Dr. Vishwanath Karad
MIT WORLD PEACE UNIVERSITY | PUNE
TECHNOLOGY, RESEARCH, SOCIAL INNOVATION & PARTNERSHIPS

PROGRAM STRUCTURE
AS PER CHOICE BASED CREDIT SYSTEM
(CBCS)

FACULTY OF ENGINEERING B.TECH.
(CHEMICAL ENGINEERING)

F.Y.B.Tech (2018-19 Batch)

and

S.Y.B.Tech (2017-18 Batch)

PROGRAMME STRUCTURE

Preamble:

The Chemical Process Industry (CPI) has experienced dramatic changes globally in the last few years and is merging into one global market with international competence. The CPI aims, particularly at energy, capital expenditure and variable feedstock cost savings due to fierce global competition and requirements for sustainable development. Today chemical engineering is considered as molecular engineering which operates at various scales to bring about transformations in a wide variety of materials. The discipline of chemical engineering is undergoing a major transformation. A new paradigm of "*borderless chemical engineering science*" is emerging and driving the profession towards achieving symbiotic relationship with other disciplines. Chemical engineering is becoming inclusive of biotechnology, nanotechnology and material science like never before. The professional arena of a chemical engineer has expanded greatly to cater to sectors as wide as pharmaceutical and electronics in addition to the more traditional oil and gas and petrochemical industries.

Parallel to these developments, the development and growth of the World Wide Web offers novel opportunities as well as new challenges. Today the modern research developments have become available from drawing rooms across the globe. This acts as a positive response tool in growing the pace of research in all fields including chemical engineering and biotechnology. There is also a remarkable amount of content, in a variety of formats, available on the internet.

Hence, an Under-graduate curriculum in chemical engineering must provide the basic foundation for a chemical engineer to be able to specialize in any area as and when the need and opportunity arise. The syllabus must integrate knowledge of the basic sciences with problem solving abilities and communication skills. It must promote a willingness to face open-ended problems with inadequate data. The curriculum must be broad enough to cover all areas from design to operation of process plants. It should be deep enough to enable the graduates to carry out research and develop products to meet rapidly changing needs and demands from modern society.

Faculty of Technology, in one of its meeting unanimously resolved that, each Board of Studies (BoS) shall prepare some Program Educational Objectives (PEOs) and give liberty to add few (PEOs) and Course Objectives (COs) and Course Outcomes (COs) to be clearly defined for each course, so that all faculty members understand the depth and approach of course to be taught, which will enhance learner's learning process. It was also resolved that, maximum senior faculty from the allied departments and experts from industry to be involved while revising the curriculum.

The feedback about the course contents as well as overall structure was taken from many experts (alumni as well as others), who are working in the areas of chemical engineering and technology, from industry and academic Institutions. These experts were from diverse backgrounds (R&D, production, design, consultancy, engineering, technology, etc.) Syllabi of Bachelor of Chemical engineering course of various Universities and Institutions around the world was studied to identify the weightages given to different components in the syllabus. Several meetings with internal faculty members and experts were conducted to discuss systematically program objectives and outcomes and the core structure of the syllabus was formulated. The B.Tech program offered in chemical engineering at MIT-WPU has a curriculum provides comprehensive theoretical, practical and real life knowledge of chemical engineering , emphasizing the fundamental, breadth of the discipline, and the necessary flexibility through specialized elective streams (Tracks of the program) such as Flow simulation, Refining and petrochemicals, Biochemical engineering and Process modelling and simulation.

Prof. (Dr.) Kiran D. Patil
Chairman, BoS in Chemical Engineering
Faculty of Engineering
Professor and Head, School of Chemical Engineering

Prof. (Dr.) L. K. Kshirsagar
Dean

Vision and Mission of the Programme

VISION

To be recognized as a global centre of educational excellence in the field of Chemical Engineering with a strong foundation of social and professional ethics.

MISSION

To produce quality Chemical Engineering Graduates from students of diversified backgrounds by providing them broad based education, team building skills, and professional values in a nurturing as well as creative learning environment.

Programme Educational Objectives

Chemical Engineering graduates will have achieved *two or more* of the following accomplishments within a few years of graduation:

PEO-1 Advance professionally with increasing responsibilities in broad areas of chemical engineering.

PEO-2 Acquire higher education in engineering, management or related fields.

PEO-3 Become entrepreneurs in engineering, management, finance and allied sectors.

PEO-4 Will work to promote health, safety and environmental concerns and address social and economic issues in professional career.

Programme Outcomes (Pos)

PO-1 An ability to apply knowledge of mathematics, science, and engineering for the solution of complex chemical engineering problems.

PO-2 An ability to identify, formulate and analyse complex engineering problems leading to substantiated conclusions through reviewing literature and applying first principles of mathematics, natural sciences and engineering sciences.

PO-3 An ability to obtain a feasible solution to complex chemical engineering problems through design of a system, component or process to meet desired needs within realistic constraints such as economic, environmental, health , safety and sustainability.

PO-4 An ability to conduct investigations of complex problems.

PO-5 An ability to use techniques, skills and modern engineering tools for modelling and simulation of complex engineering activities.

PO-6 An ability to apply contextual knowledge for the assessment of health, safety, societal and regulatory issues relevant to the engineering practice.

PO-7 An ability to understand the impact of engineering solutions in a global, economic, environmental and societal context and need for sustainable development.

PO-8 An ability to become a responsible professional following ethical principles and norms of the engineering practice.

PO –9 An ability to function effectively in the professional environment as an individual and as a member or leader of multidisciplinary teams.

PO-10 An ability to communicate effectively on complex engineering activities with the engineering community and society at large.

PO-11 An ability to apply engineering & management principles in multidisciplinary projects.

PO-12 Recognition of the need for, and an ability to engage in life–long learning to keep abreast with the emerging technologies.

Programme Specific Outcomes

PSO-I To accomplish in-depth knowledge of various unit operations and processes by making use of the concepts of mathematics, basic and engineering sciences.

PSO-II To identify, formulate, analyze and design chemical engineering problems using modern tools

PSO-III To inculcate their professional practice in chemical engineering to accomplish the contemporary needs of chemical and allied industries.

Programme Structure:

(a) Programme duration : 4 Years.

(b) System followed : Trimester

(c) Credits System:

The outcome based education, trimester based credit and grading system is introduced to ensure quality of engineering education. Trimester based credit and grading system enables a much-required shift in focus from teacher centric to learner-centric education since the workload estimated is based on the investment of time in learning and not in teaching. It also focuses on continuous evaluation which will enhance the quality of education.

(i) Per term or per year, as applicable : Credits are given per trimester
(ii) Total in the programme, as applicable : Total credits in programme: 175

(d) Credits for activities other than academics:

In the B.Tech curriculum of Chemical engineering, some credits are given to other activities such as social internship, Industry Internship / Live Project, etc

(e) Internship:

The program has rural immersion module as a part of social internship in the first year of study. The student would also have to undergo one full trimester Internship in Industry or in an R&D organization, including educational institutes with excellent research culture along with their project work during the final year. These credit based internships have credits and mandatory for all the students.

(f) Assessment Criteria:

There will be continuous assessment of a student's performance throughout the trimester and grades will be awarded by the Subject Teacher / Coordination Committee formed for this purpose.The following should be taken as a guideline to ensure uniformity of grading among all courses.

1. For arriving at a grade obtained by a student for a particular subject, initially a numeric marks obtained by the student out of 100 (hundred) is to be determined and then, the same is to be converted to letter grade.
2. For theory subjects, the subcomponents and the respective weights assigned to these are given below.

Subcomponent	Weight
Laboratory Continuous Assessment	25%
Class Continuous Assessment	25%
End-Semester Examination	50%

Various assessment tools such as tests, quizzes, assignments, project, group activities, presentations, etc would be used to evaluate the performance of the students.
The assessment Marks are valid only if Attendance criteria are met.

3. For assigning marks in Teacher's Assessment (T.A.), performance in home assignments, class tests, tutorials, viva-voce, attendance etc. are to be considered. It is recommended that at least two class tests for 4 credit theory courses and 1 test for 3 credit theory courses are to be conducted for a subject.
   The weights of different subcomponents of T.A. may be announced to the students by the teacher at the beginning of the trimester.
4. For assignment of marks in the laboratory component, the relevant subcomponents that are to be considered are: day-to-day work, regularity, tests (recommended): one test in 2 credit practical course) assignments, viva-voce etc. Percentage weights of the different subcomponents in deciding the final marks are to be announced at the beginning of the trimester. The evaluation process must be completed before the beginning of end trimester examination.
5. To the extent possible, laboratory work should be completed and evaluated every class thus ensuring continuous evaluation. Final examination and/or viva voce, if any, may not carry more than 20% marks. No external examiner shall be associated with evaluation of laboratory or theory courses.

(g) <u>Branches or Specialisations:</u>

There are four tracks in B.Tech Chemical Engineering program

Track I	:	Flow Simulation
Track II	:	Refining and Petrochemicals
Track III	:	Biochemical Engineering
Track IV	:	Process Modelling and Simulation

(h)Mandatory Attendance to appear for examination:

As per Para 13.1, Academic Ordinance: 2017 of MIT-WPU, It is expected on the part of the student to attend each and every Lecture, Tutorial, and Laboratory practical sessions in a course for the academic excellence. However, due to any contingencies, the attendance requirement will be a minimum of 90% of the classes scheduled/ held.

(j) Medium of Instruction & Examination:

As per Para 9, Academic Ordinance: 2017 of MIT-WPU, in all the Academic Programs, the medium of instruction and examination shall be English.

(k) Eligibility criteria for admission to the programme:

As per Para 4, Academic Ordinance: 2017 of MIT-WPU, the eligibility criteria for First Year admission is as below:

1. Passed HSC or its equivalent examination with Physics and Mathematics as compulsory subjects along with one of the Chemistry or Biotechnology or Biology or Technical Vocational subjects, and obtained at least 50 % marks (at least 45 % marks, in case of Backward class categories and Persons with Disability candidates belonging to Maharashtra State only) in the above subjects taken together **OR**
2. Passed Diploma in Engineering and Technology and obtained at least 50 % marks (at least 45 % marks, in case of Backward class categories and Persons with Disability candidates belonging to Maharashtra State only)
3. Obtained score in MHT-CET conducted by the Competent Authority. **OR** Obtained score in JEE (Main) conducted by the Competent Authority.

Eligibility Criteria for B.Tech (Lateral Entry)

1. The candidate should have passed in First Class / First Class with condonation, post SSC Or post HSC diploma course in Engineering / Technology of the Maharashtra State Board of Technical Education (MSBTE) **OR**
2. Any other recognized Diploma equivalent to the Diploma awarded by the Maharashtra State Board of Technical Education (MSBTE) with English as a medium of instruction at Diploma level. **OR**
3. Any other state / Territory Diploma equivalent to MSBTE, approved by AICTE, English as a medium of instruction out of state.

B. Tech Courses in Chemical Engineering

2017-18

A. Definition of Credit:-

3 Hours Lecture / Tutorial per week	2credit
2HoursPractical(Lab) per week	1credit

B. Credits:-

Total number of credits for four year undergraduate B.Tech Chemical Engineering Programme would be 175.

Structure of Credits for Undergraduate B.Tech Chemical Engineering Program:-

Sr. No.	Category	Suggested Breakup of Credits (Total 166)
1	Humanities and Social Sciences and Peace Programmes including Management courses	6
2	Basic Science courses	24
3	Engineering Science courses including workshop, drawing, Basics of electrical/mechanical/computer etc	25
4	Professional core courses	47
5	Professional Elective courses relevant to chosen specialization/branch	18
6	Open subjects–Electives from other technical and/or emerging subjects	17
7	Project work, seminar and internship in industry or elsewhere	15
8	Leadership and Personality Credits (LPC)	2
9	Mandatory Courses [Environmental Sciences, Induction training, Indian Constitution, Essence of Indian Traditional Knowledge]	12
	Total	**166+ 6 MOOC**

Comparisons of UG AICTE Model Curriculum with B.Tech Chemical Engineering:-

Credit Distribution			
Sr. No.	**Category**	**AICTE (160 Credits)**	**MIT-WPU Proposed (166 Credits)**
1	Humanities and Social Sciences including Management courses	12	6
2	Basic Science courses	25	24
3	Engineering Science courses including workshop, drawing, basics of electrical/mechanical/computer etc	24	25
4	Professional core courses	48	47
5	Professional Elective courses relevant to chosen specialization/branch	18	18
6	Open subjects – Electives from other technical and /or emerging subjects	18	17
7	Project work, seminar and internship in industry or elsewhere	15	15
8	Leadership and Personality Credits (LPC)	-	2
9	Mandatory Courses [Environmental Sciences, Induction training, Indian Constitution, Essence of Indian Traditional Knowledge]	Non Credit	12
	Total	160	166

Abbreviation	Definitions
L	Lecture
T	Tutorial
BS	Basic Science
ES	Engineering Science Courses
PC	Professional Core
PE	Professional Electives
OE	Open Electives
PR	Seminar/ Mini project/ Capstone project/ Interdisciplinary Project/or Internship
HSS	Humanity and Social Science
WP	Peace Programs
LPC	Leadership and Personality Credits

E. **Grading Scheme :**(according *to Para 12.1 of Academic Ordinances 2017*)

University shall use trimester /semester / annual as per need of a program. The credit based system provides flexibility in designing curriculum and assigning credits based on the course content and hours of teaching. The choice based credit system provides a 'cafeteria' type approach in which the students can take courses of their choice, learn at their own pace, undergo additional courses and acquire more than the required credits, and adopt an interdisciplinary approach to learning.

Grade Points:

The University shall follow a 10-point grading system with the following letter grades as given below:

Marks Out of 100	Grade	Grade Point
80-100	O: Outstanding	10
70-79	A+: Excellent	9
60-69	A: Very Good	8
55-59	B+: Good	7
50-54	B: Above Average	6
45-49	C: Average	5
40-44	Pass	4
0-39	Fail	0
Ab	Absent	NA

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B. Tech. Chemical Engineering (First Year) (Batch 2018-19)

Trimester – I

Sr. No.	Course Code	Name of Course	Type	Weekly Workload, Hrs.			Credits		Assessment Marks**			
				Theory	Tutorial	Lab.	Th.	Lab.	CCA*	LCA*	End Term Test	Total
1	ES 111	Mathematics -I	BS	3	1	--	3	--	100	-	50	150
2	ES112	Physics	BS	3	1	2	3	1	100	50	50	200
3	CE111	Applied Mechanics	ES	3	1	2	3	1	100	50	50	200
4	ME111	Workshop Practices	ES	-	-	2	-	1	-	50	-	50
5	ES113	Effective Communication	HSS	2	-	2	1	1	50	50	-	100
6		Practicing Yoga and Meditation	WP	-		1	-	-	-	-	-	-
Total :				**11**	**03**	**09**	**10**	**04**	**350**	**200**	**150**	**700**

****Assessment Marks are valid only if Attendance criteria are met**

***** CCA: Class Continuous Assessment

*****LCA: Laboratory Continuous Assessment

Weekly Teaching Hours: 23 Hours

Total Credits: First Year B. TechTrimester-I:14

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B. Tech. Chemical Engineering (First Year) (Batch 2018-19)

Trimester – II

Sr. No.	Course Code	Name of Course	Type	Weekly Workload, Hrs.			Credits		Assessment Marks**			
				Theory	Tutorial	Lab.	Th.	Lab.	CCA*	LCA*	End Term Test	Total
1	ES121	Mathematics II	BS	3	1	-	3	-	100	-	50	150
2	ES122	Chemistry	BS	3	-	2	2	1	50	50	50	150
3	ME121	Material Science for Engineers	BS	3	-	2	2	1	50	50	50	150
4	ME122	Engineering Graphics	ES	2	-	2	1	1	-	50	50	100
5	CS121	Computer Programming	ES	3	-	2	2	1	50	50	50	150
6	WPC 1	Indian Culture and Heritage	WP	3	-	-	2	-	50	-	50	100
7		Rural Immersion Programme	WP	-	-	-	-	-	-	-	-	-
8		Practicing Yoga and Meditation	WP	-	-	1	-	-	-	-	-	-
		Total :		**17**	**1**	**09**	**12**	**04**	**300**	**150**	**300**	**800**

****Assessment Marks are valid only if Attendance criteria are met**

***** CCA: Class Continuous Assessment

*****LCA: Laboratory Continuous Assessment

Weekly Teaching Hours: 27 Hours

Total Credits: First Year B. Tech.Trimester-II:16

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B. Tech. Chemical Engineering (First Year) (Batch 2018-19)

Trimester – III

Sr. No.	Course Code	Name of Course	Type	Weekly Workload, Hrs.			Credits		Assessment Marks**			
				Theory	Tutorial	Lab.	Th.	Lab.	CCA*	LCA*	End Term Test	Total
1	ES 131	Biology	BS	3	-	-	2	-	50	-	50	100
2	ME131	Engineering Design Principles	ES	3	-	2	2	1	50	50	50	150
3	EL131	Engineering Science Elective Course I*	ES	3	-	2	2	1	50	50	50	150
4	EL132	Engineering Science Elective Course II*	ES	3	-	2	2	1	50	50	50	150
5	WPC 2	Philosophers of Bharat , Great Kings and Dynasties	WP	3	-	-	2	-	50	-	50	100
6		Practicing Yoga and Meditation	WP	-	-	1	-	-	-	-	-	-
		Total :		**15**	**0**	**07**	**10**	**03**	**250**	**150**	**250**	**650**

****Assessment Marks are valid only if Attendance criteria are met**

Weekly Teaching Hours: 22 Hours

***** CCA: Class Continuous Assessment

*****LCA: Laboratory Continuous Assessment

Total Credits: First Year B. Tech.Trimester-III:13

Total First Year B. Tech Credits: 14+15+14=43

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List of Engineering Science Elective I and II

Sr. No.	Course Code	Name of Course
1		Introduction to Civil Engineering
2		Introduction to Mechanical Engineering
3		Introduction to Computer Science and Engineering
4		Introduction to Electrical Engineering
5		Introduction to Electronics Engineering
6		Introduction to Polymer Engineering
7		Introduction to Petroleum Engineering
8	CH138	Introduction to Chemical Engineering

*** Any two courses other than parent/ home discipline can be chosen from the list given above**

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B. Tech. Chemical Engineering (Second Year) (Batch 2017-18)

Trimester – IV

Sr. No.	Course Code	Name of Course	Type	Weekly Workload, Hrs.			Credits		Assessment Marks**			
				Theory	Tutorial	Lab.	Th.	Lab.	CCA*	LCA*	End Term Test	Total
1	ES214	Physical and Inorganic Chemistry	ES	3	-	2	2	1	50	50	50	150
2	CH211	Chemical Technology	PC	3	-	2	2	1	50	50	50	150
3	CH212	Mechanics of Materials	PC	3	1	2	3	1	50	50	50	150
4	CH213	Material and Energy Balance Calculations	PC	3	1	-	3	-	50	-	50	100
5	CH214	Computational Skills	PC	-	-	2	-	1	-	50	-	50
6		Indian Constitution/Environmental Science	HSS	2	-	-	1	-	50	-	-	50
Total :				**14**	**02**	**08**	**11**	**04**	**250**	**200**	**200**	**650**

****Assessment Marks are valid only if Attendance criteria are met**

***** CCA: Class Continuous Assessment

*****LCA: Laboratory Continuous Assessment

Weekly Teaching Hours: 24 Hours

Total Credits: Second Year B. Tech.Trimester-I: 15

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B. Tech. Chemical Engineering (Second Year) (Batch 2017-18)

Trimester – V

Sr. No.	Course Code	Name of Course	Type	Weekly Workload, Hrs			Credits		Assessment Marks**			
				Theory	Tutorial	Lab.	Th.	Lab.	CCA*	LCA*	End Term Test	Total
1	ES224	Organic Chemistry	ES	3	-	2	2	1	50	50	50	150
2	CH221	Fluid Mechanics	PC	3	-	2	2	1	50	50	50	150
3	CH222	Mechanical Operations	PC	3	-	2	2	1	50	50	50	150
4	CH223	Engineering Thermodynamics	PC	3	-	-	2	-	50	-	50	100
5	WPC 3	Spirit and Mind, Saints of India and Their Teachings	WP	3	-	-	2	-	50	-	50	100
6		National Study Tour	WP	-	-	-	-	-	-	-	-	-
Total :				**15**	**01**	**06**	**10**	**03**	**250**	**150**	**250**	**650**

Weekly Teaching Hours: 22 Hours

Total Credits: Second Year B. Tech.Trimester-II: 13

****Assessment Marks are valid only if Attendance criteria are met**

* CCA: Class Continuous Assessment

*LCA: Laboratory Continuous Assessment

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B. Tech. Chemical Engineering (Second Year) (Batch 2017-18)

Trimester – VI

Sr. No.	Course Code	Name of Course	Type	Weekly Workload, Hrs.			Credits		Assessment Marks**			
				Theory	Tutorial	Lab.	Th.	Lab.	CCA*	LCA*	End Term Test	Total
1	ES231	Mathematics-III	BS	3	1	-	3	-	100	-	50	150
2	CH231	Heat Transfer	PC	3	-	2	2	1	50	50	50	150
3	CH232	Chemical Engineering Thermodynamics	PC	3	-	-	2	-	50	-	50	100
4	CH233	Process Instrumentation	PC	3	-	-	2	-	50	-	50	100
5	CH234	Chemical Reaction Engineering	PC	3	-	2	2	1	50	50	50	150
6		Environmental Science/Indian Constitution	HSS	2	-	-	-	1	50	-	-	50
Total :				**15**	**02**	**04**	**11**	**03**	**350**	**100**	**250**	**700**

Weekly Teaching Hours: 21 Hours

Total Credits: Second Year B. Tech.Trimester-III: 14

****Assessment Marks are valid only if Attendance criteria are met**

* CCA: Class Continuous Assessment

*LCA: Laboratory Continuous Assessment

Total Second Year B. Tech Credits: 15+13+14=42

Prof. (Dr.) L. K. Kshirsagar
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B. Tech. Chemical Engineering (Third Year) (Batch 2017-18)

Trimester – VII

Sr. No.	Course Code	Name of Course	Type	Weekly Workload, Hrs.			Credits		Assessment Marks**			
				Theory	Tutorial	Lab	Th.	Lab.	CCA*	LCA*	End Term Test	Total
1	ES313	Numerical and Statistical Methods	BS	3	-	2	2	1	50	50	50	150
2	ES312	Mass Transfer-I	PC	3	-	2	2	1	50	50	50	150
3	CH313	Process Equipment Deign	PC	3	-	2	2	1	50	50	50	150
4	CH314	Professional Elective-I	PE	3	-	2	2	1	50	50	50	150
5	CH315	Open Elective-I	OE	3	-	2	2	1	50	50	50	150
6	WPC 6	Human Values and Professional Ethics	WP	3	-	-	2	-	50	-	50	100
Total :				**18**	**-**	**10**	**12**	**05**	**300**	**250**	**300**	**850**

****Assessment Marks are valid only if Attendance criteria are met**

***** CCA: Class Continuous Assessment

*****LCA: Laboratory Continuous Assessment

Weekly Teaching Hours:28 Hours

Total Credits: Third Year B. Tech.Trimester- I: 17

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B. Tech. Chemical Engineering (Third Year) (Batch 2017-18)

Trimester – VIII

Sr. No.	Course Code	Name of Course	Type	Weekly Workload, Hrs.			Credits		Assessment Marks**			
				Theory	Tutorial	Lab	Th.	Lab.	CCA*	LCA*	End Term Test	Total
1	CH321	Mass Transfer-II	PC	3	-	2	2	1	50	50	50	150
2	CH322	Environmental Engineering	PC	3	-	2	2	1	50	50	50	150
3	CH 323	Professional Elective –II	PE	3	-	2	2	1	50	50	50	150
4	CH324	Open Elective-II	OE	3	-	2	2	1	50	50	50	150
5		Finance and Accounting	HSS	3	-	-	2	-	50	-	50	100
6	WPC 5	Science and Spirituality	WP	3	-	-	2	-	50	-	50	100
Total :				**18**	**-**	**8**	**12**	**04**	**300**	**200**	**300**	**800**

Weekly Teaching Hours: 26Hours

Total Credits: Third Year B. Tech.Trimester-II: 16

****Assessment Marks are valid only if Attendance criteria are met**

* CCA : Class Continuous Assessment

*LCA : Laboratory Continuous Assessment

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B. Tech. Chemical Engineering (Third Year) (Batch 2017-18)

Trimester – IX

Sr. No.	Course Code	Name of Course	Type	Weekly Workload, Hrs.			Credits		Assessment Marks**			
				Theory	Tutorial	Lab.	Th.	Lab.	CCA*	LCA*	End Term Test	Total
1	CH331	Plant Design and Economics	PC	3	-	2	2	1	50	50	50	150
2	CH332	Process Dynamics and Control	PC	3	-	2	2	1	50	50	50	150
3	CH333	Professional Elective –III	PE	3	-	2	2	1	50	50	50	150
4	CH334	Open Elective-III	OE	3	-	-	2	-	50	-	50	100
5	CH335	Seminar/ Mini Project	PR	-	-	2	-	1	-	50	-	50
6	WPC 2	Gandhian Philosophy	WP	3	-	-	2	-	50	-	50	100
Total :				**15**	**-**	**8**	**10**	**04**	**250**	**200**	**250**	**700**

Weekly Teaching Hours: 23 Hours

Total Credits: Third Year B. Tech.Trimester-III: 14

Total Third Year B. Tech Credits: 17+16+14= 47

****Assessment Marks are valid only if Attendance criteria are met**

* CCA : Class Continuous Assessment

*LCA : Laboratory Continuous Assessment

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B. Tech. Chemical Engineering (Final Year) (Batch 2017-18)

Trimester – X

Sr. No.	Course Code	Name of Course	Type	Weekly Workload, Hrs.			Credits		Assessment Marks**			
				Theory	Tutorial	Lab.	Th.	Lab.	CCA*	LCA*	End Term Test	Total
1	CH 411	Professional Elective –IV	PE	3	-	2	2	1	50	-	50	100
2	CH412	Professional Elective –V	PE	3	-	2	2	1	50	50	50	150
3	CH413	Open Elective-IV	OE	3	-	2	2	1	50	50	50	150
4	CH414	Mini Project / Interdisciplinary Project	PR	-	-	4	-	2	-	100	-	100
5		Strategic Planning and Leadership	LPC	3	-	-	2	-	50	-	50	100
Total :				**12**	**-**	**10**	**8**	**5**	**200**	**200**	**200**	**600**

Weekly Teaching Hours: 22 Hours

Total Credits: Final Year B. Tech.Trimester-I:13

****Assessment Marks are valid only if Attendance criteria are met**

* CCA : Class Continuous Assessment

*LCA : Laboratory Continuous Assessment

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B. Tech. Chemical Engineering (Final Year) (Batch 2017-18)

Trimester – XI

Sr. No.	Course Code	Name of Course	Type	Weekly Workload, Hrs.			Credits		Assessment Marks**			
				Theory	Tutorial	Lab.	Th.	Lab.	CCA*	LCA*	End Term Test	Total
1	CH 421	Professional Elective-VI	PE	3	-	2	2	1	50	50	50	150
2	CH 422	Open Elective-V	OE	3	-	2	2	1	50	50	50	150
3	CH 423	Open Elective-VI	OE	3	-	2	2	1	50	50	50	150
4	CH 424	Capstone Project : Stage-I	PR	-	-	6	-	2	-	100	-	100
Total :				**9**	**-**	**12**	**6**	**5**	**150**	**250**	**150**	**550**

Weekly Teaching Hours:21 Hours

Total Credits: Final Year B. Tech. Trimester-II: 11

****Assessment Marks are valid only if Attendance criteria are met**

* CCA: Class Continuous Assessment

*LCA : Laboratory Continuous Assessment

Prof. (Dr.) L. K. Kshirsagar
Dean

B. Tech. Chemical Engineering (Final Year) (Batch 2017-18)

Trimester – XII

Sr. No.	Course Code	Name of Course	Type	Weekly Workload, Hrs.			Credits		Assessment Marks**			
				Theory	Tutorial	Lab.	Th.	Lab.	CCA*	LCA*	End Term Test	Total
1	CH431	Capstone Project with or without Internship: Stage-II	PR	-	-	24	-	10	-	300	-	300
Total :				-	-	**24**	-	**10**				

****Assessment Marks are valid only if Attendance criteria are met**

Weekly Teaching Hours:24 Hours

Total Credits: Final Year B. Tech.Trimester- III: 10

***** CCA : Class Continuous Assessment

*****LCA : Laboratory Continuous Assessment

Total Final Year B. Tech Credits: 13+11+10= 34

Total B. Tech Credits: FY+SY+TY+Final Year = 166+6 MOOC Credits

Prof. (Dr.) L. K. Kshirsagar
Dean

Humanities, Social Sciences, Management (HSS)	World Peace (WP)
• Effective Communication • Finance and Accounting • Indian Constitution • Environmental Science	• Indian Culture and Heritage • Philosophers, Great Kings and Dynasties • Science and Spirituality • Human Values and Professional Ethics • Spirit & Mind, Saints of India and their teachings • Gandhian Philosophy
Leadership and Personality Credits (LPC) • Emotional Intelligence • Leadership • Strategic Planning	

Every candidate will register for at least three MOOC courses, World Peace programmes like rural immersion, national study tour are mandatory for graduation. Students to submit the credits earned in MOOCs courses for inclusion in their grade sheet.

Year	Average Contact Hours per week	Credits	No. of Courses
First Year	24	43	5+5+5
Second Year	24	42	6+6+6+ MOOC
Third Year	27	47	6+6+7+ MOOC
Final Year	22	34	4+3+ MOOC
Total	--	**166 + 6 MOOC**	

List of Professional Elective Courses (PE):

TRACKS	Flow Simulation		Refining and Petrochemicals		Biochemical Engineering		Process Modeling and Simulation	
Electives	**Code**	**Title**	**Code**	**Title**	**Code**	**Title**	**Code**	**Title**
PE-I	CH314	A.Computational Methods in Chemical Engineering	CH314	B Refinery Operations	CH314	C.Introduction to Biotechnology	CH314	D.Process Modeling and Simulation
PE-II	CH 323	A.Multiphase Systems	CH 323	B.Petrochemical Processes	CH323	C.Enzyme Engineering	CH323	D.Process Data Analytics
PE-III	CH333	A.Computational Fluid Dynamics	CH333	B.Refinery Process Design	CH333	C.Biochemical Process Design	CH333	D.Chemical Process Optimization
PE-IV	CH411	A. Pollution Control in Process Industries	CH411	B.Natural Gas Engineering	CH411	C.Industrial Catalysis	CH411	D.Green Technology
PE-V	CH412	A.Piping Engineering	CH412	**PE-VI**	21	nergy Engineering	CH421	

CH4 A.E

B.Membrane Technology	CH412	C.Multiphase Reactor Design	CH412	D.Advanced Separation Processes
B.Chemical Process Safety	CH421	C.Process Intensification	CH421	D.Advanced Process Control

List of Open Elective Courses (OE):

List of Open Electives offered		
Professional Elective	**Course Code**	**Name of Course**
OE-I	CH315	Pinch Technology
	CH315	Green Technology and Sustainable Development
	CH315	Disaster Management
OE-II	CH324	Control Systems
	CH324	Design and Analysis of Experiments
	CH324	Piping Design and Engineering
OE-III	CH334	Health, Safety and Envirionment
	CH334	Advanced Waste Management
	CH334	Air Pollution Control Engineering
OE-IV	CH413	Energy Conservation and Management
	CH413	Industrial Safety and Hazard Management
	CH413	Material Science and Technology
OE-V	CH422	Engineering Ethics
	CH422	Risk Assessment and Management
	CH422	Project Engineering and Management
OE-VI	CH423	Catalysis
	CH423	Refining and Petrochemical Technology
	CH423	Fuels and Combustions

SYLLABUS

SY B.TECH. (CHEMICAL ENGINEERING)

BATCH – 2018-19

SY B.Tech (Chemical Engineering) (TRIMESTER-I)

Course Code	**ES214**			
Course Category	**Basic Science**			
Course Title	**Physical and Inorganic Chemistry**			
Teaching Scheme and Credits Weekly load hrs	**L**	**T**	**Laboratory**	**Credits**
	3	**-**	**2**	**2+0+1=3**

Pre-requisites: (i) H.S.C. Chemistry
(ii) F.Y.B.Tech Chemistry
(iii) S.Y.B.Tech First trimester (Organic chemistry)

Course Objectives:

(i) To inculcate fundamentals of Physical and Inorganic chemistry.
(ii) To impart knowledge of atomic structure and bonding, transition elements and their complexes, catalysis and surface chemistry.

Course Outcomes:

Course Outcomes:

After completion of this course students will be able to:

1) Explain atomic structure and bonding.(CL-II)
2) Recall concept of interfaces and surfaces.(CL-I)
3) Summarize transition metals and their complexes.(CL-II)
4) Explain concept and need of catalysis.(CL-II)
5) Correlate colligative properties with molecular weight.(CL-IV)

Course Contents:

Atomic Structure and Bonding: Electronic configuration, energy levels, orbitals, quantum numbers. Lewis dot symbols, ionic bond, lattice energy for ionic compounds. Octet rule and exceptions to octet rule. Electronegativity. Valence shell electron pair repulsion theory. Dipole moment. Chemical bonding – Covalent bond, VBT, Hybridization, Hybridizational shapes of molecules with examples (up to C. N. 6), Molecular Orbital Theory, LCAO, M.O. diagrams for diatomic Molecules like H_2, CO_2, O_2, N_2 etc. Comparison of properties of ionic and covalent compounds.

Transition elements and their complexes: Transition elements, study of 1st transition series w.r.t. oxidation states, magnetic behavior ,colour, ability to form complexes and catalytic behavior. Coordination compounds –different terms- C.N., ligand, EAN etc. Nature of metal ligand bonding- VBT and CFT Formation and above properties of tetrahedral square planer and octahedral complexes of first transition series on the basis of VBT and CFT.

Catalysis: Definition, role and classification of catalyst, Role of transition metal compounds in homogeneous and heterogeneous catalysis, steps involved, and examples. Promoter and its examples, Catalytic poisons. Autocatalysis, negative catalysis. Theories of catalysis. Acid Base catalysis. Importance of catalysis by giving some industrial examples. Biocatalysts- Enzymes, mechanism of enzyme action, enzyme catalysis, examples. Examples of the reactions involving catalysis.

Surface Chemistry: Cohesive and adhesive forces. Surface tension. Surface energy. Capillary action. Interfacial tension, wetting, surface tension measurements, electro kinetic phenomena, zeta potential

and its measurement. Emulsions and their types. Emulsifying agents, Micellization and CMC ,emulsion stability, emulsifiers, demulsifiers, numericals. Adsorption- types of adsorption isotherm, Gibb‟s adsorption equation, BET equation, surface area of adsorbents, application of adsorption on surface of solids, adsorption of higher molecular compounds**,** numericals.

Course outcomes:

After completion of laboratory work students will be able to;

1. Demonstrate preparation of transition metal complexes.
2. Determine surface tension, CMC of surfactant and effect of salt on CMC.
3. Determine molecular weight of substance measuring their colligative properties.
4. Demonstrate effect of catalyst on rate of reaction.
5. Demonstrate practical competence to successfully participate in research and development of innovative technology programmes.

List of Experiments: *(any 7 experiments)*

1. To find surface tension of liquid by stalagmometer.
2. To find CMC of surfactant.
3. Investigation of adsorption of oxalic acid by activated charcoal and test the validity of Freundlich‟s isotherm.
4. To find out effect of catalyst on reaction rate for the reaction between iodide and hydrogen peroxide in an acidic environment.
5. Preparation of Tetraammine copper (II) sulfate, monohydrate.
6. Determination of concentration of the given unknown solution of titanium by colorimetric method.
7. Preparation of hexammine cobalt (III) chloride.
8. Determination of amount of manganese (Mn) volumetrically by Volhard‟s method .
9. The comparison of rate of reaction between iron(III) nitrate and sodium thiosulfate using different transition metal ions as catalysts (Cu or Co).
10. Determine the influence of salt on the CMC of an anionic soap.

Learning Resources:

Reference Books:

1. Glasstone S., “Textbook of Physical chemistry”, McMillan and Co. Ltd. 1981.
2. Rosen M.J., “Surfactants and Interfacial Phenomenon”, 4th edition, Wiley Interscience. 2012.
3. Chang, R., “Chemistry”, 9th edition, Tata MaGraw Hill Education Pvt. Ltd. 2010.

Supplementary Reading:

1. Atkins P, Paula J., “Physical Chemistry”, 10th edition, Oxford University Press, 2014.
2. Lee J.D., “Concise Inorganic Chemistry”5th edition, Wiley Oxford University Press, 2013.

Web Resources:

Weblinks:

1. Atomic structure and bonding- http://nptel.ac.in/courses/104103069/5
   http://nptel.ac.in/courses/104103069/13
   http://nptel.ac.in/courses/104103069/15
2. Transition metals- http://nptel.ac.in/courses/104105033/
3. Catalysis- http://nptel.ac.in/downloads/103103026/
4. Surface tension- http://nptel.ac.in/courses/112104118/lecture-2/2-7-surface-tension-liquids.htm
5. Surfactants - http://nptel.ac.in/courses/116102016/10
6. Colloids - http://nptel.ac.in/courses/103104045/pdf_version/lecture1.pdf
   http://nptel.ac.in/courses/103104045/pdf_version/lecture2.pdf

MOOCs: Online courses for self-learning

1. Atomic Structure: https://www.coursera.org/learn/chemistry-1.
2. Inorganic Chemistry: https://www.coursebuffet.com/course/75/saylor/inorganic-chemistry
3. Advanced Chemistry: https://www.coursera.org/learn/advanced-chemistry
4. Colligative properties : https://www.udemy.com/chemistry-colligative-properties-of-solutions/

Pedagogy:

- Co-teaching
- Power point presentations
- Videos
- Demonstrations
- Systematic use of group work and project based learning.

Assessment Scheme:

Class Continuous Assessment (CCA): 50 marks

Assignments	Test	Presentations	Case study	MCQ	Oral	Attendance and Initiative
10 Marks	10 Marks	10 Marks	-	10 Marks	-	10 Marks

Laboratory Continuous Assessment (LCA): 50 marks

Regularity and punctuality	Understanding the objective	Understanding of procedure	Experiment Skills	Ethics
10 Marks	10 Marks	10 Marks	10 Marks	10 Marks

Term End Examination : Theory Paper of 50 marks

Syllabus:

Module No.	Contents	Workload in Hrs		
		Theory	*Lab*	*Assess*
1	**Atomic Structure and Bonding:** Electronic configuration, energy levels, orbitals, quantum numbers. Lewis dot symbols, ionic bond, lattice energy for ionic compounds. Octet rule and exceptions to octet rule. Electronegativity. Valence shell electron pair repulsion theory. Dipole moment. Chemical bonding – Covalent bond, VBT, Hybridization, Hybridizational shapes of molecules with examples (up to C. N. 6), Molecular Orbital Theory, LCAO, M.O. diagrams for diatomic Molecules like H_2, CO_2, O_2, N_2 etc. Comparison of properties of ionic and covalent compounds.	**8**	**--**	
2	**Transition elements and their complexes:** Transition elements, study of 1st transition series w.r.t. oxidation states, magnetic behavior, colour, ability to form complexes and catalytic behavior. Coordination compounds –different terms- C.N., ligand, EAN etc. Nature of metal ligand bonding- VBT and CFT Formation and above properties of tetrahedral square planer and octahedral complexes of first transition series on the basis of VBT and CFT.	**8**	**10**	
3	**Catalysis:** Definition, role and classification of catalyst, Role of transition metal compounds in homogeneous and heterogeneous catalysis, steps involved, and examples. Promoter and its examples, Catalytic poisons. Autocatalysis, negative catalysis. Theories of catalysis. Acid Base catalysis. Importance of catalysis by giving some industrial examples. Biocatalysts- Enzymes, mechanism of enzyme action, enzyme catalysis, examples. Examples of the reactions involving catalysis.	**6**	**2**	
4	**Surface Chemistry:** Cohesive and adhesive forces. Surface tension. Surface energy. Capillary action. Interfacial tension, wetting, surface tension measurements, electro kinetic phenomena, zeta potential and its measurement. Emulsions and their types. Emulsifying agents, Micellization and CMC , emulsion stability, emulsifiers, demulsifiers, numericals. Adsorption- types of adsorption isotherm, Gibb‟s adsorption equation, BET equation, surface area of adsorbents, application of adsorption on surface of solids, adsorption of higher molecular compounds**,** numericals.	**8**	**8**	

SY B.Tech (Chemical Engineering) (TRIMESTER-I)

Course Code	**CH211**			
Course Category	**Professional Core**			
Course Title	**Chemical Technology**			
Teaching Scheme and Credits	**L**	**T**	**Laboratory**	**Credits**
Weekly load hrs	**3**	**-**	**2**	**2+0+1**

Pre-requisites: Mathematics, Physics, Chemistry and Engineering Thermodynamics

Course Objectives:

1. Understand the role of chemical engineering in process industry
2. Appreciate the size and scope of chemical industry

Course Outcomes:

1. Enlist the various manufacturing routes for a product (CL-1)
2. Construct chemical process flow diagrams(CL-3)
3. Apply principles of chemistry for a process(CL-3)

Course Contents:

Introduction:
Overview of Chemical Processing Industries and Role of Chemical Engineer, Chemical Industries-Indian and Worldwide Scenario, Symbolic Representation of Unit Operations and Unit Processes.

Inorganic Chemical Industries-I:
Sulphur and Sulphuric Acid, Fertilizers, Chlor-alkali, Cement and Lime, Fuel and Industrial gases

Inorganic Chemical Industries-II:
Ceramics, Glass, Agrochemicals, Surface coating industry

Natural Product Industries:
Edible and Essential Oil Industry, Cleansing compounds, Paper and Pulp, Leather and allied industry, Food and Fermentation

Organic Chemical Industries:
Coal and Coal Chemicals, Petrochemicals derived from C_1, C_2 C_3 and C_4, Pharmaceuticals

Polymerization Industries:
Condensation polymerization products, Addition polymerization products, Man-made Fibres

Metallurgical Industries:
Production of Iron and Steel, Aluminum, Copper, Zinc, etc.

Laboratory Exercises / Practical:

Every student will carry out minimum *Six Practical*/exercises based on the above units and submit the journal, which will be evaluated as part of continuous assessment.

1. Global analysis on Chemical Industry
2. Market Survey of a Product
3. Generation of a design report for given process need
4. Preparation of detergent
5. Preparation of vanishing cream flavor
6. Synthesis of benzyl alcohol
7. Conversion of Phenol to Anisole (O-Alkylation).
8. Conversion of Benzene to Nitrobenzene (Nitration).
9. Conversion of Nitrobenzene to Aniline (Amination by Reduction).
10. Conversion of Aniline to 2, 4, 6-Tribromoaniline (Halogention).
11. Conversion of Carboxylic Acid to Ester (Esterification).
12. Experiment involving a Photochemical Conversion.

Reference Books:

1. M.Gopala Rao and Marshall Sittig, „Dryden‟s Outlines of Chemical Technology-For the 21st Century‟, 3rd Edition, Affiliated East-West Press Pvt Ltd, 2012
2. Austin, G.T., „Shreve‟s Chemical Process Industries‟, 5th Edition, Tata McGraw-Hill Edition, 2012
3. Jess, A and P. Wasserscheid, „Chemical Technology: An Integrated Textbook‟, Wiley VCH, 2013
4. Pandey, G.N, „A Text book of Chemical Technology‟ 2nd Edition, Vol-1 and Vol-2, Vikas Publishing Company, 2012

Weblinks:
http://nptel.ac.in/courses/103107081/

MOOCS: Courses by NPTEL and MIT Open Courseware

Pedagogy:

- Co-teaching
- Power point presentations
- Videos
- Demonstrations
- Systematic use of group work and project based learning

Assessment Scheme:

Class Continuous Assessment (CCA): 50 Marks

Assignments	Test	Presentations	Case study	MCQ	Oral	Any other
20 Marks	10 Marks	10 Marks	-	-	-	10 Marks

Laboratory Continuous Assessment (LCA): 50 Marks

Practical	Understanding of procedure	Experimental Skills	Oral based on practical	Problem based Learning	Site Visit
10 Marks	5 marks	5 Marks	10 marks	10 marks	10 Marks

Term End Examination :

Theory Question Paper of 50 Marks

Syllabus:

Module No.	Contents	Workload in Hrs		
		Theory	*Lab*	*Assess*
1	**Introduction:** Overview of Chemical Processing Industries and Role of Chemical Engineer, Chemical Industries- Indian and Worldwide Scenario, Symbolic Representation of Unit Operations and Unit Processes.	**2**	**4**	**-**
2	**Inorganic Chemical Industries-I:** Sulphur and Sulphuric Acid, Fertilizers, Chlor-Alkali, Cement and Lime, Fuel and Industrial gases	**5**	**10**	**-**
3	**Inorganic Chemical Industries-II:** Ceramics, Glass, Agrochemicals, Surface coating industry	**4**	**4**	**-**
4	**Natural Product Industries:** Edible and Essential Oil Industry, Cleansing compounds, Paper and Pulp, Leather and allied industry, Food and Fermentation	**6**	**-**	**-**
5	**Organic Chemical Industries:** Coal and Coal Chemicals, Petrochemicals derived from C_1, C_2 C_3 and C_4, Pharmaceuticals	**5**	**-**	**-**
6	**Polymerization Industry:** Condensation polymerization products, Addition polymerization products, Man-made fibers	**5**	**2**	**-**
7	**Metallurgical Industries:** Production of Iron and Steel, Aluminum, Copper, Zinc, etc.	**3**	**-**	**-**

SY B.Tech (Chemical Engineering) (TRIMESTER-I)

Course Code	**CH212**			
Course Category	**Professional Core**			
Course Title	**Mechanics of Materials**			
Teaching Scheme and Credits	**L**	**T**	**Laboratory**	**Credits**
Weekly load hrs	**3**	**1**	**2**	**2+1+1**

Pre-requisites:
Applied Mechanics, Engineering Material Science

Course Objectives:

1. To understand basic principles of strength of materials.
2. To understand basic design procedure.
3. To design members subjected to loads.
4. To understand design codes and standards.

Course Outcomes:

After completing this course students will be able to

1. Calculate strength of material and deformation produced when subjected to different types of loads.
2. Calculate bending and shear stresses in beams.
3. Calculate stresses induced in columns and struts.

Course Contents:

Simple Stresses and Strains:
Concept of stress, strain, modulus of elasticity, stress-strain curve for ductile materials, calculation of stress and strain produced in axially loaded members of uniform cross-section and composite/compound sections, lateral strain, Poisson‟s ratio, biaxial, tri-axial/volumetric stress system, relation between elastic constants of material, thermal stress and strain produced in simple and composite bars, strain energy due to gradually, suddenly, and impact application of loads.

Principal Planes and Stresses:
Principle of complimentary shear, normal and tangential stresses developed on oblique sections in members subjected to biaxial stress system along with complimentary shear stress, calculation of principal planes and stresses, maximum shear stress using analytical and graphical methods (Mohr‟s circle method), theories of failure, stress tensors.

Stresses in Beams:
Types of beams and supports, concept of shear force and bending moment at any section of the beam, , theory of pure or simple bending, calculation of bending and shear stresses in beams, Slope and deflection of beams (using standard formulae).

Torsion of Shafts:
Theory of pure torsion, torsion formula for circular shafts, calculation of torsional shear stress and angle of twist in shaft, power transmitted by shaft, shafts subjected to compound stresses (direct+bending+torsion), equivalent bending moment and twisting moment.

Columns and Struts:
Axially loaded compression members, crushing load, buckling or crippling load for columns with different end conditions, calculation of crippling load using Euler‟s theory and Rankine theory, direct and bending stresses- stress distribution for an eccentrically loaded circular/circular section, the middle third rule, core or kernel of a section,

Laboratory Exercises / Practical:

Every student will carry out minimum *Six Practical*/exercises based on the above units and submit the journal, which will be evaluated as part of continuous assessment.

1. Tension test on mild steel, aluminum and polymeric materials
2. Izod and Charpy impact test on mild steel, copper, brass and aluminum, cast-iron.
3. Bending test on cast-iron and timber.
4. Shear Test: Single Shear and Double Shear Test on mild steel and aluminum.
5. Different types of Hardness tests on metals i.e. Rockwell Hardness Test, Brinell Hardness Test,Shore Scleroscope Test etc.
6. Torsion test on mild steel and cast-iron.
7. Fatigue test on metals.
8. Impact test on polymeric materials.
9. Compression test on concrete and cement mortar cube.
10. Measurement of shear force and bending moment in beams.

Learning Resources:

Reference Books:

1. Khurmi R.S. "Strength of Materials", Chand (s) &Co. Ltd. ,2005
2. S.Ramamurtham, N.Narayanan, "Strength of Materials", DanpatRai Publishing House ,2013

Supplementary Reading:

Web Resources: http://nptel.ac.in/courses/112101095/

Weblinks:

1. http://nptel.ac.in/courses/112107147/
2. http://nptel.ac.in/courses/112107146/

MOOCs: Courses byMIT Open course ware and NPTEL

Pedagogy:

- Co-teaching
- Power point presentations
- Videos
- Demonstrations
- Systematic use of group work and project based learning

Assessment Scheme:

Class Continuous Assessment (CCA)*:* 50 Marks

Assignments	Test	Presentations	Case study	MCQ	Oral	Any other
20 Marks	20 Marks	-	-	-	-	10 Marks

Laboratory Continuous Assessment (LCA): 50 Marks

Practical	Oral based on practical	Site Visit	Mini Project	Problem based Learning	Any other
20 Marks	10 Marks	--	10 Marks	--	10 Marks

Term End Examination :

Theory Question Paper of 50 Marks

Syllabus:

Module No.	Contents	Workload in Hrs		
		Theory	*Lab*	*Assess*
1	**Simple Stresses and Strains**: Concept of stress, strain, modulus of elasticity, stress-strain curve for ductile materials, calculation of stress and strain produced in axially loaded members of uniform cross-section and composite/compound sections, lateral strain, Poisson‟s ratio, biaxial, tri-axial/volumetric stress system, relation between elastic constants of material (E,G,K, and μ), thermal stress and strain produced in simple and composite bars, strain energy due to gradually, suddenly, and impact application of loads.	**6**	**6**	**-**
2	**Principal Planes and Stresses:** Principle of complimentary shear, normal and tangential stresses developed on oblique sections in members subjected to biaxial stress system along with complimentary shear stress, calculation of principal planes and stresses, maximum shear stress using analytical and graphical methods (Mohr‟s circle method), theories of failure, stress tensors.	**6**	**4**	**-**
3	**Stresses in Beams:** Types of beams and supports, concept of shear force and bending moment at any section of the beam, moment of inertia of standard beam sections about neutral axis, theory of pure or simple bending, calculation of bending and shear stresses in beams, Slope and deflection of beams (using standard formulae).	**6**	**4**	**-**
4	**Torsion of Shafts:** Theory of pure torsion, torsion formula for circular shafts, calculation of torsional shear stress and angle of twist in shaft, power transmitted by shaft, shafts subjected to compound stresses (direct+bending+torsion), equivalent bending moment and twisting moment	**6**	**4**	**-**
5	**Columns and Struts:** Axially loaded compression members, crushing load, buckling or crippling load for columns with different end conditions, calculation of crippling load using Euler‟s theory and Rankine theory, direct and bending stresses- stress distribution for an eccentrically loaded circular/circular section, the middle third rule, core or kernel of a section	**6**	**4**	**-**

SY B.Tech (Chemical Engineering) (TRIMESTER-I)

Course Code	**CH213**			
Course Category	**Professional Core**			
Course Title	**Material and Energy Balance Calculations**			
Teaching Scheme and Credits	**L**	**T**	**Laboratory**	**Credits**
Weekly load hrs	**3**	**1**	**-**	**2+1+0**

Pre-requisites: HSC Standard Mathematics, Chemistry, Physics, Applied Mathematics– I, Organic Chemistry – I, Applied Physics – I, Analytical Chemistry

Course Objectives: To understand and apply fundamentals of mass and energy balance to processes

Course Outcomes:

On completion of the course, learner will be able to

1. Perform material and energy balances for a given unit operation or process
2. Carry out degrees of freedom analysis
3. Calculate utility requirements of a process
4. Use modern software tools to solve material and energy balance problems

Course Contents:

Units and Conversions: Units and Dimensions, Conversion of units. Basic process variables: Mass. Volume. Flow rate, Chemical composition: Volume, Mass and mole fractions. Wet basis and dry basis, Average molecular weight, specific gravity, API gravity, Behavior of gases: Ideal and Van der Waal Gases. Specific volume of gas mixtures.

Material Balance without reactions: Overall and Component balances. Steady state and unsteady state Processes. Degrees of Freedom analysis for given process unit. Material balance on non-reacting systems. Calculations for Absorber- Stripper, Extraction- Distillation, Recycle, Bypass and Purge operations

Material Balance with reactions: Introduction to Stoichiometry, molar table for converter, Balances on reacting systems. Limiting and excess reactants. Fractional conversion. Extent of reaction. Multiple reactions. Yield and selectivity. Mass balances in combustion operation,, Recycle, Bypass and Purge operations

Energy Balance without reactions: Energy balance for open systems, enthalpy calculations, heat capacities of solid, liquid and gases, sensible and latent heats, enthalpy change for gaseous and liquid streams, energy balance for phase change processes such as condensation and boiling, heat of mixing.

Energy Balance with reactions : Heat effects accompanying chemical reactions, Hess‟s law, Standard heat of reaction, combustion and formation, Effect of temperature on standard heat of reaction, Adiabatic reaction temperature, Heat load and utility calculations for non-adiabatic operations, Energy balances in combustion operation.

Tutorial Exercises:

Four tutorials will be conducted using Mathematical Software. Tutorial shall be engaged in four batches (batch size of 15 students) per division.

Learning Resources:

Reference Books:

1. Bhat B. I. and Vora; Stoichiometry; 2/e, Tata McGraw Hill; (2000).
2. Himmelblau D. M.; Basic Principles and Calculations in Chemical Engineering; 6/e, Prentice-Hall, India, (1996).
3. Narayanan K.V.and.Lakshmikutty B; Stoichiometry and Process Calculations; 1/e, Prentice-Hall, India, (2006).
4. Felder R. M. and R. W. Rousseau; Elementary Principles of Chemical Processes; 3/e, John Wiley and Sons; (2000).

Supplementary Reading:

Web Resources: http://nptel.ac.in/syllabus/103106076/

Weblinks:http://nptel.ac.in/syllabus/103106076/

MOOCs:http://nptel.ac.in/syllabus/103106076/

Pedagogy:

- Co-teaching
- Power point presentations
- Videos
- Demonstrations
- Systematic use of group work and project based learning

Assessment Scheme:

Class Continuous Assessment (CCA): 50 marks

Assignments	Test	Presentations	Case study	MCQ	Oral	Any other
20 Marks	20 Marks	-	-	-	-	10 Marks

Laboratory Continuous Assessment (LCA)

Practical	Oral based on practical	Site Visit	Mini Project	Problem based Learning	Any other
-	-	-	-	-	-

Term End Examination :

Theory Question Paper of 50 Marks

Syllabus:

Module No.	Contents	Workload in Hrs		
		Theory	*Lab*	*Assess*
1	**Units and Conversions:** Units and Dimensions, Conversion of units. Basic process variables: Mass. Volume. Flow rate, Chemical composition: Volume, Mass and mole fractions. Wet basis and dry basis, Average molecular weight, specific gravity, API gravity, Behavior of gases: Ideal and Van der Waal Gases. Specific volume of gas mixtures	6	-	
2	**Material Balance without reactions**: Overall and Component balances. Steady state and unsteady state Processes. Degrees of Freedom analysis for given process unit. Material balance on non-reacting systems. Calculations for Absorber- Stripper, Extraction- Distillation, Recycle, Bypass and Purge operations	6	-	
3	**Material Balance with reactions:** Introduction to Stoichiometry, molar table for converter, Balances on reacting systems. Limiting and excess reactants. Fractional conversion. Extent of reaction. Multiple reactions. Yield and selectivity. Mass balances in combustion operation,, Recycle, Bypass and Purge operations	6	-	
4	**Energy Balance without reactions:** Energy balance for open systems, enthalpy calculations, heat capacities of solid, liquid and gases, sensible and latent heats, enthalpy change for gaseous and liquid streams, energy balance for phase change processes such as condensation and boiling, heat of mixing.	6	-	
5	**Energy Balance with reactions:** Heat effects accompanying chemical reactions, Hess‟s law, Standard heat of reaction, combustion and formation, Effect of temperature on standard heat of reaction, Adiabatic reaction temperature, Heat load and utility calculations for non-adiabatic operations, Energy balances in combustion operation.	6	-	

SY B.Tech (Chemical Engineering) (TRIMESTER-I)

Course Code	**CH214**			
Course Category	**Engineering Core**			
Course Title	**Computational Skills**			
Teaching Scheme and Credits	**L**	**T**	**Laboratory**	**Credits**
Weekly load hrs	**-**	**-**	**2**	**0+0+1**

Pre-requisites: F.Y.B.Tech Mathematical Courses

Course Objectives:

1. Provide introduction to relevant computational tools required to solve Chemical Engineering problems.
2. Effectively use these tools to analyze and represent numerical data.

Course Outcomes:

At the end of the course, students should be able to :

4. Use EXCEL to process and represent numerical data (CL-3)
5. Develop programs in MATLAB to solve mathematical equations (CL-3)

Course Contents:

Introduction to EXCEL:
Data input, computation, manipulation, Built in functions, User defined functions, data plotting/visual representation.

Applications of EXCEL-I:
Roots of equations, System of algebraic equations, Linear and non-linear regression in plots, Tools like EXCEL solver and Goal seek.

Applications of EXCEL-II:
Spreadsheet calculations for material balance and energy balance, specific volume of gas mixtures, Recycle and purge

Introduction to MATLAB:
Types of variables, Mathematical operations, built-in functions, graphical representation.

MATLAB Programming-I:
m-files structure, Algorithms, Writing Scripts and functions, Loops and conditional statements

MATLAB Programming-II:
Root finding, Interpolation and Extrapolation, Matrices

Learning Resources:

Reference Books:

1. S.R.Otto and J.P.Denier, „An Introduction to Programming and Numerical Methods in MATLAB", 1st Edition, Springer Verlag London Limited, 2005
2. W.JosephBillo, „Excel for Scientists and Engineers: Numerical Methods", John Wiley and Sons, 2007
3. V.Utgikar, „Fundamental Concepts and Computations in Chemical Engineering", 1st Edition, Pearson Higher Ed USA, 2016
4. G.R.Linfield and J.E.T Penny, „Numerical Methods using MATLAB", 3rd Edition, Academic Press, 2012

Weblinks:

1. Computational Techniques, http://nptel.ac.in/courses/103106074/
2. MATLAB Programming for Numerical Computation, http://nptel.ac.in/courses/103106118/

MOOCS: Courses by NPTEL

Assessment Scheme:

Class Continuous Assessment (CCA): 50 Marks

Assignments	Test	Presentations	Case study	MCQ	Oral	Any other
-	-	-	-	-	-	-

Laboratory Continuous Assessment (LCA): 50 Marks

Practical	Oral based on practical	Site Visit	Mini Project	Problem based Learning	Any other
20 Marks	10 Marks	-	10 Marks	-	10 Marks

Term End Examination : NA

Syllabus:

Module No.	Contents	Workload in Hrs		
		Theory	*Lab*	*Assess*
1	Introduction to EXCEL: Data input, computation, manipulation, Built in functions, User defined functions, data plotting/visual representation.	-	**3**	-
2	Applications of EXCEL-I: Roots of equations, System of algebraic equations, Linear and non-linear regression in plots, Tools like EXCEL solver and Goal seek.	-	**4**	-
3	Applications of EXCEL-II: Spreadsheet calculations for material balance and energy balance, specific volume of gas mixtures, Recycle and purge	-	**5**	-
4	Introduction to MATLAB: Types of variables, Mathematical operations, built-in functions, graphical representation.	-	**3**	-
5	MATLAB Programming-I: m-files structure, Algorithms, Writing Scripts and functions, Loops and conditional statements	-	**4**	-
6	MATLAB Programming-II: Root finding, Interpolation and Extrapolation, Matrices	-	**5**	-

SY B.Tech (Chemical Engineering) (TRIMESTER-II)

Course Code	**ES224**			
Course Category	**Basic Science**			
Course Title	**Organic Chemistry**			
Teaching Scheme and Credits	**L**	**T**	**Laboratory**	**Credits**
Weekly load hrs	**3**	**-**	**2**	**2+0+1=3**

Pre-requisites: : (i) H.S.C. Chemistry
(ii) F.Y.B.Tech Applied Chemistry

Course Objectives:

(i) To impart knowledge of fundamentals of organic chemistry.
(ii) To inculcate understanding of mechanism of organic reactions, structural effects and stereochemistry.

Course Outcomes:

After completion of this course the students will be able to:

1. Illustrate correlation between effect of structure of organic compound with its reactivity.(CL-I)
2. Explain step by step electronic changes involved in organic reactions. (CL-II)
3. Recall and visualize three dimensional structure of organic compounds. (CL-I)
4. Apply the concept of aromaticity and reactions shown by aromatic compounds.(CL-III)

Course Contents:

Sources of organic compounds: : Sources of different types of organic compounds like hydrocarbons, carbohydrates, Nitrogen containing organic compounds etc.

Structural Effects and Reactivity - Hybridization of carbon- sp, sp^2, sp^3, Electronic theory of valency, electrovalency, covalency, coordinate valency and hydrogen bonding. Bond cleavage. Reagents, Reaction intermediates – Carbonium ion, carbanion, free radical and carbenes and their structure, formation and stability. Basic structural electronic effects – Inductive, resonance, electromeric, hyperconjugation.

Isomerism - Types of isomerism- Structural and stereo isomerism with examples. Conformational isomerism of ethane, propane, butane, cyclohexane, monosubstituted cyclohexane. Optical isomerism - concept of elements of symmetry, optical isomerism with one and two chiral centers (AA and AB type), enantiomers, threo, erythro, meso, distereoisomers. Geometrical isomerism (cis, trans, R, S and E, Z). Examples showing variation in properties with different isomerism.

Reaction Mechanism - Nucleophilic aliphatic substitution by alkyl halides - SN1 and SN2 reactions, Factors affecting SN1 and SN2 reactions. SN2 verses SN1 reactions. Free radical substitution reactions - Halogenations of alkanes. Electrophilic additions - additions to C = C, Markovnicov‟s rule. Diel‟s Alder reaction, Nucleophilic additions - Mechanism and examples of Grignard reaction, Aldol condensation, free radical addition reactions, peroxide effect. Elimination - E1and E2 reactions, Saytzeff and Hofmann elimination. Rearrangement - Beckman, Pinacol. Favorskii Rearrangement.

Aromatic Compounds - Structure of benzene and concept of aromaticity (Huckel‟s rule), benzenoid and non-benzenoid aromatic compounds. Nomenclature of substituted benzene compounds. Electrophilic substitution in benzene and monosubstituted benzene with orientation effect. Mechanism of Friedel –Craft alkylation and acylation reactions, nitration, halogenaion, sulphonation of benzene, phenol and nitrobenzene.

Laboratory Work:

Course outcomes:
After completion of laboratory work students will be able to;
(i) Identify unknown organic compounds.
(ii) Synthesize simple organic compounds.
(iii) Estimate organic compound quantitatively.
(iv) Demonstrate practical competence to successfully participate in research and development of innovative technology programmes.

List of Experiments: *(any 8 experiments)*

1. Volumetric estimation of amide from the given solution of amide.
2. Volumetric estimation of acetone from the given solution of acetone.
3. Preparation of m-nitroaniline from m-dinitrobenzene.
4. Preparation of benzoic acid from benzamide.
5. Organic qualitative analysis.(sample – 1)
6. Organic qualitative analysis.(sample – 2)
7. Organic qualitative analysis.(sample – 3)
8. Organic qualitative analysis.(sample – 4)
9. Organic qualitative analysis.(sample – 5)
10. Organic qualitative analysis.(sample – 6)

Learning Resources:

Reference Books:

1. Morrison R.T. and Boyd R.N., “Organic Chemistry”, 6th ed, Prentice Hall of India Private Ltd., 2011.
2. Sykes P., “A Guide Book to Mechanism in Organic Chemistry”, 6th ed, Pearson., 2003.
.

Supplementary Reading:

1. Hoffman R.V.,“Organic Chemistry”, 2nd ed, Wiley India Pvt Ltd., 2004.
2. Clayden J., Greeves N. and Warren S., “Organic Chemistry”, 2nd ed, Oxford University Press, 2012.
3. Chang R., “Chemistry”, 9th ed, Tata McGraw-Hill, 2008.

Web Resources:

Weblinks:

1. Benzene and its other Compounds : http://nptel.ac.in/courses/104103071/17
2. Nucleophilic Substitution Reactions : http://nptel.ac.in/courses/104101005/6
3. Grignard reactions : http://nptel.ac.in/courses/104101005/10
4. Elimination Reactions: http://nptel.ac.in/courses/104101005/7
5. Free radical Reactions : http://nptel.ac.in/courses/104101005/12
6. Molecular Rearrangement : http://nptel.ac.in/courses/104101005/11
7. Stereochemistry : http://nptel.ac.in/courses/104101005/4

MOOCs: *Online courses for self-learning*

1.https://www.coursebuffet.com/course/71/saylor/organic-chemistry-i

2. https://www.coursebuffet.com/course/276/coursera/introductory-organic-chemistry-part-2-univ-of-illinois-at-urbana-champaign

Pedagogy:

- Co-teaching
- Power point presentations
- Videos
- Demonstrations
- Systematic use of group work and project based learning

Assessment Scheme:

Class Continuous Assessment (CCA) :50 Marks

Assignments	Test	Presentations	Case study	MCQ	Oral	Attendance and Initiative
10 Marks	10 Marks	10 Marks	Nil	10 Marks	Nil	10 Marks

Laboratory Continuous Assessment (LCA) : (0 Marks

Regularity and Punctuality	Understanding the objective	Understanding of Procedure	Experiment skills	Ethics
10 Marks	10 Marks	10 Marks	10 Marks	10 Marks

Term End Examination : Theory Question Paper of 50 Marks

Syllabus:

Module No.	Contents	Workload in Hrs		
		Theory	*Lab*	*Assess*
1	**Sources of organic compounds:** Coal, petroleum, biomass, petrochemical processes, C I source, natural gas hydrates.	02	-	
2	**Structural Effects and Reactivity** - Hybridization of carbon- sp, sp^2, sp^3, Electronic theory of valency, electrovalency, covalency, coordinate valency and hydrogen bonding. Bond cleavage. Reagents, Reaction intermediates – Carbonium ion, carbanion, free radical and carbenesand their structure, formation and stability. Basic structural electronic effects – Inductive, resonance, electromeric, hyperconjugation.	06	-	
3	**Isomerism** - Types of isomerism- Structural and stereo isomerism with examples. Conformational isomerism of ethane, propane, butane, cyclohexane, monosubstituted cyclohexane. Optical isomerism - concept of elements of symmetry, optical isomerism with one and two chiral centers (AA and AB type), enantiomers, threo, erythro, meso, distereoisomers. Geometrical isomerism (cis, trans, R, S and E, Z). Examples showing variation in properties with different isomerism.	08	-	
4	**Reaction Mechanism** - Nucleophilic aliphatic substitution by alkyl halides - SN1 and SN2 reactions, Factors affecting SN1 and SN2 reactions. SN2 verses SN1 reactions. Free radical substitution reactions - Halogenations of alkanes. Electrophilic additions - additions to C = C, Markovnicov‟s rule. Diel‟s Alder reaction, Nucleophilic additions - Mechanism and examples of Grignard reaction, Aldol condensation, free radical addition reactions, peroxide effect. Elimination – E1and E2 reactions, Saytzeff and Hofmann elimination. Rearrangement - Beckman, Pinacol. Favorskii Rearrangement.	08	08	
5	**Aromatic Compounds** - Structure of benzene and concept of aromaticity (Huckel‟s rule), benzenoid and non-benzenoid aromatic compounds. Nomenclature of substituted benzene compounds. Electrophilic substitution in benzene and monosubstituted benzene with orientation effect. Mechanism of Friedel–Craft alkylation and acylation reactions, nitration, halogenaion, sulphonation of benzene, phenol and nitrobenzene.	06	12	

SY B.Tech (Chemical Engineering) (TRIMESTER-II)

Course Code	**CH221**			
Course Category	**Professional Core**			
Course Title	**Fluid Mechanics**			
Teaching Scheme and Credits	**L**	**T**	**Laboratory**	**Credits**
Weekly load hrs	**3**	**-**	**2**	**2+0+1**

Pre-requisites: Basic HSC Physics and Mathematics, Applied Physics – I and II, Applied Mathematics-I and II

Course Objectives: To understand basic concepts of fluid flow and its applications in chemical process industry.

Course Outcomes:

On completion of the course, the students will be able to

1. Develop an ability to write governing equations for a given flow systems based on fundamental principles
2. Develop an ability to perform pressure drop calculations and line sizing for single phase and Multiphase flows
3. Develop an understanding about the operational aspects, performance evaluation of the Fluid flow Machinery

Course Contents:

Fluid Properties and Fluid Statics

Properties of fluids, viscosity, density, vapor pressure, surface tension, capillary effect, coefficient of compressibility and volume expansion. Fluid Statics: Concept of pressure; types of manometers – simple and differential, different Fluid forces on plane and curved surfaces. Concept of buoyancy.

Fluid Kinematics and Governing Equations

Descriptions of fluid flows; Acceleration Field and Material Derivative, Deformation of fluid elements, vorticity and rotationality. Forces acting on a control volume.

Continuity Equation. Bernoulli equation. Forms of Bernoulli equation, Limitations on use of Bernoulli equation and correction terms involved in different cases, Application of Bernoulli equation. The Momentum equation and its applications

Flow Through Pipes and Flow past immersed bodies

Reynolds Number, Hagen-Poiseuille equation and its applications Turbulent flow: flow analysis for smooth and rough boundaries. Friction factor and its variations Darcy-Weisbach equations. Moody‟s diagrams. Major and Minor losses in piping system. Flow through porous media, fixed and fluidized beds, Multiphase systems

Turbulence and Boundary Layer

Turbulent Flows: Theory, Equations and its Applications, Boundary Layer Flows: Theory, Equations and its applications, Boundary layer separation.

Dimensional Analysis and Fluid Machinery

Fundamental dimensions; units; dimensional analysis; dimensionally homogeneous equation; importance of dimensional analysis in experimental work. Buckingham‟s Pi theorem. Comparison between fans, blowers, compressors. Pump‟s principle, construction and working of centrifugal pumps. Characteristic curves. NPSH concepts. Fundamental relationships, formulae and Numerical Calculations.

Laboratory Exercises / Practical: Every student will carry out minimum *Six Practical* exercises based on the above units and submit the journal, which will be evaluated as part of continuous assessment

1. Fluid property measurements such as viscosity, surface tension, density etc
2. Verification of Bernoulli‟s Equation and its applications in flow measurements
3. Single Phase Pressure drop measurements in flow through pipe (Major and Minor Losses)
4. Pressure drop measurements in flow through Packed Bed, Fluidized bed and Porous media
5. Estimation of Gas-Liquid Multiphase flow regimes in horizontal and vertical flow through pipe
6. Centrifugal Pump Characteristics
7. Demonstration of utility of Process Simulation Software for fluid flow operation

Reference Books:

1. Noel de Nevers; Fluid Mechanics for Chemical Engineers, Third Edition; McGraw Hill, 2005.
2. McCabe W. L., SmithJ. C. and Harriot P.; Unit Operations in Chemical Engineering; 5/e, McGraw-Hill Inc.; 1993.
3. Evett Jack B. & Cheng Lin; Fundamentals of Fluid Mechanics -McGraw Hill; 1987.
4. Darby Ron, Chemical Engineering Fluid Mechanics. Second Edition, Marcel Dekker, 2001

Supplementary Reading:

Web Resources: http://nptel.ac.in/courses/103104044/1
Weblinks:https://ocw.mit.edu/courses/chemical-engineering/10-52-mechanics-of-fluids-spring-2006/
MOOCs: http://nptel.ac.in/courses/103104044/1

Pedagogy:

- Co-teaching
- Power point presentations
- Videos
- Demonstrations
- Systematic use of group work and project based learning

Assessment Scheme:

Class Continuous Assessment (CCA)*:* 50 Marks

Assignments	Test	Presentations	Case study	MCQ	Oral	Any other
20 Marks	10 Marks	10 Marks	--	--	--	10 Marks

Laboratory Continuous Assessment (LCA) 50 Marks

Practical	Oral based on practical	Site Visit	Mini Project	Problem based Learning	Any other
20 Marks	10 Marks	--	--	10 Marks	10 Marks

Term End Examination : Theory Question Paper of 50 Marks

Syllabus:

Module No.	Contents	Workload in Hrs		
		Theory	*Lab*	*Assess*
1	**Fluid Properties and Fluid Statics:** Properties of fluids, viscosity, density, vapor pressure, surface tension, capillary effect, coefficient of compressibility and volume expansion. Fluid Statics: Concept of pressure; types of manometers – simple and differential, different Fluid forces on plane and curved surfaces. Concept of buoyancy	06	04	
2	**Fluid Kinematics and Governing Equations:** Descriptions of fluid flows; Acceleration Field and Material Derivative, Deformation of fluid elements, vorticity and rotationality. Forces acting on a control volume, Continuity Equation. Bernoulli equation. Forms of Bernoulli equation, Limitations on use of Bernoulli equation and correction terms involved in different cases, Application of Bernoulli equation. The Momentum equation and its applications	06	02	
3	**Flow Through Pipes and Flow past immersed bodies:** Reynolds Number, Hagen-Poiseuille equation and its applications Turbulent flow: flow analysis for smooth and rough boundaries. Friction factor and its variations Darcy-Weisbach equations. Moody‟s diagrams. Major and Minor losses in piping system. Flow through porous media, fixed and fluidized beds, Multiphase systems	06	04	
4	**Turbulence and Boundary Layer:** Turbulent Flows: Theory, Equations and its Applications, Boundary Layer Flows: Theory, Equations and its applications, Boundary layer separation.	06	04	
5	**Dimensional Analysis and Fluid Machinery:** Fundamental dimensions; units; dimensional analysis; dimensionally homogeneous equation; importance of dimensional analysis in experimental work. Buckingham‟s Pi theorem. Comparison between fans, blowers, compressors. Pump‟s principle, construction and working of centrifugal pumps. Characteristic curves. NPSH concepts. Fundamental relationships, formulae and Numerical Calculations.	06	04	

SY B.Tech (Chemical Engineering) (TRIMESTER-II)

Course Code	**CH222**			
Course Category	**Professional Core**			
Course Title	**Mechanical Operations**			
Teaching Scheme and Credits	**L**	**T**	**Laboratory**	**Credits**
Weekly load hrs	**3**	**-**	**2**	**2+0+1**

Pre-requisites: Knowledge of physics, Mathematics and Fluid flow operations

Course Objectives:

1. To gain basic understanding of properties and behavior of systems containing particulate Solids.
2. To get acquainted with the major equipment used for solid handling in chemical and allied Industries**.**
3. To predict efficiency of solid-solid or solid-liquid separation equipment.
4. To calculate power required for agitation and mixing and size reduction
5. To learn concept of solids characterization, flow, settling, and storage.
6. To correlate the scope of the subject in chemical industry.

Course Outcomes:

1. Understand mechanical unit operations and their role in chemical engineering industries
2. Analyze the performance of size reduction equipment and calculate the power requirement
3. Apply principles of settling and sedimentation for particle-fluid separation.
4. Select suitable solid-fluid separation equipment, conveyors, agitators and mixers.
5. Demonstrate basic understanding of fluid flow through packed bed and fluidized bed.
6. Apply the concept of fluidization and filtration in chemical and allied industries.

Course Contents:

Introduction to mechanical operations and Properties of particulate solids
Types of mechanical operations and their role in chemical industries, General Characterizations: size, shape (sphericity) and density (bulk and particle density).

Particle Size Analysis and Storage of solids and Solids flow
Sieve methods of analysis: Surface area determination, Number of particle in the sample mixture and average size of mixture of particles, screening equipment: Efficiency of screen and capacity and performance of screen.
Storage of solids in hoppers, bins, silos and its flow. Types of conveyers and its selection.

Size Reduction and Size Enlargement
Mechanism of size reduction, Nature of the material to be crushed and Energy relationship for size reduction, Crusher: primary and secondary crushers their principle and operation, Grinders and ultrafine grinders and cutting machines, Specialized applications, Objectives and Processes of particle size enlargement.

Particle Settling and sedimentation
Theory of motion of particles through fluids, motion under gravitational and centrifugal fields, Terminal settling velocity of particles in a fluid, Gravity settling and centrifugal settling- cyclone separator principle and design.

Principles of sedimentation, batch and continuous thickening, Kynch theory of sedimentation for continuous thickener.

Agitation and Mixing
Types of agitators,types of flow patterns, and standard design of agitated vessel, Power consumption of agitated vessels for baffled and un-baffled tank, Power number and Reynolds number and mixing time.

Important types of industrial mixers.

Filtration
Filtration Theory, Type of filtration, filter media and filter aids, Kozney-Carman equation for flow of fluids through porous media, Constant rate and constant pressure filtration, Relation between thickness of cake and volume of filtrate, calculation of rate of filtration, duration of filtration and washing, important industrial filters

Fluidization
Fundamentals of fluidization, Types of fluidization, minimum fluidizing velocity, Applications in chemical, and petroleum refining.

Laboratory Exercises / Practical: At least S*ix experiments* should be performed in laboratory by the students

1. To determine characteristics of mixture of particles such as surface area, number of particles and average size using standard sieve series.
2. To determine critical speed of ball mill & average particle size of the product obtained in ball mill.
3. To study working of Jaw crusher and determine its efficiency.
4. To determine settling velocity of solid particles in stagnant fluid (Stoke‟s Regime).
5. To study working of cyclone separator and determine its collection efficiency.
6. To determine area of thickener by conducting batch sedimentation test.
7. To determine power consumption in agitated vessel.
8. To determine filter medium resistance and cake resistance by using vacuum leaf filter.
9. To determine minimum fluidization velocity.
10. To study working of Plate and frame filter.

Learning Resources:

Reference Books:

1. Richardson J.F. &J.H. Harker; Coulson and Richardson‟s Chemical Engineering, Vol. 2 Particle Technology &Separation Processes; Fifth edition, Butterworth–Heinemann (2002).
2. McCabe W.L., J.C. Smith & P.Harriot; Unit Operations of Chemical Engineering; Fifth edition, McGraw-Hill Inc. (1993).
3. Badger W.L. &J.T. Banchero; Introduction to Chemical Engineering; Tata McGraw–Hill Edition (1997).
4. Geankoplis C.J.; Transport Processes and Separation Process Principles, Fourth edition, Eastern Economy Edition (2003).

Supplementary Reading:

Web Resources:

Weblinks:

1. Mechanical Operation Lecture:https://nptel.ac.in/courses/103107123/
2. https://www.youtube.com/watch?v=w8Ax7JJAD8k
3. https://www.youtube.com/watch?v=wUYipPFMrKo

MOOCs: NPTEL

Pedagogy:

- Co-teaching
- Power point presentations
- Videos
- Demonstrations
- Systematic use of group work and project based learning

Assessment Scheme:

Class Continuous Assessment (CCA)*:* 50 Marks

Assignments	Test	Presentations	Case study	MCQ	Oral	Any other
10 Marks	20 Marks	--	--	--	10	10 Marks

Laboratory Continuous Assessment (LCA)*:* 50 Marks

Practical	Oral based on practical	Site Visit	Mini Project	Problem based Learning	Any other
20 Marks	10 Marks	-	-	10 Marks	10 Marks

Term End Examination : Theory Question Paper of 50 Marks

Syllabus:

Module No.	Contents	Workload in Hrs		
		Theory	*Lab*	*Assess*
1	**Introduction to mechanical operations and Properties of particulate solids:** Types of mechanical operations and their role in chemical industries, General Characterizations: size, shape (sphericity) and density (bulk and particle density).	**2**	**2**	
2	**Particle Size Analysis and Storage of solids and Solids flow:**Sieve methods of analysis: Surface area determination, Number of particle in the sample mixture and average size of mixture of particles, screening equipment: Efficiency of screen and capacity and performance of screen. Storage of solids in hoppers, bins, silos and its flow. Types of conveyers and its selection.	**3**	**2**	
3	**Size Reduction and Size Enlargement:** Mechanism of size reduction, Nature of the material to be crushed and Energy relationship for size reduction, Crusher: primary and secondary crushers their principle and operation, Grinders and ultrafine grinders and cutting machines, Specialized applications, Objectives and Processes of particle size enlargement.	**4**	**2**	

	4	**Particle Settling and sedimentation:** Theory of motion of particles through fluids, motion under gravitational and centrifugal fields, Terminal settling velocity of particles in a fluid, Gravity settling and centrifugal settling- cyclone separator principle and design. Principles of sedimentation, batch and continuous thickening, Kynch theory of sedimentation for continuous thickener.	**7**	**2**		
	5	**Agitation and mixing:** Types of agitators, types of flow patterns, and standard design of agitated vessel, Power consumption of agitated vessels for baffled and un-baffled tank, Power number and Reynolds number and mixing time. Important types of industrial mixers.	**5**	**2**		
	6	**Filtration:** Filtration Theory, Type of filtration, filter media and filter aids, Kozney-Carman equation for flow of fluids through porous media, Constant rate and constant pressure filtration, Relation between thickness of cake and volume of filtrate, calculation of rate of filtration, duration of filtration and washing, important industrial filters	**5**	**2**		
	7	**Fluidization:** Fundamentals of fluidization, Types of fluidization, minimum fluidizing velocity, Applications in chemical, and petroleum refining.	**4**	**2**		

SY B.Tech (Chemical Engineering) (TRIMESTER-II)

Course Code	**CH223**			
Course Category	**Professional Core**			
Course Title	**Engineering Thermodynamics**			
Teaching Scheme and Credits	**L**	**T**	**Laboratory**	**Credits**
Weekly load hrs	**3**	**1**	**-**	**2+1+0**

Pre-requisites: Mathematics, Physics and Chemistry

Course Objectives:

1. To be able to calculate heat and work effects associated with a process
2. To learn to predict and correlate volumetric properties of fluids
3. To examine the performance of engineering devices using the laws of thermodynamics

Course Outcomes:

1. Apply the laws of thermodynamics to various systems. (CL-3)
2. Apply appropriate equation of state for representing the PVT behavior of fluids. (CL-3)
3. To calculate the efficiencies and lost work in a system.(CL-3)
4. Demonstrate the knowledge of various thermodynamic cycles (CL-2)
5. Calculate the flow properties when fluids flow at high speeds. (CL-3)

Course Contents:

First Law:
The scope of thermodynamics, Basic concepts, System and its properties, Zeroth law of thermodynamics, First law of thermodynamics for flow and non-flow processes, Internal Energy, Enthalpy, Reversible and irreversible process, Heat capacity

Volumetric Properties of Pure Fluids:
The P-V-T behavior of pure substance, the viral equation, the ideal gas, the constant volume, constantpressure,adiabatic,polytrophicprocesses,realgas,applications of Viral equation, critical properties, Vander Waal equation, Benedict- Webb–Rubin equation, Redlich– Kwong equation.

Second Law: Limitations of First Law, Heat and Work, Statements of Second law and their interpretation, Carnot cycle, Energy conversion efficiencies, Concept of entropy, Lost Work, Third law of thermodynamics.

Thermodynamic Cycles: Various thermodynamic cycles, power cycles with external combustion or heat pump cycles, power cycles with internal combustion, Refrigeration cycles for Vapor Compression and Absorption refrigeration systems.

Compressible Flows: Stagnation properties, Mach number, Isentropic flow, Flow through pipes, nozzles and ejectors

Exergy: Concept of Exergy as maximum useful work, Exergy balance of closed systems, Decrease of Exergy Principle

Reference Books:

1. Smith, J. M. and Van Ness H . C.., „Introduction to Chemical Engineering Thermodynamics", McGraw-Hill, 1996.
2. Narayanan,K.V.,„ATextbookonChemicalEngineeringThermodynamics",Prentice Hall of India Ltd, 2013
3. Rao,Y.V.C.,„AnIntroductiontoThermodynamics",UniversityPress(India)Pvt. Ltd., 2004
4. Cengel, Y.A and Boles, M.A, „Thermodynamics An Engineering Approach", Tata McGraw Hill Education Pvt. Ltd., 2011

Weblinks:

1. https://ocw.mit.edu/courses/materials-science-and-engineering/3-205-thermodynamics-and-kinetics-of-materials-fall-2006/
2. https://nptel.ac.in/courses/112105123/1

MOOCs: Courses by MIT Open course ware and NPTEL

Pedagogy:

- Co-teaching
- Power point presentations
- Videos
- Demonstrations
- Systematic use of group work and project based learning

Assessment Scheme:

Class Continuous Assessment (CCA) : 50 Marks

Assignments	Test	Presentations	Case study	MCQ	Oral	Any other
20 Marks	10 Marks	10 Marks	-	-	-	10 Marks

Laboratory Continuous Assessment (LCA): 50 Marks

Practical	Oral based on practical	Site Visit	Mini Project	Problem based Learning	Any other
-	-	-	-	-	-

Term End Examination :
Theory Question Paper of 50 marks

Syllabus:

Module No.	Contents	Workload in Hrs		
		Theory	*Lab*	*Assess*
1	**First Law:** The scope of thermodynamics, Basic concepts, System and its properties, Zeroth law of thermodynamics, First law of thermodynamics for flow and non-flow processes, Internal Energy, Enthalpy, Reversible and irreversible process, Heat capacity	**5**	**-**	**-**
2	**Volumetric Properties of Pure Fluids:** The P-V-T behavior of pure substance the viral equation ,the ideal gas, the constant volume, constantpressure,adiabatic,polytrophicprocesses,realgas,application sofViralequation, critical properties, Vander Waal equation, Benedict- Webb–Rubin equation, Redlich–Kwong equation.	**5**	**-**	**-**
3	**Second Law:** Limitations of First Law, Heat and Work, Statements of Second law and their interpretation, Carnot cycle, Energy conversion efficiencies, Concept of entropy, Lost Work, Third law of thermodynamics.	**5**	**-**	**-**
4	**Thermodynamic Cycles:** Various thermodynamic cycles, power cycles with external combustion or heat pump cycles, power cycles with internal combustion, Refrigeration cycles for Vapor Compression and Absorption refrigeration systems.	**5**	**-**	**-**
5	**Compressible Flows:** Stagnation properties, Mach number, Isentropic flow, Flow through pipes, nozzles and ejectors	**5**	**-**	**-**
6	**Exergy:** Concept of Exergy as maximum useful work, Exergy balance of closed systems, Decrease of Exergy Principle	**5**	**-**	**-**

SY B.Tech (Chemical Engineering) (TRIMESTER-II)

Course Code				
Course Category	**WP**			
Course Title	**National Study Tour**			
Teaching Scheme and Credits	**L**	**T**	**Laboratory**	**Credits**
Weekly load hrs	**-**	**-**	**-**	**0+0+1**

Every student shall undergo national study tour. This includes visits to Industries, Industrial Exhibitions, Research Laboratories and Research Organizations and Premium Institutes of National and International repute.

During the national study tour the students are expected to undergo rigorous exposure of the industry, its working style, various departments and their working, hands on experience on the various equipments available with the industry. Student should maintain a log book mentioning day to day activity he / she have carried out during the training period.

Evaluation Procedure:

Students are required to submit neatly typed and bound national study tour report after joining the department. The report should include information about working of the industry as also specific information of the work done by the student in the industry. The students are also required to attach the original certificate issued by the competent authority from the industry where he / she has visited various industries mentioning the successful completion of the industrial tour.

The department will conduct industrial tour report presentation session for every student.

Evaluation of national industrial study visit report by students will be based on:

1. Knowledge acquired by him/her during the industrial study
2. His/her performance in presentation
3. Report
4. Discussions

SY B.Tech (Chemical Engineering) (TIMESTER-III)

Course Code	**ES231**			
Course Category	**Basic Science**			
Course Title	**Mathematics-III**			
Teaching Scheme and Credits	**L**	**T**	**Laboratory**	**Credits**
Weekly load hrs.	**3**	**1**	**-**	**2+1+0**

Pre-requisites: Mathematics-I & Mathematics-II (F. Y. B. Tech)

Course Objectives:

1. To learn linear differential equations and its applications in chemical Engineering.
2. To understand integral transform techniques and their applications.
3. To learn vectors calculus for applications in engineering field.
4. To learn partial differential equation and their applications.

Course Outcomes:

After completion of this course students will be able to

1. Solve linear differential equations using various methods.(CL III)
2. Apply Laplace transform and Fourier transform techniques to solve differential equations involved in heat transfer and chemical engineering problems. (CL III)
3. Perform vector differentiation and integration, analyze the vector fields and apply to fluid flow equations.(CL IV)
4. Solve partial differential equations used in boundary value problems (CL III)

Linear Differential Equation:
Linear Differential Equation of n^{th} order with constant coefficients, Method of variation of parameters, Cauchy‟s and Legendre‟s Differential Equations, Applications to chemical Engineering problem involving batch reactions.

Transform Techniques:
Fourier Transform: Fourier Integral theorem, Fourier Sine and Cosine Transforms, Inverse Fourier Transform.

Laplace Transform: Definition, Properties, Laplace Transform of standard functions, Inverse Laplace Transform, Applications of Laplace Transform for solving Ordinary differential equations.

Vector Calculus:
Vector Differential: Physical interpretation of Vector differentiation, Vector differential operator, Gradient, Divergence and Curl, Directional derivative, Vector identities.

Vector Integration: Line, Surface and Volume Integration, Work done, Green‟s Lemma, Stoke‟s and Divergence Theorem.

Partial Differential Equations:
Basic concepts, Solution of Partial Differential equations, method of separation of variables Solution of one and two dimensional Heat flow equations, Wave equation, Solution of boundary value problems using Fourier Transform.

Tutorial Exercises:

1. Linear Differential Equations by Shortcut ,General, Variation of Parameter methods
2. Applications of Linear Differential Equations.
3. Fourier Sine and Cosine Transforms.
4. Laplace Transform and Inverse Laplace Transform
5. Vector differentiation, gradient, divergence and curl.
6. Vector integration, Work done, Green‟s Lemma, Stoke‟s and Divergence Theorem
7. Wave equation, one dimensional Heat flow equations.
8. Two dimensional Heat flow equations using Fourier transform.

Two tutorials will be conducted using Mathematical Software. Tutorial shall be engaged in four batches (batch size of 15 students) per division.

Learning Resources:

Reference Books:

1. Kreyszig Erwin, “Advanced Engineering Mathematics” 10th edition ,Wiley Eastern Limited 2015.
2. Greenberg Michael D.,“Advanced Engineering Mathematics”, 2nd edition, Pearson ,2009.
3. Grewal B.S., “Higher Engineering Mathematics” ,43rd edition Khanna Publishers 2014

Supplementary Reading:

1. O‟ Neil Peter, “Advanced Engineering Mathematics”, 8th edition, Cengage Learning 2015.
2. Weber H.J. and Arfken G.B. "Mathematical Methods For Physicists" , 6th edition, Academic Press 2011.

Web Resources:

Web links:

- Introduction to second order LDE https://www.youtube.com/watch?v=tGtCajxHoDw
- Fourier Transform, Fourier Series, and frequency spectrumhttps://www.youtube.com/watch?v=r18Gi8lSkfM

MOOCs: NPTEL, MIT OPEN COURSEWARE

- https://ocw.mit.edu/courses/mathematics/18-02sc-multivariable-calculus-fall-2010/
- https://ocw.mit.edu/courses/mathematics/18-03-differential-equations-spring-2010/video-lectures/lecture-9-solving-second-order-linear-odes-with-constant-coefficients/
- http://nptel.ac.in/courses/111103021/18

Pedagogy:

- Team Teaching
- Tutorials and class tests
- Video technique

Assessment Scheme:

Class Continuous Assessment (CCA): 50 marks

Tutorial	Test	Presentations	Case study	MCQ	Oral	Attendance
20 Marks	20 Marks	--	--	--	--	10 Marks

Laboratory Continuous Assessment (LCA): 50 Marks

Practical	Oral based on practical	Oral	Mini Project	Problem based Learning	Any other
-	-	-	-	-	-

Term End Examination : Theory Question Paper of 50 marks

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Syllabus:

Module No.	Contents	Workload in Hrs.		
		Theory	Tutorial	Assess
1	**Linear Differential Equation:** Linear Differential Equation of n^{th} order with constant coefficients, Method of variation of parameters, Cauchy‟s and Legendre‟s Differential Equations, Applications to chemical Engineering problem involving batch reactions.	08	02	--
2	**Transform Techniques:** Fourier Transform: Fourier Integral theorem, Fourier Sine and Cosine Transforms, Inverse Fourier Transform. Laplace Transform: Definition, Properties, Laplace Transform of standard functions, Inverse Laplace Transform, Applications of Laplace Transform for solving Ordinary differential equations.	08	02	--
3	**Vector Calculus**: Vector Differential: Physical interpretation of Vector differentiation, Vector differential operator, Gradient, Divergence and Curl, Directional derivative, Vector identities. Vector Integration: Line, Surface and Volume integration, Work done, Green‟s Lemma, Stoke‟s and Divergence Theorem	08	02	--
4	**Partial Differential Equations:** Basic concepts, Solution of Partial Differential equations, method of separation of variables Solution of one and two dimensional Heat flow equations, Wave equation, Solution of boundary value problems using Fourier Transform.	08	02	--

SY B.Tech (Chemical Engineering) (TRIMESTER-III)

Course Code:	**CH231**			
Course Category	**Professional Engineering**			
Course Title	**Heat Transfer**			
Teaching Scheme and Credits	**L**	**T**	**Laboratory**	**Credits**
Weekly load hrs	**3**	**-**	**2**	**2+0+1**

Pre-requisites:
Engineering Mathematics I and II, Engineering material science, Fluid mechanics, Particle technology.

Course Objectives:

1. To study various modes of heat transfer and the laws governing them.
2. To study basic principles of condensation and boiling and understand their applications.
3. To classify, select and understand the types of process design aspects for heat exchangers and evaporators.
4. To identify real plant opportunities in energy saving and optimization

Course Outcomes:

1. Demonstrate the knowledge of basic physics and mathematics involved in three modes of heat transfer and their applications.
2. Identify, formulate and solve engineering problems related to heat transfer.
3. Identify and select appropriate heat exchange equipment for a given duty and design it.

Course Contents:

Conduction-Heat transfer modes and Laws, Material properties of importance in heat transfer, Heat transfer in Cartesian, cylindrical and Spherical coordinate systems, Thermal Resistance, Insulation and critical radius, Unsteady state Heat conduction

Convection-Dimensionless groups in Heat Transfer, Heat transfer by Natural Convection from plate and cylinder. Heat transfer by Forced Convection in Laminar and turbulent flow applied to circular pipe, Momentum and Heat Transfer Analogies, Enhanced heat Transfer: Concepts of Fins.

Radiation-Basic Concepts and Laws of Radiation, Solid angle and Radiation Intensity, concepts of Radiation Shields, Introduction to different solar energy transmitting systems.

Heat Exchangers- Basic types of heat exchangers, Flow arrangements, Overall heat transfer coefficient and fouling factor calculations, Mean temperature difference, Effectiveness – NTU Method, Concept of Heat Exchange Networks.

Phase Change Heat Transfer-Types of condensation, Study of condensation on a vertical plate, vertical tube and horizontal tubes, Effect of superheated vapor and non-condensable gases, Types of boiling, boiling curves, The concept of heat pipe.

Heat Transfer Equipment Design-Heat exchanger design considerations and standards, Types of evaporators, Design of single and multiple effect evaporators, Applications of heat transfer in Chemical engineering systems as: Distillation columns, Batch reactors

Laboratory Exercises / Practical: Every student will carry out minimum *Six Practical* exercises based on the above units and submit the journal, which will be evaluated as part of continuous assessment.

1. To determine thermal conductivity of a metal bar.
2. To determine efficiency of a Pin Fin.
3. To determine the emissivity of a test plate.
4. To determine heat transfer coefficient in forced convection.
5. To determine heat transfer coefficient in natural convection
6. To determine heat transfer coefficient in Double Pipe Heat Exchanger.
7. To determine overall heat transfer coefficient (U) for Shell and Tube Heat Exchanger.
8. Study of Multiple effect evaporators.
9. To Study shell and tube heat exchanger.
10. To study unsteady state heat transfer.

Learning Resources:

Reference books:

1. Sukhatme S.P., "A Textbook on Heat Transfer", University Press (India) Private Limited, 4th Ed., 2005.
2. Holman J. P., "Heat Transfer", Tata McGraw-Hill, 9th Edition, 2002.
3. Eduardo Cao, "Heat Transfer in Process Engineering", McGraw-Hill, 2010.
4. Kern D. Q., "Process Heat Transfer", McGraw Hill, 1997.

Supplementary Reading:

Web Resources:

1. ocw.mit.edu
2.www.cambridge.org › Home › Academic › Engineering › Thermal-fluids engineering
3. https://www.hrs-heatexchangers.com/resource

Weblinks: 1. mit.espe.edu.ec/courses 2. www.ipieca.org/Resources

MOOCs:

1.https://www.class-central.com/tag/heat%20transfer
2. https://onlinecourses.nptel.ac.in/noc18_ch08
3. https://www.edx.org/course/advanced-transport-phenomena-delftx-tp201x-0

Pedagogy:

- Digital media viz. power point presentations, videos
- Problem based learning
- Technical quizzes

Assessment Scheme:

Class Continuous Assessment (CCA): 50Marks

Assignments	Test	Presentations	Case study	MCQ	Oral	Any other
10 Marks	20 Marks	-	-	-	10 Marks	10 Marks

Laboratory Continuous Assessment (LCA): 50Marks

Practical	Oral based on practical	Site Visit	Mini Project	Problem based Learning	Any other
20 Marks	10 Marks	-	-	20 Marks	-

Term End Examination: Theory Question Paper: of 50 marks

Syllabus:

Module No.	Contents	Workload in Hrs		
		Theory	*Lab*	*Assess*
1	**Basics of Heat Transfer and Conduction**-Modes and Laws, Material properties, cylindrical and Spherical coordinate systems, Thermal Resistance, Insulation and critical radius, Unsteady state heat conduction.	**6**	**4**	
2	**Convection** -Dimensionless groups, Natural convection through plate and cylinder, forced convection through laminar and turbulent flow, momentum and heat transfer analogies, Enhanced heat transfer.	**6**	**4**	
3	**Radiation**- Basic Concepts and Laws of Radiation, Solid angle and Radiation Intensity, concepts of Radiation Shields, Introduction to different solar energy transmitting systems.	**6**	**4**	
4	**Heat Exchangers**- Basic types of heat exchangers, Flow arrangements, Overall heat transfer coefficient and fouling factor calculations, Mean temperature difference, Effectiveness – NTU Method, Concept of Heat Exchange Networks.	**6**	**4**	
5	**Phase Change Heat Transfer and equipment design**-Study of condensation and boiling, effect of superheated vapors on non-condensable gas, boiling curves, heat exchanger design and types of evaporators.	**6**	**4**	

SY B.Tech (Chemical Engineering) (TRIMESTER-III)

Course Code	**CH232**			
Course Category	**Professional Core**			
Course Title	**Chemical Engineering Thermodynamics**			
Teaching Scheme and Credits	**L**	**T**	**Laboratory**	**Credits**
Weekly load hrs	**3**	**1**	**-**	**2+1+0**

Prerequisites: Mathematics, Physics, Chemistry and Engineering Thermodynamics

Course Objectives:

1. Classify thermodynamics properties.
2. To appreciate the importance of chemical potential as a measure of chemical equilibrium.
3. To gain insight into phase equilibria and chemical reaction equilibria.
4. To get acquainted with multiphase equilibria.

Course Outcomes:

1. Calculate the thermodynamic properties in the absence of experimental data. (CL-3)
2. Distinguish between ideal and non-ideal solutions (CL-4)
3. Apply the criteria of phase equilibrium to solve problems of Multicomponent and complex hydrocarbon systems under different thermodynamic conditions. (CL-3)
4. Determine temperature and pressure conditions for a particular reaction system or process for obtaining optimum yield. (CL-4)
5. Compute the compositions when partially miscible liquids or vapors are mixed. (CL-3)

Course Contents

Thermodynamic Properties of Fluids: Classification of thermodynamic properties, Helmholtz and Gibbs free energy, Fundamental property relations for closed systems, Maxwell relationships, Clausius-Clapeyron equation, thermodynamic diagrams.

Solution Thermodynamics-I: Fugacity and Fugacity Coefficient: Pure Species and Species in Solution, Activity and Activity Coefficient, Partial Molar Properties

Solution Thermodynamics-II: Chemical Potential, Ideal and Non-ideal Solutions, Lewis Randall rule, Raoult‟s law, Henry‟s law, Gibbs-Duhem Equations, Property changes of mixing of solutions

Phase Equilibrium: Criteria of Phase Equilibrium, Phase Rule for Non-reacting Systems, Phase diagrams for binary systems, Vapour Liquid Equilibria for ideal and non-ideal solutions, Azeotropes, Activity Coefficient Equations, Multicomponent VLE

Chemical Reaction Equilibria: Reaction Stoichiometry, Equilibrium Constant and Standard Free Energy Change, Effect of the following on Equilibrium Constant: Temperature, Pressure, Inert Materials, Excess reactants and Products., Heterogeneous Reaction Equilibria, Phase Rule for Reacting Systems.

Multiphase Equilibria: Liquid-Liquid Equilibria (LLE, Vapour-Liquid-Liquid Equilibria (VLLE): Phase Diagrams, Concept of UCST and LCST, Calculation of equilibria using Activity coefficient models and EOS, Solid-Liquid Equilibria (SLE): Computing the solubility solute in a liquid.

Laboratory Exercises / Practical: Every student will carry out minimum *Six Practical* exercises based on the above units and submit the journal, which will be evaluated as part of continuous assessment

1. Experimentation based on energy conversion for different thermodynamic systems
2. Determination of Joule Thomson coefficient
3. Determination of COP for refrigeration
4. Determination of compressor efficiency
5. Determination of change in entropy
6. Experimental determination of VLE for binary mixtures
7. Guidelines for selection of proper thermodynamic package for commercial simulation software
8. Generating Thermodynamic Property Diagrams for hydrocarbons in commercial simulation software
9. Determination of Dew Point and Bubble Point for a Multicomponent hydrocarbon mixture using commercial simulation software.
10. Multicomponent Flash Calculations using commercial simulation software.
11. Simulating LLE and VLLE on commercial simulation software.
12. Simulating Chemical Reaction Equilibria on commercial simulation software.

Reference Books:

1. Smith, J. M. and Van Ness H. C., Introduction to Chemical Engineering Thermodynamics, McGraw-Hill, 2001
2. Narayanan, K.V.,A Textbook on Chemical Engineering Thermodynamics, Prentice Hall of India Ltd., 2013
3. Cengel, Y.A. and Boles, M.A., Thermodynamics: An Engineering Approach, Seventh Edition, Tata McGraw Hill Education Pvt. Ltd, 2011
4. Sandler, S.I., Chemical, Biochemical and Engineering Thermodynamics, Fourth Edition, John Wiley and Sons Inc., 2006

Weblinks:

1. https://ocw.mit.edu/courses/materials-science-and-engineering/3-205-thermodynamics-and-kinetics-of-materials-fall-2006/
2. http://nptel.ac.in/courses/103101004/

MOOCs: Courses by MIT Open course ware and NPTEL

Pedagogy:

- Co-teaching
- Power point presentations
- Videos
- Demonstrations
- Systematic use of group work and project based learning

Assessment Scheme:

Class Continuous Assessment (CCA): 50 Marks

Assignments	Test	Presentations	Case study	MCQ	Oral	Any other
20 Marks	20 Marks	5 Marks	-	-	-	5 Marks

Laboratory Continuous Assessment (LCA): 50 Marks

Practical	Oral based on practical	Site Visit	Mini Project	Problem based Learning	Any other
-	-	-	-	-	-

Term End Examination :

Theory Question Paper of 50 marks

Syllabus:

Module No.	Contents	Workload in Hrs		
		Theory	*Lab*	*Assess*
1	**Thermodynamic Properties of Fluids:** Classification of thermodynamic properties, Helmholtz and Gibbs free energy, Fundamental property relations for closed systems, Maxwell relationships, Clausius-Clapeyron equation, thermodynamic diagrams.	**5**	**2**	**-**
2	**Solution Thermodynamics-I:** Fugacity and Fugacity Coefficient: Pure Species and Species in Solution, Activity and Activity Coefficient, Partial Molar Properties	**5**	**2**	**-**
3	**Solution Thermodynamics-II:** Chemical Potential, Ideal and Non-ideal Solutions, Lewis Randall rule, Raoult‟s law, Henry‟s law, Gibbs-Duhem Equations, Property changes of mixing of solutions	**5**	**2**	**-**
4	**Phase Equilibrium:** Criteria of Phase Equilibrium, Phase Rule for Non-reacting Systems, Phase diagrams for binary systems, Vapour Liquid Equilibria for ideal and non-ideal solutions, Azeotropes, Activity Coefficient Equations, Multicomponent VLE	**5**	**4**	**-**
5	**Chemical Reaction Equilibria:** Reaction Stoichiometry, Equilibrium Constant and Standard Free Energy Change, Effect of the following on Equilibrium Constant: Temperature, Pressure, Inert Materials, Excess reactants and Products., Heterogeneous Reaction Equilibria, Phase Rule for Reacting Systems	**5**	**4**	**-**
6	**Multiphase Equilibria:** Liquid-Liquid Equilibria (LLE, Vapour-Liquid-Liquid Equilibria (VLLE): Phase Diagrams, Concept of UCST and LCST, Calculation of equilibria using Activity coefficient models and EOS, Solid-Liquid Equilibria (SLE): Computing the solubility solute in a liquid.	**5**	**2**	**-**

SY B.Tech (Chemical Engineering) (TRIMESTER-III)

Course Code	**CH234**			
Course Category	**Professional Core**			
Course Title	**Chemical Reaction Engineering**			
Teaching Scheme and Credits	**L**	**T**	**Laboratory**	**Credits**
Weekly load hrs	**3**	**-**	**2**	**2+0+1**

Pre-requisites: Students should know basic Chemistry pertaining to Chemical Reactions, Chemical formula etc. They are required to be aware of Chemical processes and unit operations used for the manufacturing of chemical products. Simple to complex numerical methods of solving one and two dimensional Mathematical equations.

Course Objectives:

1. Write a rate law and define reaction order and activation energy
2. Develop kinetic model for homogeneous reactions giving emphasis on various types of reactions in adiabatic or non-isothermal conditions.
3. Demonstrate the ability to quantitatively predict the performance of common chemical reactors using simplified engineering models
4. Development of design strategy for homogeneous reactions considering different types of reactors

Course Outcomes:

At the end of the course, students should be able to :

1. Size batch reactors, semi batch reactors, CSTRs, PFRs, for isothermal operation given the rate law and feed conditions.
2. Define and develop rate equations for homogeneous reactions
3. Derive design equations for different types of reactors based on mole and energy balance
4. Relate rate of reaction with design equation for reactor sizing.

Course Contents:

Introduction and Reaction Kinetics of Homogeneous Reactions :

Chemical kinetics and thermodynamics of reaction, Homogeneous and Heterogeneous Reaction rates, rate constants, stoichiometry, and reactor mass balance, Kinetics of homogeneous reaction, Temperature dependency of rate constant – Arrhenius law, Transition state theory and Collision theory

Analysis of Batch Reaction Kinetic Data:

For Constant volume and variable volume batch reactor – Integral method and Differential method of analysis of experimental data, Regression analysis in fitting rate models ,Concept of half-life /fractional life. Over all order of irreversible reactions, Empirical rate equation for n^{th} order reactions, reactions. Auto Catalytic reactions. Shifting order reactions.

Design for Ideal Flow Reactor

Ideal batch reactor and concept of batch time. Flow reactor and concept of space time / space velocity and holding time / residence time. Ideal mixed flow reactor (MFR) and plug flow reactor (PFR)

Design for Single Reactions

Single reactor performance of reversible and irreversible first order, pseudo first order, second order reactions for MFR, PFR. Graphical and analytical techniques.

Design for Multiple Reactions :

Yield and selectivity, Parallel reactions Requirements for high yield. Best operating condition for mixed & plug flow reactors, Series reactions, Maximization of desired product rate in a plug flow reactor and back mixed reactor.

Laboratory Exercises / Practical: Every student will carry out minimum *Six Practical* exercises based on the above units and submit the journal, which will be evaluated as part of continuous assessment.

1. Effect of concentration and temperature on reaction rate.
2. Batch reactor.
3. Verification of Arrhenius law
4. Differential and integral analysis.
5. Acidic hydrolysis.
6. Condensation polymerization kinetics.
7. Constant flow stirred tank reactor (CSTR).
8. Plug flow reactor (PFR).
9. PFR-CSTR combination in series
10. CSTRs connected in series.

Learning Resources:

Reference Books:

1. Lenvenspiel, O.,Chemical Reaction Engineering, 3rd Edn., John Wiley & Co., 2004
2. Smith J.M., Chemical Engineering Kinetics, McGraw Hill. , 1992
3. Laidler, K.J., Chemical Kinetics, Tata McGraw Hill, 1997.
4. Fogler, H.S., Elements of Chemical Reaction Engineering, 4th Edn. PHI, 2008

Supplementary Reading:

Web Resources: MIT Courseware
https://ocw.mit.edu/courses/chemical-engineering/10-37-chemical-and-biological-reaction-engineering-spring-2007/
Weblinks: http://nptel.ac.in/courses/103106116/
MOOCs: Courses by MIT Open course ware and NPTEL

Pedagogy:

- Co-teaching
- Power point presentations
- Videos
- Demonstrations
- Systematic use of group work and project based learning

Assessment Scheme:

Class Continuous Assessment (CCA): 50 Marks

Assignments	Test	Presentations	Case study	MCQ	Oral	Any other
20Marks	20 Marks	--	5 Marks	--	--	5 Marks

Laboratory Continuous Assessment (LCA) : : 50 Marks

Practical	Oral based on practical	Site Visit	Mini Project	Problem based Learning	Any other
20 Marks	10 Marks	--	10 Marks	--	10 Marks

Term End Examination :: Theory Question Paper of 50 marks

Syllabus:

Module No.	Contents	Workload in Hrs		
		Theory	*Lab*	*Assess*
1	**Introduction and Reaction Kinetics of Homogeneous Reactions :** Chemical kinetics and thermodynamics of reaction; Homogeneous and Heterogeneous Reaction rates, , Kinetics of homogeneous reaction, Temperature dependency of rate constant – Arrhenius law, Transition state theory and Collision theory	**4**	**4**	
2	**Analysis of Batch Reaction Kinetic Data:** For Constant volume and variable volume batch reactor – Integral method and Differential method of analysis of experimental data, Regression analysis in fitting rate models, Concept of half-life /fractional life. Over all order of irreversible reactions, Empirical rate equation for n^{th} order reactions. Analysis of complete rate of reactions, Auto Catalytic reactions. Shifting order reactions.	**8**	**4**	
3	**Design for Ideal Flow Reactor** Ideal batch reactor and concept of batch time. Flow reactor and concept of space time / space velocity and holding time / residence time. Ideal mixed flow reactor (MFR) and plug flow reactor (PFR)	**6**	**4**	
4	**Design for Single Reactions** Single reactor performance of reversible and irreversible first order, pseudo first order, second order reactions for MFR, PFR. Graphical and analytical techniques.	**6**	**4**	
5	**Design for Multiple Reactions :** Yield and selectivity, Parallel reactions, Requirements for high yield. Best operating condition for mixed & plug flow reactors, Series reactions Maximization of desired product rate in a plug flow reactor and back mixed reactor.	**6**	**4**	

Prepared By

(Dr. Vikrant D. Gaikwad)
Associate Professor

Checked By

(Datta B. Dandge)
Associate Professor

Approved By

(Prof. Kiran D. Patil)
Chairman, BoS in Chemical Engg.
Head , School of Chemical Engg.

Prof. (Dr.) L. K. Kshirsagar
Dean