS, IR and 1H-NMR spectroscopy, Chromatographic methods of separation and analysis, potentometric and amperometric methods of analysis

Electrochemical Systems : Electrochemical cells and EMF, Applications of EMF measurements: Thermodynamic data, activity coefficients, solubility product and pH, corrosion.

Kinetics of Chemical Reactions : Reversible, consecutive and parallel reactions, steady state approximation, chain reactions, photochemical kinetics.

Course MA204- Mathematics-II

Linear dependence of vectors, basis, linear transformations, rank and inverse of a matrix, solution of algebraic equations. Eigenvalues and eigenvectors, Hermitian and skew Hermitian matrices.
Convergence of improper integrals, tests of convergence, Beta and Gamma functions elementary properties, differentiation under integral sign, differentiation of integrals with variable limits.
Rectification, double and triple integrals, computations of surfaces and volumes, Jacobians of transformations, integrals dependent on parameters applications. Scalar and vector fields, level surfaces, directional derivative, Gradient, Curl, Divergence, Laplacian, line and surface integrals, theorems of Green. Gauss and Stokes, orthogonal curvilinear coordinates.

Finite differences, Newton’s forward and backward interpolation formulae, Central difference interpolation. Trapezoidal rule and Simpson’s 1/3rd rule of integration. Solution of polynomial and transcendental equations, bisection method, Newton Raphson method and Regula falsi method.

Course CS205- Basic Electronics

Introduction to electronics and electronic systems, Sem PN junction, V- I characteristics, break down mechanism, Zener diode and their application, half and full wave rectifiers, clipper, clampers, Semiconductor and devices like diodes, BJT, FET, MOSFET, Rectifier and Filters, Transistor biasing. Bipolar junction transistors, characteristics, Early effect, biasing, different mode of operation, use of BJT as amplifier, single stage amplifier, feedback amplifier.
Small signal transistor amplifiers, Operational amplifier and its application, Feedback and Oscillators, Digital circuit and combinational logic, Sequential logic and flip-flops, ADC & DAC, Data acquisition systems,

Course ME206- Engineering Mechanics

Statics: Basic concepts, Scalars and vectors, parallelogram law, Lami’s theorem, Application of Vectors in Mechanics, Force Systems in two Dimensions; Moments and Couples; Resultants and Components in concurrent coplanar forces, parallel forces in a plane, Free Body Diagram Concept, Fundamentals of Friction, Limiting angle of Friction, Centroid, Moment of Inertia , Plane Trusses; Frames and Machines. Applications to wedges.
Dynamics: Introduction to vector calculus, Definition of vectors in Dynamics, Two dimensional article Kinematics in Rectangular Co-ordinates, Cylindrical Co-ordinates and in terms of Normal and Tangential Components;
Rectilinear Motion, Curvilinear motion of particle and description of different coordinate systems, Kinetics, Newton's Law and D' Alembert's principle,and application to rectilinear and curvilinear motion, constrained motion, Energy and Momentum methods. Linear Impulse ; Angular Impulse and Momentum – Central Force Motion.

B. PRACTICAL

Physics-II Lab: PH207
Determination of :
i)Wavelength of light by grating
ii)Focal length of concave mirror
iii)Optical activity of polarimeter
iv)Resistances in series and parallel combinations
v)Mutual inductance
vi)Voltage gain of amplifier

Chemistry-II Lab: CH208
i)Estimation of Copper in brass by iodometry
ii)Estimation of iron in cement by dichromatometry
iii)Determination of different organic groups known and unknown
iv)Preparation of emulsion and study of its stability
v)Determination of hardness of water
vi)Determination of fats and oils

Electronics Lab- ET209
i)Study the Multi-meter
ii)Study of Cathode Ray oscilloscope
iii)V-I Characteristics of P-N junction Diode

iv)Rectifier Circuit(H.W./F.W./B.R) with different filter arrangement
v)Digital logic trainer
vii) Tenor characteristics

Workshop Pracice- ME210
Fitting Shop **:** Introduction to different hand tools , equipment and measuring devices , sawing, filing & drilling. Practice Jobs on MS Plate, making of nuts and bolts.
Carpentry Shop **:** Specification of wood and wood products, Introduction to Tools and equipment, different wood joints. Practice jobs on Dove Tail Notch or Dovetail Bridle Joint or Cross Joint
Forging Shop **:** Arc welding practice, Demonstration of forging a Octagonal Chisel, Sheet metal funnel making

Engineering Drawing- ME211
i)Lettering, Numbering, Dimensioning
ii)Plane Scales, Diagonal Scales & Venier Scales
iii)Curves – Parabola, Ellipse, Involutes
iv)Projection of Points, Lines, Surfaces, Solids and Section of solids.
v)Orthographic and Isometric projection
vi) Introduction to CAD tools – basics; Introduction of Development and Intersection of surfaces.

B. Tech 3rd Semester syllabus

A. THEORY

Fluid Mechanics (ChE-301)

Module-I **(No. of classes: 10)**
Fundamentals: Definition of fluid; scope of fluid mechanics; basic concept of system and control volume; methods of description: Lagrangian and Eulerian; fluid as continuum; velocity field and dimensionality of flow; flow representations; stress as tensor and stress field; concept of viscosity; Newtonian and non-Newtonian fluids, descriptions and classifications of fluid motion; basic formalism of boundary layer flow.
Fluid Statics: Fundamental equation of fluid statics; manometer calculations; hydraulic force on submerged surface; fluids in rigid body motion.

Module-II: **(No. of classes: 10)**
Conservation equations: Conservation equations in integral form for a control volume; Reynolds Transport Theorem and related application; Bernoulli's equation as an outcome of energy balance; Introduction to differential analysis of fluid motion: continuity equation, stream function; acceleration of a fluid particle; fluid rotation and deformation; force balance over a differential volume and Navier-Stokes equation.
Internal incompressible viscous flow: flows in pipes and ducts; stress distribution; velocity profile equation; momentum and kinetic energy correction factor, concept of head loss in details; different piping network problems.

Module-III: **(No. of classes: 10)**
Flow measurement: Primary and secondary flow measuring devices, calibration; different internal restriction meters: orifice meter and venturimeter; Area meters: rotameter; target meter and turbine meter; Point velocity measurement device: pitot tube; LDA and thermal anemometers; open channel flow measurements: Manning's equation.
External incompressible flow: Concept of boundary layer; boundary layer thickness; displacement thickness, momentum thickness, kinetic energy thickness; Blasius solution of boundary layer (laminar); von-Karman momentum integral equation; Basic concept of turbulent flow and turbulent boundary layer.

Module-IV: **(No. of classes: 10)**
Pumps: Classification of fluid machines; Centrifugal pumps: Basic principle and construction details; different types of impeller and volutes; Euler turbo machine equation; net head developed by a pump; manometric efficiency; losses in centrifugal pumps; vane loading and slip factor; head-discharge and power-discharge characteristics of a centrifugal pump; principle of similarity and dimensional analysis in rotodynamic machines;

concept of specific speed; matching of pump and system; pumps in series and parallel; Muschel iso-efficiency plot; cavitation and NPSH; Positive displacement pumps: classifications; reciprocating pump: rate of delivery; slip factor; head-discharge characteristics: indicator diagram with and without inertial and friction head; multi-cylinder pumps; Air vessels; Rotary positive displacement pumps: gear, lobe, cam, screw and vanes: applications.

Books/References:

Text:

1. R.W. Fox, P.J. Pritchard and A.T. McDonald, Introduction to Fluid Mechanics, Wieley-India.

Reference:

1. J.O. Wilkes, Fluid Mechanics for Chemical Engineers, Prentice Hall.
2. P.K. Kundu and I.M. Cohen, Fluid Mechanics, Academic Press.
3. J. F. Douglas, J. Gasiorek and J. Swaffield, Fluid Mechanics, Pearson/Prentice Hall.

Heat Transfer-I (ChE-302)

Module-I **(No. of classes: 10)**

Introduction: Mechanism of heat transfer in different materials; Various modes of heat transfer.

Heat transfer by conduction: Fourier's Law; heat conduction in isotropic; anisotropic and orthotropic conduction; General equation for conduction; Thermal conductivity; Compound resistance in series; Steady state heat conduction in hollow cylindrical and spherical body with uniform heat generation and without heat generation; Critical thickness of insulation; Steady state heat transfer analysis through extended surface; Unsteady state heat conduction with and without heat generation; Lumped and distributed models: Biot and Fourier number, Hessler chart.

Module-II: **(No. of classes: 10)**

Introduction: Thermal boundary layer; thickness relation to hydrodynamic boundary layer through Prandtl number; differential energy balance equation for thermal boundary layer: viscous dissipation and Eckert number.

Forced convection: Forced convection in laminar and turbulent flow: Dittus-Boelter equation, Sieder-Tate equation; Overall heat transfer coefficient: U_C and U_D; Wilson plot; Momentum and heat transfer analogies.

Module-III: **(No. of classes: 10)**

Free convection: concept; free convection from hot vertical plate or cylinder, hot horizontal plate or cylinder, rough plate; Coefficient of thermal expansion, Grashof and Rayleigh number; Corrections of free convection in case of laminar flow; coupled effects of forced and free convection.

Heat transfer of fluids with phase change: Dropwise and film condensation; Film condensation on vertical surface; Nusselt equations for vertical and horizontal surfaces; Condensation number; Promotion of condensation: Effects of noncondensables and surface geometry; Boiling: pool boiling and flow boiling phenomena; Analysis of boiling curve.

Module-IV: **(No. of classes: 10)**

Introduction: Absorptivity, Reflectivity and Transmissivity; Black and gray body; Emissivity of a surface; Monochromatic and total radiating power.

Black body radiation: Plank's distribution law; Wein's displacement law; Kirchhoff's Law; Stefan-Boltzmann's law; Concept of intensity: spectral and total, View Factor, summability and reciprocity relation; view factor algebra; Hottel cross string method.

Concept of gray body: Radiation between gray surfaces; Radiosity and Irradiation, idea of surface and space resistances, reradiating surfaces; Network method for radiation exchange between gray bodies; Radiation intercepted by a shield.

Books/References

Text

1. B. K. Dutta, Heat Transfer: Principles and Applications, Prentice Hall India.

References

1. J. P. Holman, Heat Transfer, Mc-Graw Hill.
2. A. J. Chapman, Heat Transfer, Macmillan.

3. M. N. Ozisik, Heat Transfer: A basic Approach, Mc-Graw Hill.
4. W.H. MacAdams, Heat transmission, Mc-Graw Hill.
5. F.K. Incropera and D.P. DeWitt and T. Bergman, Introduction to Heat Transfer, Wiley.

Introduction to Chemical Engineering (ChE-303)

Module-I: **(No. of classes: 10)**
Role of a Chemical Engineer: Introduction; Chemical Engineering in everyday life, scaling up or down; application in portable devices; Challenges in the petroleum sector: Operational flexibility in refineries, Euro Norms and Bharat Stage norms; Versatility of the discipline: Novel material development, energy generation, semiconductor processing, biomedical engineering and biotechnology, interfacial science, environmental engineering, food processing and nanotechnology.

Module-II: **(No. of classes: 10)**
Modern Chemical Engineering Plants: Introduction; Idea of unit operations and unit processes; Batch processing with examples, such as paint manufacture, antibiotic production etc; Transition from batch to continuous processing: Case study of sulphuric acid, soda ash etc; Implications of coupling and recycling: start-up and shutdown.
Basic elements of Chemical Engineering: Momentum, heat and mass transfer; importance of thermodynamics, reaction engineering, importance of process control and instrumentation.

Module-III: **(No. of classes: 10)**
Application of Basic Science: Introduction; Conservation equations and rate laws: applications in closed and open systems; Lumped and distributed parameter approach: macroscopic and microscopic control volume analysis; stability issues in a system.
Empirical and semi-empirical approaches: Dimensional analysis: units and dimension; unit conversion; Rayleigh and Buckingham method, standard dimensionless groups and their importance in chemical engineering, similarity relations and scale-up; regression analysis: importance, least-square method, log-log and semi-log plots; Nomography.

Module-IV: **(No. of classes: 10)**
Material and energy balances: Idea of flow sheets, steps of material balance calculations; recycle and purging; case studies of material balance with and without chemical reactions; Energy balance: fundamental energy balance equation; reacting systems: heat of reaction, effect of temperature on heat of reaction; steps of energy balance calculations; case studies of energy balance.

Books/References:
Text:
1. S. Pushpavanam, Introduction to Chemical Engineering, PHI.
2. S.K. Ghosal, S.K. Sanyal, S. Datta, Introduction to Chemical Engineering, Tata McGraw-Hill.
Reference:
1. O.M. Himmelblau, Basic Principles and Calculations in Chemical Engineering, 4th ed., Prentice-Hall.
2. W.L. McCabe, J.C. Smith and P. Harriot, Unit Operations of Chemical Engineering, McGraw-Hill.
3. R.H. Perry and D. Green, Perry's Chemical Engineer's Handbook, McGraw-Hill.

Energy Resources and Utilization (ChE-304)

Module-I **(No. of classes: 10)**
Introduction: Conventional and non-conventional energy resources and reserves; Energy production and consumption pattern in India and in the World.
Solid Fuels: Coal: Origin and Composition; Rank of coal, Coal classification (Peat, Lignite, Sub-Bituminous coal, Bituminous coal, Anthracite coal, Cannel and Bog Head coal); Proximate and Ultimate analyses; Calorific value; Washability tests; Cleaning, Washing and Storage; Coal carbonization (Low-, Medium- and High-Temperature Carbonization); Gas Retorts: Horizontal and Vertical types; Detailed process and structural descriptions of Beehive and Byproduct recovery types of Coke Ovens, Details of byproduct recovery. **Biomass as solid fuel:** Wood and Charcoal, Wood Waste, Bagasse, Agricultural Wastes.

Module-II **(No. of classes: 10)**

Liquid Fuels: Liquid fuels from Petroleum Crude Oil: Origin, composition and characterization; Overview of Indian petroleum crude oil processing (refining) operation for production of liquid fuels: primary and secondary refining; Properties and testing of petroleum and petroleum products – Specific Gravity, Viscosity, Flash Point, Fire Point, Pour Point and Cloud Point, Smoke Point and Char Value, Carbon Residue, Sulfur Content, Moisture, Ash, Octane Number, Cetane Number, Aniline Point and Diesel Index etc. **Liquid fuels from Coal and Coal Tar Fractions:** Bergius Process, Fischer-Tropsh Process; H-Coal Process. **Other Synthetic Liquid fuels:** Motor Benzol, Gasohol, Power Alcohol, Shale Oil.

Module-III **(No. of classes: 10)**

Gaseous Fuels: Types of gaseous fuels based on occurrence, production and calorific values; Wobbe Index; **LPG from Natural Gas:** Origin of Natural gas and processing of raw natural gas for producing LPG; **Coal Gasification:** Producer Gas, Water Gas, Carburetted Water Gas, Lurgi Gasification, Winkler's Process, Koppers-Totzek Gasification; Cleaning and purification after gasification. **Underground Gasification of Coal:** Fundamentals, methods, advantages and disadvantages; **Coal Bed Methane (CBM):** CBM Resources, CBM Recovery with special reference to environmental issues, Enhanced CBM Recovery, uses; **Other Gaseous Fuels:** Oil gasification; Blast Furnace Gas; Coke Oven Gas; acetylene and hydrogen; **Combustion calculation.**

Module-IV **(No. of classes: 10)**

Non-conventional Energy Sources: Solar Energy: Different types of solar collectors; Measurement of solar flux; Solar energy utilization - room heating, water heating, solar pond, solar Photovoltaic system and silicon technology; **Geothermal Energy and Wind Energy:** Utilization of geo thermal energy; operating principles of different types of wind energy mills; Tidal energy from ocean. **Bio Gas:** Principles and operation of aerobic and anaerobic digestors, Biogas generation with special reference to waste utilization; **Nuclear Energy:** Sources of nuclear fuels; Indian scenario; Power generation by nuclear reactors (Breeder reactor), reaction and operation; **Fuel cells:** Introduction; operating principles; different types of fuel cells; construction.

Books/References:

Text:

1. Samir Sarkar. Fuels and Combustion. University Press (India) Private Limited, 3e, 2009.
2. O.P.Gupta. Elements of Fuels, Furnace and Refractories. Khanna Publishers. 2013

Reference:

1. S.P.Sharma and Chander Mohan. Fuels and Combustion. Tata McGraw-Hill, New Delhi, 1987.
2. G.D.Rai. Non-conventional Energy Sources. Khanna Publishers. 2011.
3. D.S.Chauhan and S.K.Srivastava. Non-Conventional Energy Resources. New Age International (P) Publishers. 3e, 2013.
4. D.Mukherjee and S.Chakrabarti. Fundamentals of Renewable Energy Systems. New Age International (P) Publishers. 1e, 2011.
5. S.A. Kalogirou, Solar Energy Engineering Processes and Systems, Elsevier.
6. S. P. Sukhatme, Solar Energy, Tata McGraw-Hill.
7. S.T. Revankar and P. Majumdar, Fuel Cells: Principles, Design, and Analysis, CRC Press.

Chemical Engineering Mathematics-I (ChE-305)

Module-I: **(No. of classes: 10)**

Systems of ordinary differential equations (ODEs): Basics of matrices and vectors; systems of ODEs as state models: case studies; theory of the system of ODEs; constant coefficient system, phase plane method; criteria of critical points and stability; qualitative methods for nonlinear systems; non-homogeneous linear systems of ODEs.

Module-II: **(No. of classes: 10)**

Series solutions of ordinary differential equations (ODEs): Power series method: theory, convergence interval and radius of convergence, existence of power series solution, analytical function and singular points, Frobenius method: indicial equation, recurrence relation and solution; Lengendre's equation and Legendre polynomial; Bessel's equation and Bessel functions of first and second kind; Stum-Liouville functions: eigenvectors and eigenvalues, orhtogonality of eigen functions.

Module-III: **(No. of classes: 10)**

Fourier Analysis: Fourier series; functions of arbitrary period; even and odd functions: half range expansion; application in forced oscillation; approximations by trigonometric polynomials; Fourier integral; Fourier cosine and sine transforms; Fourier transforms; discrete and fast Fourier transforms.

Module-IV: **(No. of classes: 10)**
Partial differential equations (PDEs): Basic concepts; modeling: vibrating string, wave equation; solution by separating variables; use of Fourier series; D'Alembert's solution of the wave equation: characteristics; heat equation: solution by Fourier series; heat equation: solution by Fourier integrals and transforms; modeling: membrane, two dimensional wave equation; rectangular membrane: double Fourier series; Laplace equation in cylindrical and spherical coordinates, potential; solution of PDE by Laplace transforms.

Books/References:
Text:
1. E. Kreyszig, Advanced Engineering Mathematics, Wieley-India.
Reference:
1. B.S. Grewal and J.S. Grewal, Higher Engineering Mathematics, Khanna Publishers.
2. J. Bird, Higher Engineering Mathematics, Elsevier.
3. R.G. Rice and D.D. Do, Applied mathematics and modeling for Chemical Engineers, Wiley.
4. B. K. Dutta, Mathematical Methods in Chemical and Biological Engineering, CRC Press.

Strength of Materials (ChE-306)

Module-I: **(No. of classes: 10)**
Tension and Compression: Stress, Strain, Elasticity, Elastic limit, Hooke's Law, Young's Modulus, Stress-Strain diagram: Working stress; Classification of materials: Elastic, Plastic, Ductile, Brittle; Stresses and Strains in bars of varying cross sections, Stresses and Strains in statically indeterminate structures, Limit design, Strain energy in tension and compression, Stress concentration in tension and compression members, Thermal stresses and strains.
Tests for mechanical properties of materials: Tensile test, Compression test, Impact test, Fatigue test, Fatigue and stress concentration, Fatigue under compressive stress, Physical properties of materials at high temperatures.

Module-II: **(No. of classes: 10)**
Biaxial Tension and Compression: Biaxial stress, Stresses in thin-walled pressure vessels, Mohr's circle, Riveted and welded joints in pressure vessels,
Shear and Torsion: Stress, Modulus of Rigidity, Torsion of a circular shaft, Strain energy in Shear and Torsion, Torsion of thin-walled tubes, Shaft of rectangular section, Stresses in shaft due to combined bending and torsion, Strain energy and impact loading.

Module-III: **(No. of classes: 10)**
Stresses in beams: Shear force and bending moment, Shear and bending moment diagrams, Principal stresses in beams, Bending stresses in beams, Shear stress in bending, Plastic bending of beams, Beams of two materials, Reinforce concrete beam, Bending of beams of arbitrary cross section, Bending stresses in curved beams, Bending stresses in composite beams, Deflection of beams.

Cantilever: Cantilever with a point load at its free end, Cantilever with a uniformly distributed load, Cantilever with a gradually varying load.

Module-IV: **(No. of classes: 10)**
Column and Strut: Eccentric loading, Euler's column formula and its limitations, Empirical formula. Representation of imperfection by equivalent eccentricity

Thin cylindrical and Spherical Shells: Stresses, Change in dimension and volume due to internal pressure, failure, Design.

Thin Spherical Shells: Change in diameter and volume due to internal pressure

Thick Cylindrical and Spherical Shells: Stresses in single shell and in compound shells

Books/References
Text

1. S. Timoshenko and D. H. Young, Elements of Strength of Materials, van Nostrand.

References

1. R. S. Khurmi, Strength of Materials, S, Chand.

B. PRACTICAL

Computer Programming-I (ChE-307)

Learning FORTRAN-90: Introduction; algorithm development and program design: Basic programming tools, sequential execution of instructions, branching operation, the select case structure, loops, debugging tips, representation of algorithm through flowchart; Input and Output: List directed input and output, the format statement, edit descriptions, decision-based control structures: conditional statements and constructs, the block-IF structure, the ELSE IF construct; Loops: the counted loop, nesting and the DO loop, the conditional DO loop, EXIT and CYCLE statements; Subscripted variables and arrays: the need for arrays, the declaration statement, two-dimensional and higher-order arrays, input and output of arrays, formatting of array output, the parameter and data statement; Subprograms: concept of modularity, the function subprogram, subroutines, the COMMON statement, applications of subprogram in solving engineering and science problems; Data files: types of files, opening a sequential files, closing a sequential file, sequential file positioning statement, direct access files; Graphics in FORTRAN 90.

Instrumental Method of Analysis (ChE-308)

At least 8 (eight) experiments are to be performed

1. Development of Calibration Curve of an Organic compound followed by estimation of its unknown concentration using UV-VIS Spectrophotometer.
2. Identification of functional groups of organic/inorganic compounds using FTIR.
3. Determination of particle size using Malvern Particle Size Analyzer.
4. Separation of Mixture of Lipids by Colum Chromatography.
5. Estimation of Iron content in Cement by Colorimeter Method.
6. Determination of Turbidity of Water using NepheloTurbidity Meter.
7. Determination of Viscosity of a Non-Newtonian Fluid by Rheometer.
8. Determination of Total Organic Carbon of organic compounds using TOC Analyzer.
9. Estimation of an organic mixture (benzene & toluene) by Abbe refractometer.
10. Determination of any optically active substance in the presence of non-active species by a polarimeter.
11. Demonstration of working of HPLC.
12. Demonstration of working of AAS.
13. Demonstration of working of BET Analyser.

Fuel Technology Laboratory (ChE-309)

At least 8 (eight) experiments are to be performed

1. Determination of moisture content of Coal/Coke.
2. Determination of volatile matter and ash content of Coal/Coke.
3. Atmospheric Distillation of a petroleum product.
4. Determination of Flash Point & Fire Point of an oil by Abel apparatus.
5. Determination of Flash Point & Fire Point of an oil by closed-cup Pensky-Martin apparatus.
6. Determination of kinematic viscosity of oil by Redwood Viscometer.
7. Determination of viscosity by Ostwald Viscometer.
8. Determination of carbon residue of fuel oil.

9. Determination of aniline point of a fuel oil.
10. Determination of vapour pressure of petroleum product using Reid apparatus.
11. Determination of calorific value of solid and liquid fuel by Bomb Calorimeter.
12. Determination of calorific value of gaseous fuel by Junker's apparatus.
13. Determination of moisture content of fuel oil by Dean & Stark apparatus.
14. Analysis of a gaseous mixture by Orsat apparatus.
15. Determination of Smoke point of kerosene.

Workshop Practice (ChE-310) (audit course)

Metal Joining: Manual metal arc welding technique and equipment, AC and DC welding, electrodes, constituents and functions of electrodes, welding positions, types of weld joint.

Bench work and Fitting: Tools for laying out, chisels, files, hammers, hand hacksaw, their specifications and uses.

Metal Cutting: Introduction to machining and common machining operations, Cutting tool materials, geometry of cutting tool, cutting fluid, Definition of machine tools, specification and block diagram of lathe, shaper, milling and drilling machine and job work. Common lathe operations, such as turning, facing and chamfering and parting. Difference between drilling and boring, use of measuring instruments like micrometer/vernier caliper.

Books/References
Text
1. O.P. Khanna, "Workshop Technology" Dhanpat Rai Publications.
References
1. M.L. Begeman and B.H. Amstead, "Manufacturing Process" John Wiley.
2. W.A.J. Chapman and E. Arnold, "Workshop Technology" Vol. 1, 2 & .3
3. S.K.Hajra Choudhury, "Elements of Workshop Technology" Media Promoters of Publishers.

Engineering Drawing (ChE-311) (audit course)

Basics: lines, lettering and dimensioning; **Scales:** plain and diagonal scales; **Geometrical construction and curves:** cycloid, involute, Archimedean spiral; **Projection:** projection of points, lines, surfaces: orthographic projection-first angle and third angle projection, projection of solids: cube, pyramid, prism, cylinder, cone, frustums; **Isometric view and isometric projection:** prism, pyramid, cylinder, cone and examples of simple solid objects/models; **Sectional views of solids:** true shape of a section; examples of threads and nut-bolt.

Books/References
Text
1. Bhatt N.D. "Elementary Engineering Drawing", Anand'98.
References
1. French and Vireck, "The Fundamental of Engineering Drawing and Graphic Technology", McGraw Hill, 4th Ed.,1978.
2. 'IS:696 (1972) Code of Practice for General Engineering Drawing", ISI New Delhi.
3. P.S. Gill, "A Text Book of Machine Drawing", Katson Publishing House.
4. Giesecke, Mitchell, Spener, Hill and Dygon, "Technical Drawing", McMillan & Co., 7th Ed.

B. Tech 4th Semester syllabus

A. THEORY

Transport Phenomena-I (ChE-401)

Module-I: **(No. of classes: 10)**
Introductory concepts of transport phenomena: Flux gradient and Transport properties; Newton's law of viscosity revisited with Fourier's law of heat conduction, Fick's law of diffusion and Ohm's law of charge transport; Driving force-resistance concept; Flux laws in three dimensions.
One-dimensional diffusive transport: Introduction; equilibrium relations and mass transfer coefficients; generation and accumulation of transport variables; momentum heat and mass diffusions; boundary condition catalogue.

Module-II: **(No. of classes: 10)**
Introduction to Computational Fluid Dynamics (CFD): Governing equations for fluid flow systems; solutions of linear and non-linear algebraic equations, time marching solutions; discretization of derivatives-finite difference; finite volume methods.
Drag analysis and flow through packed bed: Flow past an immersed body; concept of drag and lift forces; flow over flat plate parallel and perpendicular to the flow; flow over a sphere; pressure and friction drag; streamlining; motion of solid particle through a fluid under gravity and centrifugal force fields; flow over a bed of solids; Ergun equation, friction factor vs. modified Reynolds number plot for packed bed; Incorporating packed bed in piping networks.

Module-III: **(No. of classes: 10)**
Fluidization: Concept of fluidization; different types of fluidization; minimum fluidization velocity; Archimedes number; industrial applications of fluidized bed.
Introduction to Compressible Flow: Review of Thermodynamics; propagation of sound wave and mach cone; stagnation properties; One dimensional compressible flow; isentropic flow of ideal gas-area variation; Isentropic flow in a converging-diverging nozzle; Flow in a constant area duct with friction-Fanno line; Normal Shocks.

Module-IV: **(No. of classes: 10)**
Gas Machineries: Introduction; Classifications; Fans and Blowers; Centrifugal compressor: principle of operation, velocity triangles, stagnation pressure and temperature rise; Axial flow compressor: cascade flow and nomenclature, velocity triangles, degree of reaction, chocking and surging of compressor; Testing, and characteristics of Fluid Machinery.

Books/References:
Text:
1. J. F. Douglas, J. Gasiorek and J. Swaffield, Fluid Mechanics, Pearson/Prentice Hall.
2. J. Plawsky, Transport Phenomena Fundamentals, CRC Press.

Reference:
1. O. Levenspiel and D. Kunii, Fluidization Engineering, Reed Publishing.
2. R.W. Fox, P.J. Pritchard and A.T. McDonald, Introduction to Fluid Mechanics, Wieley-India.
3. S.M. Yahya, Turbines Compressors and Fans, Tata McGraw-Hill.

Process Heat Transfer (ChE-402)

Module I **(No. of classes: 10)**
Heat Exchanger: Classification; Double pipe heat exchanger and its design; LMTD, LMTD correction factor, Dirt factor, Individual and overall heat transfer coefficient; Shell and tube heat exchanger and its design; Flow arrangements in shell and tube heat exchanger for increased heat recovery; Extended surfaces for further heat recovery: longitudinal and transverse fins.

Module II **(No. of classes: 10)**
Compact Heat Exchanger: Introduction, recent developments, basic aspects of compactness, Heat exchanger reactors.

Industrial compact heat exchangers: Plate and frame heat exchangers and their derivatives: brazed plate, welded plate; Plate-fin heat exchangers; Tube-fin heat exchangers; Compact shell and tube heat exchanger; Spiral heat exchanger; Maintenance of compact heat exchangers.

Module III **(No. of classes: 10)**
Fired Heater: Types: Tube still heater, Shell still heater, Convection type heater; Comparison of fuel fired heater with electrical heater; Selection of a fired heater; Typical applications: charge heaters and preheaters, reheaters and reboilers, thermal reactors (visbreakers, steam-hydrocarbon reformers, pyrolysis heaters); Design of fired heater.

Module IV **(No. of classes: 10)**
Evaporation: Capacity, steam economy; boiling point elevation (Dühring rule); classification of evaporators: horizontal tube, long tube (vertical), calandria type, basket type, forced circulation evaporators: inside/outside and horizontal/vertical heating elements; multiple effect evaporator: forward feed, backward feed, mixed feed, parallel feed; material and energy balance of single and multiple effect evaporators; design procedure.

Books/References
Text
1. Process Heat Transfer, D. Q. Kern, McGraw Hill
2. B. K. Dutta, Heat Transfer: Principles and Applications, Prentice Hall India.
References
1. Units Operations of Chemical Engineering, W. McCabe, J. Smith and P. Harriot, McGraw Hill.
2. Heat Exchangers: Selection, Design and Operation, J. E. Hesselgreaves, Pergamon.
3. Heat Transfer Design Methods, J. J. McKetta, Marcel Dekker.

Mechanical Operations (ChE-403)

Module-I **(No. of classes: 10)**
Particulate solids: Characterization of solid particles, particle shape, particle size, mixed particle sizes and size analysis, specific surface of mixture, average particle size; Screen analysis: Types, screen effectiveness, differential/cumulative analysis, material balance over screen, screen capacity; Screening equipment. Size Reduction: Principles, power requirements & crushing efficiency; Empirical relationships: Kick's, Rittinger's & Bond's law with their limitations, Work index; Equipments: Operating principles, constructional features, capacity & application of Primary& Secondary crushers, Grinder, Cutting machines; Close & open circuit operations.

Module-II **(No. of classes: 10)**
Transportation and storage of solids: Operation and performance of different types of conveyors (Belt, Screw, Apron, Flight, Pneumatic) and elevators; Storage of solids and discharge pattern from storage bin, theory and measurement of granular solid flow through orifice.
Separation based on motion of particles through fluids: Free and hindered settling; Stoke's law & Newton's law regimes of settling; Gravity settling processes, gravity classifiers; Sorting classifiers: sink-and-float method, differential settling. Clarification, flocculation, batch and continuous sedimentation, rate of sedimentation, sedimentation zones; Description and design of Clarifier & Thickener.

Module-III **(No. of classes: 10)**
Mixing: Principles of agitation, agitation equipment; Flow patterns: prevention of swirling/vortex, draft tubes; Standard turbine design, power consumption, power correlation, significance of dimensionless groups, effect of system geometry, calculation of power consumption in Newtonian liquids. Solid-solid mixing equipment, Mixing effectiveness and mixing index; Agitator scale up.
Froth Flotation: Theory, operation, types, Flotation agents, Flotation cells.

Module-IV **(No. of classes: 10)**
Filtration: Theory and principle of solid-liquid filtration, industrial filters, type of filtration; Discontinuous pressure filter: principle and working of filter press, compressible and incompressible filter cakes, filter medium resistance, constant pressure & constant rate filtration, principles of cake filtration, pressure drop through filter cake, cake washing and filtration cycle; Theory & working principle of Continuous vacuum filter (e.g. rotary drum filters), Horizontal vacuum belt filters and Centrifugal filter; Filter media; Filter aids.

Centrifugal Separators: Cyclones, hydrocyclones, centrifugal decanters.

Books/References

Text

1. J.M.Coulson, J.F.Richardson. Chemical Engineering. Vol 2. Pergamon Press. 3e 1977.
2. C.J.Geankoplis. Transport Processes and Unit Operations. Prentice-Hall India. New Delhi. 3e 1997

References

1. G.G.Brown and Associates. Unit Operations. John Wiley & Sons, New York. 1950
2. A.S.Foust, L.A.Wenzel, C.W.Clump, L.Maus, L.B.Andersen. Principles of Unit Operations. John Wiley & Sons, New York. 2e 1980.
3. W.L.Badger, J.T.Banchero. Introduction to Chemical Engineering. McGraw-Hill, 1955
4. W.L.McCabe, J.C.Smith and P.Harriot. Unit Operations in Chemical Engineering. McGraw-Hill. 4e, 1984.

Chemical Technology (ChE-404)

Module-I: **(No. of classes: 10)**

Inorganic chemicals: Production & consumption pattern, raw materials, principles, process description with process flow diagram, advancement of process technology, major engineering problems and uses with reference to Caustic Soda and Chlorine (Membrane Cell), Soda-ash (Solvey Porcess), Sulfuric acid (Contact and DCDA process), Nitric acid (Ostwald Process), Phosphoric acid (from rock phosphate).

Module-II: **(No. of classes: 10)**

Fertilizers: Production & consumption pattern, raw materials, principles, process description with process flow diagram, advancement of process technology, major engineering problems and uses with reference to Ammonia, Urea, Di Ammonium Phosphate, Single & Triple Super Phosphates. **Cement:** Composition, Raw materials, dry and wet processes for manufacturing cement clinker, setting and hardening of cement. **Glass & Ceramics:** Raw materials, manufacturing process, composition & annealing of glass; Raw materials & manufacturing process of porcelain. **Refractories:** Raw materials, manufacturing process.

Module-III: **(No. of classes: 10)**

Study of selected organic chemical industries emphasizing the principles underlying unit processes, unit operations, materials of construction, economics and Indian scenario with reference to: **Oils and fats:** Methods of extracting vegetable oils; modification of oils; production processes for soap, detergent; **Sugar and starch:** production processes; **Fermentation:** absolute and industrial alcohol; **paper and pulp:** classification of pulping processes; Kraft pulping process; making paper from pulp; **Paints, pigment and surface coating industries:** Raw materials, methods of production and uses.

Module IV **(No. of classes: 10)**

Petrochemicals: Petrochemical feed stocks, raw material trend for petrochemical industries, manufacture of synthesis gas, manufacturing of petrochemicals (such as ethylene, styrene, butadiene, vinyl chloride, ethylene oxide, isopropanol, phenol, phthalic anhydride etc.). **Polymer:** Introduction; definitions and concepts of terms used in polymer engineering; classification of polymers; standard polymerization techniques: addition polymerization (bulk, solution, suspension and emulsion) and condensation polymerization (melt and solution polycondensation); industrial productions of PE, PP, PVC, PS, PET, Nylon 6 and Nylon 66.

Books/References

Text Books:

1. M. Gopal Rao & M. Sittig. Eds. Dryden's Outlines of Chemical Technology. Affiliated East-West Press Pvt. Ltd., New Delhi
3. P. H.Groggins, Unit Processes in Organic Synthesis, McGraw-Hill Book Co., NY

References:

1. G.T.Austins, Shreeve's Chemical Process Industries, McGraw-Hill Book Co., 5e.
2. S. Venkateswarlu, (Ed.) CHEMTECH, Vols. 2 & 4, Chemical Engineering Development Centre, IIT, Madras
3. Kirk & Othmer (Ed.), Encyclopedia of Chemical Technology.

Chemical Engineering Mathematics-II (ChE-405)

Module-I: **(No. of classes: 10)**
Data Analysis: Collection and classification of data; graphic representation of data; measures of central tendency: mean, median and mode; measures of dispersion: range, quartile and semi-interquartile range, mean deviation, standard deviation, variance, coefficient of variation, idea of statistical moments-skewness and kurtosis.
Probability theory and discrete probability distributions: Definitions and basic theorems, sample points and sample space, unions, intersection and complements, independent events, Baye's theorem; random variable: discrete probability distribution, distribution function, moment generating function, repeated trials, standard discrete distributions and their properties: Binomial distribution, Poisson distribution, geometric and hypergeometric distributions.

Module-II: **(No. of classes: 10)**
Continuous probability distributions: Introduction; probability density function; cumulative distribution function; normal distribution: normal approximation to binomial distribution, properties, probable error and applications; other standard continuous distributions: rectangular, gamma, exponential and Weibull; Distributions of several random variables: two-dimensional distributions, marginal distributions, functions of random variables, addition of means and variances.

Module-III: **(No. of classes: 10)**
Mathematical statistics: Introduction; random sampling; point estimation of parameters: maximum likelihood method; confidence intervals; Testing of hypothesis: one-sided and two-sided alternatives, errors in test, test for μ of the normal distribution with known and unknown σ^2, comparison of means and variances; quality control: control charts for mean, variance, standard deviation and range; acceptance sampling: errors and rectifications; goodness of fit: χ^2-test; nonparametric tests; regression analysis: confidence intervals, correlation analysis, test for correlation coefficient.

Module-IV: **(No. of classes: 10)**
Graph theory: Introduction to graphs and digraphs; computer representation; shortest path problems, complexity of an algorithm; Bellman's principle, Dijstra's algorithm for shortest path; shortest spanning trees: Greedy and Prim's algorithm; flows in a networks, flow augmenting paths, cut sets; maximum flow: Ford-Fulkerson algorithm; bipartite graphs: maximum cardinality matching, augmenting path theorem.

Books/References:
Text:
1. E. Kreyszig, Advanced Engineering Mathematics, Wiley-India.
Reference:
1. B.S. Grewal and J.S. Grewal, Higher Engineering Mathematics, Khanna Publishers.
2. J. Bird, Higher Engineering Mathematics, Elsevier.
3. S. Deo, Graph Theory with Applications to Engineering and Computer Science, PHI.
4. J. Morrison, Statistics for Engineers, Wiley.

Process Calculation (ChE-406)

Module-I **(No. of classes: 10)**
Single and multiphase systems: Liquid and solid densities; ideal gases, equations of state for real gases; compressibility factor; Single component phase equilibrium; Gibbs phase rule Multiple component phase equilibrium.
Material balance: Introduction to material balances; process classification; material balance problems for single units; balances on multiple units; recycle, purging and bypass; stoichiometry and Chemical reaction equations; material balance on reactive processes; combustion calculations.

Module-II **(No. of classes: 10)**
Energy balance on non-reactive processes: First law of thermodynamics; internal energy and enthalpy; energy balances on closed systems; energy balances on open system at steady state; temperature change calculation; phase change operation; mixing and solutions.

Energy balance on reactive processes: Heats of reaction; formation reaction and heat of formation; measurement and calculation of heats of reaction-Hess's law; heats of combustion; adiabatic flame temperature; energy balances on reactive processes.

Module-III **(No. of classes: 10)**

Computer aided balance calculations: Degrees of freedom analysis: single process unit (flash vaporizer), multiple unit processes; sequential modular simulation: introduction, fundamental elements of modular simulation, developments of modular subroutines; cyclic systems and convergence blocks; equation based simulations: case studies; introduction to commercial simulation packages.

Module-IV **(No. of classes: 10)**

Balances on transient processes: Importance of transient analysis; general balance equation; differential and integral balance equations; transient material balance over different process units; energy balances on single-phase non-reactive processes; simultaneous transient balances-case studies of start-up and shut down analysis.

Books/References:

Text:

1. R.M. Felder and R.W. Rousseau, Elementary Principles of Chemical Processes, Wiley.
2. D.M. Himmelblau, Basic Principles and Calculations in Chemical Engineering, Prentice Hall.

Reference:

1. O.A. Hougen, K.M. Watson and R.A. Ragatz, Chemical process principles, Part I, CBS publishers (1973).
2. B.L. Bhatt, and S.M. Vora, Stoichiometry, Tata McGraw-Hill (2004).

B. PRACTICAL

Fluid Mechanics laboratory (ChE-407)

At least 8 (eight) experiments are to be performed

1. Viscosity measurement of non-Newtonian fluids.
2. Calibration of Orifice meter.
3. Calibration of Venturi meter.
4. Calibration of a rotameter.
5. Calibration of weirs and notches.
6. Open drum orifice and draining time.
7. Flow through straight pipe.
8. Flow through annular pipe.
9. Local velocity measurement by Pitot tube.
10. Losses in pipe fittings and valves.
11. Characteristic curves of pumps.
12. Pressure drop studies in packed column.
13. Hydrodynamics of fluidized bed.
14. Drag coefficient of solid particle.

Heat Transfer laboratory (ChE-408)

At least 8 (eight) experiments are to be performed

1. Determination of thermal conductivity of solid.
2. Determination of thermal conductivity of liquid.
3. Determination of thermal conductivity of insulating powder.
4. Determination of heat transfer coefficient in natural convection.
5. Determination of heat transfer coefficient in forced convection.
6. Determination of Biot number in unsteady state heat transfer.
7. Determination of overall heat transfer coefficient in film-wise condensation.
8. Determination of overall heat transfer coefficient in drop-wise condensation.
9. Determination of overall heat transfer coefficient in parallel/ double pipe heat exchanger.
10. Determination of overall heat transfer coefficient in shell and tube heat exchanger.

11. Determination of Stefan-Boltzmann constant.
12. Determination of overall heat transfer coefficient in plate type heat exchanger.
13. Experiment with heat pipe demonstrator.
14. Experiment with lagged pipe apparatus.
15. Determination of emissivity.
16. Heat transfer through composite wall.
17. Heat transfer from pin-fin apparatus.

AUTOCAD drawing (ChE-409)

AUTOCAD drawings of:

Projection of lines and solids: Projection of lines and solids, auxiliary projections

Sections and developments: Sections of solids and development of surfaces.

Projections: Conversion of projections: Orthographic projection, isometric projection of regular solids & combination of solids.

Books/References:
Text:
1. T. Jeyapoovan, Engineering Drawing and Graphics using AutoCAD 2000, Vikas Publishing. .
2. K.L. Narayanan and P. Kannaiah, Engineering Graphics, Scitech Publications.

Reference:
1. N.D. Bhatt, Elementary Engineering Drawing (First Angle Projection), Charotar Publishing Co.
2. K. Venugopal, Engineering Drawing & Graphics, New Age international Pvt. Ltd.
3. K.V. Natarajan, Engineering Drawing & Graphics, Private Publication.

Seminar-I (ChE-410)

Each candidate shall have to make a presentation, in a seminar, on a topic of his/her choice or selected by the Teacher-in-Charge. The topic shall be in any areas of Chemical and Allied Engineering. A hard copy report shall also to be submitted.

B. Tech 5th Semester syllabus

A. THEORY

Numerical Methods in Chemical Engineering (ChE-501)

Module-I: **(No. of classes: 10)**

Introduction: Importance of numerical analysis in chemical engineering; Error Analysis: Taylor series expansion, truncation error; round-off error vs. chopping-off error, propagation of error.
Solution of simultaneous linear equations: Gauss elimination, Gauss-Jordon Method: pivoting and ill-conditioning; Iterative methods: Jacobi iteration, Gauss-Seidel; successive-over-relaxation method, application in steady-state isothermal CSTRs in series; Tri-Diagonal Matrix: Thomas algorithm.

Module-II: **(No. of classes: 10)**

Solution of Non-linear equations: Bisection method, Newton-Raphson method, Secant method, modified Newton-Raphson method for multiple roots: application in thermodynamic property calculation, bubble point and dew point calculation; determination of roots of polynomials; solution of a set of non-linear equations: Newton's method, Jacobian matrix, characteristics equations and stability analysis of solution; steady-state solution of non-isothermal reactors.

Module-III: **(No. of classes: 10)**

Interpolation and Curve-fitting: Linear least-square method for straight lines and polynomials; Lagrange interpolation; Newton's backward and forward interpolation techniques.

Numerical Solution of ordinary differential equations (ODE): Initial and boundary value problems: Euler's Method, Runge-Kutta Method (2^{nd}, 3^{rd} and 4^{th} order), Euler's predictor-corrector method, finite difference method (forward, backward and central differences); solution of a set of ODEs; applications in chemical and bio-chemical engineering systems.

Module-IV: **(No. of classes: 10)**
Numerical Integration: Introduction; rectangular method, trapezoidal rule, Simpson's $1/3^{rd}$ and $3/8^{th}$ rules, Romberg integration.
Numerical Solution of partial differential equations: Explicit, implicit and Crank-Nicholson method for elliptical and parabolic equations; convergence and stability criteria; application in transient analysis: tubular reactor analysis and heat transfer in slabs.

Books/References
Text
1. S. K. Gupta, Numerical Methods for Engineers, New Age International Publishers, India.

References
1. H. S. Mickley, T. S. Sherwood and C.E. Reed, Applied Mathematics in Chemical Engineering, Tata McGraw-Hill Publication.
2. A. Constantinides, Applied Numerical Methods with Personal Computers, McGraw-Hill, Chemical Engineering series, 1987.
3. R.W. Hamming, Numerical Methods for Scientists and Engineers, McGraw-Hill.
4. S.C. Chapra and R.P. Canale, Numerical Methods for Engineers, 6^{th} Ed., McGraw-Hill, NY, 2010 .
5. H.K.Versteeg and W. Malalasekera, An inteoduction to Computational Fluif Dynamics, Longman Scientific & Technical, UK, 1995

Material Science (ChE-502)

Module I **(No. of classes: 10)**
Structure of materials: Various types of bonds: ionic and covalent; metallic bonding and secondary bonding; crystal geometry: concepts of unit cell and space lattice, packing factor, crystal directions and planes; X-ray diffraction for determining crystal structure: Bragg's law; structure of solid: crystalline and non-crystalline states; structures of inorganic solids: ionic and covalent solid, metals and alloys; structures of polymers: crystalline and non-crystalline structures; structural imperfections: point, line, surface and volume, impacts on properties.

Module II **(No. of classes: 10)**
Phase diagram and related topics: The phase rule, single component systems, phase diagrams of binary systems, The lever rule, phase diagrams of ternary systems, iron-carbon diagram; heat treatment: introduction and purposes; T-T-T Curve.
Phase transformations: nucleation and growth, applications: precipitation, solidification and crystallization, recovery, recrystallization and grain growth.

Module III **(No. of classes: 10)**
Elastic behaviour of materials: atomic model, anelastic behaviour of materials: relaxation processes, viscoelastic behaviour of materials: spring-dashpot model; plastic deformation and creep in crystalline materials; fatigue, fracture: ductile, brittle, ductile-brittle transition, fracture toughness.
Corrosion: Mechanisms, classification; uniform and localized corrosions: crevice, filliform, pitting, erosion, cavitation damage, fretting, stress corrosion cracking, hydrogen damage, hydrogen embrittlement, biological; prevention: selection of materials, design rules, coating, cathodic and anodic protection.
Materials of construction (for various chemical process equipments): metals and alloys, ceramic and polymeric materials.

Module IV **(No. of classes: 10)**
Materials with featured applications: Inorganic and organic amorphous materials, their structural and property characteristics; electrical, electronic, optical and optoelectronic properties of material: conductivity, resistivity, effects of crystal structure on these properties; conductors and resistors: free electron theory, materials, superconducting materials; semiconductors: energy gap in solids, extrinsic and intrinsic semiconductors, semiconductor materials, magnetic materials: magnetic moments due to electron spin, ferromagnetism, hysteresis loop, soft and hard magnetic materials; dielectric materials: polarization, temperature

and frequency effects, ferroelectric materials; composite materials and their use; nanomaterials: classification, processing and properties.

Books/References

Text

1. V. Raghavan, Materials Science and Engineering, A First Course, 6th Ed., PHI Learning Pvt. Ltd., India.

References

1. J. C. Anderson, K. D. Leaver, P. Leevers, R. D. Rawlings, Materials Science for Engineers, 5th Ed., Nelson Thrones Ltd., U.K.
2. L. H. van Vlack, Elements of Material Science and Engineering, 6th Ed., Addison-Wesley, USA.
3. H. W. Hayden, W. G. Moffatt, J. Wulff, Mechanical Behavior, John Wiley and Sons, New York.

Separation Process-I (ChE-503)

Module I **(No. of classes: 10)**

Diffusion: Principles of molecular diffusion in fluids, diffusivity, diffusion in solids: Fick's law, multicomponent diffusion, Knudsen, surface and self diffusion, applications of molecular diffusion.

Mass transfer coefficients: in laminar and turbulent flow, turbulent or eddy diffusion, wetted wall column, different theories of mass transfer, analogies between mass, momentum and heat transfer.

Module II **(No. of classes: 10)**

Interphase mass transfer: equilibrium between phases, Raoult's and Henry's law, mass transfer between two phases, overall mass transfer coefficients, mass transfer in stage wise contact of two phases.

Gas-liquid contacting equipment: plate column and its operational features, tray design, agitated vessels, bubble column, spray tower, venturi scrubber, packed tower: loading and flooding, comparison between plate and packed tower, plate columns: absorption factor, determination of number of plates, Kremser equation; efficiency: point, overall, Murphree tray efficiency: vapour and liquid.

Module III **(No. of classes: 10)**

Gas absorption: mechanism, selection of solvent, limiting gas-liquid ratio; gas and liquid film coefficients, design calculation of packed column: determination of diameter and height, H.E.T.P., H.T.U. and N.T.U.; absorption with chemical reaction.

Module IV **(No. of classes: 10)**

Distillation: introduction, vapour-liquid equilibria, relative volatility; ideal solutions: positive and negative deviations from ideality; enthalpy-concentration diagram; flash distillation: introduction to q lines, q lines for different thermal states of feed, batch distillation, Rayleigh equation, continuous rectification of binary systems, calculation of number of plates in a distillation column by McCabe-Thiele method, minimum reflux ratio, total reflux and its importance: Fenske-Underwood-Gilliland method, determining the optimum reflux ratio, Ponchon-Savarit and Lewis-Sorel methods.

Books/References

Text

1. R. E. Treybal, Mass Transfer Operations, 3rd Ed., McGraw Hill.
2. B. K. Dutta, Principles of Mass Transfer and Separation Processes, PHI Learning Pvt. Ltd., India.

References

1. W. L. McCabe, J. C. Smith and P. Harriott, Unit Operations of Chemical Engineering, 7th Ed., McGraw Hill.
2. C. J. Geankoplis, Transport Processes and Separation Process Principles, 4th Ed., Pearson Education Ltd.
3. J. M. Coulson and J. M. Richardson, J. R. Backhurst and J. H. Harker, Chemical Engineering, Vol. 2, 5th Ed., Butterworth-Heinemann.

Machine Design (ChE-504)

Module-I: **(No. of classes: 10)**

Introduction: Mechanical Engineering Design; traditional design methods, design synthesis, aesthetic and ergonomic considerations, use of standards and selection of preferred sizes; **Engineering materials:** Selection of materials; cast iron, B.I.S system of steel designation; plain carbon steel, free cutting steels and alloy steels; heat treatment and case hardening of steels; cast steels; copper alloys.

Design against static load: Modes of failure, factor of safety, stress strain relation for ductile and brittle materials, stress due to bending and torsional moments; theories of failure: maximum normal stress theory, maximum shear stress theory, distortion energy theory.

Module-II: **(No. of classes: 10)**

Design against fluctuating load: Stress concentration and concentration factors; reduction of stress concentration effect; fluctuating stress and fatigue failure; endurance limit: idea and approximate estimation; cumulative damage in fatigue; Soderberg and Goodman diagrams, modified Goodman diagram.

Threaded and welded joints: I.S.O metric screw threads; bolted joints under tension, torque requirement for tightening; Eccentrically loaded bolted joints in shear; bolted joints under fluctuating loads; types of welded joints; stresses in butt and fillet welds; strength of welded joints; welded joints subjected to eccentric load, bending moment and fluctuating forces.

Module-III: **(No. of classes: 10)**

Shafts, keys and couplings: Transmission shafts; design under static load, design for torsional rigidity; keys: design of square and flat keys, splines; coupling: rigid and flexible coupling; design for lateral rigidity, Castigliano's theorem; area-moment method, graphical integration method.

Helical Springs: Stress and deflection equation; spring materials and styles of end; design against static and fluctuating load; optimum design of helical spring; multi-leaf springs.

Belt drives: Flat and V-belts; belt constructions; geometric relationships and analysis of belt tensions; condition for maximum power; selection of belts from manufacturer's catalogue.

Module-IV: **(No. of classes: 10)**

Spur gears: Gear drives: classifications of gears, gear selection, law of gearing, terminologies of spur gear and standard system of gear tooth; force analysis, gear tooth failure, selection of materials and construction details, number of teeth calculation; face width, beam sand wear strength of gear tooth, effective load on gear tooth; estimation of modulus based on beam and wear strengths; gear design for maximum power transmission capacity.

Pressure vessels: Thin cylindrical and spherical vessels; thick cylinders: principal stresses, Lame's equation, Clavarino's and Birnie's equations; cylinders with external pressure; autofrettage; compound cylinders; gaskets, bolts and flange joints; thickness estimation; covers and end closures; opening in pressure vessels.

Books/References

Text

1. P.C. Sharma and D.K. Aggarwal, Machine Design, S. K. Kataria & Sons, India.

References

1. V.B. Bhandari, Design of Machine Elements, Tata McGraw-Hill, India.
2. L.E. Brownell and E.H. Young, Process Equipment Design, John-Wiley, 1959.
3. R.S. Khurmi and J. K. Gupta, A Textbook of Machine Design, S. Chand, India.

Reaction Engineering-I (ChE-505)

Module I **(No. of classes: 10)**

Fundamentals: Definition of reaction rate; kinetics of homogeneous reaction: concentration-dependent term of a rate equation; reaction classifications: single and multiple reactions, elementary and non-elementary reactions; molecularity and order of reaction; non-elementary reactions: classification and kinetics, idea of active intermediates, formulating the rate equation for enzymatic and chain reactions; temperature dependent term of a rate equation: Arrhenius law, collision theory, transition-state theory.

Batch reactor analysis: constant-volume reactor, integral method of analysis: general procedure, zero-order reactions, irreversible first and second order reactions, irreversible reactions in parallel and in series, homogeneous and autocatalytic reactions, reversible reactions; differential method of analysis; variable-volume reactions: zero, first and second-order reactions.

Module II **(No. of classes: 10)**

Flow reactors: Introduction; space-time and space-velocity, ideal flow reactors: continuous stirred tank and plug flow reactors (CSTR and PFR), design equations, graphical representation and comparison.

Multiple-reactor systems for single reactions: Series-parallel combinations of PFRs, Identical and different CSTRs in series: infinite nos. of CSTRs in series, Jone's method; series-parallel combinations of reactors: optimum sequence; recycle reactor: definition of recycle ratio, design equation and the optimum recycle ratio.

Module III **(No. of classes: 10)**

Design for multiple reactions: Reactions in parallel: product distribution, instantaneous and overall fractional yield, selectivity; reactions in series: irreversible reactions in series, product distribution: examples of first order followed by zero order reaction and the reverse, irreversible reactions of different orders in series; irreversible series-parallel reactions: applications, Denbigh reactions.

Module IV **(No. of classes: 10)**

Nonisothermal reactor: General energy balance in a reacting system; non-isothermal continuous flow reactors at steady state: CSTR, adiabatic tubular flow reactor; CSTR, PFR and batch reactors in unsteady state; non-adiabatic reactors: case studies; multiple steady state: ignition-extinction curve, steady state bifurcation analysis.

Books/References

Text

1. O. Levenspiel, Chemical Reaction Engineering, 3rd Ed., Wiley.
2. H. S. Fogler, Elements of Chemical Reaction Engineering, 3rd Ed., PHI Learning.

References

1. J. M. Smith, Chemical Engineering Kinetics, 3rd Ed., McGraw Hill.
2. L. D. Schmidt, Engineering of Chemical Reactions, 2nd Ed., Oxford University Press.
3. M. E. Davis and R. J. Davis, Fundamentals of Chemical Reaction Engineering, 1st Ed., McGraw Hill.

Engineering Thermodynamics (ChE-506)

Module-I: **(No. of classes: 10)**

Introduction: The scope of thermodynamics; dimensions and units; idea of force, temperature, pressure, volume, work, energy and heat; Basic concepts: Joule's experiments; internal energy; first law of thermodynamics; thermodynamic state and state functions; path variables; concept of enthalpy; equilibrium; Gibbs phase rule; idea of reversibility; heat capacities; different standard thermodynamic processes: isothermal, isochoric, isobaric, adiabatic and polytropic.

Volumetric properties of pure fluids: Graphical representation of P-V-T behavior; mathematical representation of P-V-T behavior: ideal gas law, cubic equations of state, virial equation of state and its application, law of corresponding states, generalized correlations for gases and liquids, acentric factor.

Module-II: **(No. of classes: 10)**

Heat effects: Sensible heat effects; latent heat of pure substances; standard heat of reaction (ΔH^0); standard heat of formation; temperature dependence of ΔH^0.

Second law of thermodynamics: Limitations of the first law of thermodynamics; statements of second law; heat engine, heat pump and refrigerator with a special emphasis on Carnot cycle; Carnot theorem; idea of entropy; entropy change calculations; Clausius inequality; mathematical statement of second law.

Thermodynamic properties of fluids: property relations for homogeneous phases; Maxwell's equations; canonical variables and generating function; residual property; two-phase systems: Clapeyron and Clausius-Clapeyron equations; Antoine equation; thermodynamic diagram: T-S, P-H and H-S diagrams; generalized property correlations for gases.

Module-III: **(No. of classes: 10)**

Thermodynamics of flow processes: Concepts of control volume and control mass; revisiting Reynolds transport theorem; balance equations over control volume: mass, energy and entropy; applications of unsteady state energy equations: filling and draining of tanks; application of steady flow energy equations: duct flow of compressible fluids, flow through nozzles and diffusers; turbines and compressors; heat exchangers and throttling valve; Joule-Thompson coefficient; inversion curve; thermodynamic analysis of processes: calculation of ideal work; lost work; calculations of lost work in complex thermodynamic systems under steady state.

Module-IV: **(No. of classes: 10)**

Production of power from heat: steam power plant: introduction, process description and related calculations for: Carnot cycle; Rankine cycle; Rankine cycle with regenerator and feed water heater; supercritical Rankine cycle; binary cycle etc; internal-combustion engines: overview; concept of air standard cycles; Otto, Diesel and dual cycles; gas-turbine power plant: Brayton cycle.

Refrigeration and Liquefaction: Introduction; Carnot refrigerator; description, process sequence and calculations of vapor-compression and absorption refrigerator cycles; comparisons of refrigeration cycles; choice of refrigerant; liquefaction process: different processes of liquefaction, description, process sequence and calculations of Linde and Claude liquefaction processes: relative advantages and disadvantages.

Books/References

Text

1. J.M. Smith, H.C. Van ness and M.M. Abbot, Introduction to Chemical Engineering Thermodynamics:, 6th Edn. McGraw-Hill, 2001.

References

1. Y.V.C. Rao, An Introduction to Thermodynamics, Universities Press, 2004.
2. Y.A. Cengel and M.A. Boles, Thermodynamics-An Engineering Approach, McGraw-Hill, 2006.
3. B.G. Kyle, Chemical and Process Thermodynamics, Prentice-Hall of India, 1999.
4. B.F.Dodge, Chemical Engineering Thermodynamics, McGraw-Hill, 1944.

B. PRACTICAL

Mechanical Operations Laboratory (ChE-507)

At least 8 (eight) experiments are to be performed

14. Determination of 'reduction ratio', 'capacity' of a blake jaw crusher and verification of Rittinger's law.
15. Determination of 'reduction ratio', 'capacity' of a roll crusher and verification of Rittinger's law.
16. Determination of 'reduction ratio' and 'capacity' of a ball mill.
17. Determination of 'reduction ratio' and 'capacity' of a hammer mill.
18. Determination of overall effectiveness of a sieve shaker for a given solid sample of unknown size.
19. Determination of average particle size of a given solid sample using a sieve shaker by (i) random sampling method and (ii) coning and quartering method.
20. Determination of overall efficiency of cyclone separator.
21. Demonstration of efficiencies of different frothing agents in recovery of a given sample by froth floatation.
22. Demonstration of the settling and sedimentation characteristics of given slurry and to calculate the area of the continuous thickener.
23. Verification of Rittinger's law by drop weight crusher.
24. Demonstration of the power number and power consumption for a given liquid in an agitated vessel

Machine Drawing (ChE-508)

Symbols of Machine elements and welded joints; Fasteners: drawings of various views of Screw threads, metric and BSW threads, square thread and multi-start threads; nut-bolts, washers and foundation bolts; Riveted joints: forms and proportions of river heads, different views of different types of riveted lap and butt joints.

Drawings of various views of cotter joint and knuckle joint; different keys and shaft coupling; shaft bearing: solid and bush bearing, plummer block, footstep bearing; pipe joint: flanged joint, socket and spigot joint, pulley: belt pulley, v belt pulley, fast and loose pulley, speed cone pulley, built up pulley; spur gear in mesh with approximate construction of tooth profile,

Assembly and detailed drawings of engine parts: piston, stuffing box, cross head, vertical and horizontal engine, connecting rod, crank, Eccentric; **valves:** steam stop valves, feed check valve, safety valves, blow off cock.

Books/References

Text

1. N.D. Bhatt, Machine Drawing, Charotar Publishing House, India.

References

1. P.S. Gill, Machine drawing, Kataria & Sons, Delhi, India
2. N.D. Junnarkar, Machine drawing, Pearson Education, Delhi, India

B. Tech 6th Semester syllabus

A. THEORY

Separation Process-II (ChE-601)

Module I **(No. of classes: 10)**

Brief overviews on multi-component, azeotropic, extractive and reactive distillation processes.

Adsorption: Introduction; commercial adsorbents (activated carbon, molecular sieves, silica gel, activated alumina etc) and their applications; characteristics and properties of adsorbents; adsorbent selection; batch adsorption; adsorption isotherms: Langmuir, Freundlich, Temkin, Toth, Henry, BET; heat of adsorption; adsorption equipment, mass transfer zones and breakthrough curves, length of unused bed, design of fixed bed adsorption column; other adsorption equipments; thermal regeneration of adsorbents; pressure swing and temperature swing adsorption.

Module-II **(No. of classes: 10)**

Liquid-liquid extraction: Introduction, liquid-liquid equilibria, triangular diagram, selectivity and choice of solvents, industrial of solvent extraction (separation of aromatics from petroleum, extraction of antibiotics, caprolactum etc.) crosscurrent and countercurrent extractor with miscible and immiscible solvents; determination of minimum reflux ratio; determination of number of equilibrium stages by graphical method, design of stage wise extractor; classification and selection of industrial liquid-liquid extraction equipment; hydrodynamics and mass transfer of a stirred liquid-liquid extraction vessel: drop size, minimum impeller speed, power requirement, correlations of mass transfer coefficient, importance of internal circulation and Marangoni effect.

Solid-liquid extraction: Introduction, classification of solid-liquid extraction system; rate of the extraction process; solid-liquid contacting equipments; equilibrium relation: triangular and Ponchon-Savarit diagrams; batch, crosscurrent and countercurrent extraction calculation; analytical technique to determine the number of stages; supercritical fluid extraction.

Module-III **(No. of classes: 10)**

Drying: Introduction, drying rate curve, drying mechanism, time of drying from drying rate data, the mechanism of moisture movement during drying, classification and selection of dryer, direct and indirect-heat batch and continuous dryers, preliminary design of rotary dryer.

Crystallization: Introduction, solid-liquid phase equilibria, nucleation, growth and distribution of crystals, batch crystallization, crystallizer and its design considerations.

Module-IV **(No. of classes: 10)**

Humidification and dehumidification processes: Introduction, characteristics of saturated and unsaturated vapor gas mixtures, dry and wet bulb thermometry, psychometric chart, adiabatic saturation curves, gas-liquid contact, design of humidifiers, dehumidification operation, classification of cooling towers, relative advantages and disadvantages; cooling range and approach; design of cooling towers; gas temperature profile in a cooling tower; blowdown.

Books/References

Text

3. R. E. Treybal, Mass Transfer Operations, 3rd Ed., McGraw Hill.
4. B. K. Dutta, Principles of Mass Transfer and Separation Processes, PHI Learning Pvt. Ltd., India.

References

4. J. M. Coulson and J. M. Richardson, J. R. Backhurst and J. H. Harker, Chemical Engineering, Vol. 2, 5th Ed., Butterworth-Heinemann.

5. C. Geankoplis, Transport process and Unit Operations, 3rd Edn., PHI.
6. B.D. Smith, Design of Equilibrium Stage Processes: MGH.

Process Control (ChE-602)

Module I **(No. of classes: 10)**

Introduction: Incentives for chemical process control, idea of set point, disturbance and manipulated variables, design elements of a control system, control aspects of a complete chemical plant, use of digital computers in process control. **Development of Mathematical models:** State variables and state equations of a chemical process, use of conservation and rate laws, examples of mathematical model, degrees of freedom analysis, linearization of state equations, use of deviation variables, linearization of multivariable state equation. **Input-Output Model:** problems of time domain I/O model and use of Laplace transform, transfer function and block diagram, Transfer functions of SISO and MIMO processes: transfer function matrix, poles and zeros of a transfer function.

Module II **(No. of classes: 10)**

Dynamic Behavior of a first order system: Identifying a first order system, standard examples of first order system (storage tank, mercury in glass thermometer, isothermal CSTR, RC circuit, spring-dashpot, surge tank), dynamic response of pure capacitive process, dynamic response of a first order lag, general idea of static gain, first order systems with variable time constant and gain. **Dynamic Behavior of a second order system:** Identifying a second order system, dynamic response of a second order system, origin of a second order system: multicapacity processes, first order systems with controller, inherent second order systems (LCR circuit, spring-dashpot-mass, pneumatic control valve, U-tube manometer). **Dynamic behavior of systems with dead time and inverse response:** Padé approximation and criterion of positive zero,

Module III **(No. of classes: 10)**

Introduction to feedback control: concept of feedback control, types of feedback controllers and their transfer functions, measuring devices and transmission lines, final control elements with special emphasis on pneumatic control valves and their characteristic curves; dynamic behavior of feedback control processes: block diagram and control loop response; effect of P, on-off, PI, PD and PID controllers on the response of a controlled process. **Stability analysis of feedback systems:** notion of stability, characteristic equation, Routh-Hurwitz criterion of stability, root locus analysis. **Design of Feedback controllers:** outline of the design problem, simple performance criteria, time-integral performance criteria, selection of a feedback controller, controller tuning based on Cohen-Coon tuning technique.

Module IV **(No. of classes: 10)**

Frequency response analysis: Response of a first order system to a sinusoidal input, frequency response characteristics of a general linear system; Bode, Nyquist and Nichols plot; design of feedback controllers using frequency response technique: Bode stability criterion, gain and phase margins, Ziegler-Nichols tuning technique, Nyquist stability criterion.

Introduction to advanced control systems: control systems with multiple loops: cascade control, selective control and split range control systems; feed forward and ratio control: logic and effectiveness of feed forward control scheme, designing a feed forward controllers, practical aspects and feasibility, combined feedback-feed forward control system, ratio control as a special type of feed forward control strategy.

Books/References

Text

1. G. Stephanopoulus , Chemical Process Control, PHI.
2. P.K. Sarkar, Process dynamic and control, PHI.

References

4. D. R. Coughanowr, Process system analysis & Control, McGraw Hill.
5. D.E. Seborg, D. A. Mellichamp and T.F. Edgar, Process dynamic and control, Wiley.

Process Instrumentation (ChE-603)

Module I **(No. of classes: 10)**

Characteristics of measurement system: introduction; functional units; classification; instrument terminology and performance characteristics: range, elevated zero, suppressed zero, span of instrument, error, accuracy, accuracy rating, resolution, calibration, repeatability, reliability, gain, drift, point drift, span shift, zero shift, dead band, hunting, sensitivity, linearity, response time etc; dynamic characteristics of measuring elements:

examples of pressure, flow, temperature, level, chemical composition sensors; electro-pneumatic converters; pneumatic, electrical and digital mode transmission.

Module II **(No. of classes: 10)**
Measurement of pressure and vacuum: introduction; manometer: U tube, inclined tube and well type manometers; elastic pressure sensor instruments: bourdon gauge, capsule gauge, differential pressure gauge, pressure switch; vacuum measurement: Mcleod gauge, thermal conductivity gauge, ionization gauge; electronic pressure/differential pressure transmitter: capacitive, piezo-resistance and resonating wire type.
Measurement of level: introduction; gauge glass, bi-colour, magnetic and reflex level gauge; float and displacer type instrument-gauge and switch; differential pressure sensors and their installation arrangement; capacitive type level instrument; ultrasonic and microwave type level sensors.

Module III **(No. of classes: 10)**
Measurement of temperature: temperature scale; fixed points and interpolation equations; filled in systems: liquid, gas and vapour filled systems, ranges, errors, construction details and comparison; bimetallic elements; resistance temperature detectors: review of materials, construction, classification, measuring circuits, ranges, errors and error minimization techniques; thermocouples: classification, thermoelectric effects, circuits, ranges, errors, cold junction compensation, compensating cables; radiation thermometry: basic principle, total radiation type, optical pyrometer; very high and very low temperature measurement.
Instruments for analysis: introduction, pH and conductivity measurement, Nucleonic type density measurement, gas analysers, liquid analysers, X-ray methods, chromatography, nuclear magnetic resonance spectroscopy, electron spin resonance/electron paramagnetic resonance spectroscopy, mass spectrometry, sampling techniques.

Module III **(No. of classes: 10)**
Installation requirement: introduction; installation of pressure measuring instruments with accessories like seals, snubbers, 2-valve manifolds; installation of differential pressure measuring instruments with head producing devices; straight run requirement for flow meters, installation of temperature elements: thermowell.
Hazardous area instrumentation: basic concepts, classification based on site, material and temperature: IEC and North American system; methods of protection: explosion proof, intrinsic safety, purging and pressurization, non-incendiary; IEC equipment protection level (EPL), NEMA and IP codes.

Books/References
Text

1. D. Patranabis, Principles of industrial instrumentation, Tata McGraw Hill.

References

1. B.G. Liptak, Instrument Engineers Handbook, vol-1 and vol-2, Chilton Book Co., Philadelphia.
2. E.O. Doeblin, Measurement systems-Application and design, Tata McGraw Hill.
3. A. Barua, Fundamentals of Industrial instrumentation, Wiley, India.

Chemical Engineering Thermodynamics (ChE-604)

Module I **(No. of classes: 10)**
Introduction to Solution thermodynamics: fundamental property relations for closed and open systems; chemical potential and phase equilibria; partial properties: introduction, summability and Gibbs-Duhem equation, graphical interpretation for binary solutions, ideal gas mixture and Gibb's theorem; fugacity and fugacity coefficients for pure species: idea of residual property, determination of pure species fugacity from virial and cubic equations of state, Poynting factor, determination of residual enthalpy and entropy; fugacity and fugacity coefficients for component species in solution: residual partial molar properties, fundamental residual property relation, determination of component species fugacity from virial equation and from equation of state.

Module II **(No. of classes: 10)**
Excess properties: standard state and ideal solution; excess properties and activity coefficients; fundamental excess property relation; Lewis-Radall rule and Henry's law, trends of excess Gibbs energy. **Activity coefficient models for liquid mixtures:** semi-empirical models: two-suffix and three-suffix Margules models, Redlich-Kister model, Whol's formulation, van Laar model, theory of regular solutions, Scatchard-Hilderbrand model; local composition models: Wilson equation as an extension of Flory-Huggins theory, NRTL, UNIQUAC and UNIFAC models; theories for electrolyte solutions.

Module III **(No. of classes: 10)**

Property changes on mixing: property changes on mixing for ideal and non-ideal solutions, heat effects of mixing processes, molecular basis of mixture behavior.
Vapor-Liquid equilibrium: introduction; qualitative behavior: P-x-y, T-x-y, P-T and P-T-x-y diagrams, retrograde condensation; the gamma/phi formulation of VLE: general equilibrium relation, Roult's law and modified Roult's law; VLE calculations: BUBL-P, DEW-P, BUBL-T and DEW-T; P-T flash calculations: Rashford-Rice function; introduction to molecular dynamic simulation as a tool to study VLE.

Module IV **(No. of classes: 10)**
General phase equilibria: criterion of phase stability: convexity of ΔG_{mix}; liquid-liquid equilibrium: equilibrium relation, solubility diagram and critical solution temperatures; vapor-liquid-liquid equilibrium: VLLE for miscible and immiscible liquids, solid-liquid equilibrium: equilibrium relation, ideal liquid state, immiscible solid state: eutectic point; equilibrium adsorption of gases on solids: spreading pressure-molar area relation, adsorption isotherm, heat of adsorption. **Chemical reaction equilibria:** idea of reaction coordinate, application of equilibrium criteria to chemical reactions; relation of standard Gibbs energy change and the equilibrium constant, effect of temperature on equilibrium constant, relation of equilibrium constant to composition: gas and liquid phase reactions; reactions in heterogeneous systems.

Books/References
Text

2. J.M. Smith, H.C. Van ness and M.M. Abbot, Introduction to Chemical Engineering Thermodynamics:, 6th Edn. MacGraw-Hill, 2001.
3. Y.V.C. Rao, An Introduction to Thermodynamics, Universities Press, 2004.

References

1. E. G. de Azevedo and J.Prausnitz, Molecular Thermodynamics of Fluid-phase Equilibria, Prentice-Hall.
2. Ismail Tosun, The Thermodynamics of Phase and Reaction Equilibria, Elsevier.
3. K.V. Narayanan, A textbook of Chemical Engineering Thermodynamics, PHI.

Reaction Engineering-II (ChE-605)

Module I **(No. of classes: 10)**
Catalysis: Catalysts, their preparation and properties, catalyst promoter and inhibitor; steps in a catalytic reaction: adsorption, surface reaction, desorption; mechanism, rate limiting step and rate law of a catalytic reaction; catalyst deactivation and determination of its order.
Catalytic reactor: design for gas-solid reactions, heterogeneous data analysis for reactor design.

Module II **(No. of classes: 10)**
Steady state nonisothermal continuous flow reactors: general steady state energy balance equation for a reactor; adiabatic operation: tubular reactor and tank reactors; non-adiabatic reactors: steady state tubular and tank reactors with heat exchange; case study; multiple steady states; nonisothermal multiple reactions in CSTR and PFR.
Unsteady state nonisothermal reactors: Unsteady state energy balance: batch, semi batch, CSTR, PFR, transient reactors with heat exchanger; multiple reactions; reactor safety.

Module III **(No. of classes: 10)**
Residence time for chemical reactor: General characteristics of distribution; residence-time distribution (RTD) function; measurement of the RTD: pulse and step input; characteristics of RTD: integral relationships, mean residence time, RTD in ideal reactor; concept of macromixing & micromixing, zero parameter model: segregation model and maximum mixedness model; models for nonideal reactors: introduction; one-parameter models: tanks in series model, dispersion model.

Module IV **(No. of classes: 10)**
Multiphase reactors: Fluidized bed reactor and its two-phase modeling, slurry reactor and its modeling, trickle bed reactor and its modeling.
Microreactor: Physical characteristics, flow regime, fabrication, applications in homogeneous, liquid-liquid biphasic, gas-liquid, bioorganic and biocatalytic reaction.

Books/References
Text

3. H. S. Fogler, Elements of Chemical Reaction Engineering, 3rd Ed., PHI Learning.

References

1. J. M. Smith, Chemical Engineering Kinetics, 3rd Ed., McGraw Hill.
2. T. Wirth (Ed.), Microreactors in Organic Chemistry and Catalysis, Wiley-VCH.

B. PRACTICAL

Mass Transfer Laboratory (ChE-606)

At least 8 (eight) experiments are to be performed

1. Determination of diffusivity of volatile liquid in air using Stefan tube.
2. Study of simple batch distillation to verify Rayleigh's equation.
3. Construction of boiling point diagram and equilibrium diagram of a binary system using Othmer still
4. Determination of mass transfer coefficient using wetted wall column.
5. Determination of mass transfer coefficient of a single solid sphere of naphthalene under forced convection and verification of Froessling correlation
6. Study of the absorption in a packed tower.
7. Determination of the drying rate and plotting a rate of drying curve under constant drying conditions.
8. Verification of adsorption isotherms by batch adsorption.
9. Determination of the overall mass transfer coefficient for counter current liquid-liquid extraction.
10. Determination of the diffusivity of a volatile solid in gas.
11. Study of drying characteristics in a Rotary Dryer.
12. Study of the internals of a distillation column

Thermodynamics and Reaction Engineering laboratory (ChE-607)

At least 8 (eight) experiments are to be performed

1. Study of vapor-liquid and liquid-liquid phase equilibria.
2. Volume change on mixing two liquids.
3. Determination of Joule-Thompson coefficient from a throttling experiment.
4. Study of work interaction in an adiabatic compression process.
5. Determination of rate constant and activation energy for a non-catalytic liquid phase homogenous reaction carried out in an isothermal batch reactor.
6. Determination of rate constant for a non-catalytic liquid phase homogenous reaction carried out in an isothermal semi-batch reactor.
7. Determination of rate constant of a non-catalytic homogenous liquid phase reaction at ambient condition in a plug Row reactor.
8. Determination of rate constant for a non-catalytic, homogenous reaction carried out in an isothermal continuous stirred tank reactor (CSTR).
9. Study of RTD in a packed bed reactor using a pulse input of the tracer to measure the axial dispersion coefficient.
10. Study of RTD in a straight tube PFR using a pulse input of the tracer to measure the axial dispersion coefficient.
11. Study of a heterogeneous catalytic reaction conducted in a spinning basket reactor.
12. Study of a heterogeneous photo-Fenton remediation in a continuous solar reactor.

Process Control and Instrumentation laboratory (ChE-608)

At least 8 (eight) experiments are to be performed

1. Determination of time constant of a mercury in glass thermometer.
2. Calibration of a pressure gauge using a Dead Weight Tester.
3. Liquid-Level Measurement using Air-Purge Method.
4. Dynamic response study of single liquid tank and determination of time constant.
5. Dynamic response study of a non-interacting second order system
6. Dynamic response study of a interacting second order system
7. Measurement using Load Cell
8. Studies on Characteristics of Control Valve
9. Studies on the Stability and tuning of a Flow Controller
10. Studies on the Stability and tuning of a Temperature Controller

11. Studies on the Stability and tuning of a level Controller
12. Response of a P & PI Controller

Process Equipment Design and Drawing-I (ChE-609)

Combined process and mechanical design along with drawing of typical process equipments used for storage (liquid storage tank and pressure vessel) and heat transfer (shell and tube heat exchanger, condenser, evaporator etc.).

Books/References

Text

1. M.V. Joshi and V.V. Mahajani, Process Equipment Design, Macmillan India Ltd.
2. J.H. Perry, Perry's Chemical Engineers Handbook, McGraw Hill.

References

1. W.L. McCabe, J.C. Smith and P. Harriot, Unit Operations of Chemical Engineering, McGraw Hill, New York.
2. D.Q. Kern, Process Heat Transfer, Tata McGraw Hill.

B. Tech 7th Semester syllabus

A. THEORY

Modern Separation Techniques (ChE-701)

Module-I **(No. of classes: 10)**

Membrane: Definition and structure; membrane properties: pore size, predicting flux from pore statistics, passage tests, factors affecting retentivity of membrane; membrane separation processes: definition, classification and physical chemistry.

Fouling: Characteristics, consequences, mathematical models, factors affecting fouling.

Cleaning: Various methods of enhancement of flux through cleaning.

Dialysis, Haemodialysis, Pervaporation, Electrodialysis and Reverse osmosis: Introduction, definition, theory, design and applications.

Module-II **(No. of classes: 10)**

Membrane performance and engineering models: Velocity and concentration boundary layer, concentration polarization, mass transfer (film theory) model, resistance model, osmotic pressure model, factors affecting flux.

Ultrafiltration: Module and process configurations, applications and economics.

Microfiltrtation: Theories and applications for dead-end and crossflow microfiltration.

Emulsion liquid membrane: Theory, design and application.

Module-III **(No. of classes: 10)**

New applications of membrane: Membrane based solvent extraction, hollow fibre with liquid membrane, membrane reactor for reaction with separation.

Chromatographic techniques: Adsorption chromatography; affinity chromatography; countercurrent chromatography: antibiotics and lipid separation, elution chromatography in columns: HPLC and GC; combination of two chromatographic techniques; supercritical fluid chromatography; gel chromatography.

Module-IV **(No. of classes: 10)**

Micro-separator: construction, applications.

Reactive distillation: Introduction; scope; steady state design of ideal ternary reactive distillation systems: without and with inerts.

Azeotropic distillation: principle; process; prediction of azeotropes.

Extractive distillation: Process; application; differences with azeotropic distillation.

Books/References

Text

1. W. S. W. Ho and K. K. Sircar (Ed.), Membrane Handbook, Springer Science LLC, New York.
2. M. Cheryan, Ultrafiltration and Microfiltrtation Handbook, CRC Press, New York.

References

1. J. Cazes, Encyclopedia of Chromatography, Vol. 1, Taylor and Francis, New York.
2. H. Determann, Gel Chromatography, Springer-Verlag, Berlin.
3. N.-T. Nguyen and S. T. Wereley, Fundamentals and Applications of Microfluidics, Artech House, London.
4. W. L. Luyben, C.-C. Yu, Reactive Distillation: Design and Control, Wiley, USA.
5. L. F. Albright, Albright's Chemical Engineering Handbook, CRC Press, New York.
6. J. J. Mcketta (Ed.), Unit Operations Handbook, Vol. 1: mass Transfer, Marcel Dekker, Inc., New York.
7. Membrane Technology & Applications, Baker, R. W., John Wiley and Sons Ltd.
8. Transport Processes and Unit Operations, Geankoplis, C. J., Prentice-Hall, India.

Industrial Economics and Management (ChE-702)

Module I **(No. of classes: 10)**

Economic activity: Nature; production and consumption of commodities; consumers and firms; fundamental economic problems in exchange economy: problems of scarcity and choice; economic systems: market mechanism, planned economy and mixed economy.

Demand: Demand for a commodity; law of demand: the demand function, the supply function; the equilibrium market price: demand-supply interaction, elasticity of demand; production function: linear homogeneous production function.

Cost concepts: Total, average and marginal costs, the cost curves.

Module II **(No. of classes: 10)**

Price: Price determination under different market conditions: pure competition, imperfect competition (oligopoly and monopolistic competition); theory of factor-pricing; returns to scale; marginal productivity; wages and profits.

The macroeconomic concept: National income and product, investment and outcome; price level: inflation, stagnation and recession, monetary and fiscal policies; outline of welfare economics; resource accounting and sustainability; economic role of Government, economic policies: industrial policy, trade policy, banking policy, economic planning, problems of economic development.

Module III **(No. of classes: 10)**

Industrial Management: Scope, brief history of industries (particularly, chemical) in India; Characteristics, principles and responsibilities of management, functions of management: planning, motivating, leading, controlling; Introduction to organization, basic types of organization, levels of management, skills of management, inter relation between skills and levels of management,

Production Management: Modern approach, manufacturing systems, interface management; manufacturing/operations strategy: principles & concept, various strategies: investment strategy, capacity strategy, quality strategy, customer focus strategy, product flexibility strategy, quick time delivery strategy, etc., concepts of Productivity.

Module IV **(No. of classes: 10)**

Financial Management: Sources of capital, investment decisions, financial statements: balance sheet, fund flow analysis, financial ratios and their significance, cost control by variable analysis, budgeting and budgetary control.

Quality Management: Use of control charts for implementing the quality plan: X-R chart, moving average chart, p-chart, c-chart.

Sampling: Acceptance sampling, AOQ, AQL, LTPD, chain sampling plan.

Maintenance Management: Causes, costs, classifications, equipment & plant reliability and availability, management of shutdowns and turnarounds, preventive and predictive maintenance.

Materials Management: Management of project materials and maintenance materials, purchasing and vendor development, store-keeping and inventory control.

Text Book

1. M. Adhikary, Business Economics, Excel Books, New Delhi.
2. C. R. Basu, Business Organization and Management, Tata McGraw Hill, New Delhi.

References

3. J. L. Riggs, D. D. Bedworth and S. U. Randhawa, Engineering Economics, Tata McGraw Hill, New Delhi.
4. S. Mishra, Engineering Economics and Costing, Prentice Hall India Pvt. Ltd., New Delhi.

5. J. Lal and S. Srivastava, Cost Accounting, Tata McGraw Hill, New Delhi.
6. I. M. Pandey, Financial Management, Vikas Publishing House Pvt. Ltd., New Delhi.
7. E. L. Grant, R. S. Leavenworth, Statistical Quality Control, Tata McGraw Hill, New Delhi.
8. J. Levitt, The Handbook of Maintenance Management, Industrial Press, New York.
9. J. R. T. Arnold, S. N. Chapman, L. M. Clive, Introduction to Materials Management, Pearson, New Delhi.

Environmental Engineering and Process Plant Safety (ChE-703)

Module-I: **(No. of classes: 10)**

Impact of man on the environment: Overview; the biosphere; hydrologic and nutrient cycles; consequences of population growth; energy problem; pollution of air, water and soil; towards solution; classification of pollutants. Legislative aspects including water act, Air Act and effluent standards.

Air pollution-source, effect and meteorological aspects: Classification and properties of air pollutants; emission sources; importance of anthropogenic sources; behavior and fate of air pollutants; photochemical smog; effect of air pollution; parameter effects: temperature lapse rate, wind velocity and turbulence, plume behavior, dispersion of air pollutants, atmospheric dispersion equation and Gaussian plume model.

Module-II: **(No. of classes: 10)**

Air pollution sampling, measurement: Types of sampling and measurement; ambient air sampling; collection of gaseous and particulate pollutants; stack sampling; analysis of air pollutants: SO_x, NO_x, CO, hydrocarbons and particulate matters.

Air pollution control methods and equipments: Control methods; source correction methods; cleaning of gaseous effluents; particulate emission control: gravity settling chamber, cyclone separators, fabric filters, electrostatic precipitators, wet scrubbers, selection of equipment; control of gaseous emission: adsorption by liquids and adsorption by solids; control of specific gaseous pollutants: control of SO_x, NO_x, CO and hydrocarbons; mobile sources.

Noise pollution and control: Definition and measurement of noise, sources and adverse effects of noise pollution, noise criteria and control.

Module-III: **(No. of classes: 10)**

Water pollution: Sources of wastewater; types of water pollutants and their effects; wastewater sampling and methods of analysis: physical characteristics, determination of organic and inorganic substances, bacteriological measurements, water quality standards.

Wastewater treatment: Introduction; primary treatment: pretreatment, sedimentation and flotation; secondary (biological treatment): activated sludge process and trickling filters, sludge treatment and disposal; advanced wastewater treatment: removal of suspended and dissolved solids, nitrogen and phosphorus removal, advanced biological systems, chemical oxidation.

Solid waste management: Sources and classification; public health aspects; methods of collection; disposal methods.

Module-IV: **(No. of classes: 10)**

Safety and Hazard management: Scientific principles; engineering aspects of industrial safety in relation to economic and operational aspects; safety regulations; hazards due to fire, explosions and toxic chemicals, fire triangle, BLEVE, runaway reaction etc; dust explosion, tools for hazards identification: HAZOP; fault Tree; event Tree; FMEA; Dow fire and explosion index; Mond Index, safety Audits.etc; Engineering control of chemical plant hazards, corrective control technologies to prevent fire and explosions, fundamentals of static charge development, accident potential and control techniques, explosions proof instruments, ventilation and sprinkler system, relief system.

Books/References

Text

1. A.P. Sincero and G.A. Sincero, Environmental Engineering, Prentice Hall, 1996.
2. D.A. Crowl and J.F. Louvar, Chemical Process Safety: Fundamentals with Applications, 3rd Ed., 2011.

References

1. M.L. Devis and D.A. Cornewell, Introduction to Environmental Engineering, McGraw-Hill Education; 5th Ed., 2012.
2. S.P. Mahajon, Pollution Control in process industries, McGraw Hill Education, 2001.
3. F.L. Burton, Metcalf & Eddy, Wastewater Engineering: Treatment, Disposal, and Reuse, McGraw Hill Education, 1991.

4. R.W. King and J. Majid, Industrial Hazards and Safety Handbook, Butterworth-Heinemann Ltd, 1979

Project Engineering (ChE-704)

Module I **(No. of classes: 10)**

Engineering ethics, Concept of project, project development: scale-up and scale-down techniques, role of a project engineer; brief overview of feasibility study: site selection and its various governing factors.

Pre-design cost estimation, basic engineering: process description and flow diagram (PFD), P&I diagram, plant layout, equipment specification, utilities; detailed engineering: specification, drawing, codes and standards, checking and incorporating vendor's information, procurement of equipment and materials, plant Commissioning and start-up.

Module II **(No. of classes: 10)**

Capital cost estimation and control: equity and debt, concept of fixed cost and working cost, calculation of fixed capital investment and working capital investment; gross and net profit, PBT, PAT.

Simple interest, nominal and effective interest rates, continuous interest, annuities, perpetuity; depreciation, concepts of service life, salvage value and book value, depreciation calculation methods: straight line, multiple straight line, declining balance method, sum-of-the-years digit method and sinking fund method.

Module III **(No. of classes: 10)**

Profitability analysis: Rate of return on investment, internal rate of return, discounted cash flow method, payout period (with and without interest), present worth method, capitalized cost, effect of inflation on profitability.

Alternative investment: Choices among various alternatives, replacements, methods of profitability evaluation for replacements.

Module IV **(No. of classes: 10)**

Optimum design: Analytical and graphical methods, break-even point, optimum production rates, optimum conditions in cyclic operations, optimum economic pipe diameters, optimum flow rate of cooling water.

Basic steps of project: Planning, scheduling, allocation, control; project scheduling: bar chart, Gantt chart, milestone chart.

Concepts of network analysis: Critical path method (CPM), calculation of critical path, float, project evaluation and review technique (PERT), statistical distribution associated with PERT.

Books/References

Text

1. M. S. Peters, K. D. Timmerhaus, Plant Design and Economics for Chemical Engineers, McGraw-Hill Inc.
2. R. K. Sinnot, Chemical Engineering Design, Coulson and Richardson's Chemical Engineering Series, Volume 6, Elsevier (Butterworth-Heinemann).

Reference

1. R. Sinnot, G. Towler, Chemical Engineering Design, Coulson and Richardson's Chemical Engineering Series, Elsevier (Butterworth-Heinemann).
2. E. D. Ludwig, Applied Process Design for Chemical and Petrochemical Plants, Vol. 1, 2, 3, Gulf Publishing.

Transport Phenomena-II (ChE-705)

Module-I: **(No. of classes: 10)**

Introduction to momentum Transport: Shell momentum balance and velocity distribution in laminar flow: flow of a falling film, flow through a circular tube and annulus, flow of two adjacent immiscible liquids, flow in a cone-and-plate viscometer, flow around a sphere; Equation of change for isothermal systems: the equation of continuity, the equation of motion, the equation of change for mechanical energy, common simplification of the equation of motion, problems with one and more than one independent variables: flow near wall, flow near a slowly rotating sphere, parallel disk compression viscometer, transient Poiseuille flow; lubrication flow theory.

Module-II: **(No. of classes: 10)**

Velocity distribution in turbulent flow: Comparison of laminar and turbulent flows, time and ensemble averaging, correlation and spectra, averaged equations of motion, turbulence production and cascade, the

Kolmogorov microscale, spectrum of turbulence in inertial subrange, wall-bounded shear flow, Eddy viscosity and mixing length, Taylor's theory of turbulent dispersion.
Non-Newtonian liquids: Non-Newtonian viscosity and the generalized Newtonian models, viscoelastic models, Flow of Non-Newtonian fluids (i) in a circular duct (ii) in a narrow slit (iii) through a tapered tube etc.

Module-III: **(No. of classes: 10)**
Shell energy balance in solids and laminar flow: energy balance and boundary conditions, heat conduction (i) in a steam pipe (ii) with temperature dependent thermal conductivity (iii) in a cooling fin, mechanical energy conservation with viscous dissipation, forced and free convection.
Energy equation: general and special forms of energy equation, Boussinesq approximation, problems with one and more than one independent variables: steady state forced convection heat transfer in laminar flow through a circular tube, freezing of a spherical droplet, forced convection in a slot, heat conduction with phase change.

Module-IV: **(No. of classes: 10)**
Mass Transport: Shell mass balance and concentration distribution in solids and laminar flow, diffusion of gases through solids, diffusion with a homogeneous and heterogeneous chemical reaction, diffusion into a falling liquid film; convection-diffusion-reaction equation, steady and unsteady state problems; concentration distribution in turbulent flow: fluctuation and time-smoothed concentration, time-smoothed continuity equation, semi-empirical expressions for the turbulent mass flux, enhancement of mass transfer by a first order reaction in turbulent flow

Books/References:
Text:
1. R.B. Bird, W.E. Stewart, E.N. Lightfoot, D.J. Klingenberg, Introductory Transport Phenomena, Wiley, 2013
Reference:
1. J.C. Slattery, Advanced Transport Phenomena, Cambridge University Press, 1999.
2. P.K. Kundu and I.M. Cohen, Fluid Mechanics, Academic Press.
3. W.M. Deen, Analysis of Transport Phenomena (Topics in Chemical Engineering), Oxford University Press.

Modeling, Simulation and Optimization (ChE-706)

Module-I: **(No. of classes: 10)**
Introduction to mathematical model and simulation: Concept of mathematical model, simulation and process analysis, lumped and distributed parameters models: hydraulic tank, mixing vessel, simultaneous mass and energy balance; modeling of batch and continuous process: batch heating of multi-component flash drum, steady-state flow processes involving non-reactive systems: extraction column (plate type), continuous heating in a stirred tank using jacket and coil, mixing in flow processes.

Module-II: **(No. of classes: 10)**
Modeling of heat and mass transfer operations: Concentration gradient across a bubble plate, simultaneous heat and mass transfer in packed bed, start-up of double pipe heat and shell and tube heat exchangers, simulation of multi-component multi-stage mass exchangers: formulation of MESH equations, general strategy, equation tearing procedure, Wang-Henke method, sum-rates method for absorption and stripping, isothermal sum-rate method for liquid-liquid extraction, Inside-out method.

Module-III: **(No. of classes: 10)**
Chemical reactor simulation: Modeling and simulation of isothermal and non-isothermal operation of batch reactor, CSTR and semi-batch reactor, steady-state CSTRs in series, thermal stability analysis of CSTR, non-isothermal operation of a single-homogeneous gas phase reaction in PFR, diffusion and chemical reaction-catalytic reaction in packed bed reactor.

Module-IV: **(No. of classes: 10)**
Process optimization: Concept and utility of process optimization; single variable optimization techniques: Newton's method, Secant method, dichotomous search, Fibonacci and golden search method; constrained and unconstrained multivariable optimization techniques: direct search, simplex method, Rosenbrock search technique, Powell search, complex method of Box and gradient search techniques.

Books/References:
Text:
1. W.L. Luyben, Process Modeling Simulation and Control, 2nd Ed., McGraw Hill, 1990.

2. B.K. Dutta, Mathematical Methods in Chemical and Biological Engineering, CRC Press, 2016.

Reference:

1. B.W. Bequette, Process Dynamics-Modeling, Analysis and Simulation, Prentice Hall, Englewood Cliffs, NJ, 1998.
2. A. Hussain and K. Gangaiah, Optimization Techniques for Chemical Engineering, MacMillan, Delhi, 1976.
3. T.F. Edgar, D.M. Himmelblau and L.S. Lasdon, Optimization of Chemical Processes, 2nd Ed., McGraw Hill, New York, 2001.

B. PRACTICAL

Project Work (ChE-707)

Each student shall be required to carry out investigation on a research problem under the supervision of a departmental faculty member. The research problem shall be assigned to a candidate during 6th semester.

In-Plant training (ChE-708)

Each student shall be required to undergo in-plant training, for a period of four to six weeks in a chemical process industry, R&D laboratory of an industry or design/consultancy organization after 6th semester.

Process Equipment Design and Drawing-II (ChE-709)

Combined process and mechanical design along with drawing of absorption/distillation column, cooling tower (induced draft, cross flow type) and catalytic reactor.

Books/References

Text

3. M.V. Joshi and V.V. Mahajani, Process Equipment Design, Macmillan India Ltd.
4. J.H. Perry, Perry's Chemical Engineers Handbook, McGraw Hill.

References

3. W.L. McCabe, J.C. Smith and P. Harriot, Unit Operations of Chemical Engineering, McGraw Hill, New York.
4. D.Q. Kern, Process Heat Transfer, Tata McGraw Hill.

B. Tech 8th Semester syllabus

A. THEORY

Polymer Engineering (ChE-801)

Module I **(No. of classes: 10)**

Introduction: Definition and concepts of various useful terms; classification of polymers.

Polymerization reactions: Classifications; mechanism and kinetics of step (condensation) polymerization, mechanism and kinetics of chain (addition) polymerization with free radicals, mechanism and kinetics of cationic, anionic and coordination polymerizations; copolymerization.

Module II **(No. of classes: 10)**

Polymerization processes: Polymerizations in homogeneous system (bulk and solution polymerization); polymerizations in heterogeneous system (emulsion, precipitation and suspension polymerization).

Polymerization reactors: Types, reactor design.

Chemical reactions of polymers: Crosslinking during polymerization, crosslinking after polymerization (vulcanization), degradation, its kinetics and products.

Module III **(No. of classes: 10)**

Characterization of polymers: Measurement of molecular weight and size, molecular weight distribution, analysis and testing of polymers.

Structure and properties of polymers: Morphology and order of crystalline polymers, rheology and mechanical properties of polymers, structure and physical properties of polymers, electrical properties of polymers.

Module IV **(No. of classes: 10)**

Polymer processing: Molding: compression, injection, blow, reaction-injection, rotational, thermoset, transfer; extrusion: co-extrusion, film extrusion; calendering, casting, coating, foaming, forming, laminating and low-pressure molding.
Multipolymer systems: Multilayer films, polymer blends, interpenetrating polymer networks, composites.
Engineering plastics: Processes of manufacturing, properties and fields of applications of– nylon, ABS, PE, PP, PET and reinforced plastics.

Books
Text
1. F. W. Billmeyer, Text Book of Polymer Science, John Wiley, New York.
2. P. Ghosh, Polymer Science & Technology, Tata McGraw Hill, New Delhi.

References
1. G. Odian, Principles of Polymerization, John Wiley & Sons, New Jersey.
2. T. Whelan, Polymer Technology Dictionary, Springer Science & Business Media, 1994.
3. R.O. Ebewele, Polymer Science and Technology, CRC Press, 2000.

Process Plant Simulation (ChE-802)

Module-I: **(No. of classes: 10)**
Introduction: Process synthesis and analysis, solving material and energy balance for steady state processes, equipment sizing and analysis of process flowsheet; salient features of simulation: modular approach, equation solving approach, decompositions of networks, convergence promotion, physical and thermo-physical properties, specific purpose and dynamic simulation.
Classification of mathematical modeling: Independent and dependent variables, model classification based on (i) the type of independent variables (lumped and distributed) (ii) the state of the process (static, dynamic and complete mathematical models) (iii) the type of the process (deterministic and stochastic); black box principle: introduction to artificial neural network (ANN), network training, modes of training, network architecture, back propagation algorithm, application.

Module-II: **(No. of classes: 10)**
Treatment of experimental results: Propagation of error through addition, subtraction, multiplication and division, sources of error, error measurement, precision errors, errors of methods, significant figures; data regression: theoretical methods of data regression and the associated problems.
Approaches of plant simulation: Modular approach of process plant simulation - analysis vs. design mode, sequential and simultaneous modular approaches; equation-solving approach – precedence ordering of equation sets, disjoining, tearing a system of equations, substitution algorithm, maintaining sparsity.

Module-III: **(No. of classes: 10)**
Decomposition of networks: Tearing algorithms – (i) algorithms based on signal flow graphs: Barkley-Motard algorithm, Pho-Lapidus algorithm; (ii) algorithms based on reduced digraphs: Kehat-Shacham algorithm, Murthy-Hussain algorithm; comparison of various tearing algorithms.
Convergence promotion and thermodynamic properties: Introduction, direct substitution, Newton's and quasi-Newton's methods, Wegstein method; thermodynamic properties: review of thermodynamic models, sources, data banks, modularity and routing.

Module-IV: **(No. of classes: 10)**
Specific purpose simulation and dynamic simulation: Introduction, problem description and formulation, simulation, results-discussion and inferences of (i) auto-thermal ammonia synthesis reactor (ii) thermal cracking operation (iii) design of a shell and tube heat exchanger and (iv) pyrolysis of biomass.
Introduction to professional plant simulation packages (ASPEN or equivalent): Basic features, idea of integrated simulation environment, package products, interactive process modeling, stepwise methodology of usage to a chemical plant simulation.

Books/References
Text
1. B.V. Babu, Process Plant Simulation, Oxford University Press, 2004.
References
1. I.D. Gil Chaves, J.R.G. López, J.L. García Zapata, A. Leguizamón Robayo, G. Rodríguez Niño, Process Analysis and Simulation in Chemical Engineering, Springer Internationa, 2016.

2. W. Reonick, Process Analysis and Design of Chemical Engineers, Wiley-Interscience, 1983.
3. A. Husain, Chemical Process Simulation, Wiley, 1986

Biotechnology (ChE-803)

Module I **(No. of classes: 10)**

Basic biochemistry and microbiology: Introduction (role of chemical engineers in biotechnology); cell structure and chemistry; Gram staining technique; structure of amino acids and proteins, carbohydrates and polysaccharides, lipids, fats and steroids, nucleic acids, RNA and DNA; cell nutrients: macro and micro nutrients; morphological and biochemical characteristics of microorganisms; basics of genetic engineering and tissue culture: recombinant DNA technology.

Module II **(No. of classes: 10)**

Enzyme and its kinetics: Structure function relations and classification of enzymes; mechanisms of enzyme action, Michaelis-Menten equation, Briggs-Haldane equation, experimental determination of rate parameters: Lineweaver-Burk and Eadie-Hofstee plot; enzyme inhibition: competitive, uncompetitive and noncompetitive.

Enzyme immobilization methods: Physical adsorption, entrapment, cross-linking, covalent bonding, surface analysis technologies for immobilized enzyme: applications of TGA, FESEM, SEM, TEM, XPS, SPR by UV detection, etc.

Applications of enzymes in industry.

Module III **(No. of classes: 10)**

Bioseparation processes: Separation of insoluble biomolecules and products–filtration, centrifugation, coagulation and flocculation; separation of soluble products–precipitation, salt precipitation, isoelectric precipitation; application of chemical engineering principles in bioseparation, two-phase extraction, adsorption, dialysis, microfiltration and ultrafiltration, reverse osmosis; electrophoresis: principles and methodologies.

Module IV **(No. of classes: 10)**

Bioprocess development: Kinetics of microbial growth, models; mass transfer in microbial system, oxygen supply and demand, single and multiple baffle aeration, spargers and aeration equipment; fermentation–fundamentals, design of fermenter; principles and mechanism of sterilization, design of sterilization equipment, bioreactor design and its scale up; integration of downstream processing with bioprocessing, bioprocess for production of alcohols, acids, vitamins, antibiotics, etc.

Books

Text

1. J. E. bailey and D. F. Ollis, Biochemical Engineering Fundamentals, McGraw Hill, New York.
2. M. L. Shuler and L. F. Kargi, Bioprocess Engineering-Basic Concepts, Prentice Hall.

References

1. M. J. Pelczar, R.D. Reid and E.C. S. Chan, Microbiology, Vol 1, McGraw Hill, New York.
2. K. Wilson and J. Walker, Principles and Techniques of Biochemistry and Molecular Biology, Cambridge University Press, Cambridge.

Nanotechnology (ChE-804)

Module-I: **(No. of classes: 10)**

Introduction: Background; definition and possible applications of nanotechnology; natural abundance of nanoforms; nanomaterials: crystal bonding, structure, growth and symmetries; structure and density states at nanoscale: energy bands and density of states at low dimensional structures; electrical transport in nanostructures: electrical conduction in metals, insulator and semiconductors; various conduction mechanisms in 3D (bulk), 2D (thin film) and low dimensional systems.

Module-II: **(No. of classes: 10)**

Introductory quantum mechanics for nanotechnology: Introduction; self-effects in smaller systems – pre-quantum; quantum behavior of nanometric systems: wave-particle duality, de Broglie wavelength, wave function associated with an electron, uncertainty principle, Schrödinger equation; application of Schrödinger equation: nanodots, nanosheets, nanowires, excitons, quantum confinement effect in nanomaterials.

Module-III: **(No. of classes: 10)**

Growth techniques of nanomaterials: Introduction; top-down vs. bottom-up approach; nanolithgraphic techniques: plasma arc discharge, sputtering, evaporation, chemical vapour deposition, pulsed laser deposition, molecular beam epitaxy, sol-gel technique, electrodeposition etc.

Characterization tools of nanomaterials: Scanning Probe Microscopy-introduction, basic principle and application; Atomic Force Microscopy-scanned proximity probe microscope, laser beam deflection, cantilevers, piezoceramics, feedback loop, alternating imaging modes and applications; Electron microscopy: introduction, resolution vs. magnification, Scanning Electron and Tunneling Electron microscopes.

Module-IV: **(No. of classes: 10)**

Nanoengineering devices: Lab-on-chip (LOC) – material and fabrication, advances and examples of LOC; nanomachinery: nanomotors, nanopores and nanosensors – production methods and predicted applications, synthetic molecular motors - chemical and light driven rotary molecular machines.

Nanomedicine: Medical applications of nanomaterials – cancer, surgery, visualization, nanoparticle targeting, cell-repair mechanisms; nanoparticles as controlled drug delivery devices: PEO-PLA/PBLA nanospheres, PEG coated nanospheres, AZT/DDC nanoparticles, insulin loaded nanoparticles, microporous chitosan, alginate-poly-L-lysine microcapsules, triglyceride liposphere, glutamate and TRH microsphere.

Books/References

Text

1. K.K. Chattopadhyay and A.N. Banerjee, Introduction to Nanoscience and Nonotechnology, PHI, 2010.

References

1. K.E. Drexler, Nanosystems, Wiley, 1992.
2. David J. Griffiths, Introduction to Quantum mechanics, Cambridge University Press, 2017.
3. G.L. Timp, Nanotechnology, Cbspd, 2005.
4. B.S. Murty, P. Shankar, B. Raj, B.B. Rath, J. Murday, Textbook of Nanoscience and Nanotechnology, Springer-Verlag Berlin Heidelberg, 2013.
5. H. Singh Nalwa (Ed.), Handbook of Nanostructured Materials and Nanotechnology, Elsevier.

B. PRACTICAL

Process Plant Simulation (ChE-805)

Introduction to any commercial simulation package, such as ASPEN and different similar products; opening a file a selection of the proper thermodynamic model; steady state simulations of the following unit operations: pump and compressor, heat exchanger, flash drum, absorption distillation and extraction columns, reactors; design and simulation of a complete chemical plant.

Project Work (ChE-806)

Each student shall be required to carry out investigation on a research problem under the supervision of a departmental faculty member. The topic should be a continuation of what has been done in ChE-707.

General Viva-Voce (ChE-807)

A comprehensive viva-voce will be conducted to test the student's overall understanding of the principles of Chemical Engineering and allied subjects.